FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

FEED THE FUTURE INNOVATION LAB FOR HORTICULTURE

ANNUAL REPORT FY2022

USAID FROM THE AMERICAN PEOPLE

HORTICULTURE INNOVATION LAB

UC DAVIS UNIVERSITY OF CALIFORNIA

Feed the Future Innovation Lab for Horticulture

Annual Report 2021-22

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This publication is made possible by the generous support of the American people through the United States Agency for International Development (USAID). The contents are the responsibility of the Horticulture Innovation Lab and do not necessarily reflect the views of USAID or the United States Government.
COVER PHOTO: Dried okra in Guinea. Horticulture Innovation Lab photo by Siobhan Rubsam.

The Feed the Future Innovation Lab for Horticulture at the University of California, Davis (UC Davis) will work with and promote local leadership in communities across the globe to advance horticultural and social innovations for nutritional and financial security. Initiated in October, 2021 with a base $15 million investment from U.S. Agency for International Development (USAID) the Horticulture Innovation Lab is a five-year program and is the second competitive Feed the Future Horticulture Innovation Lab awarded to UC Davis. The competitive award for the Horticulture Innovation Lab was first received in 2009 when USAID selected UC Davis to lead a $14.6 million, five-year program (then called the Horticulture Collaborative Research Support Program, or Horticulture CRSP). The university was awarded a subsequent five-year phase for the Horticulture Innovation Lab ending in 2019 for $18.75 million.

The program team and its projects will help the world's poorest people break out of a persistent cycle of poverty by improving smallholder farmers' abilities to grow and sell high-value crops. Improving livelihoods—through higher profits and diversified, nutrient-rich diets—is a primary goal for the Horticulture Innovation Lab's research efforts around the world. The program's work will be guided by ensuring gender equity, youth empowerment, improved nutritional outcomes, improving information access, targeting innovative technologies and increasing research capacity.

Horticulture Innovation Lab projects will span the value chain of fruit and vegetable production, from seed systems to postharvest processing. Through partnerships and collaborative research, the program also aims to build the capacity of researchers, institutions and farmers to advance horticultural science.

MANAGEMENT ENTITY

The Horticulture Innovation Lab Consortium is managed by a team in the UC Davis College of Agricultural and Environmental Sciences, under the Department of Plant Sciences and the International Programs Office.

Members of the management entity:

- Elizabeth Mitcham, Director
- Erin McGuire, Associate Director
- Archie Jarman, Operations Manager
- Katie Schroeder, Financial Officer
- Siobhan Rubsam, Graduate Student Researcher
- Kristen Becker, Graduate Student Researcher
- Max Luepke, Undergrad Assistant

As part of this Management Entity Team, Consortium Specialists consistently engage with the Management Entity. Specialists include:

- Christine Stewart, Nutrition Specialist
- Hilary Proctor, Youth Specialist
- Janelle Larson, Gender Specialist

CONSORTIUM PARTNERS

Along with Consortium Specialists, the Consortium consists of Partners that are recognized as global experts in horticulture research and related fields. Partners include:

- Florida Agricultural and Mechanical University
- Michigan State University
- Texas A&M University

- World Vegetable Center

Along with Partners and Specialists, the Consortium also includes Scaling Partners that have experience with broad dissemination of innovations. Scaling Partners include:

- Cultivated New Frontiers in Agriculture
- International Fertilizer Development Center

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TECHNICAL AND/OR ADVISORY COMMITTEE INFORMATION

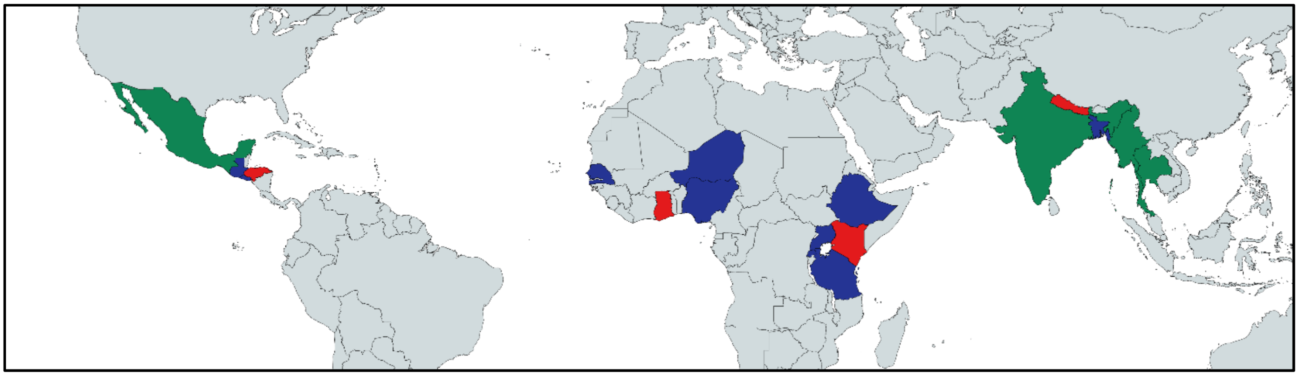
The Horticulture Innovation Lab's International Advisory Board (IAB) is the program's senior advisory council. The IAB ensures that Horticulture Innovation Lab priorities are met and integrated for maximum effectiveness. The IAB helps set priorities and ensure that USAID, Global Horticulture Assessment and Horticulture Innovation Lab objectives are met.

Members of the Horticulture Innovation Lab International Advisory Board:

- Daniel Bailey, U.S. Agency for International Development (ex-oficio), Agreement Officer Representative
- Maria Ester Bucaro, Counterpart International, Regional Program Director
- Rafael Flor, Bill and Melinda Gates Foundation, Senior Program Officer
- Anna Lartey, University of Ghana, Professor of Nutrition
- Hazel Malapit, International Food Policy Research Institute, Senior Research Coordinator
- B. Jan Middendorf, Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification at Kansas State University, Associate Director
- Latha Nagarajan, International Fertilizer Development Center, SOILS Consortium Director
- Kushal Naharki, Youth Ambassador - Nepal
- Vincent Roger, Cultivation New Frontiers in Agriculture, Regional Director of Program Development – West Africa
- Mary Ann Sayoc, East West Seed, Public Affairs Lead
- Lusike Wasilwa, Kenya Agricultural & Livestock Research Organization, Director of Crop Systems

LOCATIONS OF WHERE WE WORK

Although a majority of research projects will not be developed until early FY2023, after local challenges and opportunities are assessed, the Horticulture Innovation Lab plans to focus research activities in Feed the Future countries, with Regional Hub countries in Ghana (serving West Africa – Mali, Niger, Nigeria, and Senegal), Kenya (serving East Africa – Uganda, Ethiopia), Honduras (serving Central America - Guatemala), and Nepal (serving South/Southeast Asia - Bangladesh).



Countries where the Horticulture Innovation Lab is planning a Regional Hub are indicated with solid red and in blue are locations where regional research activities would impact. Green are countries with DryCard activities only.

LIST OF PROGRAM PARTNERS

United States – Cultivating New Frontiers in Agriculture; Florida Agricultural and Mechanical University; Institute for Global Nutrition, University of California, Davis; International Fertilizer Development Center; Making Cents International; Michigan State University; Pennsylvania State University; Texas A&M University

Ghana – University of Ghana; Afori Agrochemical Services (DryCard Entrepreneur)

Guatemala – EarthEmpower (DryCard Entrepreneur)

Honduras - Pan-American Agricultural School, Zamorano

India - Vivia Foundation (DryCard Entrepreneur)

Kenya – International Center for Evaluation and Development; Jomo Kenyatta University of Agriculture and Technology; GROOTS Kenya, BetterCrops Ltd. (DryCard Entrepreneur)

Mexico – EarthEmpower (DryCard Entrepreneur)

Myanmar – Myanmar Innovative Life Sciences (DryCard Entrepreneur)

Nepal –University of Agriculture and Forestry University; Forum for Rural Welfare and Agricultural Reform for Development; R&D Innovative Solutions (DryCard Entrepreneur)

Nigeria – Willow Foundation (DryCard Entrepreneur)

Rwanda – Development Solutions Consulting (DryCard Entrepreneur)

Taiwan – World Vegetable Center

Tanzania –Market Infrastructure, Value Addition and Rural Financial Services (DryCard Entrepreneur)

Thailand –Go Organics (DryCard Entrepreneur)

Uganda –Mwino Group (DryCard Entrepreneur)

ACRONYMS

AFU Nepal–Agriculture and Forestry University Nepal

AGRF–Africa Green Revolution Forum

AOR–Agreement Officer's Representative

BEO–Bureau Environmental Officer

CEP–Critical Engagement Projects

DDL–Development Data Library

EMMP–Environmental Management and Mitigation Plan

FAMU–Florida Agriculture and Mechanical University

FORUM–Forum for Rural Welfare and Agricultural Reform

FORWARD–Forum for Rural Welfare and Agricultural Reform

FTF–Feed the Future

GSR–Graduate Student Researcher

HIL - Horticulture Innovation Lab

IAB–International Advisory Board

ICED–International Center for Evaluation and Development

ICT–Information Communication Technology

JKUAT–Jomo Kenyatta University of Agriculture and Technology

KALRO–Kenya Agriculture and Livestock Research Organization

MILS–Myanmar Innovative Life Sciences

MORE–Market-Oriented Research for Empowerment

PERSUAP–Pesticide Evaluation Report and Safe User Action Plan

RFP–Request for Proposal

UC Davis–University of California Davis

UEI–Unique Entity Identifier

USAID–US Agency for International Development

WUR–Wageningen University and Research

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I. EXECUTIVE SUMMARY

The Feed the Future Innovation Lab for Horticulture at the University of California, Davis (UC Davis) works with and promotes local leadership in communities across the globe to advance horticultural and social innovations for nutrition and financial security. Initiated in October, 2021 with a base $15 million investment from U.S. Agency for International Development (USAID) the Horticulture Innovation Lab is a five-year program and is the second competitive Feed the Future Innovation Lab for Horticulture awarded to UC Davis. The program's work is guided by ensuring gender equity, youth empowerment, and; improved nutritional outcomes, improving information access, targeting innovative technologies and increasing research capacity.

Although a majority of our research projects will not be developed and initiated until early FY2023, after local challenges and opportunities have been assessed, the Horticulture Innovation Lab plans to focus research activities in Feed the Future countries, with Regional Hub countries in Ghana (serving West Africa –Ghana, Mali, Niger, Nigeria, and Senegal), Kenya (serving East Africa – Kenya, Uganda, Ethiopia), Honduras (serving Central America – Honduras, Guatemala), and Nepal (serving South/Southeast Asia – Nepal, Bangladesh). In this first year, the Horticulture Innovation Lab established a strong foundation for our locally led, globally supported program approach. Although activities experienced some lengthy start-up times; in part due to challenges with contracting with local organizations, and providing space and time for local organizations to develop projects; the outcomes from this approach will have long-term positive impacts.

Four Regional Horticulture Workshops were held in FY2022 in Kenya, Ghana, Honduras and Nepal, hosted by the International Center for Evaluation and Development, the University of Ghana, Zamorano University, and FORWARD Nepal, respectively. By having local organizations lead the implementation of a workshop gathering local experts in the horticulture, gender equity, youth engagement, and nutrition, the findings of these workshops (along with supplemental surveys and focus groups) will accurately identify local opportunities and challenges that demand additional research that could be supported by the Horticulture Innovation Lab and led by local organizations.

Through these workshops and accompanying surveys and literature reviews, the local organizations who hosted the workshops developed comprehensive assessment reports that established priorities and challenges in their region, across biophysical and socioeconomic themes. There was considerable overlap in the challenges and opportunities for the horticulture sectors in each of the four regions, but a few differences in the top priorities that emerged from each region. There was general agreement on prioritizing improved postharvest handling to reduce losses. Research to increase consumer demand for horticulture products was highlighted in East Africa, West Africa and Central America, with an emphasis on the benefits of indigenous vegetables in South Asia. Improvements in seed systems was highlighted in West Africa and South Asia, and research to improve production efficiencies was highlighted in East Africa and South Asia. The need to improve information services, including extension, was highlighted in West Africa and Central America, while research to improve practices for protected cultivation was highlighted in South Asia. These reports will be shared with USAID Missions and other stakeholders in each region, and form the basis for requests for proposals (RFPs) for research from the Horticulture Innovation Lab that address the challenges and opportunities as defined by local experts and stakeholders.

Two Critical Engagement Research Projects were developed, and the project led by Wageningen University and Research on the usage and adoption of plastic crates in informal tomato value chains in Rwanda and Nigeria was initiated in summer 2022. A second Critical Engagement Project went through a lengthy but beneficial competitive then co-collaboration process to develop a research program that will look at the socioeconomic and nutritional trade-offs in short and long value chains, and the socioeconomic and nutritional impacts that digital apps or information communication technologies (ICTs) have in those value chains. This research project will be led by Jomo Kenyatta University of Agriculture and Technology (JKUAT) and GROOTS Kenya, and we have initiated the approval and contracting process.

The Trellis Fund Fellowship program, originally launched in 2015 under the first phase of the Horticulture Innovation Lab, will be led by Consortium Partner, Florida Agriculture and Mechanical University (FAMU) in this phase of the program. The Trellis Fund is a capacity building program that connects local, in-country organizations in developing countries and in-country graduate students, with U.S. graduate students from 1890 universities who have agricultural expertise to conduct research projects, thus generating benefits for both the students and the institutions. Having FAMU coordinate the Trellis program this round has injected new and beneficial perspectives on how the Fellowship could be operated that will make this round of Trellis unique from previous versions, and we expect positive outcomes because of their fresh ideas. The program is expected to begin in January 2023.

The Horticulture Innovation Lab will have a Regional Hub in Honduras, Kenya, Ghana and Nepal. Zamorano University, the International Center for Evaluation and Development, and the University of Ghana have been selected as the Regional Hub organizations for the Horticulture Innovation Lab. We are finalizing contracts and key staff are in the process of onboarding. We will soon finalize our Regional Hub for South Asia. The Regional Hub Managers will be key members of the Horticulture Innovation Lab Management Team and facilitate local engagement with researchers, USAID, and other stakeholders.

It has taken some time to get the Horticulture Innovation Lab program to this point at the end of its first year, where we are poised to initiate the bulk of our research program. We believe the preparation time taken was essential to engage with local stakeholders in a meaningful way, to determine the priorities for our locally-led, globally-supported research program.

II. FOCUS COUNTRY KEY ACCOMPLISHMENTS

In this first year, the Horticulture Innovation Lab established a strong foundation for the locally led, globally supported program approach. Although activities experienced some lengthy start-up times in part due to challenges with contracting with local organizations or providing space for local organizations to prepare projects, the outcomes from this approach will have long-term positive effects. Beyond the initiation of two Critical Engagement Projects, the Regional Workshops helped the Horticulture Innovation Lab build up its network of local experts, gather input directly from those local experts, and led to the formalization of long-term relationships with local organizations through the establishment Regional Hub Managers that will feed and support research activities for the next four years.

REGIONAL HORTICULTURE WORKSHOPS

Four Regional Horticulture Workshops were held in FY2022. The workshops were in Nepal, Ghana, Kenya, and Honduras and invited participants throughout their respective regions to provide expertise on gender equity, youth engagement, nutrition, and the horticulture sector. Through these workshops and accompanying surveys and literature reviews, the local organizations who hosted the workshops developed comprehensive assessment reports that established priorities and challenges in the region across biophysical and socioeconomic themes. These reports will be used by the Horticulture Innovation Lab to build request for proposals (RFPs) for research that address challenges and opportunities as defined by local expertise.

REGIONAL HUB MANAGERS

The success of the workshops helped the Horticulture Innovation Lab in its process to select Regional Hub Managers. These Regional Hub Managers will play project management, financial management, monitoring and evaluation, and networking roles in four regions – Central America, East Africa, West Africa, and South Asia. The hosts of the workshops in Honduras, Kenya, and Ghana were Zamorano University, International Center for Evaluation and Development, and University of Ghana respectively, and they have been selected as the Regional Hub Managers for the Horticulture Innovation Lab. With the regional workshop in Nepal occurring later in the year, the Management Entity is still determining Regional Manager for South Asia. It must be noted that FORWARD Nepal, the host of the workshop in Nepal along with the Agriculture and Forestry University, put on an exceptional workshop.

CRITICAL ENGAGEMENT PROJECTS

One Critical Engagement Project started on-the-ground research activities in FY2022. The project, led by Wageningen University and Research, will research the motivations in the informal horticulture market sector to adopt new technologies that can increase food safety and reduce postharvest losses. Specifically, the project will examine the usage and adoption of plastic crates in tomato value chains in Rwanda and Nigeria and determine barriers to adoption or opportunities to leverage to increase adoption. The research will examine two programs that have already started introducing plastic crates into the informal value chain. The second Critical Engagement Project went through a lengthy but beneficial competitive then co-collaborative process to develop a research program that will look at the socioeconomic and nutritional trade-offs in short and long value chains (short being 1 intermediary or less) and the socioeconomic and nutritional impacts that digital apps or information communication technologies (ICTs) have in those value chains. This research project will be led by Jomo Kenyatta University of Agriculture and Technology (JKUAT) and GROOTS Kenya and focus on six commodities in twelve districts in Kenya.

SCALING TECHNOLOGIES

The Horticulture Innovation Lab's DryCard (a dryness indicator that can be used on any dried commodity) is now being sold by three new entrepreneurs in Kenya, Myanmar, and Nigeria. Additionally, testing and evaluation of two solar dryers developed by the Horticulture Innovation Lab occurred in Guinea and in Dominica by two U.S.-based graduate students conducting thesis research. A product of this research will be new and improved manuals for building and using the technologies. Finally, the Horticulture Innovation Lab has adopted the GenderUp scaling tool into its program and will utilize it to promote inclusive scaling.

III. RESEARCH PROGRAM OVERVIEW AND STRUCTURE

RATIONALE FOR HORTICULTURE RESEARCH

Investment in horticulture is important because of the close link between poverty, hunger and malnutrition. Horticulture development offers the opportunity to improve nutrition and health in the developing world, while providing prospects for income diversification and economic advancement of the rural poor. In addition, women are, in many regions, the main producers and marketers of horticulture crops, so increased horticultural production often leads to an improved income streams for women and youth. Horticulture research is crucial to enabling small-scale producers to overcome agronomic market barriers and realize the benefits offered by horticultural development.

TECHNICAL LEADERSHIP

UC Davis and its Consortium Partner institutions, (Florida Agricultural and Mechanical University; Michigan State University; Texas A&M University, and the World Vegetable Center), its Consortium Specialists (Pennsylvania State as gender specialist; Institute for Global Nutrition at UC Davis as nutrition specialist; and Making Cents International as youth specialist), and its Consortium Scaling Partners (Cultivating New Frontiers in Agriculture and International Fertilizer Development Center), and Regional Hub Managers (University of Ghana, ICED, Zamorano University, and FORWARD Nepal) provide a broad range of horticulture for development expertise to support locally-led research. The Management Entity regularly meets with the Specialists and Regional Hub managers for guidance and to build connections with in-country researchers seeking solutions to challenges in the horticulture sector.

INTERNAL CROSS-CUTTING THEMES:

Capacity development at all levels: Human and Institutional Capacity Development is both a management strategy and a cross-cutting theme for the UC Davis-led Consortium. Capacity development is essential for addressing current challenges and building opportunities, and for long-term sustainability of horticulture value chains.

Climate Change Adaptation and Mitigation: As one of the more pressing global challenges, tenets of climate-smart and agro-ecological principles will be critical to each of our projects. Further the Horticulture Innovation Lab will aim to not just mitigate climate change, but also increase ecosystem services through horticulture crops.

Gender and Equity: The Innovation Lab's research and interventions will be built to empower vulnerable people. The questions the Lab will ask will be informed by leaders within the most marginalized communities, and the Horticulture Innovation Lab will design innovations and interventions that specifically provide opportunities to these groups. The Innovation Lab will also integrate inclusivity into the project teams through training and accountability mechanisms for equity, equality, inclusion, and responsive project planning.

Youth: Providing a path to meaningful economic engagement through horticulture is an important goal of the UC Davis-led Consortium. The Horticulture Innovation Lab will engage with youth to determine their wants and needs to create youth-centered, age-appropriate opportunities, and help catapult youth into leadership positions in the horticulture sector.

Nutrition and behavior change: The Horticulture Innovation Lab will support research that improves understanding of nutritious crops from production to consumption. This includes furthering understanding of horticulture for nutrition interventions and their impact on behavior and dietary diversity. Development of food safety practices are essential in addressing health in the communities the Lab's networks serve. Research projects will be nutrition sensitive and incorporate appropriate nutrition objectives and benchmarks throughout the project term.

Resilience: Horticulture crops offer unique pathways to financial diversification, quick access to food and cash, and are often farmed by women, youth, and other marginalized communities. The Horticulture Innovation Lab will capitalize on this by designing research projects to capture these lessons and leverage them for larger populations.

RESEARCH APPROACH

The Horticulture Innovation Lab recognizes there are many challenges that limit further development of the horticulture sector. The Horticulture Innovation Lab's strategic approach to research is to ground-truth these challenges and also learn about opportunities within the four selected regions, highlighting local stressors that impact the horticulture sector, and brainstorm solutions during our Regional Workshops. The Horticulture Innovation Lab, in collaboration with local stakeholders, will prioritize those areas of greatest need and potential impact and empower local experts - that will be globally supported by experts within the Horticulture Innovation Lab Consortium - to conduct research to improve the horticulture sector and to develop appropriate, affordable, and scalable technological solutions. Additionally, there are important research topics in the social science area, such as understanding the drivers of fruit and vegetable consumption, testing models and understanding the constraints for youth/women/disadvantaged group engagement in horticulture, that will be integral within the Horticulture Innovation Lab research strategy. There will be two types of research projects that will be locally led, globally supported. Market-Oriented Research for Empowerment projects will research regional market solutions in the horticulture sector that also have gender equity, youth engagement, and nutritional benefits. Critical Engagement Projects will be smaller-scale, targeted research projects addressing the Innovation Lab's internal cross-cutting themes, and have research deliverables that will inform in part inform the activities of the broader, Market- Oriented Research for Empowerment projects.

THE LOCALLY-LED, GLOBALLY-SUPPORTED MODEL

(An adapted version of text below was first submitted as a 2-pager at the 2022 International Horticulture Congress)

Horticulture Innovation Lab Model: The locally-led, globally-supported model recognizes the benefits of locally-led research, while also acknowledging the importance of international networks to exchange ideas and promote continued learning. The Global North has been privileged to the lion's share of resources for basic research and development and therefore is responsible for sharing not only these results, but the resulting technical expertise globally. Thus, the Horticulture Innovation Lab's locally-led, globally-supported model partners with U.S.-based universities, NGOs, development implementers, and the World Vegetable Center to support and engage with academic leaders in the Global South. Each research project awarded over the life of the Horticulture Innovation Lab program will be Global South led, with an emphasis on developing the capacity of students and promoting the academic advancement of those in the Global South; supported by partnership with international experts. The Horticulture Innovation Lab believes this will result in better science and more effective horticulture research for development in the short and long term.

IMPLEMENTATION OF THE USAID FEED THE FUTURE INNOVATION LAB FOR HORTICULTURE MODEL

The systematic approach for establishing this model is described below in further detail. These mechanisms have been put in place to overcome logistical challenges to developing this new model within systems that have been historically developed for (intentionally or not) Global North to Global North contracting, monitoring and evaluation, and financial management.

Understanding the landscape and partners: To begin the process of identifying Global South partners and understanding on-the-ground priorities, the Horticulture Innovation Lab designed Regional Workshops to take place in the first 6-months of the 5-year funding cycle. As noted, these Regional Workshops were held in Kenya, Ghana, Honduras, and Nepal. The primary goal of these Regional Workshops was to collaboratively determine, based on local expertise, research opportunities that will have broad impacts across both biophysical and social sciences. Additionally, the workshops aimed to foster relationships and networks that can be leveraged in the implementation of project activities (and beyond). To address potential power-dynamics that could hinder voices during these Regional Workshops, intentionally designed break-out groups that facilitate engagement and anonymous surveys were utilized. While 40-60 regional experts attended the workshops, focus groups and interviews were conducted in the field with stakeholders, such as farmers and women's groups, who might not as easily attend the workshops. In-country organizations, mostly universities, were contracted to organize and lead the conferences and submit a report on their findings. Where universities were not able to hold such contracts, we contracted with intermediary organizations that then worked with subject matter experts. This activity provides a Global South led landscape assessment and network that will be foundational for the Horticulture Innovation Lab research project design and implementation.

Regional Management: The Regional Hubs and the Regional Hub Managers will operate on-the-ground coordination, networking, monitoring, needs-assessment, and information dissemination. Regional Hub Managers will play a key role in consistently connecting the Horticulture Innovation Lab with the network of local experts and leaders throughout the duration of the 5-year award. This allows real-time and regular input from regional stakeholders on new challenges or appropriate innovation. These Regional Hub Managers will also serve as a resource for PIs and subaward staff to overcome roadblocks during project implementation that may hinder research deliverables.

Global Consortium: The Horticulture Innovation Lab's global network of experts will provide technical expertise in most fields relevant to horticulture research for development. The Global Consortium does not prescribe perceived horticulture sector challenges and opportunities within a region, rather provides expertise when requested by local leaders of research projects. The global network of experts will be engaged to respond to and partner with local stakeholders and leaders. Connecting experts from around the globe with professionals tackling regional challenges is meant to develop a robust network of horticulture research for development knowledge. Results generated regionally will feed into a global network for the most impact, and an exchange of shovel-ready and promising innovation will inform regional-based research questions and challenges.

Awarding projects and contracting: For all newly awarded Horticulture Innovation Lab projects, local organizations receive the bulk of the project funding and responsibility, and the Global Consortium members operate as subcontractors, receiving approximately 30 percent of the total funding. Driven at the local level, these projects will be more responsive to regional needs and produce significant local institutional and individual capacity development. Extra care in the contracting process will be needed to determine the appropriate funding mechanism for local partners, along with forward-funding schemes. For instance, if subcontracting to project partners isn't an option for a local lead, the Horticulture Innovation Lab will directly contract with that partner, while maintaining the management flow of command. Additionally, if appropriate administrative costs are not included on top of the overall budget, budget line-items can be included to compensate administrative staff and contribute to operational costs.

Publication and Information Dissemination: Publication efforts are intentionally written into grants, with Global South PIs and students retaining first authorship. The Horticulture Innovation Lab encourages using a regionally appropriate language for documents and workshops, and ensures that budget line-items include translation services. We have found both steps to be key. Use of local language ensures participation by all, and translation facilitates report writing and analysis in the first language, while making the results accessible to a wider audience in English.

The Horticulture Innovation Lab has a framework for routine collection of data and feedback designed to facilitate improvements and adaptations in the horticulture sector. We will be waiting to see over the years the efficacy and success of the locally led, globally-supported model. There are some challenges that have already surfaced, around co-collaboration and contracting speed, power dynamics, administrative capacity of limited resourced local entities, and cross-cultural working styles. However, we remain optimistic that these overcoming and managing these challenges will ultimately produce more effective and long-lasting results.

IV. THEORY OF CHANGE AND IMPACT PATHWAY

The Horticulture Innovation Lab is a global research network that works with and promotes local leadership to advance horticulture and social innovations to empower smallholder fruit and vegetable farmers to earn more income while better nourishing their communities. To support this goal, the Horticulture Innovation Lab has locally led, globally supported activities that include Market-Oriented Research for Empowerment Projects and Critical Engagement projects. Along with other activities, this approach will lead to outcomes such as increased financial capacity and entrepreneurship, long-term degree attainment, empowered regional leadership, well-connected market systems, and institutional development. Ultimately, the outcomes of these activities will contribute to developing capacity of local networks and building resilient horticulture management systems, improved community nutrition, inclusive and profitable market systems, and gender equity, youth engagement and social inclusion. The overall focus on local researchers addressing local challenges and opportunities while promoting inclusion generates sustained impacts beyond the life of the Feed the Future Innovation Lab for Horticulture award, increasing resilience, access to nutritional fruits and vegetables, and improved livelihoods for stakeholders in the horticulture value chain.

See diagram below that describes all of the Horticulture Innovation Lab Activities, and how they work together within our sphere of control, influence, and interest.

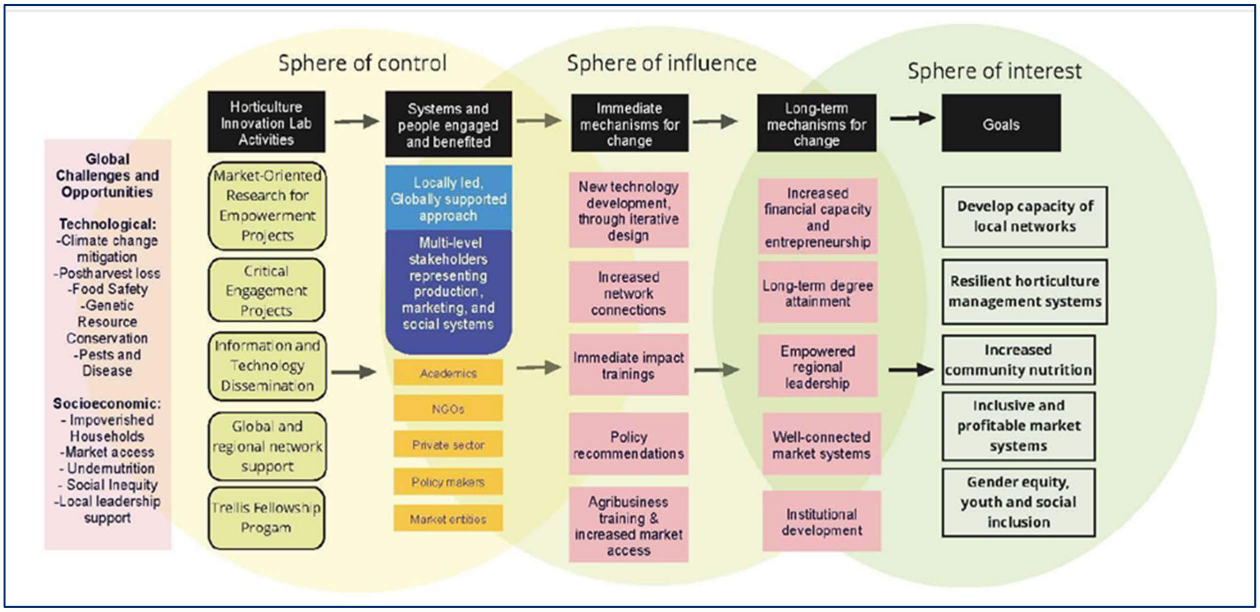

Figure 1Feed the Future Innovation Lab for Horticulture Theory of Change.

In addition, we believe that locally led, globally supported strategy builds long-term healthy entrepreneurial and expert eco-systems, regional technical expertise and thought leadership, and creates academic networks that can be engaged during regional crises. These outcomes build regional and systemic resiliency, an overarching goal of social transformation, increased incomes and nutrition, and are represented throughout the Feed the Future Initiatives.

V. RESEARCH PROJECT REPORTS

The Horticulture Innovation Lab is a global research network that works with and promotes local leadership to advance horticulture and social innovations to empower smallholder fruit and vegetable farmers to earn more income while better nourishing their communities. To support this goal, the Horticulture Innovation Lab has locally led, globally supported activities that include Market-Oriented

Research for Empowerment Projects and Critical Engagement projects. Along with other activities, this approach will lead to outcomes such as increased financial capacity and entrepreneurship, long-term degree attainment, empowered regional leadership, well-connected market systems, and institutional development. Ultimately, the outcomes of these activities will contribute to strengthening capacity of local networks and building resilient horticulture management systems, improved community nutrition, inclusive and profitable market systems, and gender equity, youth engagement and social inclusion. The overall focus on local researchers addressing local challenges and opportunities while promoting inclusion generates sustained impacts beyond the life of the Feed the Future Innovation Lab for Horticulture award, increasing resilience, access to nutritional fruits and vegetables, and improved livelihoods for stakeholders in the horticulture value chain.

I. HORTICULTURE REGIONAL WORKSHOPS AND HUBS

REGIONAL HORTICULTURE WORKSHOP EAST AFRICA

Location: Nairobi, Kenya
Description: A regional horticulture consultative workshop themed 'Assessing on-the-ground challenges and opportunities for innovative ideas and technologies that constrain/contribute to practical and academic horticultural pursuits' was convened. The physical workshop was preceded by pre-workshop scoping studies in Kenya, Uganda, and Ethiopia. The purpose of the scoping studies was to identify gaps in the available evidence within the horticulture landscape in the targeted countries. The scoping studies included desk reviews (Kenya and Ethiopia) and key informant surveys complemented by focus group discussions (Uganda). The studies also sought to document emerging trends, innovation advancements within the horticulture sector while highlighting documented challenges and opportunities in key horticultural value chains in the East African Countries. The pre-workshop findings guided the design of a 3-day regional consultative workshop that brought together key stakeholders in the horticulture sector in East Africa. The purpose of the workshop was to validate the findings from the scoping studies and also provide further insights into the challenges and opportunities in the horticulture sector.
Theory of Change: By having local organizations lead the implementation of a workshop gathering local experts in the horticulture, gender equity, youth engagement, and nutrition, the findings of this workshop (along with supplemental surveys and focus groups) will accurately be the local identification of opportunities and challenges that demand additional research, and additional research that could be supported by the Horticulture Innovation Lab and led by local organizations.
Collaborators: International Center for Evaluation and Development (ICED); University of Nairobi; Kenya Agricultural and Livestock Research Organization (KALRO)
Achievements: The workshop brought together a total of 132 participants representing key horticulture sector stakeholders and practitioners. They included representatives of farmers/farmer organizations, input suppliers, private sectors, traders, civil society, sector regulators, government, processors, researchers, academia, development partners, NGOs, community based organizations, among others. A total of 73 participants including 37 females and 36 males attended the physical convening while 59 participated virtually. Some key areas that emerged for areas needing additional research (full report in Appendix):

- Research to increase yield, quality, and efficiency for profitability.
- Research into technologies and practices to preserve quality and reduce postharvest losses.
- Research into market linkages and access (local, regional, and international).
- Research into nutrition awareness, consumer demand/preferences and knowledge as the drivers.
- Research into improving extension into capacity building.

Capacity Building: N/A

Lessons Learned: No lessons learned to report.

Presentations and Publications:

1) International Center for Evaluation and Development. (2022). East Africa Regional Workshop Report. Full report in the appendix.

REGIONAL HORTICULTURE WORKSHOP WEST AFRICA

Location: Accra, Ghana
Description: Bringing together leading experts and key stakeholders in the horticulture sector from 10 countries in West Africa, the Horticulture Workshop West Africa approach included the participation and involvement of a wide variety of stakeholders. Presentations were made by guest speakers who highlighted the emerging regional trends in the horticulture sector. The thematic areas for the presentations included (i) contribution of horticultural crops to healthy diets and improved nutrition (ii) food safety and post-harvest handling of horticultural produce (iii) role of the youth and gender in transforming horticulture (iv) horticultural funding and financing (v) role of research for horticultural development and (vi) challenges faced by smallholder horticulture farmers
Theory of Change: By having local organizations lead the implementation of a workshop gathering local experts in the horticulture, gender equity, youth engagement, and nutrition, the findings of this workshop (along with supplemental surveys and focus groups) will accurately be the local identification of opportunities and challenges that demand additional research, and additional research that could be supported by the Horticulture Innovation Lab and led by local organizations.
Collaborators: University of Ghana
Achievements: This Workshop was part of the FY2022 workplan and the original proposal for the Horticulture Innovation Lab. Experts in horticulture, gender equity, youth empowerment, and nutrition provided critical insights that were gathered and analyzed by University of Ghana team. Some key recommendations for research (for report in the appendix):

- Research should begin by focusing on all the horticultural products for conservation purposes, and then move on to specific crops.
- There is a need for research to assess the seed systems in West African countries, as this was an important topic that came out strongly during the conference.
- Research should also pay attention to market-oriented strategies to promote the consumption of horticultural products, thus creating an avenue for the private sector to come in and fund research.

Some key challenges reported:

- Compared to men, women rarely own land but cultivate smaller pieces of land. Also, land ownership by the youth is difficult due to the land tenure systems in most farming communities.
- Due to cultural norms, women in some communities are not allowed to plough their lands or attempt production until the men have. This is in the belief that a woman cannot lead a man.
- Distance to market centers and poor road networks are the main causes of the high postharvest losses. In addition, produce is also exposed to the sun leading to weight loss.
- There is a low consumption of fruits and vegetables in West Africa. Some of the reasons why; (i) Do not have the habit of using them in diet (ii) Lack of promotion and marketing of indigenous crops (iii) Low production leading to unavailability on the market (iv) The lack of knowledge about the nutrition content of horticulture crops.

Capacity Building: N/A

Lessons Learned: There are no lessons learned to report at this time.

Presentations and Publications:

1) University of Ghana. (2022). West Africa Regional Horticulture Conference Report; Horticulture for Food, Nutrition, and Livelihoods. See appendix for report

REGIONAL HORTICULTURE WORKSHOP CENTRAL AMERICA

Location: Tegucigalpa, Honduras
Description: The workshop set out to identify challenges, as well as possible opportunities in the horticultural and fruit value chain of the Northern Triangle of Central America of Central America, through work meetings using a focus group methodology.
Theory of Change: By having local organizations lead the implementation of a workshop gathering local experts in the horticulture, gender equity, youth engagement, and nutrition, the findings of this workshop (along with supplemental surveys and focus groups) will accurately be the local identification of opportunities and challenges that demand additional research, and additional research that could be supported by the Horticulture Innovation Lab and led by local organizations.
Collaborators: University of Zamorano
Achievements: to relevant section of annual work plan Performance Management Plan.): This workshop in Central America was outlined in the workplan for FY2022 and original proposal. A total of 48 representatives of key institutions and organizations of the horticultural sector in Honduras, El Salvador and Guatemala participated in the workshop. Additionally, 8 focus groups were developed; six groups in Honduras, with the participation of 110 actors of the chain from the different departments, one in El Salvador with 25 participants and another with actors from Guatemala that for reasons of the pandemic was developed virtually with the participation of 14 institutional representatives. Through these activities, quantitative and qualitative information was compiled on the constraints, problems, and opportunities, as well as the group agreements found in each component of the vegetable value chain studied, for subsequent analysis and general presentation of the results. Key challenges identified by the workshop that would benefit from research include (full report attached in the Appendix):

- *Lack of Knowledge Management*: Such as poor adaptation and appropriation of technologies, little or no technical assistance, little or no training and knowledge transfer, little or no business development, little or no communication of information.
- *Natural Resources, Environment and Socioeconomic Challenges*: Poor access and management of water, soil degradation and poor soil management. Poor access to financing. Little or no action to regulate product imports.
- *Limited Access to Technologies*: Limited infrastructure and equipment for value addition, lack of technology adoption.
- *Post-harvest and Processing Challenges:* High volumes of harvest waste, low product quality and safety.
- *Market Challenges in terms of Product Commercialization and Distribution:* Lack of enforcement of regulations, existence of an informal market, little access to high-value markets, low cultural identity in consumption.

Capacity Building: N/A

Lessons Learned: No lessons learned to report.

Presentations and Publications:

1) University of Zamorano. (2022). Analysis of the Challenges and Opportunities of the Horticulture Value Chain of the Northern Triangle Countries. (see appendix)

REGIONAL HORTICULTURE WORKSHOP SOUTH ASIA

Location: Kathmandu, Nepal

Description:
Theory of Change: By having local organizations lead the implementation of a workshop gathering local experts in the horticulture, gender equity, youth engagement, and nutrition, the findings of this workshop (along with supplemental surveys and focus groups) will accurately be the local identification of opportunities and challenges that demand additional research, and additional research that could be supported by the Horticulture Innovation Lab and led by local organizations.
Collaborators: Forum for Rural Welfare and Agricultural Reform (FORUM) Nepal; Agriculture and Forestry University (AFU) Nepal
Achievements: to relevant section of anual work plan Performance Management Plan.): To identify the priorities in the South Asia regional level, a three-day (12-14 September, 2022) Regional Horticulture Workshop was organized in Kathmandu, Nepal in which 89 in-person, local and regional leaders in academia, private sector, and NGOs working in Nepal and Bangladesh were gathered and thematic papers were presented in 18 priority areas followed by group discussion. Prior to this workshop, short studies including surveys (63 in Nepal and 25 in Bangladesh), focus group discussions (17 Nepal and 12 in Bangladesh), key informant interviews (36 in Nepal, 10 in Bangladesh) were also carried out to get the primary data in this regard.

Some of the recommended research priority areas that emerged from the workshop include:

- Development of quality seed, seedling, or sapling production for different crops.
- Enhancement of productivity through the adoption of high yielding variety, agronomic practices, management of serious insect pest and diseases.
- The development of improved practices for the emerging industry of protected cultivation of fruit and vegetables.
- Promotion of major indigenous fruits and vegetables.
- Development of proper post-harvest handling practices for the commercially produced fruits and vegetables.

Capacity Building: N/A

Lessons Learned: No lessons to report at this time.

Presentations and Publications: FORWARD Nepal. (2022). Project Report Feed the Future Innovation Lab for Horticulture in South Asia (see appendix)

REGIONAL HUBS

The Horticulture Innovation Lab in FY2022 selected Regional Hub sites. The Regional Hubs will primarily serve as a host for the Regional Hub Manager both in terms of providing an office space and as employer of the Regional Hub Manager. The Regional Hub Manager is an employee of the Regional Hub, but also be considered a part of the Management Entity of the Horticulture Innovation Lab. The Regional Hub Manager lives in-country and coordinates and monitors projects and trainings, introduces and advocates for new innovations, as well as cultivates in-country networks including USAID mission relationships. The three selected Regional Hub locations are ICED, University of Ghana, and Zamorano University. The Regional Hub Managers in those locations each have extensive, local, horticulture experience and will be amazing resources for research projects. The Regional Hub in Nepal will be determined in very early FY2023.

II. CRITICAL ENGAGEMENT PROJECTS

INFORMAL MID-STREAM ACTORS IN NIGERIA AND RWANDA

Location: Rwanda, Nigeria
Description: This study will test a methodology to diagnose the (potential) involvement of informal midstream actors in contributing to food system outcomes. This study will enhance understanding among policy makers and impact investors of the role of informal midstream actors using case studies in Nigeria and Rwanda (a previous Horticulture Innovation Lab project).

Theory of Change: By deepening our understanding of the informal economy and what drives its actors, we can engage them in enhancing food system outcomes, such as food safety and consumer demands to access nutritious and safe foods. We have to deepen our understanding of the informal economy and what drives its actors in order to achieve gains as efforts to reduce these value chain constraints often fail as the mid-stream actors are not registered and are operating in informality. Beyond conventional economic measures, there are likely other incentives could be more successful to drive change in the informal sector. .

Collaborators: Wageningen University and Research (WUR)

Achievements: This project is a Critical Engagement Project as outlined in the FY2022 workplan. In FY2022, WUR's research team conducted a mission to Rwanda to meet with the on-the-ground expert in Rwanda and Nigeria on-the-ground expert who will be leading the field research. Together the team created a joint approach to the development of the research methodology. They also created a joint understanding of challenges and issues in the informal midstream of the fruit and vegetable value chain. Finally, the team conducted test interviews with stakeholders involved in the informal midstream in Rwanda. The stakeholders were part of an earlier Horticulture Innovation Lab project evaluating and integrating plastic crates into the horticulture sector. Data collection will start in earnest in October in Rwanda and November in Nigeria.

Capacity Building: WUR trained the two local experts in Rwanda and Nigeria on the research method.

Lessons Learned: A key lesson learned is that 'informal' is regarded as very different across countries. For example, in Rwanda, most networks or groups are formalized by registration. This makes it sometimes difficult to create joint understanding. Therefore, it is better to refer to private sector-led midstream innovation instead of informal midstream innovation.

Presentations and Publications: N/A

ICT LANDSCAPE IN HORTICULTURAL VALUE CHAINS FOR INCLUSIVE COMMUNITY FOOD SYSTEM RESILIENCY AND POTENTIAL PATHS FOR SOCIAL TRANSFORMATION IN KENYA

Location: Kenya: Makueni, Kilifi. Kajiado, Kirinyaga, Kwale, Meru, Narokand Machakos, Kisii, Bungoma

Description: This study seeks to investigate the nutritional, economical, and social (gender equity and youth engagement) impacts – trade-offs - on producers along both short and long value chains of banana, mango, tomato, Kales, Cowpeas and African Nightshade, and, determine to what extent are Information and Communications Technology (ICT) incorporated and what are their benefits and or impacts. The study outputs will increase understanding of the level of penetration and utilization of ICT in selected horticulture value chains; inform evidence on suitable horticulture access pathways that increase stability in markets and increase value chain efficiencies; document the enabling environments and key characteristics that facilitate positive aspects of access pathways and establish how access pathways can either marginalize or empower vulnerable groups.

Theory of Change: Since the trade-offs may be complex and dynamic, monitoring of their intended and unintended effects along the value chain therefore becomes important. The study impacts will improve understanding on the level of penetration and utilization of ICT in the selected horticulture value chains; informed evidence on the suitable horticulture access pathways that increase stability in markets and increase value chain efficiencies; documentation of the enabling environments, levers, and key characteristics that facilitate positive aspects of horticulture access pathways (as identified by the nutrition, economic, and social trade off analysis) and establishment of how horticulture access pathways can either marginalize or empower women, youth, and other marginalized groups. With that understanding, research findings can be applied to other short or long value chains and horticulture systems incorporating ICT.

Collaborators: Jomo Kenyatta University for Agriculture and Technology (JKUAT) Kenya; GROOTS Kenya; International Center for Evaluation and Development, Kenya

Achievements: This is one of two Critical Engagement Projects as outlined in annual workplan. The two implementers, JKUAT and GROOTS, provide unique strengths for the project. JKUAT has extremely strong experience conducting horticulture-related research and GROOTS has a robust on-the-ground network of farmers that they routinely interact with. Challenges with UEI dramatically slowed the awarding of this proposal, and will now start on November 1rst, 2022.

Capacity Building: Research activities have not begun. However, it is worth noting that during the co-collaboration process and awarding of the proposal, institutional capacity building occurred for both JKUAT and GROOTs in terms of building competitive proposals for USAID-oriented awards.

Lessons Learned: We will now look into registering for UEI's without asking for SAMS.gov clearance as we recently learned that this may be a faster avenue.

Presentations and Publications: N/A

III. SCALING

DRYCARD FRANCHISE PROJECT

Location: USA, Tanzania, Rwanda, Nigeria, Thailand, Mexico, Guatemala, Myanmar, Kenya, Ghana, India, Uganda, Nepal

Description: The goal of this project is to increase awareness and adoption of the DryCard technology to improve storage systems and reduce postharvest losses. The Horticulture Innovation Lab is forming partnerships with organizations, businesses, and entrepreneurs to supply the DryCard to local communities of developing countries. This technology was highlighted in FY2022 workplan as a one that the Horticulture Innovation Lab continues to promote.

Theory of Change: By increasing awareness of the importance of properly drying and storing dried products, and empowering local entrepreneurs to be the distributor of an effective tool to measure dryness, smallholder farmers and traders will have greater access to nutritious dried fruits and vegetables, lower exposure to aflatoxins in maize and groundnuts in particular, and increased income from selling quality dried products.

Collaborators: Postharvest Consulting and Capacity Building Company, Tanzania; Agrifood Business Consulting, Rwanda; Willow Foundation, Nigeria; Go Organics, Thailand; EarthEmpower, Mexico and Guatemala; Ofori Agrochemical Services, Ghana; Mwino Group, Uganda; R&D Innovative Solution, Nepal; Vivia Foundation, India; Myanmar Innovative Life Sciences, Myanmar; BetterCrops Ltd., Kenya

Achievements: In FY2022, three new entrepreneurs were firmly established – BetterCrops Limited in Kenya, Willow Foundation in Nigeria, and Myanmar Innovative Life Sciences (MILS) in Myanmar. These entrepreneurs have been selling DryCards and in the case of MILS, using the DryCards in an FTF project they are a part of. The DryCard was highlighted by Administrator Powers in a tweet, promoted at Africa Green Revolution Forum (AGRF), and has made it to final rounds of scaling evaluations conducted by the USAID scaling team.

Capacity development: The Management Entity did not engage directly in capacity development with the exception of training the new entrepreneurs on how to construct and use the DryCard. However, there are trainings being provided to entrepreneurs in different settings while selling the DryCards.

Lessons Learned: Many are still unaware of the concept of water activity and postharvest losses. The Horticulture Innovation Lab is hopeful that working at the government level provide a conduit for widespread messaging of the importance of proper drying to reduce losses and aflatoxin contamination, thus the policy brief. However, no firm connections within governments in target countries have been realized.

Presentations and Publications

1) Feed the Future Innovation Lab for Horticulture. (2022). Policy Brief: Fungal Toxins and Food Insecurity. https://horticulture.ucdavis.edu/information/policy-brief-fungal-toxins-and-food-insecurity

IV. TRELLIS FELLOWSHIP

TRELLIS FUND FELLOWSHIP FOR 1890 GRADUATE STUDENTS

Location: Kenya, Honduras, Ghana, Nepal – Districts to be determined

Description: The Trellis Fund was started during the first phase of the Horticulture Innovation Lab. During this phase, 2021 to 2026, the Trellis Fund Fellowship program will be led by Consortium Partner, Florida Agriculture and Mechanical University (FAMU). The Trellis Fund will be a capacity building program that connects local, in-country organizations in developing countries and in-country graduate students, with U.S. graduate students from 1890 universities who have agricultural expertise to conduct research project, thus generating benefits for both the students and the institutions.

Theory of Change: By providing international research opportunities to 1890 graduate students, and connecting those students with in-country graduate students and organizations, all parties benefit from field research experience, sharing of knowledge and experience, and develop data and technology beneficial for smallholder horticulture growers.

Collaborators: Florida Agricultural and Mechanical University (FAMU)

Achievements: The Trellis Program is in the FY2022 workplan and in the original proposal for the Horticulture Innovation Lab. FAMU will manage the program for four years. The university is developing detailed workplans and budgets for the program. Including in the program will be training for selected U.S.-based graduate students in monitoring and evaluation, working in international settings, inclusion, and other pertinent topics. FAMU will coordinate with the Council of 1890s to select students for the Trellis Fund Fellowship.

Capacity Building: None conducted in FY2022

Lessons Learned: There are no lessons learned that need to be particularly highlighted. However, it is worth noting that FAMU coordinating the Fellowship has injected new and beneficial perspectives on how the Fellowship could be operated that will make this round of Trellis unique from previous versions and we expect positive outcomes because of their fresh ideas. These will be formalized once a final proposal is received and submitted to USAID for approval.

Presentations and Publications: N/A

VI. ASSOCIATE AWARD RESEARCH PROJECT REPORTS

No associate awards to report in FY2022.

VII. HUMAN AND INSTITUTIONAL CAPACITY DEVELOPMENT

FY2022 SHORT TERM TRAINING

Country of Training	Brief Purpose of Training	Who was Trained	Number Trained		
			M	F	Total
Rwanda	Team training on joint method development to assess midstream actors	Civil Society	2	0	2
Kenya, Nigeria, Myanmar	DryCard entrepreneur training	Private Sector	4	0	4

FY2022 LONG TERM TRAINING

Home Country	Name	Sex	University	Degree	Major	Graduation Date (Mo/Yr)
United States	1	Female	University of California, Davis	Bachelor’s	International Agricultural Development	June 2022
United States	2	Female	University of California, Davis	Master’s	International Agricultural Development	June 2023
United States	3	Female	University of California, Davis	Master’s	International Agricultural Development	June 2023
United States	4	Male	University of California, Davis	Bachelors	Horticulture and Agronomy	June 2023

FY2022 INSTITUTIONAL CAPACITY BUILDING

1) Description: Implementation of assessment oriented, data-gathering, regional horticulture workshops. The Horticulture Innovation Lab supported the development of survey questions, agendas, determination of topic areas, and attendees – which was led by local organizations. This process and event helped grow the networks of the organizations or universities across the regions and promote them as sources for horticulture expertise.
2) Partners: University of Ghana; ICED; University of Nairobi; Zamorano University; FORWARD Nepal; Agriculture and Forestry University; KALRO

VIII. INNOVATION TRANSFER AND SCALING PARTNERSHIPS

The Horticulture Innovation Lab supports the development of disruptive innovations and technologies to stimulate and facilitate horticultural development worldwide. Technologies and innovations have the ability to solve problems and to reduce barriers within the horticulture sector. With proper needs assessment, research, input and support, these technologies have the potential to change the lives of the world’s smallholder farmers for the better. The Horticulture Innovation Lab will focus on technologies that reduce on-farm costs, reduce postharvest losses, use labor more efficiently, empower women and youth, take advantage of information communications technologies opportunities, and use limited natural resources more sustainably. Technologies and innovations come in a variety of forms. “Hard” technologies are devices, prototypes and designs that improve our lives and, in some way, change the current system. “Soft” technologies encompass innovation in systems, behaviors, and methods within the horticulture sector. Assemblies of ideas and thought processes make up a soft technology.

The Horticulture Innovation Lab has two Scaling Partners within the Consortium – Cultivating New Frontiers in Agriculture and the International Fertilizer Development Center. Two individuals from these large-scale development entities were selected in the first half of FY2022 to serve on the Innovation Lab’s International Advisory Board and their insights and networks will be invaluable for strategies to disseminate technologies and reach a broad segment of smallholder farmers in target countries.

During FY2022, the Horticulture Innovation Lab has also collaborated with USAID’s Scaling Team and their efforts to get more technologies on to the market in a sustainable way. This has included evaluations of the CoolBot, DryCard, Solar Water Pump, Chimney Dryer, and Pallet Dryer. Additionally, the Horticulture Innovation Lab has offered to help with the testing of the new I2I life-cycle assessment program developed by the Soybean Innovation Lab. The two technologies that will be evaluated will be the Pallet Dryer and GenderUp Scaling Tool. Briefly, the Pallet Dryer is a low-cost bin dryer for bulk horticulture and staple crops and GenderUp is a tool to promote inclusive scaling outcomes that promote gender equity. Technologies were also highlighted through iReach in the technology showcase in Ghana.

Additionally, during FY2022, two graduate student researchers (GSRs) with the Horticulture Innovation Lab conducted research on the uptake of the Chimney Solar Dryer in Guinea and field tested the Pallet Dryer for coffee drying in Dominica. Findings from Guinea revealed that usage decreased in a village near Kindia due to damage to the Chimney Solar Dryer, but this can be repaired, and the village community still had positive reviews of the Chimney Solar Dryer while it was in operation. To assist in the rebuild, the GSR is developing a building and use manual for the Dryer in French that utilizes primarily images to convey how to adapt the Dryer so damage does not occur again. For the Pallet Dryer, the GSR tested drying coffee with the cherry (natural drying) in the Pallet Dryer. Due to the nearby hurricanes, the Horticulture Innovation Lab now knows that modifications can easily be made to make the unit more robust to high winds. The data from the drying trial is currently being evaluated. The GSR is similarly developing a manual on how to build and properly use the Pallet Dryer.

For the DryCard technology (a low-cost dryness indicator developed by the Horticulture Innovation Lab) scaling through in-country entrepreneurs continued in FY2022. The Willow Foundation in Nigeria, BetterCrops Ltd. in Kenya, and Myanmar Innovative Life Sciences in Myanmar were established as DryCard entrepreneurs and began manufacturing the DryCard.

IX. ENVIRONMENTAL MANAGEMENT AND MITIGATION PLAN

The Horticulture Innovation Lab submitted an Environmental Management and Mitigation Plan (EMMP) template to our Agreement Officer's Representative (AOR) for review. As no projects have been formally funded or initiated, no EMMPs have been completed. At the initiation of projects, research activities will be categorized in an EMMP, and the Innovation Lab will seek guidance from AOR and Bureau Environmental Officer (BEO) for any activities that do not meet the predetermined types of activities listed in the to-be-approved EMMP, or, do not qualify for categorical exclusion. No PERSUAPs are currently anticipated, but if needed, these will be sent for review and approval by the AOR and BEO prior to any research activities. The Management Entity will gladly provide completed EMMPs as they are submitted and project compliance with EMMPs will be tracked through the Piestar Database.

X. OPEN DATA MANAGEMENT PLAN

The Open Data Management Plan (plan) is tracked in our Piestar database in a format that aligns with approved Data Management Plan template. Data ready for submission will be either uploaded directly into the Development Data Library (DDL) or submitted to the DDL through a link to a publicly available data repository such as Harvard Dataverse. Updated Data Management Plans can be exported from Piestar and provided upon request.

XI. GOVERNANCE AND MANAGEMENT ENTITY ACTIVITY

The extensive horticulture experience UC Davis, the Regional Hubs, and the Consortium bring to the management of the Horticulture Innovation Lab gives tremendous value to this program and to USAID. The Management Entity at UC Davis uses this expertise and previous experience to develop strategic plans for promoting the benefits of horticultural crop production and marketing to improve livelihoods in developing countries. In addition to our Director, Associate Director, Operations Manager, and Financial Officer, we are supported by three specialists with expertise in high priority areas of gender equity, youth engagement and nutrition. They provide insight into all of our management activities. Our locally led approach, with support from this global expertise, positions the Innovation Lab to determine research priorities and develop requests for proposals that will meet the local needs, increase local capacity, and promote the sustainability and scalability of the program deliverables. The Management Entity of the Horticulture Innovation Lab is structured to minimize administrative overhead, ensure flexibility and transparency, and foster collaboration between institutions in the United States (including within the Consortium) and the developing world in building capacity for horticultural research, outreach and implementation.

The Horticulture Innovation Lab has successfully set-up three of the four regional hubs. These regional hubs provide global technical expertise that is locally focused, but shared throughout our network. Based at the University of Ghana, Zamorano Pan-American Agricultural School (Zamorano University), and the International Center for Evaluation and Development (ICED), these Regional Hubs are extensions of the Management Entity. Each hub has high-level management that is connected and experienced within the horticulture sector and a day-to-day manager of Horticulture Innovation Lab activities in the region. These managers are also experts within their field, most with recent doctorates. The Nepal Regional Hub is also nearly set-up, with a pending offer to FORWARD Nepal. These technical experts have already been involved in an extensive horticulture landscape analysis, and will play a leading role in setting priorities for the region, guiding research activities, and informing the work of the Management Entity.

We also are supported by the Horticulture Innovation Lab Consortium which consists of university-based scientists with broad expertise in biophysical, social, and economic sciences, WorldVeg with highly specific horticulture knowledge, and scaling partners with expertise in wide dissemination of hard and soft technologies. The Management Entity coordinates the Consortium's global expertise to collaborate with in-country experts to solve challenges and pursue opportunities in the horticulture sector. For each contract that is awarded to in-country leaders, about 30% of funds are reserved for any additional expertise the project leaders request from the consortium.

Additionally. the International Advisory Board plays a key role in ensuring the Horticulture Innovation Lab is positioned to achieve its programmatic research objectives set internally and guided by Feed the Future. The Advisory Board consists of global experts based in focus regions, and specialize in horticulture, economics, policy, nutrition, gender-equity, and youth engagement. We are also proud that this board is predominantly women and represents the diverse places we work. Our first board meeting was held in September where participants gave important programmatic insights and offered connections to ongoing horticulture activities in their networks. Our first all consortium, all board, all project meeting will be held in June 2023 in either Kenya or Ghana.

XII. OTHER TOPICS

The Horticulture Innovation Lab has adopted GenderUp into its programming. The scaling tool which promotes inclusive scaling practices was developed as a collaboration among WUR, CIAT Bioversity Alliance and UC Davis. This scaling tool will be utilized by projects and training to be a facilitator we be provided to both U.S.-based graduate students and international graduate students.

The Horticulture Innovation Lab's website continues to receive significant traffic, with over 10,000 unique visits a month. Since the restart of the Innovation Lab, traffic has trended upwards.

The reports from each of the Regional Workshops are valuable horticulture assessments from local experts. These will be foundational to the Horticulture Innovation Lab's research, but will also be disseminated to applicable Missions, organizations, and individuals.

Surveys developed by the Horticulture Innovation Lab were conducted at each Regional Workshop. The purpose of these surveys is to create an Innovation Network analysis that will be a baseline to determine the effectiveness of the Horticulture Innovation Lab to grow networks and leverage networks that have qualities (to be determined through analysis) that promote scaling of innovations. Already maps of organizations, their connections to one-another, and attributes are being generated and will be examined.

XIII. ISSUES

A major issue that the Horticulture Innovation Lab encountered in FY2022 was the acquisition of Unique Entity Identifier (UEI) numbers for in-country partners. Specifically, GROOTS Kenya and FORWARD Nepal have faced immense difficulties with the UEI process. FORWARD Nepal was able to proceed as a UEI number was tracked down, but GROOTS still lacks a UEI. The challenge is not only with garnering subaward approval with USAID, but also internally at UC Davis. With thanks to USAID, there seems to be a recognition of the extent of this issue and the delays caused (in the case of GROOTS, the delay has been approximately five months and counting) and has adjusted to allow exemptions. This will hopefully relieve UC Davis' expectation of a UEI for subawards.

XIV. FUTURE WORK

The second year of the Horticulture Innovation Lab program will usher in a significant increase in project activity. The work during year one has positioned the program very well for a rapid expansion in activities. By early November, we will have all four regional reports on opportunities and challenges of the horticultural sector, and the Consortium will meet with the Management Entity and our Regional

Workshop leaders to discuss the priority research needs in each region. Following this meeting, RFPs will be prepared and distributed for our Market-Oriented Research for Empowerment (MORE) projects, and new projects should be awarded by January 2023. Projects will include both technical and social aspects of horticulture for development. The lead organizations for these projects will be from our four focus regions of East Africa, West Africa, South and Southeast Asia, and Central America. Our multidisciplinary Global Consortium experts will provide assistance to projects, as needed.

Over the next two months, we will be finalizing agreements with our four Regional Hubs and the Regional Hub managers will be hired and begin to participate in Management Entity meetings. The Regional Hub managers will be responsible to coordinate Horticulture Innovation Lab activities within their region, represent the program at local meetings, and network within the horticulture industry and research communities.

In addition, our two Critical Engagement Projects (CEP) will both be underway by January 2023, with the addition of a new activity in Kenya to explore the resiliency and inclusivity of short and long horticulture value chains, and of use of ICTs in value chains. The first CEP was initiated in July 2022 to investigate the role of informal value chains in adoption of improved produce cartons in Rwanda and Nigeria. Results from this activity should be available by Summer 2023.

Our program will host its annual meeting in late Spring or early Summer, likely in Kenya. This event will bring all project leads together with our Consortium and our International Advisory Board for a joint meeting to share progress and lessons learned. There will also be a separate board meeting during this time. Our Regional Hub in Kenya will organize and host this meeting.

We expect to have our Communications Specialist on board in November 2022, and are looking forward to sharing more regularly about the activities of the Horticulture Innovation Lab and its partners. We also plan to continue our efforts in thought leadership within the development community.

XV. APPENDICES

APPENDIX A. LIST OF AWARDS GIVEN TO U.S. PARTNERS

To Be Awarded in Early FY2023 - Florida Agriculture and Mechanical University

- *Project: Trellis Fund Fellowship for 1890 Graduate Students*
- *Duration: FY2023 to FY2026*
- *Award total: $400,000*

APPENDIX B. SUCCESS STORIES

APPENDIX C. PUBLICATIONS (ATTACHED TO ANNUAL REPORT)

Success Story: GenderUp Scaling Tool Adopted by the Horticulture Innovation Lab

Women play a critical role in horticulture and technologies need to be scaled responsibly to promote gender equity

Gender up is an innovation scaling tool developed in a collaboration among Wageningen University and Research, CIAT Bioversity, and UC Davis, that is discussion based. The purpose of the tool is to guide innovation teams through several modules that promote the scaling of innovations in a socially inclusive, gender responsible way.

Existing tools for innovation scaling are generally limited to addressing, broadly, barriers to adoption without an analysis of scaling in a gender responsible way that generates equity for marginalized social groups.

Across three training workshops, innovation teams progress through five stages:

- Stage 1: Defining the innovation and scaling ambition
- Stage 2: Exploring relevant dimensions of diversity
- Stage 3: Understanding implications of intersectionality
- Stage 4: Mitigating consequences and embracing opportunities
- Stage 5: Integrating GenderUp into your project management

In this fifth stage, innovation teams collaborate with a trained GenderUp facilitator to review how the innovation team's scaling approach has been adjusted to be gender responsible, and the facilitator helps the innovation team further refine their approach. GenderUp program also includes a facilitator training program. This facilitator plays a critical role in the tool's process as the facilitator's expertise is relied upon prior to finalization of an inclusive scaling approach.

The Horticulture Innovation Lab will adopt the GenderUp scaling tool through several programmatic avenues. First, the tool will be utilized in all research projects. Innovation teams in each project will participate in the workshops to promote inclusive scaling of any research deliverables developed by the Horticulture Innovation Lab. Second, the Horticulture Innovation Lab will support and provide training to both U.S.-based graduate students and in-country graduate students. These new facilitators will then be positioned to assist innovation teams utilizing the training tool. Gender equity is a significant objective for Feed the Future.

To elaborate on the facilitator training, graduate students will be certified as facilitators and as a facilitator they will have an opportunity to collaborate with innovation teams across the globe working in a range of socioeconomic contexts. Their engagement in this process will help ensure innovations generate equitable and inclusive outcomes rather than perpetuating social norms that can marginalize women.

The Horticulture Innovation Lab anticipates significant snowballing effects from the training of graduate students to be facilitators. Graduate students, as part of a university, are interacting with innovation teams routinely, offering a setting where they can share what they have learned as facilitators. Furthermore, this will build the pool of facilitators for GenderUp, making the tool even more capable to work with a broad set of innovation teams.

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Success Story: Regional Horticulture Workshops

The Feed the Future Innovation Lab for Horticulture collaborated with local partners to host four highly successful workshops this past summer: in East Africa (Kenya), West Africa (Ghana), Central America (Honduras), and South Asia (Nepal). Each workshop was not just about highlighting the major horticultural challenges facing each region, but provided a platform for experts from private, public, and academic spheres to brainstorm solutions and opportunities moving forward. The success of each workshop was due in large part to the regional hosts, who took responsibility for organizing the venue, inviting attendees, and facilitating the agenda. These included the International Centre for Evaluation and Development (ICED) in Kenya, the University of Ghana, Zamorano University in Honduras, and Forum for Rural Welfare and Agricultural Reform (FORWARD) in Nepal.

Participants of the Central America Horticulture Regional Workshop in Honduras

While there were some overarching themes that surfaced in all four regions that address Feed the Future goals and objectives –gender and youth empowerment being number one–each workshop had a different take on what issues were most important to address in their part of the world.

· **East Africa:** Kenya kicked off the series of workshops in Nairobi in May. One of the most prominent discussion points that surfaced was how insufficient infrastructure was causing significant post-harvest loss. Since many villages in East Africa are remote and only accessible by unpaved roads, it takes significant transportation time from field to market–during which produce can spoil without refrigeration. But post-harvest challenges also present exciting opportunities, especially for young people, to research new technologies and business enterprises that focus on food preservation and transformation.

West Africa: Just a few weeks after the conference in Nairobi, the West Africa Regional Horticulture Workshop was underway in Accra, Ghana. Their major focus was the lack of quality inputs available to smallholder farmers. Since good quality seeds, fertilizer, and pesticides are expensive, farmers are forced to purchase what they can afford–which means they are buying from middlemen who are sometimes selling counterfeit products. Not only do these products often produce low yields, they also contain unregulated chemicals that cause health hazards and prevent products from passing export standards. Presenters stressed the importance of rural financing services, as well as a robust extension system, so smallholders can access safe and effective inputs and be well-informed on their use.

Central America: Honduras marked the next location in mid-June, attended by 45 people traveling primarily from Honduras, El Salvador, and Guatemala. One of their main focal points was how the region's current export regime leaves little access to fruits and vegetables for people actually living in the areas those products are grown. Presenters emphasized the importance of increasing local demand for fruits and vegetables, which would not only increase nutrition but also encourage exports to shift to more local and regional distribution. The government of Honduras is taking steps to make this happen, including implementing extension programs into universities to boost its efficacy throughout the region.

South Asia: The final destination was Nepal, taking place in mid-September. This workshop took a slightly different direction than the others, reflecting the extreme topography and climate of a region severely impacted by climate change. Their main focus was fruit tree cultivation–as not only an important source of revenue, but also a tool to combat deforestation. While there is significant potential in this sector, it is crucial that farmers have access to improved fruit tree varieties in order for it to be profitable.

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FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

Success Story: Exciting New Phase of the Trellis Fund Fellowship Project – Linking 1890 Land Grant Graduate Students with In-Country Organizations to Improve Horticulture

The Feed the Future Innovation Lab for Horticulture implemented the Trellis Fund project during the first two phases of the Lab. The Trellis Fund project awarded small in-country organizations grants to conduct research related to horticulture. As part of the award, a U.S.-based graduate student would be selected through a competitive process to collaborate with the local organization to conduct the research both remotely and in the field. Furthermore, in-country graduate students were encouraged to join with the U.S.-based student to implement the research project, thus building the capacity of the local organization, the U.S.-based student, and in-country students over the course of the year-long

Group photo from a 2014 Trellis Fund project, after a farmer workshop in Kenya focused on improving postharvest practices with mangoes, led by the University of Nairobi

In this new iteration of the Horticulture Innovation Lab, we are privileged to have Florida Agricultural and Mechanical University (FAMU) as a Partner in our Consortium. FAMU has extensive international agriculture, research for development experience. They also are an 1890 Land Grant university and part of a council of 1890 universities. Considering this, FAMU is an ideal leader to implement the newest phase of the Trellis Fund project. For four years, graduate students from 1890 Land Grant universities will conduct research with local organizations in Kenya, Honduras, Nepal, and Ghana. The students will collaborate with the local organizations on an annual basis to implement the research, however the projects will be four years long. This allows for the research projects to be more comprehensive, generate more sustainable impacts, and the experience of the U.S.-based graduate students to progressively build on one another's experience. Additionally, U.S.-based students will collaborate with in-country graduate students.

The Trellis Fund Fellowship project aligns with several Feed the Future initiatives and themes. The research is locally-led has promoted horticulture, gender equity, youth engagement, and nutrition. The research will address multiple components of the horticulture value chain, from seed to consumption.

The alterations to the original Trellis Fund project format that are being made by FAMU are exciting. The original Trellis Fund project was successful, but we anticipate that with the program being led by FAMU there will be unique benefits in the program due to their approach in implementation. The first set of students will be selected in 2023 and connected with local organizations for research. The students will travel in the summer of 2023 to each of the countries to implement the field-based part of the research program. Information about how to apply will be posted through both FAMU and Horticulture Innovation Lab communication channels.

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FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

THE FEED THE FUTURE INNOVATION LAB FOR HORTICULTURE

LED BY THE UNIVERSITY OF CALIFORNIA AT DAVIS

Our global research network works with and promotes local leadership to advance horticulture and social innovations, empowering smallholder farmers to earn more income while better nourishing their communities.

Fruits and vegetables are high-value crops that can help boost farmer income.

Why Horticulture: Fruits and vegetables represent an important opportunity to improve community health, while also increasing income for smallholder farmers. Horticulture crops generate high economic returns per unit of land and offer ample off-farm entrepreneurial opportunities **- creating more holistic and inclusive food systems**. Women, youth, and other marginalized social groups are often the main producers and marketers of horticulture crops. This, combined with the high value of fruits and vegetables makes investments in these crops a step toward social transformation. Horticulture also has a unique role in **ensuring access to and availability of diverse, nutritious food.**

Fruits and vegetables are valuable sources of nutrients for healthy diets

The newly awarded **Feed the Future Innovation Lab for Horticulture at UC Davis** will follow a ***locally-led, globally supported*** model for program development and implementation.

The model integrates **four regional hubs** that will support holistic, systems-driven horticulture value chain research projects that cross borders to integrate learnings from different cropping systems, climate-change resilient agriculture practices, and social sciences**.** The hub locations are Ghana, serving West Africa; Kenya, serving East Africa; Honduras, serving Central America; and Nepal, serving South/Southeast Asia.

This model supports community and regional leadership and expertise through local identification of regional priorities and contractual partnerships with in-country and regional stakeholders to manage and lead research activities. Global support provided by the Horticulture Innovation Lab includes **expertise in horticulture, agronomics, agri-sociology, agribusiness and agri-policy**. Horticulture Innovation Lab consortium researchers will enable the long-term development of regional expertise and co-produce new knowledge to be applied regionally.

FEED THE FUTURE INNOVATION LAB FOR HORTICULTURE

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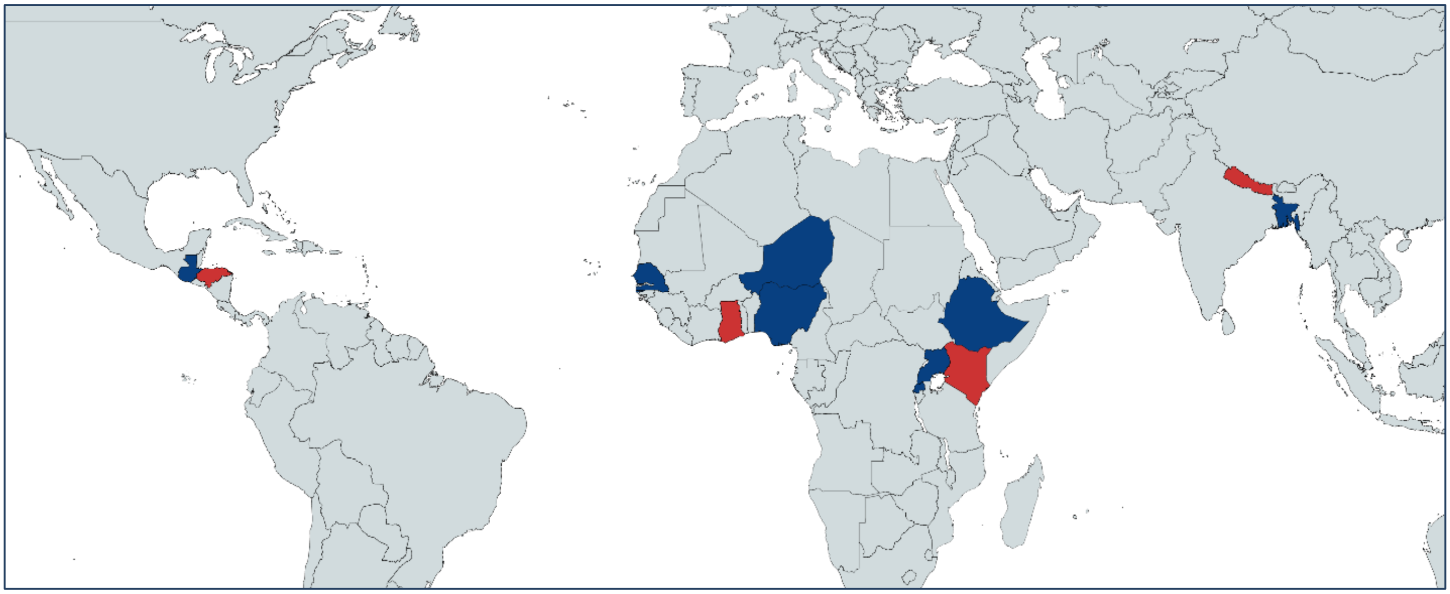
Focus Countries for Future Research Activities



In the map above, countries where the Horticulture Innovation Lab is planning a Regional Hub is are indicated with solid red, blue are countries where we anticipate research activities to occur

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Our Consortium

UC Davis is joined in a consortium with Florida A&M University, Michigan State University, Texas A&M, and World Vegetable Center, along with subject matter experts from Penn State University and Making Cents International, to help manage this program.

FLORIDA A&M UNIVERSITY
FLORIDA AGRICULTURAL AND MECHANICAL UNIVERSITY

MICHIGAN STATE UNIVERSITY

World Vegetable Center

TEXAS A&M UNIVERSITY

PennState

MAKING CENTS INTERNATIONAL

UCDAVIS
DEPARTMENT OF NUTRITION

CNFA

IFDC
Developing Agriculture from the Ground Up

FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

EAST AFRICA REGIONAL HORTICULTURE WORKSHOP 2022

ICED
The International Centre for Evaluation and Development
Your global evaluaton and development partner

THEME:

Assessing on-the- ground challenges and opportunities for innovative ideas and technologies that constrain/contribute to practical and academic horticulture pursuits.

WORKSHOP REPORT

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We also express our sincere gratitude to the representatives of the ministries, agencies, departments, programs, nongovernmental organizations, civil society organizations, private sector actors, and youth networks that participated in the regional consultative workshop and provided data and lessons on their programs.

We wish to thank as well all those who in diverse ways contributed to the compilation of this workshop and report.

Finally, we wish to recognize the generous funding from Feed the Future, Horticulture Innovation Lab, and United States Agency for International Development (USAID), without which all these activities would not have been possible.

Sincerely,

Dr. David Sarfo Ameyaw
President & CEO
International Centre for Evaluation and Development (ICED)

ABBREVIATIONS

ALVs- African Leafy Vegetables

CBOs- Community Based Organizations

CGIAR- Consultative Group on International Agricultural Research

DRC- Democratic Republic of Congo

EA- East Africa

EAC- East African Countries

EU- European Union

GAP- Good Agronomic Practices

GDP- Gross Domestic Product

GIZ- Deutsche Gesellschaft für International Zusammenarbeit

GYEM- Gender and Youth Empowerment in Horticulture Markets

HIL- Horticulture Innovation Lab

ICED- International Centre for Evaluation and Development

MELTA- Mentorship, Empowerment, Linkages, Training, Access

NGOs- Non-governmental Organizations

SNV- Stichting Nederlandse Vrijwilligers (Netherlands Development Organization)

UAE- United Arab Emirates

USAID- United States Agency for International Development

VMG- Vulnerable and Marginalized Groups

WHO- World Health Organization

EXECUTIVE SUMMARY

The horticulture sector significantly contributes to food and nutrition security, employment creation, poverty alleviation and livelihoods of many households in Kenya, Uganda, and Ethiopia. The sector has enormous potential that remains untapped due to various constraints and challenges at all stages of the supply chain from input supply to market access and consumer preferences. Alongside the challenges, there exists unexplored opportunities for inclusive growth especially for youth and women. Identification and prioritization of the challenges and opportunities by key stakeholders and practitioners in the horticultural value chains is critical for targeted interventions to achieve productive, efficient, sustainable, and inclusive growth of the horticulture sector in East Africa. Therefore, the feed the future Horticulture Innovation Lab together with partner institutions organized a regional consultative workshop to identify opportunities and challenges in the horticultural sector in the East Africa region, which could be explored or addressed through research, capacity building and targeted investments. The findings will guide design and implement locally led, globally supported programs that will produce systemic, sustainable, and inclusive improvements in the horticulture sector.

To achieve this, a regional horticulture consultative workshop themed 'Assessing on-the-ground challenges and opportunities for innovative ideas and technologies that constrain/contribute to practical and academic horticultural pursuits' was convened. The physical workshop was preceded by pre-workshop scoping studies in Kenya, Uganda, and Ethiopia. The purpose of the scoping studies was to identify gaps in the available evidence within the horticulture landscape in the targeted countries. The scoping studies included desk reviews (Kenya and Ethiopia) and key informant surveys complemented by focus group discussions (Uganda). The studies also sought to document emerging trends, innovation advancements within the horticulture sector while highlighting documented challenges and opportunities in key horticultural value chains in the East African Countries. The pre-workshop findings guided the design of a 3-day regional consultative workshop that brought together key stakeholders in the horticulture sector in East Africa. The purpose of the workshop was to validate the findings from the scoping studies and also provide further insights into the challenges and opportunities in the horticulture sector. The hybrid event brought together producers, horticulture sector leaders, researchers, academia, private sector practitioners, development agencies, civil society, NGOs, CBOs, and policy makers to learn, share information, build networks and partnerships. The diverse stakeholders sought to identify challenges, opportunities in the horticulture sector and effective strategies and interventions for systemic, sustainable, and inclusive improvements in the horticulture sector. The workshop theme was unpacked into six sub themes which guided the different workshop sessions including keynote presentations; panel and plenary discussions; breakout sessions/focus group discussions and experience sharing. There were also exhibitions by eight organizations across the region highlighting various projects, activities, and products. This report provides a summary of the key findings of the pre-workshop studies which were corroborated by the deliberations of the three-day regional consultative workshop. The report highlights the key challenges and opportunities at the various stages of the horticultural value chains – from input supply to markets. Opportunities for youth, women and the marginalized as interest groups in the horticulture sector are highlighted. Given the diversity of the sector, the challenges and opportunities highlighted apply indiscriminately to various horticultural value chains. Further, the report highlights research, investment and capacity gaps in the horticulture sector and interventions to address them. The report also provides a call to action by different stakeholders to ensure a productive, resilient, efficient, sustainable, and inclusive horticulture sector in East Africa.

1.0 INTRODUCTION

The Horticulture sector is key for food and nutrition security and a major engine for economic growth in Kenya, Uganda, and Ethiopia. Horticultural commodities (fruits, vegetables, herbs, and spices) constitute dietary staples for many households. Their vitamin, mineral and fiber content are critical for healthy populations. The sector contributes significantly to the gross domestic product (GDP) and is among the leading foreign exchange earners in the three countries. For example, in Kenya, the horticulture sector contributes 24% of the GDP and earns the country approximately 150 billion KES (1.5 million USD) annually. In addition, the sector directly employs over 350,000 people and supports another six million people indirectly. The horticulture sector is a source of raw materials for many agro-industries and is seen to have great potential for growth of cottage industries in rural areas. Uganda is second to Nigeria as far as the export of fresh fruits and vegetables is concerned. Uganda currently exports 5.8 million tons of fresh fruits and vegetables annually and aims to raise export earnings to $1 billion annually. The horticulture sector in Uganda contributes about 7% of the GDP and earns the country approximately 114.2 million USD annually. In Ethiopia, the horticulture export sector is young, and has shown quite an exponential growth in the last ten years. However, there is very limited reliable data on the annual contribution of horticulture to Ethiopia's GDP.

Horticultural production in the region is dominated by small scale farmers (>80%) who produce intensively on small parcels of land (some less than 2 acres). Most of the horticultural commodities are consumed in the domestic market and a small percentage exported to various export destinations including the EU, Middle East, China, United Arab Emirates, Australia, and the United Kingdom. In Kenya only 5% of the produce is exported while the rest is consumed locally in the fresh form and a small percentage (<10%) processed. In Uganda, the majority of the horticultural produce, approximately 89% is consumed locally while the remaining percent (11%) is either exported to regional or international markets. A similar trend is observed in Ethiopia where most of the horticultural crops produced by smallholder farmers are consumed locally. After harvest, they are transported to rural market centers for local consumers or are bought at the farm by neighbors. Others are transported to bigger market centers where many producers utilize the open-air markets once or twice a week.
The table below shows the major fruits and vegetables produced in Kenya, Uganda, and Ethiopia – for domestic and export markets.

	Kenya	**Uganda**	**Ethiopia**
Fruits	1. Banana	Mango	Banana
	2. Mango	Banana	Avocado
	3. Avocado	Watermelon	Mango
	4. Passion fruit	Papaya	Papaya
	5. Watermelon	Pineapples	Oranges
Vegetables	1. Kales	Tomatoes	Pepper
	2. Cabbage	Onions	Ethiopian cabbage
	3. Tomatoes	Cabbage	Cabbage
	4. Potatoes	Cucumbers	Tomatoes
	5. French beans (export)	Leafy Indigenous vegetables	Swiss Chard

Mango and banana are among the top five fruits while tomatoes and cabbages top the list of vegetables in all the three countries.

The sector has experienced significant growth over the years driven by increasing demand for nutritious and protective foods locally and globally. The critical role of fruits and vegetables in diets came to the fore during the Covid-19 pandemic when consumption of these commodities as protective foods increased exponentially leading to a sharp increase in their demand. The increasing number of the middle class with more disposable income to spend on high quality, nutritious, safe food and convenience has also driven growth and diversification in the sector. On the other hand, for many, especially the low-income population living in urban areas, consumption of fruits and vegetables is low because of availability and affordability. Therefore, many do not meet the WHO-recommended dietary requirements of 400 g per day. For example, in Kenya only 2.5 million out of a total population of about fifty million, consume the recommended quantities of fruits and vegetables. A similar trend has been reported in Uganda, where the majority of adults do not meet the recommended minimum requirements for fruit and vegetable consumption, with just 1 in 10 adults meeting the recommended minimum. Similarly, the overall consumption of fruit and vegetables in Ethiopia is very low, with only 1.5% of the population consuming the WHO-recommended amount of 5 servings a day (400 g).

Although the region is endowed with favorable agro-ecological and edaphic conditions that favor production of fruits, vegetables, herbs and spices, productivity remains very low. This is attributed to many challenges at the various stages of the value chains. At the production stage, low quality inputs (seeds/seedlings, fertilizers), indiscriminate use of agrochemicals without observing regulations/requirements and other poor crop husbandry practices negatively affect the yields and quality of the horticultural produce. In addition, the majority of the smallholder farmers depend on rainfall for their production hence seasonality in some commodities. This situation has been aggravated by unreliability of rainfall which is attributed to the effect of climate change.

Postproduction, poor harvest, and postharvest management practices have been shown to lead to high postharvest losses estimated to be 40 – 50% of the total production. The losses are attributed to various drivers and causes at the micro, meso and macro levels. Poor market information and market access coupled with poor infrastructure (roads, processing, cold chain) are key drivers of high postharvest losses in the horticultural value chain. The sector is also characterized by inefficiency and long value chains with poorly organized actors. The losers in these inefficient systems are smallholder farmers who lack access to information and technologies to improve their operations. This makes the farmers vulnerable and in most cases are at the mercy of traders who have better knowledge of markets and the market requirements and use this advantage to exploit the farmers. The horticulture sector globally is very dynamic and requires the practitioners to be well versed with knowledge and emerging trends for their ventures to remain competitive and profitable. Multi-thronged strategies to address these challenges present enormous opportunities to engage youth and women in meaningful agribusiness ventures thereby harnessing their unexplored capacity.

Although the individual East African countries have national strategies and policies aimed at developing and improving in-country horticultural sectors, there are also regional initiatives with the same goal. Examples of these include the EAC regional fruits and vegetable strategy and action plan 2020-2030 which is aimed at providing a regional perspective to horticultural investment, promoting effective partnerships in EAC as well as policy harmonization to maximize synergies and sustainable horticultural growth. Another example is the EAC food and nutrition strategy 2018-2022 is aimed at improving sustainable and inclusive agricultural production, strengthen resilience among households, communities and livelihood system and improve access to and utilization of nutritious, diverse, and safe foods. In addition, there is the EAC industrialization strategy 2021-2032 whose objective is to enhance industrial production and productivity and accelerate the structural transformation of the economies of the EAC for attainment of sustainable wealth creation, improved incomes, and a higher standard of living for the community.

Actualization of the national and regional policies and strategies requires targeted investment to address the challenges highlighted. Targeted research and translation of the research into tangible outputs is required to address the challenges. Capacity building at all levels is required to ensure that practitioners in the sector are well equipped with current knowledge and practical skills in the dynamic horticulture sector. Linkages between the various actors through horizontal and vertical integration are key to ensure efficiency and equity in the value chains. An enabling policy environment and political good will are key ingredients for the desired growth in the sector.

In this regard, the Horticulture Innovation Lab (HIL) at University of California Davis is seeking to support local initiatives to address the challenges while harnessing opportunities in the horticulture sector. This will be achieved through a locally led, globally supported program that will produce systemic, sustainable, and inclusive improvements in the horticulture sector. To ensure ownership and buy-in to this initiative, HIL in partnership with regional experts in Horticulture held a regional consultative workshop that brought together diverse stakeholders in the horticulture sector of three feed the future countries in East Africa (Kenya, Uganda, and Ethiopia). The aim of the consultative workshop was to identify challenges and gaps within Africa's horticulture landscape with respect to research, capacity, innovation, and technology. This would then inform specific research, capacity development and investment opportunities.

1.1 Workshop Objectives

The overall objective of the workshop is to identify effective strategies and interventions for ensuring systemic, sustainable, and inclusive improvements in the horticulture sector.

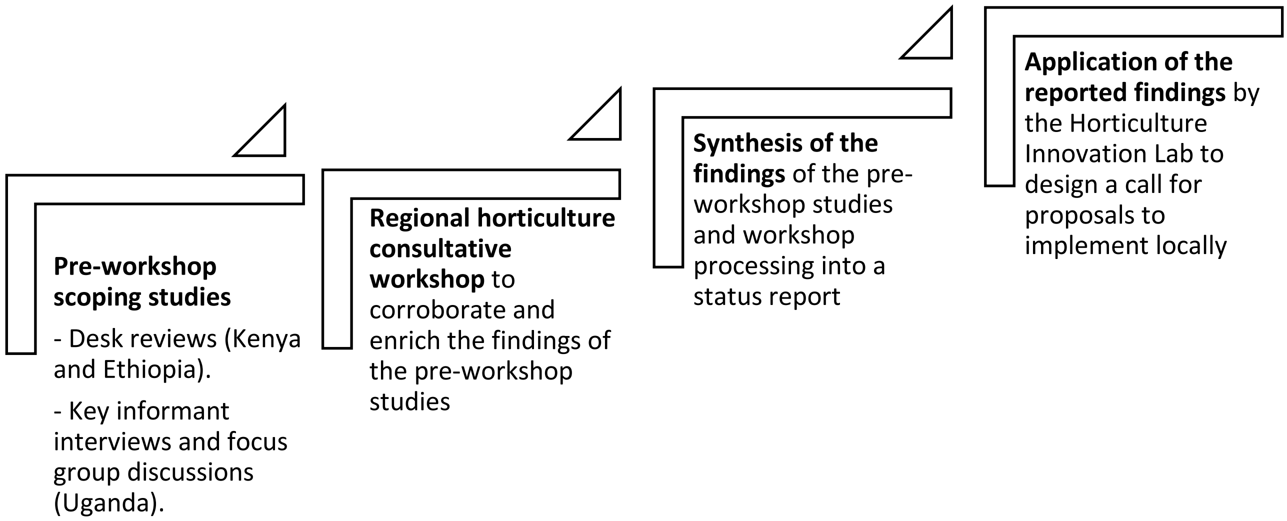
1.2 Specific objectives

1. To facilitate dialogue and present on horticulture opportunities in the region and how they could be effectively explored.
2. To identify effective interventions to address challenges within the horticulture value chain.
3. To agree on a set of priorities for future research, capacity building or investment within the sector.

4. To produce the best possible ways to generate and utilize trustworthy and rigorous evidence and research relevant to Africa's context in support of the horticulture sector
5. To propose models for collaboration and ownership that could be adopted in the region
6. To highlight and share what has worked and what has not worked in using cutting-edge innovation, technologies, research, and evaluation results to enhance growth in the sector.
7. To discuss the impact of the covid-19 pandemic and climate change on the sector as well as and adaptations to improve yield, profitability, and resilient recovery for smallholder farmers.

2.0 APPROACH/METHODOLOGY

The process of gathering information, synthesis, and application of information about the horticulture sectors of Kenya, Uganda and Ethiopia is described below:



2.1 Pre-workshop Studies

The pre-workshop scoping studies were used to systematically map out challenges and opportunities in the regional horticulture sector as documented in literature. The studies also identified evidence gaps with respect to research, capacity building and investment in the sector. These studies yielded a white paper (Kenya) and a sector report (Ethiopia). In the case of Uganda, semi-structured questionnaires were used to conduct focus group discussions and key informant interviews targeting key stakeholders and practitioners along selected horticultural value chains.

The pre-workshop studies were used to map out the key stakeholders in the sector in each country and informed the design/structure of the regional consultative workshop.

2.2 Regional Horticulture Consultative Workshop

The 3-day hybrid workshop was held at the Hermosa Garden Hotel in Nairobi from 25th to 27th May 2022. The workshop brought together a total of 132 participants representing key horticulture sector stakeholders and practitioners. They included representatives of farmers/farmer organizations, input suppliers, private sectors, traders, civil society, sector regulators, government, processors, researchers, academia, development partners, NGOs, CBOs, among others. A total of 73 participants including 37 females and 36 males attended the physical convening while 59 participated virtually through the 'Whova' platform.

2.3 Workshop Theme and Subthemes

The workshop theme '*Assessing on-the-ground challenges and opportunities for innovative ideas and technologies that constrain/contribute to practical and academic horticultural pursuits*' was unpacked into 6 subthemes described below:

1. Production/preharvest	Yield, quality, and efficiency for profitability
2. Postharvest Management	Technologies and practices to preserve quality and reduce
3. Markets	Linkages and access (Local, Regional, and International
4. Consumer demand/preferences	Trends, nutrition awareness and knowledge as the drivers
5. Capacity building	Targeting smallholder farmers and other stakeholders
6. Cross cutting issues	Gender, Vulnerable and Marginalized groups (VMG)

The workshop agenda was structured into various sessions to address each of the six subthemes. The sessions included a framing keynote presentation, panel discussions, plenary discussions, breakout sessions and an experience sharing session by sector practitioners. In addition, there was an exhibition (services, products, and posters) by eight institutions from the three countries.

3.0 FINDINGS

3.1 PRE-WORKSHOP SCOPING STUDY

3.1.1 Kenya Situation

Horticultural production at a farm level in Kenya is quite concentrated, as most households play a part in the production of some horticultural produce. Although production Kenya has modern technology for the large-scale farmers, and even able to use modern techniques to improve the quality of their produce. However, the same is not observed among most of the smallholder farmers, who are the majority. Though Kenya has the ability to meet the high quality and adequate food demand per the vision of the USAID program; Feed Future, there are several challenges that farmers currently face along the horticultural value chain that ought to be first addressed. Farmers in Kenya face a number of pre-harvest challenges. Among them is the increased lack of adequate knowledge and skills concerning sustainable production and proper harvesting techniques among many farmers. This has led to low yields and even promoted the production of low-quality horticultural produce. Similarly, many smallholder farmers lack high quality inputs for their farms due to the involved cost or unavailability, an aspect that limits the quality and quantity of produce. The other major challenge in Kenya is the high population which has seen reduced land available for farming. This has forced farmers to use alternative methods such as hydroponics, vertical gardening, and urban horticulture. In addition, farmers also face wide-ranging pests and diseases, which remains problematic to most Kenyan farmers. The pesticides and herbicides supply in the country is not accessible to all due to the cost involved and sometimes geographical limitations.

Post-harvest management remains one of the biggest challenges for most Kenyan farmers, as it contributes to around 40%–50% post-harvest losses in fruit and vegetables. This occurs due to poor post-harvest handling practices, insufficient and unsuitable storage equipment, inadequate value-addition knowledge, contamination, poor marketing schemes, insects, pests, micro-organisms, and rodents' infestations. It was also observed that their limited adoption rates of new post-harvest innovations mostly due to the high cost involved. Therefore, there is a need to train farmers on proper post-harvest handling methods and value addition of the produce. Further, there is a need to avail post-harvest tools and technologies at a cheaper price for Kenyans in order to increase adoption, thus reduce food wastage.

At the marketing level, it was noted that most of the horticultural commodities in Kenya are procured from small-scale traders in or around municipal markets or retailers selling from small shops, kiosks, or roadside stalls. Locally, the exploitation of farmers by intermediaries is a major marketing constraint in Kenya. Farmers are left with no option rather than to sell their produce to the intermediaries due to lack of cold storage facilities and congested markets. Also, poor road infrastructure in the rural areas contributes to high transportation costs and postharvest losses. In addition, smallholder commercial horticulture is inhibited by insufficient technical information and skills amongst farmers, hindering them from sourcing marketing information. In addition, the high cost of doing business in the country due to high government levies and taxes and cost of utilities remain a problem for many farmers.

Finding cheaper means to promote international market access, especially by sea, would benefit the farmers and the country.

In order to boost horticultural production in Kenya, several opportunities were identified, which if addressed can help address the above-mentioned challenges. This include the need to develop empowerment programs to educate and train farmers across the country, while using tools that are suitable for varying farmers. This will help to increase the level of their production, harvesting and postharvest knowledge and skills. There is also a need to avail quality farm inputs such as fertilizers, herbicides, and pesticides for farmers, at an affordable price. There is a need to fund research to avail high quality seeds that are drought, diseases, and pest resistant, as this will eliminate many of the highlighted constraints in the country. The importance of enacting policies that promote market accessibility, therein shortening the gap between financial and agricultural markets to improve productivity cannot be over emphasized. Another identified opportunity is to conduct survey studies to establish verifiable data on horticultural produce from production statistics, postharvest losses statistics, technologies, and interventions available, the adoption rates and the factors hindering/promoting the adoption percentages. A targeted approach is necessary to reach out to the youth and create “new” jobs and income generating activities that support the development of a sustainable, inclusive sector such as involving them in the digital/technology aspect.

Despite the perceived growing trend of increased consumer awareness in the recent past, there is still low knowledge concerning the importance of healthy eating and quality food in the Country. This has led to consumers in the country still not take as much of the vegetables and fruits as required to meet their health needs. This review identified that consumption of particular horticultural products is impacted by economic capacity. For example, much of the vegetables are consumed by the low-income persons, who use them as the staple food while most fruits are consumed by the middle and upper-income classes designed to boost their immunity. It was noted that consumers in Kenya, especially for fruits and related added-value products are growing sensitive about the agro-processing, packaging, and quality standards in the domestic market, which are still less developed.

Several cross-cutting issues on Gender, Vulnerable and Marginalized Groups (VMG) Involvement strategies were identified, in Kenya. It was observed that contrary to times before, when women were significantly secluded from horticultural farming, the representation of women has been on an increase in Kenya. However, it was noted that there is limited access to vegetable production and marketing training, membership in farmers’ groups, and extension services, for women compared to men. Further, it was observed that women even in the production sector face varying challenges including discrimination during promotion, sexual harassment, and wages, an aspect that continues to demotivate them into taking part in the reduction of hunger in the country. This means that there is a need to promote equality and fairness in the workplace if production is to improve. For the youth, GIZ is implementing a project promoting youth employment in western Kenya where the multidisciplinary team looks to enhance youth employment prospects by better equipping them for the labor market and at the same time increasing the demand for labor and improving labor market functioning and matching mechanisms.

3.1.2 Uganda Situation

Uganda is currently the second largest producer of fresh fruits and vegetables in Sub Saharan Africa after Nigeria, producing about 5.3 million tons per year. The several actors within the horticultural value chain are overly critical for uplifting the horticulture sector, however, each actor plays their own role and cannot be underestimated or substituted for another as they are all key in their own ways. The actors include input dealers, producers, transporters, traders, processors, exporters, researchers, policy makers and (social) media influencers, government institutions and NGOs. The success of the key stakeholder actors in the Uganda value chain was attributed to quality of produce and services offered, technical expertise, experience, passion, commitment, arduous work, creating innovative solutions to problem solving, operating in effective groups and associations with good governance, teamwork, using effective marketing strategies or sensitizations. There is minimum competition since there are not many professional actors in horticulture.as reported by the stakeholders. The full potential of Uganda's horticulture sector is not fully exploited due to a myriad of challenges along the value chain identified by the key stakeholders. This includes limited funds available to finance horticultural research activities, limited technical knowledge by most stakeholders, counterfeit agro-inputs, increasing cost of inputs and production, increasing occurrence of pest and diseases, climate change, corruption, low capital base, inefficient production systems, misconception of horticulture, absence of horticultural research agenda for Uganda and absence of horticultural policy. The low purchasing power of some consumers as they tend to prioritize staple foods, ignorance about the use and importance of fruits, vegetables and herbs in diets and negative attitude towards consumption are some of the key factors affecting consumption of these horticultural produces.

Majority of the stakeholders recorded market systems as a key limiting factor in the horticultural sector. Some of the identified factors limiting market access are low product quality, sanitary and phytosanitary standards, consumers demand, lack of value addition and inconsistent production volumes, pandemics like covid 19 and political instabilities in the neighboring countries. Also, low organization levels of producer groups and associations, lack of access to finance and no infrastructural developments such as transport facilities and advanced storage facilities limit market access. Lack of accredited national testing laboratories has also affected market access. Currently the Hortifresh association is pushing for capacity building to ease compliance to these standards as well as reviewing policies to meet the current trends. The stakeholders reported that in Uganda, there are no professional packaging industry for fresh/dried Fruits and Vegetables and traders are taking advantage of buying produce per bag instead of per kilo of pre-packed produce. Overall, Uganda trends regionally with its neighboring countries such as Kenya, South Sudan, Democratic Republic of Congo (DRC) and Rwanda.

Majority of the stakeholders highlighted that a lot of research work lies on paper and not being implemented and would have otherwise been extremely significant in improving Uganda's horticulture sector. The first strategy would, therefore, be to effectively implement these research results. The stakeholders confirmed that they are willing to adapt innovative technology so long as it works well for them. However, they will always run trials to see how good the technology is before adapting it. Some will benchmark and see if the technologies are working for their colleagues or other entities then they can take it up. Availability of funds to purchase new equipment and build capacity can enhance uptake of new technology in the country. In order to bridge the gap between research-extension and end users, the stakeholders recommended for up scaling trainings, capacity building and sensitization programs in the country. Several research gaps to address constraints in the horticulture sector were identified. This includes statistics on average current yields per crop varieties and profitability, profitability of professional production of organic open field crops, lack of market information per horticultural crops as well as germplasm improvement for yield, quality, adaptability and resistance to pests and diseases. Further, access to pest and disease management information for growers, value addition on horticultural produces, market research regarding consumer behaviors, storage solutions, bio inputs and quality preservation and post-harvest handling were identified.

The Ugandan horticulture industry has immense opportunities which includes active research programs in place, Uganda's favorable climate, good soils, supportive government, hospitable and hardworking citizens, large readily available local, regional, and international markets with locally a growing population, high demand for Uganda's fresh fruits and vegetables with widening product ranges, strategic locations to markets, minimal competition in the sector locally. Employment opportunities for the unemployed youth, women, and vulnerable and marginalized groups. Start national promotion and use of improved cultivars and superior varieties in different microclimates combined with creating awareness of Good Horticultural Practices. Establishing certified trader associations in horticulture can help the poorest people to break out of the persistent cycle of poverty.

3.1.3 Ethiopia Situation

The Horticultural sub-sector is important in Ethiopia, where the country produces various types of fruits and vegetables. Most of these commodities are consumed locally, with only a small proportion being exported. In Ethiopia, there is an increased trend in the use of hybrid seeds especially in the vegetable subsector with many international seed companies being active in the country. However, there is a need to strengthen the local seed production industry whose major challenge is seed certification at certified seed production level. To address the challenge of pests and diseases in the country, Integrated Pest Management is being established. However, the tedious process involved in the registration of biological crop protection products is discouraging investment by various international companies. Most of the horticultural production takes place under irrigation in the Central Rift Valley, with both smallholder and investor farmers active in intensive production systems. Therefore, in order to increase production, there is a need to develop sustainable business cases for seed production of local leafy vegetables. So far, limited success has been achieved in this area. Also, more knowledge on soil fertility management is needed, with tailored fertilizer recommendations for the combination of soil type and crop type.

At the postharvest level, the losses are particularly high for fruit crops that have a strong seasonal production peak such as mango and avocado (estimated to be 33.4%). However, there is limited data on postharvest losses in vegetables which seem to have minimal losses attributed to high turnover with the time between harvesting, transport, trade, and consumption often taking place within 48 hours. In terms of postharvest technologies in the sector, there is limited cold chain facilities for domestic produce, and only individual exporters have professional packing and grading centres for specific produce such as green beans, herbs, and avocado. There is a gap in packaging material availability for exports, especially in terms of quality carton boxes, which are still often imported.

For the domestic market, many vegetables are transported in unhygienic large wooden crates in open trucks with limited protection against rain/hail. This results in high mechanical injuries and contributes to low quality produce which is in turn sold at exceptionally low prices. Processing in the county is more developed in the spices sector, however, there are very few fruit/vegetable processors to absorb the available produce especially during the peak season.

Most fruits and vegetable sales run through the district markets, and afterwards the central market in Addis Ababa, as well as intermediaries (brokers/traders). Currently, the new market at Atkilt Terra / Haile Garment is well developed and more organized than before. The larger crop specific wholesalers in the sector dominate the market and set prices. The export phytosanitary system is well developed for flowers, but less so for fruits and vegetables. Individual companies themselves are in the lead for ensuring good phytosanitary standards, with limited government inspection capacity available. There are a few local supermarkets that have stricter sourcing practices in place (Fresh Corner and Queens supermarket), often sourcing from larger commercial farmers that have some form of food safety / hygiene protocols in place. Most of the fruits and vegetables are sold to neighboring countries such as Djibouti and Somalia for banana, citrus, mango and, as well as to the Middle East (UAE and Saudi Arabia) for avocado, melons, and strawberry. Currently, there is limited exports to the EU markets, only for green beans in the Netherlands. There is limited online sales, and used by restaurants (meal deliveries).

The stakeholders identified the presence of many initiatives which are in place, in order to promote the production and consumption of fruits and vegetables in the country both at rural household level and urban centers. These initiatives are often spearheaded by nutrition development programs, focusing on home gardens, local vegetables, and vertical/urban farming. So far, limited scale has been achieved by these projects. Overall, the demand for fruits and vegetables in the county is often high compared to the supply. The well-developed extension system together with projects such as HortiLIFE have supported continuous capacity building especially to the smallholder farmers in the country. This is mostly achieved through farmer field schools' approach where training and demonstration activities are done.

In terms of cross cutting issues (Gender, Vulnerable and Marginalized groups) involvement strategies there are some initiatives to promote gender in horticulture, and involve vulnerable and marginalized groups, especially in project activities. For example, the Netherlands Development Organization (SNV) works on a Gender and Youth Empowerment in Horticulture Markets (GYEM) project. This project aims to enhance women's and youth's social and economic power in the horticulture value chains in Ethiopia. It was noted that, despite women being the majority of laborer, where they provide about 75 percent of farm labor, their production remains about 35 percent less than male farmers due to the low level of accessing extension services and inputs. This means that if empowerment across gender occurs, women ought to be provided with extension and input services, an aspect that would promote production, therein meeting food demand. The issue of decision-making power over production and how income is spent was also identified.

3.2 REGIONAL CONSULTATIVE WORKSHOP

3.2.1. The Horticulture Landscape in East Africa (Kenya, Uganda, and Ethiopia)

Across the region, there is vast potential for production of fresh fruits and vegetables contributing up to 36% GDP in EAC. The industry employs many, contributes to food and nutritional security and agro-industry development, ameliorating poverty amongst the farmers hence the horticultural sector is considered an important driver of regional development. The region has good climatic conditions which favors production of diverse types of fruits and vegetables as well as other horticultural crops. Majority of production is done by smallholder farmers in the open field and rain fed although greenhouse production, irrigation agriculture and hydroponics are picking up in the region. Horticultural production in the region is characterized by use of traditional farming practices, inappropriate use of agricultural inputs such as excess fertilizer application and, inappropriate pest management techniques.

The horticulture sector is not well developed and has not been a priority for the governments in the region. Across the three countries, the government policies in place only focuses on food security crops, for instance, in Ethiopia, it was reported that policies available were mostly on developing cereal crops. It was also observed that land allocated for fruits and vegetables is extremely limited in the region. The fruit and vegetable subsector of horticulture is at low level of development, however, there is encouraging improvement both in area coverage and production in the last few years. The region has now developed policies for growth and development of the sector including 5th EAC development strategy 2016-2021; EAC regional fruits and vegetable strategy and action plan 2020-2030; EAC food and nutrition strategy 2018-2022 and EAC industrialization strategy 2021-2032.

The region is composed of a youthful population around 80% (18-35 years), who are considered innovative and can be exploited to make the horticulture sector competitive through digital innovation, artificial intelligence, and application of big data to optimize crop yields.

3.2.2 Challenges Hindering Productivity and Growth in The Sector

At the pre-production/farm input level, farmers face shortage of supply and untimely delivery of improved seeds and planting materials for horticultural crops. Most farmers use non-certified seeds across the region. This is because only a few organizations participate in quality production of seed or planting materials of fruits and vegetables and their distribution is mostly through the private companies who sell at high prices. This has forced many farmers to retain seeds that produce low yields with poor quality. However, there is a commendable trend that has seen private nurseries booming to bridge the seed gaps especially for African leafy vegetables. Another deterrence to sustainable production is the shortage of fertilizers that usually are sold at high prices. Pest control products that are of poor quality are supplied to farmers mostly by private traders and agrovet who are not certified. For example, it was observed that some of the blacklisted products in Kenya were in use in a neighboring country. Sometimes traders supplied farmers with expired pesticide products which caused quality loss in horticultural produce. Many of the farmers, therefore, opt to plant these crops without these inputs and as such only get low yield from an otherwise very lucrative sector. Also, in some cases, farmers do not follow the instructions laid down by pesticide manufacturers on application procedure and amount to be applied. This results in marketing of fruits and vegetables, contaminated with chemical residues which cannot be sold in the international markets.

At the production level, high incidence of emerging new pests and diseases such as *Tuta absoluta* in tomatoes, brown rot of potato, banana, which have spread across the East Africa regions has significantly affected horticultural crops. It was also highlighted that many farmers do not have knowledge to identify and classify the pest and diseases and, cannot effectively control and/or seek for appropriate management strategy. Lack of good agricultural practices by smallholder farmers and extension officers has led to production of low-quality fruits and vegetables in the region. Over reliance on rainfed agriculture by majority of the smallholder farmers in the region, has led to total crop failure or low yields due to unreliable rainfall patterns in the recent past.

The region experiences high postharvest losses ranging from 40-50%, especially for the perishable horticultural commodities. This is attributed to poor infrastructure, lack of knowledge regarding cultivar selection in relation to shelf life, low capital base, minimal capacity to handle the produces, failure to observe proper postharvest handling during harvesting, sorting, packaging and transportation. Also, the lack cold storage facilities as many fruits and vegetables require low temperature and high humidity storage conditions to remain fresh for an extended period. This has forced smallholder farmers to sell their produce at low prices at the farm gate. Poor roads and communication networks that are not efficient for timely flow of horticultural produce to the markets further worsens the situation. Lack/limited processing facilities for smallholders in the region is a major challenge. This is mostly attributed to the seasonal supply of most fruits and vegetables leading to input supply problems for the processing industry and this discourages the investment from the private sectors who are driven by sustainability of profits.

Some of the factors hindering market access are little or no market linkages and information exists among producers and potential buyers such as wholesalers, traders, agro-processing companies, and exporters. The farmers are forced to sell their products through negotiation with intermediaries or brokers who in most cases take advantage and buy at extremely low prices. Lack of aggregation centers/failure of farmers being organized into groups, leading to exploitation of individual farmers who have no bargaining power and cannot control market price of their produce. Seasonality of some produce, especially fruits such as mango, results in low prices during the glut period as there are no cold storage facilities for farmers and traders to store their produce. Trade within the region is impeded by bureaucracy and long transportation days to market. The stakeholders noted that it is easier and faster to move produce from Uganda to the Netherlands than it is between Uganda and Kenya because of restrictive border issues and logistical delays for produce with a short lifespan. Restriction of regional and international markets due to emerging pests such as fruit fly and mango weevil which have caused total ban of some produce to specific export markets.

3.2.3 Existing strategies to address the challenges and spur growth in the sector

Investing in research to help producers understand climate variability and specific risks concerning crop phenology, management of extreme heat, rainfall, floods using advanced weather forecast technologies. This will help in predicting more accurate temperature, rainfall and enhance decisions on what to grow at a particular time.

Adoption of new strategies including selection of tolerant cultivars to suit changing climate and reducing carbon footprints. Research should also focus on sensory aspects ALVs and marginalized fruits, value-addition, nutrient bioavailability, research on anti-nutrient in under-utilized fruits and mechanisms to stabilize the active ingredients in value-added products from this group of vegetables and fruits. Strengthening linkages between the farmers and researchers is needed since there is a lot of information being generated by researchers, but it has never been put into use. Through these partnerships, farmers will be able to easily tap to the new knowledge being generated by researchers.

Capacity building to empower farmers to know the importance of using certified quality planting materials, proper use of fertilizers and agrochemicals, and harvesting their produce at the right stage for better quality and shelf life. Also, through training of farmers in phytosanitary measures and compliance to help increase access to lucrative markets. Harmonization of regional policies and strategies to maximize synergies and sustainable horticultural growth will help spur growth in the sector. Providing an enabling environment by the government and the region at large will attract private investors who will transform the region through industrialization in different sectors such as private nurseries, fertilizer production and distribution, pest control products and value addition. Adoption of irrigation technology to minimize over reliance on rainfed agriculture will allow all season production of horticultural produce in the region.

In order to reduce the high post-harvest losses currently being reported in the region, it is necessary to train farmers on proper post-harvest handling methods and value addition of their produce. Further, post-harvest infrastructures including cold technologies, storage, and refrigerated transport for marketing of fresh produce should be availed. Proper packaging materials during transportation such as using crates instead of gunny bags helps reduce injuries which results in loss of quality and faster deterioration at the marketplace. Organizing farmers in groups will make transportation easy since they can transport their produce as a group, help in market access, and it is easy for farmers organized in a group to access capital and invest in innovative technologies such as cold storage facilities. To shorten the otherwise long horticultural chain from farm to market can have some experts source the produce from farmers and sell them to high niche, as is the case of Twiga food in Kenya who are linking farmers directly to markets.

Adopting digitization in marketing is important as this provides opportunities for farmers to sell their produce online, shortening the horticultural chain. In order to reconnect trade within the region, the restrictive border issues and logistical challenges causing delays and spoilage of produce should be addressed. It was noted that the cost of transportation is cheaper from Uganda to Kenya but expensive from Kenya to Uganda, therefore, the region should invest in common logistics. There is a need to explore new markets such as supermarkets, however, it was highlighted that huge wastages arise within the supermarkets and a study needs to be done to ascertain if supermarkets buy only what is needed. In addition, product diversification is needed for marginalized indigenous fruits like jackfruit which can be processed to jackfruit meat and dry jackfruit biscuits.

In order to encourage women and youth participation in the lucrative horticultural sector, there is need to improve access to land by women and youth, implementation of policies and strategies for instance the two-thirds gender rule in Kenya, youth empowerment and implementation of the GAP labor laws are plausible ways to promote gender equality. It is important that while addressing gender issues 'as-a-whole' at the household level where both men and women are considered for empowerment interventions would offer leverage as men would not feel insecure.

3.2.4 Current investment to address the challenges in the sectors – government, development partners

In order to spur sustainable growth of the horticulture sector in the region, collaborations between the government and development partners should be considered. Collaboration is noted to spur success as was the case for Ethiopia where the fruits and vegetable flagship programs included government technical committees and task forces, development partners, academia, research centers like CGIAR engaging rural economic developments stakeholders to champion production and food security. Efforts in collaborations should avoid duplication of responsibilities and enhance efficient utilization of scarce resources.

Government should invest in ensuring good roads and communication networks especially in rural areas where most of the horticultural production takes place. This will ensure timely flow of horticultural produce to the markets. Most of the production sites are not accessible by vehicles and means of transportation are not well developed in the region. Therefore, transportation of produce is done using donkeys, carts, wheelbarrows, humans, and bicycles which takes longer time to reach the market and affects the quality of the produce. Further, the government together with development partners should increase funding to support research directed towards addressing constraints on production, processing, grading, packaging, transportation, marketing, and cold storage. Also, government and development partners should support capacity strengthening through university partnerships, extension programs, effective monitoring, and evaluation of key development areas in the horticulture sector is critical in the region. An enabling policy environment and political good will from the government are key ingredients for the desired growth of the sector.

Both the private and public investments are required to support value addition in each partner state in the region which will help in reducing postharvest losses and enhance market access by producers translating to increased returns. The government as well as development partners can invest in supporting farmers to comply with the current legal market norms and certification requirements especially for the export markets. To enhance value addition and processing of horticultural commodities, it is necessary for the government, private sector, and development partners to invest in value addition and processing facilities. For example, 40% of fruits like avocado goes to waste and therefore, there is a need to involve other specialty markets and players e.g., cosmetic industries to utilize avocado oils.

3.2.5 Emerging threats to the Horticulture sector, their impact and adaptation/mitigation measures

Global pandemics such as Covid-19 was a major threat which caused disruption of incomes in the self-reliant horticulture sector which employs more casual laborer. The pandemic caused heavy fall back on semi-skilled labors who depended on daily pay to sustain livelihood. There was introduction of new restrictions to movement across nations, flight cancellations and this created disruption in the international markets. Trade within the region was hindered by the extra border checks which resulted in delays that were detrimental to fruits and vegetables. Many businesses were shut, eateries closed, and farmers got stuck with produce leading to huge losses. On the slip side, the pandemic resulted in the boom and demand for herbs with emphasis being given on building immunity to fight Covid-19. Due to lock down, there was increased online marketing through various digital channels. This is a positive impact which will continue beyond the pandemic season.

Climate change is a major threat to the horticultural sector that has grave consequences and impose significant economic costs on horticultural production. The main threats in the horticultural sector include effect on water resources where there is reduction in water levels, erratic weather patterns causing floods and droughts that lead to crop failure and soil fertility losses. Moreover, drastic fluctuations in weather patterns causing elevated temperatures and floods resulted in high incidences of pests and diseases. Research is therefore needed to help producers understand climate variability and specific risks concerning crop phenology, management of extreme heat, rainfall, floods using advanced weather forecast technologies. This will help in predicting more accurate temperature, rainfall and enhance decisions on what to grow at a particular time. There is a need to adopt new strategies including selection of tolerant cultivars to suit changing climate and reducing carbon footprints. Also, there is a need for water harvesting which can be used for crop production through irrigation as we "do not have a contract with the ocean' where all the runoff goes.

Political instability like instability in DRC, South Sudan and the current war in Ukraine significantly affects the sector by increased transport costs towards markets and increasing input prices. Also, natural calamities like landslides, hailstorms, wild animals from the National parks are very destructive to crops and can harm humans hence threatens productivity. Other threats being experienced in the sector include misuse of chemicals that can have adverse effects on humans and the ecosystem, counterfeit agro-inputs, NGO's, and donors promoting wrong practices, agro-inputs due to lack of horticultural knowledge/corruption, competition from other regional and international actors, overproduction from neighboring countries, and lack of storage facilities. Very fragile market systems, interception of produces in the international market, poor implementation of policies, increasing pest and disease occurrence, corruption, changing consumers' taste and weak regulatory framework also threatens the thriving of the sector.

3.2.6 Research/academia disconnect and efforts to bridge the gap

It was observed that research conducted in academic and research institutions do not align with the needs of the small holder and as such are not addressing the pressing challenges that are affecting the sector. This has resulted to a dis-connect between the research institutions and the private sector and farmers. For example, research institutions are known to release new modern varieties which have failed to reach farmers due to the inefficiency of the varietal seed multiplication system. This is due to lack of interdisciplinary collaboration among the producers, and researchers who are key stakeholders in the sector. To address this challenge, there is a need to 'take innovation from lab to land' and consider consumer preference right from inception. The adoption of most of the ideas and technologies by researchers end up failing especially when tried for smallholders for diverse reasons. However, this trend is slowly changing as research organizations such as the University of Nairobi have produced outreach programs for connecting with farmers.

All the stakeholders in the sector (private sectors, academic and non-academic research institutions, government) should therefore, co-create knowledge through a demand driven research that starts with the farmer. Researchers need to have priority focus on rapidly growing areas which include agro-industrialization, affordable eco-friendly cold chain systems, nutritional security, and pest and diseases management for ease adoption in the horticultural sector. Other areas that can receive higher uptake include research in introduction of new varieties, inputs, new post-harvest technologies, new marketing strategies and improved knowledge base for production of horticultural produce.

3.2.7 Capacity building for the Horticulture Sector

The horticulture sector is considered as a catalyst towards poverty alleviations in EAC and therefore everybody needs to be brought on board. Youth, women and VMGs contribute a lot in the horticultural subsector as workers and agents in the region. In order to involve the youth, women and VMGs in horticulture capacity building is needed. This can be achieved through encouraging participation in agriculture through 4k clubs in Kenya, using the family farming model to bring youths on board, encouraging family ties to continue with family agriculture related business, wholesome empowerment for family and promoting community network and campaign programs. Gender mainstream should be emphasized where women and VMGs are purposefully encouraged to form specific groups where they can be trained on diversification to generate income. An acronym concept referred to as 'MELTA' was coined during the workshop to summarize the critical area that needs strengthening. 'MELTA' is anchored on five key points including 'mentorship,' 'empowerment' by being given room to speak, offering 'linkages,' 'training' and improving their 'access' to credit and resources.

It was highlighted that capacity building at all levels along the value chain is crucial to ensure that practitioners in the sector are well equipped with current knowledge and practical skills. Majority of smallholder farmers do not have the skills and knowledge on good agricultural practices of horticultural crops. To improve yield and sustainable production, farmers and extension officers must be trained on the importance of using certified seeds, proper use of agricultural inputs as per the manufacturer's instructions, appropriate pest management techniques, crop diversification, water harvesting and irrigation techniques, and good agronomic practices (GAP) for increased quality produce.

At the postharvest level, there is need to empower farmers on proper post harvesting practices and value addition of the produce. It was reported that many smallholder farmers do not observe proper postharvest handling during harvesting, sorting, packaging, and transportation. As a result, there has been a high incidence of post-harvest losses ranging from 40-50%. If farmers are empowered through training and provision of credit, they can easily acquire processing facilities to enhance value addition of most fruits and vegetables which are seasonal. Further, traders and transporters should be empowered in terms of proper handling of produce during transportation, storage, and display during marketing. Also, traders should be empowered to build associations to harmonize the modern market system. Farmers, especially the smallholder ones, require training and support to comply with phytosanitary requirements and improve market access to high-end export and regional markets.

The need for capacity building at the government level was highlighted. The existing personnel need to be trained on up-to-date trends in the sector such as current production practices, phytosanitary measures, and demand/market driven approach. Capacity building on better modes of knowledge dissemination adaptable to various stakeholders and research programs in horticulture is very paramount. The stakeholders emphasized on the importance of using tools that are suitable for varying groups along the value chain.

4.0 PRIORITIES FOR THE NEXT 5 YEARS

4.1 PRIORITIES FOR RESEARCH

Better linkages between research/academic institutions and horticulture sector practitioners and the private sector will ensure that research is better aligned to the needs of the sector and that the research outputs/products have the desired impact. Several priority research areas were identified at various stages of the supply chain and described below:

1. **Research to find better/suitable production inputs** includes seed, seedlings, nutrients (organic and inorganic), pest/disease management products. The research areas identified by the stakeholders are summarized in the figure below:

Crop varieties and germplasm/genetic resources

Mapping available genetic resources/germplasm for various horticultural crops (fruits, vegetables, herbs, spices)

Establish agro-ecological adaptation for various crops – develop suitability maps for various species and varieties for different agro-ecological zones with respect to yield and quality

Nutritional profiling of fruits and vegetables (including indigenous species) in different agro-ecological zones

Establish certified seed and seedlings systems - develop relevant protocols

Mass propagation protocols (including invitro culture) for selected high value crops

Research on rootstocks suitable for various soil conditions such as salinity, alkalinity, disease-infected soils, dwarfing traits for some fruit trees

Breeding and/or selection of better adapted (including drought tolerance) and market demanded accessions/varieties

Pest and disease management

Mapping and surveillance of pest and diseases of importance in key crops e.g., *Tuta Absoluta* in tomato, fruit fly and mango weevil in mango, false codling moth etc

Integrated pest management strategies to address the important pests and diseases including optimization of biological control measures, standardization, certification of biopesticides, pest free zones for pests like fruit fly

Development of a compendium of pest and diseases – useful for farmers and extension agents

Water and nutrient management

Soil mapping, characterization, and testing to determine suitability for different crops and appropriate nutrient regime

Alternative nutrient regimes – low external input nutrition programs, generative agricultural programs

Development and optimization of bio-fertilizers

Deficit irrigation and water use efficiency studies to optimize yield and quality with less water use

2. Optimization, diversification, and modernization of crop production systems

Good agricultural practices

Optimization of water and nutrient use in horticultural crops
Optimization of integrated pest management options
Use of pollinators in enhanced/assisted pollination and their effect on yield and quality of fruits and vegetables
Precision agriculture
Climate smart production practices and technologies

Off-season production technologies for seasonal crops

Cultural practices such as controlled/deficit irrigation, pruning
Off-season flower induction chemicals

Innovative and modern production systems

Vertical gardens, soil-less culture, aeroponics, hydroponics for high value fruits and vegetables
Develop and/or optimize the sytems

3. **a) Better harvest and postharvest management to preserve quality, reduce losses, diversify utilization, and returns for farmers.** The areas of interventions that require scale up or additional research include:

- Research in maturity indices and maturity prediction methods for fruits and vegetables
- Develop harvest tools to minimize injury on fruits and make harvesting easy even for women
- Adaptive research/optimization of eco-friendly, affordable, and appropriate cold storage facilities/technologies
- Develop optimal ripening technologies/practices for climacteric fruits
- Develop appropriate packaging technologies
- Quality preservation and shelf-life extension technologies to extend marketing period
- Cost/benefit analysis of the postharvest technologies including crates, cold storage, shelf-life extension technologies
- Data – postharvest losses and wastage in horticultural value chains; critical loss points and mitigation measures
- Determine the impact of loss reduction technologies/strategies in priority value chains

b) Value addition and processing ('the sleeping giant')

To awaken the 'sleeping giant' in value addition, there was a proposal to adopt the 'one product per County/region' approach which capitalizes on the major crop produced in each County/Region

- Develop diverse and nutritious food products from fruits, vegetables, spices, and herbs including dried and wet processed products
    - These include blended and fortified products such as juices, nutrient bars, flours etc.
- Development of specialty products targeting niche markets
- Optimization of processing protocols and parameters to ensure nutrient preservation
- Research in valorization of the processing waste into other food and non-food products e.g., wines, animal feed, compost manure, biogas
- Develop standards for new processed products from horticultural commodities

4. Marketing and market access

Market information

- Target market requirements for various crops (species, variety, maturity stage etc.)
- Specialty market options and volumes demanded e.g., organic
- Volumes required and period (season) – domestic and export markets
- Volumes produced in various regions and different seasons
- Annual/periodic price variation – domestic and export markets
- Market stratification for various grades

Market access strategies for smallholder farmers

- Available options and their benefits/advantages e.g., contract farming, group marketing through aggregation centers, direct sales to retailers (like supermarkets), use of brokers, off taker model connecting farmers directly to traders (e.g., Twiga foods in Kenya)
- Exploit the ready markets in schools and other institutions such as hospitals, prisons - for fresh and processed products

Innovative marketing options

- Digital marketing

4.2 PRIORITIES FOR CAPACITY BUILDING

Priorities for capacity strengthening was discussed for each level from input suppliers, breeders, growers to consumers.

Capacity building needs and opportunities for practitioners at different stages of the supply chain were identified as follows:

Input suppliers

- Training of input dealers on basic information regarding inputs such as fertilizers, seeds, pesticides e.g., optimum use, safety regulations and requirements, preharvest interval (PHI), MRLs etc. which can also be passed on to their clients (farmers)
- Training can be done for dealers organized in groups which could be sub-national, national, regional
- Formation of a professional group, local or regional to ensure that these groups have self-regulation

Breeders

- Training in modern breeding technologies targeting priority horticultural crops – through targeted graduate programs - national or regional
- Harmonize demand-need driven breeding and build synergies in breeding programs within region
- Develop/streamline the requisite infrastructure for breeding – variety development and/or improvement
- Support efforts to promote and commercialize locally developed or improved varieties/accessions of horticultural crops in the region

Producers

- Training on integrated pest management targeting pest and diseases in key commodities in each country, regional
- Good agricultural practices to ensure optimized and sustainable production practices for better yields and high-quality standards required by the target markets
    - Optimized soil and nutrient management including agro-ecological production practices
    - Orchard management practices such as pruning/training, thinning, etc
- Modern farming practices such as vertical gardens, hydroponics, aeroponics etc – especially targeting youthful farmers. e.g., in Kenya, use of the 4K Agriculture clubs in schools
- Governance, farm management, record keeping and agribusiness skills to manage productive enterprises
- To do this, there is need for modes of training and training platforms which are practical and highly adaptable to farmer's condition
- Need for an information portal (digital) where farmers can access relevant information for different horticultural crops including varieties, pests & diseases, production practices, value addition, market opportunities etc

Traders and transporters

- Market information gathering
- Proper handling of produce to reduce postharvest losses
    - Practices to ensure food safety – farm to fork
    - Cold chain management practices and technologies
    - Packaging practices and technologies to preserve quality during transport, at collection centers, at the market
    - Cost benefit analysis of some of the postharvest management technologies such as cold storage, use of plastic crates
    - There is an opportunity to address data gaps e.g., data on postharvest losses
    - There is an opportunity to organize traders in groups based on region, commodity etc. which can be used for training and serve to self-regulation of the traders

Researchers	Designing research for development – bridging the gap between academic research and research for development Packaging and dissemination of research for different users of the research outputs. These include training modules or extension bulletins for farmers, traders, Policy briefs for policy makers and development partners Translation of research findings into products for target end users Commercialization of research into innovative products for end users
Consumers	Awareness campaigns on the importance of fruits and vegetables in the diet and the recommended daily requirement 400 g per day Develop a national or regional campaign strategy to promote consumption of fruits and vegetables Showcase nutritional profiles of important fruits and vegetables – especially the neglected, locally adapted fruits and vegetables Develop and promote recipes for utilization of various fruits, vegetables, herbs, spices Home/kitchen gardens including balcony, rooftop, sack, bucket gardens for urban households Practices for quality preservation and value addition of fruits and vegetables
Government	Capacity building on better modes of knowledge dissemination adaptable to various stakeholders Capacity building to equip government extension officers with modern/up to date knowledge and skills in horticulture – from inputs to markets and consumer trends Training on packaging of information for different stakeholders/practitioners on the sector Need for a government-led coordination unit for horticulture sector practitioners and stakeholders

4.3 PRIORITIES FOR INVESTMENT

Targeted investments are required to address the challenges hindering growth of the horticulture sector. This can be achieved while creating an enabling agribusiness environment at all stages of the value chain. Some of the investment opportunities identified for the different stages of the supply chain are summarized below.

Production

- Facilitate farmers to access quality production inputs including fertilizers, certified seeds, pest/disease management products, on-farm storage technologies, irrigation infrastructure. This could be through cost sharing initiatives, cheap credits, government subsidies and other innovative financing options
- Irrigation coupled with water harvesting to supplement rainfall and ensure year-round and off-season production of fruits and vegetables
- Protected environment production e.g., greenhouses, shade nets
- Harness solar power for various production applications such as irrigation
- Training/capacity building programs for producers
- Smallholder farmers aggregation centers equipped with requisite technologies for postharvest handling and storage of produce

Postharvest management

- Cool chain services for smallholder farmers
- Logistics solutions – farm to fork
- Value addition – technologies and services
- Innovative packing solutions
- Traceability systems
- Capacity building for various practitioners on good postharvest handling practices

Marketing

- Produce and products promotion to enhance consumption
- Market information systems
- Market linkage infrastructure

Finance

- Asset finance
- Cash flow records
- Horticultural crop insurance

Legislation and standardization

- Standardization of weighing scales
- Eco-friendly packaging material to replace plastics and polythene
- Reward mechanism for compliance to standards and quality produce
- Quality based pricing and consumer awareness
- Regulations on market practices such as packaging size and limits
- Simplification of the certification process for inputs and products

Research

- Functional laboratories to offer diverse services to horticulture sector practitioners e.g., soil testing, quality analysis, MRLs testing
- Innovative technologies and quality products to address various challenges in horticultural value chains
- Exchange programs between research institution to enhance research capacities and knowledge exchange

5.0 CALL TO ACTION – WAY FORWARD

Joint complementary multi-stakeholder/multi-institutional actions are required to address the challenges and exploit the opportunities in East Africa's horticulture sector as highlighted in the preceding sections. Some of the action points from the foregoing are highlighted in the section below.

Research

Identify priority research areas and allocate funds to develop research products required to address the prioritized challenges facing practitioners in horticultural value chains of importance at national and/or regional level.

Establish centers of excellence in research based on important horticultural crops and/or research areas such as breeding, agronomy/production, postharvest management etc.

Train researchers on development of winning proposals for development/research projects that are evidence-based and repeatable

Address the deficit of research funds - required for demand driven research. Researchers should create advocacy groups to lobby for funds from various sources including government, private sector, development

Capacity building

Establishing regional centers of excellences or practical training centers for practitioners in the horticulture sector. These could be hosted at research institutions/centers or universities. Such centers will be tasked with capacity building and training of practitioners in horticultural value chains including farmers/producers, extension service providers, transporters, traders (including exporters), processors and others. The centers should be equipped with requisite facilities to impart practical skills for trainees/practitioners from input acquisition to market and market access and agribusiness skills.

Youth and women empowerment

Exploit the enormous potential in well-educated and tech savvy youth in East Africa. This may require retooling youth to provide innovative services and products to horticulture sector practitioners. Leverage the existing programs that target youth in Agriculture e.g., the 4K clubs' initiative in Kenya

Empower youth in value addition initiatives and connect them to resources and markets

Empower women in rural areas to produce and manage their production for household nutrition and sale of surplus; value addition at the household level to preserve surples produce

Adopt comprehensive gender-mainstreaming strategies as a prerequisite for effectively addressing gender-based

Market and market access

Explore innovative strategies to improve market access for smallholder farmers

Exploit opportunities in schools and other institutions as a ready market for local farmers - streamline logistics

Investment in regional exporting zones to access main export markets. Strengthen the regional market to match the increasing demand from emerging markets e.g., South Sudan, Congo etc.

Improve market intelligence to promote market-led production by scheduling of planting and harvesting operations. Harmonization of market standards (including phytosanitary standards) to facilitate regional trade in fresh produce and processed products from fruits, vegetables, herbs, and spices

Postharvest management and loss

Improve the postharvest management infrastructure - farm to market/fork

Cold storage facilities at the farm level to aggregate and store smallholder farmers produce as they wait for buyers

Cold storage facilities at the market to help small-scale traders preserve perishable produce

Processing facilities at the farm and market to transform unsold produce into shelf-stable products

Data gaps

Urgent need to address data gaps in horticultural value chains. Reliable and verifiable data is key lobbying policy interventions.

Need for multi-disciplinary teams to work with private sector players to generate requisite data in various commodities and at all stages of the supply chains - from production to markets and consumption patterns.

Coordination and linkages

There is need to establish regional horticulture working group of stakeholders within the sector to drive the exchange of knowledge and services in the region

Need for collaboration and coordination of horticultural research initiatives across the region to address challenging interdisciplinary research and development issues

Need for horticultural research repository and/or advisory centers. This can serve as a one stop shop for information on horticulture for various stakeholders. An advisory center/unit can serve to offer professional

Consumer awareness

To address the low consumption of fruits and vegetables in the region, there is need for aggressive and targeted campaigns to promote fruit and vegetable consumption.

There is need for strategies to make these commodities accessible and affordable to all, especially the low-income households in rural and urban areas

FEED THE FUTURE

WEST AFRICAN REGIONAL **HORTICULTURE** CONFERENCE

Horticulture for Food, Nutrition, and Livelihoods

31ST MAY-1ST JUNE, 2022

UNIVERSITY OF GHANA

USAID FROM THE AMERICAN PEOPLE

HORTICULTURE INNOVATION LAB

UCDAVIS UNIVERSITY OF CALIFORNIA

WEST AFRICAN REGIONAL HORTICULTURE CONFERENCE

THEME

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ACKNOWLEDGEMENTS

The successful organization of this conference depended upon the valuable input of stakeholders and the assistance of all the coordinators. Firstly, the team acknowledges the conference participants for their efforts and thoughtful articulation of challenges and opportunities in the horticulture sector from the local to regional levels.

The effective contributions of members of the steering committee have made this workshop a success. This committee was made of Prof. Irene S. Egyir (Dean of the School of Agriculture), Prof. Anna Lartey (Professor of Nutrition; Former Director of Nutrition of FAO, UN) Dr Naalamle Amissah (Department of Crop Science), Dr Freda Asem (Department of Agricultural Economics and Agribusiness), Dr Angela Parry-Hanson Kunadu (Department of Nutrition and Food Science, University of Ghana), Prof. George Nkansah (Director, Institute of Applied Science and Technology, University of Ghana), Prof. Amos Laar (School of Public Health, University of Ghana), Ms Esther Agyekum (Ministry of Food and Agriculture (MOFA)), Dr Charles Nyaaba (Peasant Farmers Association of Ghana (PFAG)) and Mr Philip Quaye (Ghana Institute of Horticulturist).

Special thanks go to Erin McGuire, Associate Director of USAID Feed the Future Innovation Lab for Horticulture, University of California, Davis.

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LIST OF ACRONYMS

ACRONYMS	
WA	West Africa
AI	Artificial Intelligence
DBG	Development Bank of Ghana
EU	European Union
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
MOFA	Ministry of Food and Agriculture
NGO	Non-Governmental Organization
USAID	United States Agency for International Development
WIAD	Women in Agricultural Development
EPA	Environmental Protection Authority
FDA	Food and Drug Authority
FI	Financial Institutions

A MAP OF WEST AFRICA SHOWING PARTICIPATING COUNTRIES (marked with red dots)

INTRODUCTION

Horticultural crops especially fruits and vegetables have a tremendous potential to contribute to food and nutrition security in West Africa by enhancing the nutritional quality of diets by, providing key minerals (zinc, iodine & iron), vitamins (A and C) and fibre. Micronutrient malnutrition as a result of the inadequate intake of fruits and vegetables has been known to cause serious disorders, especially in women and children. These nutrients are essential for pregnant and lactating women to ensure the proper development of the brain of the unborn and breastfeeding child. They are also required for growing children to ensure normal growth. It is estimated that about 2 billion people globally who are mostly concentrated in developing countries suffer from micronutrient deficiency, referred to as hidden hunger. Hidden hunger not only causes the lowering of a person's IQ but also stunting and blindness, with children and women being especially vulnerable.

The location, climate, and suitable soil conditions of West Africa (WA) make it ideal to become Europe's next large supplier of horticulture products at a time when the EU imports large quantities of fruits and vegetables to meet growing demand and broadening taste for new, high quality, and ready-to-eat foods. Fruits and vegetable export growth have the potential to significantly boost economic growth in West African countries, generate employment and income in rural areas, while creating opportunities for smallholder inclusion in the value chain. In addition, the sector provides year-round sources of income in rural and urban areas for women, thus improving their standard of living. Women play an essential role in many aspects of the horticulture value chain.

The West Africa horticulture conference was organized together with local horticulture experts and other stakeholders to identify on-the-ground challenges and opportunities in the sector. This is to inform specific capacity development activities for stakeholders, including industry experts and leaders. This is also to encourage local engagement and ownership, influencing the sustainability of this work to continue beyond the Horticulture Innovation Lab's involvement. Thus, contributing to inclusive economic growth and a more resilient system led by the regional experts.

The Horticulture Innovation Lab will focus its efforts in four regions with a country region serving as a hub. This includes West Africa (Ghana), Eastern Africa (Kenya), Asia (Nepal) and Central America (Honduras). It aims to implement locally-led, globally supported programs that will lead to improvement in the horticulture sector.

Conference Approach

The West Africa Horticulture Conference was held in Accra, from 31st May to 1st June 2022, bringing together leading experts and key stakeholders in the horticulture sector from 10 countries in West Africa. The conference approach stressed on the participation and involvement of a wide variety of stakeholders. Presentations were made by guest speakers who highlighted the emerging regional trends in the horticulture sector. The thematic areas for the presentations included (i) contribution of horticultural crops to healthy diets and improved nutrition (ii) food safety and post-harvest handling of horticultural produce (iii) role of the youth and gender in transforming horticulture (iv) horticultural funding and financing (v) role of research for horticultural development and (vi) challenges faced by smallholder horticulture farmers.

In the breakout sessions, participants were put in four different working groups each consisting of at least 10-12 people. The groups discussed the following topics, highlighting the challenges and opportunities in the sector;

Groups	Topics
Group 1	Research and Development–Funding, Seed Systems, Improved Varieties, Climate-smart horticulture
Group 2	Youth and Gender in Horticulture
Group 3	Postharvest Technology-Losses, Key Challenges, and Opportunity
Group 4	Nutrition and Health; Nutrition-Sensitive Horticulture, Role Horticulture Crops, and Nutrition Awareness

Simultaneous translation for all plenary sessions ensured effective communication and participation between French and English speakers. The four groups later presented the outcome of their group discussions in a plenary.

In addition, presentations by country coordinators were done highlighting emerging trends, challenges and opportunities in their respective countries. The participating countries include Burkina Faso, Cote d'Ivoire, Ghana, Liberia, Mali, Nigeria, Senegal, Sierra Leone, Togo, and the Gambia.

Welcome, Address-Prof. Irene Susana Egyir

The participants of the conference were welcomed by Prof. Irene Susan Egyir, the Dean of the School of Agriculture, University of Ghana. She also explained that the University was chosen by the Horticulture Innovation Lab to lead the organization of the conference. According to her, the University of Ghana aims to become a world-class research-intensive university. The School of Agriculture has 10 units with 7 Departments and 3 Research Centers. She noted that all the units have direct research activities relating to the horticulture sector. These include investigating suitable soils, crops for food, extension service and capacity building for smallholder farmers, agribusiness models, and consumer sciences. She further explained why the theme 'Horticulture for Food, Nutrition, and Livelihoods' is appropriate for the conference and encouraged participants to actively participate in the discussion.

Chairperson's Remarks-Prof. Boateng Onwona-Agyeman

The chairperson gave his introductory remarks and introduced the speakers and country coordinators of the conference. He explained that the conference was organized by the University of Ghana in collaboration with the Horticulture Innovation Lab of UC Davis with funding from the United States Agency for International Development (USAID). The conference aimed to bring together major stakeholders in the horticulture value chain, i.e. regional leaders in production, processing, academia, and NGOs to identify the challenges and opportunities in the sector. He noted that fruits and vegetables are important in achieving food and nutrition security. However, the FAO recommended requirement for 400g per day has not been met in most developing countries. Sub-Sahara Africa recorded 75g per day. The challenge in West Africa is how to increase fruits and vegetable production to achieve the Sustainable Development Goals of ending all forms of malnutrition by 2030.

He explained that some of the problems of fruits and vegetable production in West Africa include (i) high cost of farm inputs (ii) obsolete agriculture technology (iii) extensive use of agrochemicals (iv) use of untreated wastewater for irrigation (v) high post-harvest losses and (vi) poor infrastructure. These problems are worsened by climate change resulting in unpredictable rainfall patterns. Recently, the impact of Covid-19 has made the situation dire. To obtain the full benefits of fruits and vegetables, policies and strategies need to be implemented by member countries which aimed at increasing production and consumption. He concluded his address by declaring the conference opened and wished all the participants a pleasant stay.

1. PRESENTATIONS

Theme 1: Contribution of Horticultural Crops to Healthy Diets and Improved Nutrition

Mrs Paulina S Addy

(Directorate of Women in Agricultural Development (WIAD) – MOFA)

Classification of Horticulture Sector

The horticulture sub-sector in Ghana is made up of five commodities including fruits, vegetables, medicinal, aromatic, and ornamental plants. In Ghana, major fruits produced are mangoes, pineapples, melons, citrus, soursop, sweetsop, avocado, banana, guava, shea fruit, vitex (shoh), Velvet tamarind (yooyi/Akatsi gold), tamarind (Agboku yooryi), Africa star apple (Laasa/Alaasa), berries (strawberries), coconut (Green), pear and cashew apples. Vegetables include bulbs (onions, garlic), flower (cauliflower), fruit (pepper, okra, garden eggs, tomato, cucumber), leaf (kontomire, amaranthus, spinach, lettuce, cabbage), root (beetroot, carrots, potato) stem (Asparagus), seed (peas, french beans).

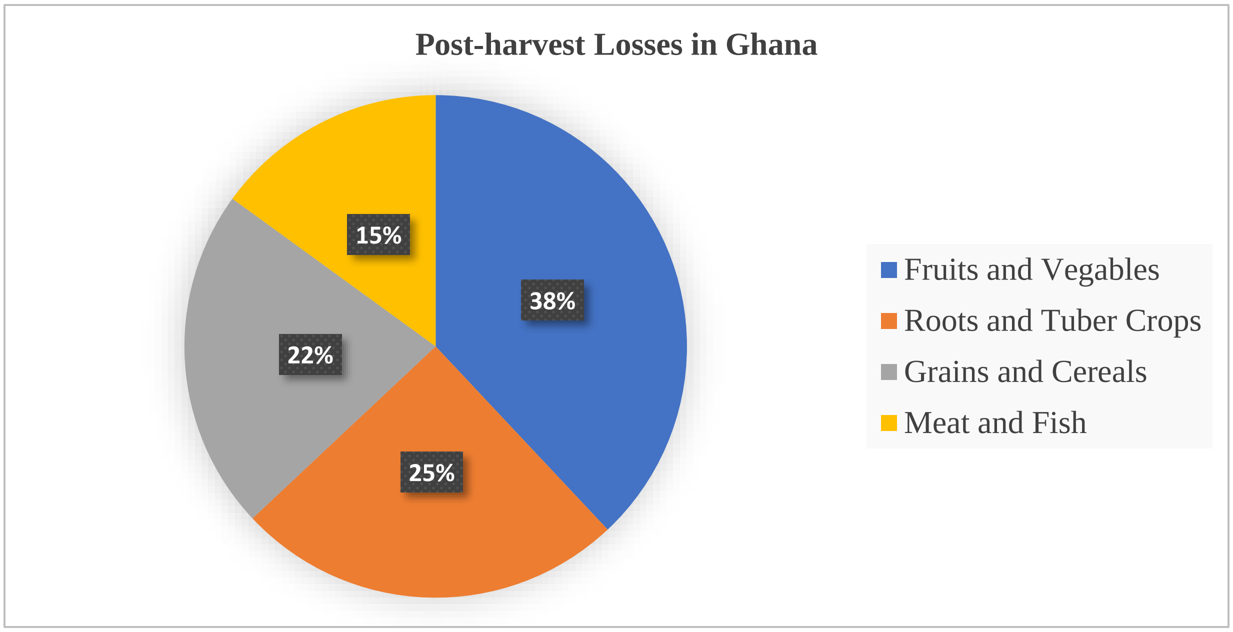
Nutritional Benefits of Fruits and Vegetables

Fruit and vegetables are rich sources of vitamins and minerals such as vitamin A (vision/cell health), vitamin C (cellular health/iron absorption), folate, vitamin K, vitamin E, and iron as well as other micronutrients that are essential for a healthy life. They also provide organic acids, which stimulate appetite, help digestion and provide dietary fibres and natural compounds (antioxidants, phytochemicals, anti-inflammatory agents) that can protect health. These nutrients are also essential for pregnant and lactating women to ensure the proper development of the brain of the unborn and breastfeeding child. They are also required for growing children to ensure normal growth. Inadequate consumption of fruits and vegetables poses serious health consequences.

Challenges of the Fruits and Vegetables Sector

Pre- and post-harvest losses for fruits and vegetables in Ghana are very high. In 2021, post-harvest losses for fruits and vegetables were 38% compared to other crops such as cereals (22%), roots and tubers (25%), and meat and fish (15%). Losses are highest in sub-Saharan Africa, commonly between15 to 50 percent. Losses are lower in East and South-Eastern Asia (with a maximum of 13 percent) and ever lower in Central and South Asia (with a maximum of 7 percent). The main causes of post-harvest loss and food waste are (i) unsuitable harvest timing (ii) unexpected harsh climatic conditions and environment (iii) Insect and pest infestations (iv) harvest and handling practices (v) infrastructure and marketing challenges (vi) lack of storage facilities

Other challenges facing the sector include the high price of fruits and vegetables leading to low consumption, excessive application of agrochemicals, and inadequate land for urban/peri-urban are for production and water quality.



Source: AGI/MoFA

Way Forward

She concluded by suggesting the following for the development of the sector:

i. Planned production systems that require documenting the production process in addition to information sharing.
ii. Promoting increased consumption of fruits and vegetables. This entails sustained promotion efforts and sensitization of consumers.
iii. Promoting safe production and handling – Ghana CARES programme on improved handling of F&V – Green Label and GAPS – Support to UPA Farmers (safe water)
iv. Value addition (Diversity) – Producing fruits and vegetables into juices, frozen veggies, etc
v. Improved Transportation systems – Reefer/Refrigerated vans

Theme 2: Food Safety: Post-harvest Handling and Sanitation of Horticultural Produce in West Africa

Prof. Obadina, Adewale Olusegun

Department of Food Science and Technology,
Federal University of Agriculture, Abeokuta, Nigeria

Food Safety and Horticulture Sector

Horticulture can be classified into vegetables, fruits, edible nuts, and other ornamental crops. Fruits and vegetables are known to convey health benefits which are vital sources of fibre, micronutrients, vitamins, antioxidants, steroids as well as flavonoids (Olatona et al., 2018; Hussain and Gooneratne, 2017; Angela et al., 2010; Mathilda et al, 2012). Food safety is a major concern because food systems may have adverse impacts on nutrition and health through food-borne diseases, naturally occurring toxicants, indiscriminate use of agrochemicals, exposure to pesticides and other chemicals, antimicrobial resistance, and other factors related to food and agriculture. Horticulture produce (fruits and vegetables) could be contaminated by physical and biological hazards before harvesting, during harvesting period and cross-contamination during transportation, handling, and storage as a result of poor agricultural and hygienic practices, thus predisposing consumers to food-borne illnesses.

Pre and Postharvest Handling of Fruits and Vegetables in West Africa

Good pre-harvest, harvest, and post-harvest practices are essential in preventing fruits and vegetables from being contaminated. For instance, untreated manure when used in growing fruits and vegetables can harbour pathogenic microorganisms including *L. monocytogenes*, *E. coli* O157:H7, *Salmonella* spp., *Mycobacterium* spp., *Brucella* spp., *Bacillus anthracis*, *Yersinia enterocolitica*, *Clostridium perfringes*, and *Klebsiella* spp. These microbial contaminations of fruits and vegetables in the field are more likely in West Africa where growing conditions are unhygienic and protective practices such as the use of plastic mulch that prevents contamination of soil-borne microorganisms are lacking.

Additionally, harvesting methods also predispose fruits to microbial contamination; these often involve violently shaking tree branches so that the fruits fall to the ground or hitting them with sticks or similar objects leading to harvest injuries which promote infection. Transportation of fresh produce from the farm gate to the primary and secondary collection centers is primarily done using head loads or using farm animals, wheelbarrows, carts, bicycles, motorcycles, and motor vehicles of all sorts. At the collection centers, fresh fruits and vegetables are often heaped together in piles in the open without any form of protection.

From these centers, the produce is transported by road to urban central wholesale markets mainly in open non-refrigerated trucks with capacities ranging from less than 10 tons to up to 30 tons. The common practice in the fresh produce supply chain in West Africa is to transport products in bulk or packed in raffia or bamboo baskets, wooden containers or salvaged fiberboard cartons, and other improvised containers previously used to package imported or locally manufactured products.

The central wholesale market occupies a prime position in the fresh produce supply chain in West Africa and it is here that the price levels of commodities are determined to a large extent by market players. Regrettably, these markets are often in very poor shape. They are, invariably, badly located, heavily congested, badly maintained, and lack the physical facilities and essential infrastructure including electricity and potable water from municipal sources and waste disposal facilities to handle the large volume of produce that pass through them. Since potable water is often lacking, practices such as wetting leafy vegetables with water or placing them in a bucket of water to control moisture loss and wilting, though desirable for maintaining freshness, may lead to contamination with waterborne disease organisms.

Sanitation of Horticulture Produce

The majority of the farmers and vendors do not assess the quality of the water used in washing their harvested produce. Smallholder farmers use drain water, pipe or well water for irrigation. Few of them who have daily contact with animals do not always wash their hands after touching animals.

The vehicles are not always washed while those washed are not with clean water. The vehicles are not disinfected before loading with fresh produce. Most of the vehicles for transporting fruits and vegetables are opened.

Most of the vendors do not practice the hygiene of washing hands before preparing fruits and vegetables for sale. Very few wash their hands after using the toilet, before eating, and none of them washes their produce after harvesting. Many of the vendors do not use disinfectant to clean containers nor do they clean their containers before reusing them. Most of the consumers eat vended produce without washing. Some use salt or vinegar solution in washing their produce at home before eating. The eateries/restaurants also wash the fresh produce with clean water while some add chlorine bleach and potassium permanganate.

Conclusion

Food safety is a critical issue and promoting good practices in the production, harvesting and post-harvest handling of fresh produce lowers the risk of food contamination and helps maintain quality. In the last three decades, there is the widespread of indiscriminate use of agrochemicals in West Africa. However, legislations that regulate pesticide residues and other chemicals in foods are often simply not in place, are poorly enacted, or not enforced. In recent years, there is growing food safety concerns concerning fresh fruits in West Africa. For instance, the use of cheap, readily available calcium carbide for artificially ripening fruits is a growing concern. Calcium carbide is alkaline and can irritate the mucosal tissue of the abdominal region causing stomach disorders that has been reported after eating mangoes artificially ripened with calcium carbide. Food-borne illnesses due to microbial and chemical contamination are a major public health concern and fresh fruits and vegetables are the likely primary sources. Poor handling practices along the fresh produce supply chain from farm to market and from rural to urban areas, poor infrastructure including transport and market infrastructure, and lack of refrigeration capacity in a tropical environment (within West Africa) promote the growth of pathogenic organisms with adverse consequences for food safety and public health.

Theme 3: Challenges Faced by Smallholder Horticulture Farmers in West Africa
Mr. Emmanuel Oduro Owusu

GLOBAL FARMRITE

The horticulture sector has been identified as the key driver for sustainable growth in West Africa. In recent years, there has been a high demand for horticulture produce in domestic, export markets (the EU), and other emerging markets. However, horticulture production continues to be dominated by smallholders and farmer groups with about 80-95% of farm sizes less than 2ha. The smallholder farmers in the sector are confronted with several challenges including:

Marketing

The marketing challenges confronting the sector include (i) unreliable/glut at certain times of the year (ii) limited market information (iii) poor quality produce (iv) price competition with imports from other countries and (v) unavailability throughout the year. Access to high-value markets requires food safety, quality, and private voluntary standards conformance (health and safety, MRLs, GLOBAL G.A.P).

Credit Access

Inadequate credit facilities for the farmers (women and the youth) are some of the major challenges of the sector. High-interest rates from banks and delays in the release of approved funds have significant impacts on the sector by affecting the cost of burrowing money and investment decisions. Government and other financial institutions should reserve special funds for the smallholder farmers, particularly for women and the youth in horticulture.

Quality and Cost of Inputs

The high cost of good seeds also poses a challenge to smallholder farmers. For example, 1000 seedlings of tomato cost about US$120. The use of poor-quality seeds/planting materials, fertilizer, and plant protection products has a negative effect on crop yield. There is an urgent need for improved vegetable seeds (okra, chillies, tomatoes) tolerant to viral diseases.

Poor Agronomic Practices

Poor nursery practices such as over sowing, overcrowded seedlings, etiolated seedlings leading to very weak seedlings, and damping-off are common. In addition, seedlings are transplanted too early or too late when almost flowering at the nursery, and inadequate protection of seedlings from pests and diseases at the nursery stage. This results in the complete loss of seedlings.

Limited access to recommended fertilizer because of the high cost poses a huge challenge to smallholder farmers. Inadequate knowledge of fertilizer recommendations for some horticulture crops grown by smallholders leads to misapplication. The performance of the sector is poor due to inadequate extension services or limited capacity to provide the services needed by farmers.

Another major challenge for smallholder farmers is poor knowledge regarding the harvesting and post-harvest handling practices. For instance, inadequate knowledge of maturity indices of some crops for good quality and long shelf life of some crops may result in produce being harvested too early or too late (watermelon, avocado, citrus, okra, pineapple, etc).

Lastly, high pest and disease infestation leads to crop failures. In some instances, a whole field of okra, tomato, watermelon, melon, and chillies may fail due to diseases and pests' infestation.

Difficulties in managing some specific quarantine pests (fall armyworm, fruit flies, thrips, whiteflies, eggplant fruit and shoot borers) have advers effects on agricultural productivity.

Way Forward

- Improve accessibility to fields through the construction of farm roads
- Private investment in nurseries in communities to sell good quality seedlings to farmers.
- Provide continuous training in the nursery, and integrated Pest and postharvest management to reduce pre-and post-harvest losses.
- Educate and sensitize farmers to use certified planting materials through the provision of subsidies on agricultural inputs.
- Harmonization and production of extension materials to be used by all offering training.
- Build Capacity of Extension Staff to provide efficient and effective extension services.
- Ensure ready markets for produce through identified contract farming arrangements.

Theme 4: Role of the Youth and Gender in Transforming Horticulture in West Africa

Mrs. Gifty Kafui Mensah

Executive Business Director (Maphlix Trust Ghana Limited)

The global population is projected to reach 9 billion by 2050. The number of young people (aged 15-24) is also expected to increase to 1.3 billion by 2050, accounting for almost 14 percent of the projected global population. While the world's youth cohort is expected to grow, employment and entrepreneurial opportunities for youth particularly those living in developing countries and economically stagnant rural areas remain limited, poorly remunerated, and of poor quality. The unemployment rate for youth is currently three times that of adults in all regions of the world (Food and Agriculture Organization (FAO, 2021). The horticulture sector constitutes a significant segment of the total agricultural production value chain, in most West African countries. The horticultural sectors' ample potential to provide income-generating opportunities for the youth, will require full participation without any form of gender disparity on the part of the youth and intends bring major transformation to the sector.

Youth and Gender in Transforming Horticulture in West Africa

Young entrepreneurs in this sector should be more innovative, thus tapping technologies like greenhouse production, artificial intelligence (AI), remote sensing, drone technology and a variety of precision tools to provide services. The youth need to adopt block-chain (forecast, recording, and tracking) and decision-making technologies to better understand produce supply chains and make informed choices for improving crop yield, to secure higher prices. To transform the horticulture sector, the youth need to understand the need to increase capacity as many do not have the required knowledge and skills to take advantage of the opportunities in this sector (e-learning platforms, short hands-on practical training). The youth should create online platforms to market their products instead of the conventional approach.

Women should have equal access to agricultural training, use of machinery and adoption of new advanced technologies, to enable them to engage in improved agricultural practices. In addition, there is a need to improve women's access to education. Access to land and finance is a major challenge for women in the sector.

Theme 5: Horticultural Funding and Financing

Mr Kwasi Korboe

CEO of GIRSAL LTD

The attractiveness of the Horticulture Sector

Horticultural products form an integral part of human nutrition and health needs and are demanded on a daily bases. Financing of horticultural production is attractive because horticultural products/produce have a higher yield per acre compared to other value chains. That is the output per acre for most horticulture products is more than cereals and grains. In addition, the pricing per yield for horticultural products is higher than those in other value chains. Due to their high value, they can be cultivated throughout the year under irrigation and greenhouse technology. The risk associated with cultivating horticulture products is mitigated because of the use of modern technologies and good agronomic practices.

Positioning Agribusiness for Funding

To access funding, agribusiness has to go beyond identifying the market or off-takers of their products and understand the details of quality standards or specifications required by buyers. Additional market information on the size of the market, market share, knowing players in the target market, and the financial capacity of the off-taker.

Good Production / Activity Plan

Agribusiness must have a clear indication of the various activities to be undertaken as part of a project. This entails details of the approach/technologies you intend to use, identified risks, mitigation measures, and resources (inputs, expertise, equipment, and other logistics) needed at each stage. A good activity plan demonstrates knowledge of your business and helps to justify your fund requirements.

Detailed Funds Utilization & Cashflow

It is important to indicate the level of funding needed at each stage and provide as much detail as possible. A good plan helps the financial institutions to determine your funding needs, and to structure your loan appropriately. Agribusiness firms requesting funding must determine how much is needed for activities planned for funds to be made available to you as and when it is needed. Financial Institutions (FI) may be more comfortable disbursing funds as and when needed than in-bulk in advance (less risk of diversion). This helps the FI to determine a client’s expected inflows to enable them to design a repayment plan. An incomplete fund utilization plan may result in approval of less than or more than is needed.

Transparency is necessary for acquiring funds for business activities. The accuracy and completeness of supporting documentation are of prime importance. Credit history or previous debts may not necessarily harm a client's application. This could be due to circumstances beyond the client’s control or general business environment/industry challenge (e.g. Covid-19, pests, and diseases). Propose a plan to pay off alongside your new loan where possible.

Loan application assessments take time (especially for complex projects), thus sufficient time may be needed to review, validate or confirm certain aspects of an application. The FI may reach out for additional information or to clarify certain aspects of an application. Late applications may result in late disbursement resulting in funds being released while production season may have passed. Also, conditions around the project may change (pricing, etc.) or missed opportunities. FIs may also be the source of delay.

Funding sources include long-term funding from the Development Bank of Ghana (DBG) - GIRSAL PFI which benefits from agriculture CRG and TA. Funding from equity investors, family, and friends.

Theme 6: Role of Research for Horticultural Development in West Africa

Dr. Rosaine N. Yegbemey
Interim Regional Director for WCA, World Vegetable Center

Globally, agriculture is a high-priority sector on the development agenda. Well-known as the backbone of the economy and providing 30–50% of GDP for most countries in West Africa, The sector is the primary source of livelihood, providing employment, income and food and nutritional security. However, public and private investments in agriculture are largely focused on staple and oil crops, not on commodities rich in micronutrients. Out of its 308 million inhabitants, 40 million people are undernourished and suffer from chronic malnutrition. Every year, food crises affect millions of people. In recent years, both food security and the importance of dietary diversity for good health are now acknowledged. A consensus is that the horticultural sector can make an important contribution to food and nutritional security and also enhance the livelihoods of smallholder farmers.

Benefits of Vegetables Production and Consumption

Fruits and vegetables can be produced on small amounts of land, have high profits in a relatively short period, and the existence of ready markets. Technical: Farm diversification strategies, can reduce farmers' vulnerability to climate change (diversity of vegetable crops, short growing cycles, and efficient use of irrigation), and ability to fit into year-round production systems.

Fruits and vegetables are low in fat and calories, no cholesterol, sources of many nutrients, including potassium, dietary fiber, folate (folic acid), vitamin A, and vitamin C. Vegetables are essential and irreplaceable parts of healthy diets. Additionally, their role in preventing diet-related non-communicable diseases is well established.

Challenges of Vegetables Production and Consumption

Several challenges confront the production and consumption of fruits and vegetables in West Africa. These include:
(i) Low knowledge of good agricultural practices among producers (ii) High pests and diseases occurrence (iii) climate change (iv) poor soil quality (v) limited access to inputs (seeds, fertilizers, and pesticides) (vi) poor inputs quality (seeds, fertilizers, and pesticides) (vii) perception of vegetables to be not commercial crops (viii) poor postharvest handling practices (ix) limited knowledge/awareness on the benefits of vegetable consumption (x) limited household income (xi) price and availability of vegetables and (xii) consumers preferences (education, cultural beliefs, norms, etc.)

Potential areas of intervention to realize the potential of vegetables

The presenter identified both supply and demand-side factors as potential areas for intervention. On the supply side, he noted an increase in the availability of a diverse range of safe vegetables. This requires (i) improving on-farm productivity (Improved vegetable varieties, safe and sustainable pest management, protected cultivation) (ii) ensuring that vegetables are safe to eat (iii) Reducing postharvest losses, and (iv) improving market access

In addition, the demand side entails increasing vegetable consumption to improve nutrition. This requires (i) increased awareness of a balanced diet and concept of nutritional security (ii) behaviour change communication on vegetable consumption (iii) home gardens, rural vegetable consumption, school meals, and (iv) modify food systems for better nutrition

Role of Research for Horticultural Development

Current Challenges	Research needs	Research Priority Areas
Yields of most vegetables are very low in most West African countries	How to improve productivity through the use of sustainable production methods	Vegetable breeding research to improve variety performance
Adoption of improved varieties and other inputs is also low	How we can improve the adoption rate of improved varieties?	Work with the private and public seed sector (capacity strengthening) - AVBC
Market relations are often unstable /opportunistic	How to strengthen vegetable value chains to improve quality and reduce losses	Strengthening of vegetable business networks
Vegetable (and fruit) consumption is low	How do food environments influence people's choice to eat fruit and vegetables?	Research on food environments
Food environments are not always conducive: vegetables and fruits are often expensive or not accessible	What interventions can influence people to eat more fruit and vegetables?	Addressing access to vegetables through, for instance, school meal provision
Fruit and vegetables are often not explicitly considered in policies or regulations (most are developed with cereals in mind)	How to get fruit and vegetables more recognized in policy decision-making?	- Analysis of seed policies affecting the vegetable seed sector; capacity strengthening of stakeholders - Analysis of nutrition policies

2. GROUP DISCUSSION AND PRESENTATIONS

Breakout sessions were carried out to discuss the following thematic areas in detail. The following are the summaries of what was discussed.

Group 1: CHALLENGES AND OPPORTUNITIES IN THE HORTICULTURE SECTOR RESEARCH AND DEVELOPMENT

(*Funding, Seed Systems, Improved Varieties, Climate-smart horticulture*)

The group had discussions on areas that researchers need to focus on. These include:

- Research should be done to better understand the food systems in the respective countries.
- In addition, a value chain analysis should be carried out to identify the challenges confronting the horticultural sector and to attract policy attention in the respective countries.
- We should begin by focusing on all the horticultural products for conservation purposes, and then move on to specific crops.
- There is a need for research to assess the seed systems in West African countries, as this was an important topic that came out strongly during the conference.
- Research should also pay attention to market-oriented strategies to promote the consumption of horticultural products, thus creating an avenue for the private sector to come in and fund research.
- Research should be carried out to investigate the most effective funding model for a sustainable horticultural sector in each country. There should be funding to support research as this will help in building well-equipped research laboratories and capacity building for personnel who will operate these pieces of equipment.
- Research should investigate the development of digital technologies for effective use of resources, early detection of pests and diseases, and e-crop budgeting for various countries.

Group 2: YOUTH AND GENDER IN HORTICULTURE DEVELOPMENT

Members of the group discussed several issues which in one way or the other hindered the engagement of the youth and especially women in horticulture.

Barriers to Youth and Women in the Horticulture Sector

Major barriers for the youth and women in horticulture development include:

- Difficulty in acquiring land by the youth and women. This is a cultural problem in many communities in West Africa. Compared to men, women rarely own lands but cultivate smaller pieces of land. Major crops such as tubers, maize, rice, and soybeans are grown by men. Also, land ownership by the youth is difficult due to the land tenure systems in most farming communities.
- Also, due to cultural norms, women in some communities are not allowed to plough their lands or attempt production until the men have. This is in the belief that a woman cannot lead a man.
- Youth and women also lack access to finance to rent or purchase land.
- Also, the absence of specific interventions for people with disability is a barrier that hinders such people from participating in horticulture and this is mostly due to discrimination.

Challenges

The key points discussed were:

- Lack of certification of seeds and planting materials.
- Inadequate education on horticultural agronomic practices
- Women’s traditional roles especially with child care increase their workload and restrict them from performing certain farm activities.
- Most men in certain communities in the northern regions are not comfortable with their wives having frequent interactions with male extension officers. This hinders the transfer of new skills and knowledge from male extension officers to women in farming.
- Due to inadequate agricultural mechanization in West Africa, cultivating horticultural commodities is tedious and labour-intensive, making the profession unattractive to the youth.
- The youth want 'quick' money and with certain tree crops, they have to wait for a long time. The risks that come with the waiting period make it unattractive.
- Availability of support services is almost absent in most communities. Hence challenges faced by individuals who venture into horticulture are mostly left unaddressed.
- Poor market development.
- Poor road networks and high cost of transportation.
- Accessing markets are impossible due to the lack of inputs and infrastructure.
- Theft
- No contract agreement with buyers
- Poor internet and telephone connectivity hinder marketing and sourcing for inputs.
- Unattractive packaging of harvested produce
- Some consumers have concerns about chemical residue abundance
- Poor harvesting methods

Opportunities

- Information flow and training: make a conscious effort to bring information to the youth and women and include visuals aid in the training.
- Promote home gardening using modern technologies such as vertical farming
- Advocacy to disabuse certain cultural mentalities
- Mechanize the horticultural subsector and take away some of the drudgery associated with agriculture.
- Government policies should incentivize the youth and women in horticulture
- Establishment of training centers closest to them and innovation centers that would provide the required expertise.
- Media spaces should promote agriculture
- Producer Association should help in pricing commodities to motivate youth and gender in horticulture.
- Use of technology to track consumer preference.

Group 3: POSTHARVEST TECHNOLOGY-LOSSES, KEY CHALLENGES, AND OPPORTUNITY

The group deliberated on whether post-harvest loss and waste is an issue in West Africa. Members present agreed that issues of postharvest losses exist in their respective countries. For instance, in Liberia, post-harvest losses for fresh horticultural produce such as garden eggs, tomatoes, and pineapple can range from 60% to 70%. Distance to market centers and poor road networks are the main causes of the high losses. In addition, produce is also exposed to the sun leading to weight loss. In Ghana, the postharvest loss situation was attributed to a lack of planning. Farmers tend to produce for non-existent markets leading to losses and waste. The discussant also mentioned that transporters sometimes mix different commodities during transportation, resulting in cross-contamination and unwanted ripening. In the Gambia, inadequate curing of onions causes deterioration and shortens the storage life.

Key Challenges of the Horticulture Sector

The following are the key challenges that were discussed;

- Poor road network linking producing communities
- Inadequate knowledge by farmers on harvesting procedures
- Inadequate knowledge of the appropriate harvesting indices
- Poor packaging (use of traditional packaging such as traditional buckets and cane baskets leading to bruising of fruits and vegetables as well as contamination of the tissues)
- Unavailability of transportation facilities
- Poor and inadequate storage facilities
- Inadequate processing facilities
- No means of preservation
- Inadequate technology transfer
- Inadequate value addition
- Huge expenditure associated with processing
- Issues of the seasonality of harvested produce
- Unavailability of data on production volumes, consumer demand, food safety etc

Opportunities for the Sector

- Use of solar dryers
- Packaging of produce
- Processing of produce into food ingredients instead of the usual finished product
- Capacity building of all the actors along the value chain
- Technology transfer (e.g. Zero Energy Cooling Chamber), advisory and extension services
- Revamp feeder roads department to enable the construction of roads leading to producing communities
- Establish Produce Buying Companies and National Food Distribution Companies
- Establishment of cold chain storage facilities
- The use of Controlled Atmosphere Storage and Modified Atmosphere Packaging
- The use of ice chests with ice cubes on vending bicycles

Roles of the Various Stakeholders in Preventing Post Harvest Loss

Stakeholders	Roles in Preventing Postharvest loss
Local Government	• Construction and repair of dilapidated roads especially, feeder roads • Building capacities of actors along the postharvest value chain • Investigation of food-borne disease outbreak • Raise the standard of compliance of horticultural produce meant for local consumption • Set aside a day for the closure, cleaning, and disinfection of marketing and retailing centers • Provision of Water Sanitation and Health facilities at marketing and retailing centres • Segmentation of a market to prevent cross-contamination
Agric Officers or Extension Officers	• Capacity building of farmers • Monitoring and Evaluation • Collection of data • Test new postharvest technologies and transfer knowledge to farmers
Farmers	• Take advice from researchers and extension officers • Take advantage of contract farming and the establishment of off-taker agreements • Adoption of good agro-ecological practices • Application of climate-smart agriculture and precision farming • Proximity farming
Researchers (Academia)	• Invent low-cost innovative post-harvest technologies that can be easily adopted by farmers and other actors along the postharvest value chain (eg, the use of corn starch, cassava starch, and bee wax as edible coatings, Zero energy Cooling Chambers, Solar Dryers) • Proximate analysis after processing should be intensified • A regular and periodic gathering of data on postharvest issues to inform policy • Research on labelling and traceability of fresh horticultural produce and how it can be integrated into our local settings
Consumers	• Consumers must be willing to pay for value-added products • Consumers should be encouraged to buy fresh agricultural produce from credible sources

Group 4: NUTRITION AND HEALTH: NUTRITION-SENSITIVE HORTICULTURE, ROLE OF HORTICULTURE CROPS AND NUTRITION AWARENESS

The group identified some underutilized, indigenous horticultural crops in West Africa. These include taami, miracle berry, Frafra potatoes, baobab fruit tree, star fruit, turkey berry, roselle, tamarind, almond, jute mallow (Ayoyo). Also, reasons for the low consumption of fruits and vegetables in West Africa were discussed. The following were some of the reasons; (i) That we do not have the habit of using them in our diet (ii) The lack of promotion and marketing of these indigenous crops (iii) Low production leading to its unavailability on the market (iv) The lack of knowledge about the nutrition content of these crops.

As part of our solution, it was suggested that we incorporate these indigenous crops into school lunch plans so that children grow up understanding these crops, their health advantages, and the right techniques to prepare these crops to get the most nutrition out of them. Since food safety is not tangible, it is difficult to identify some concerns. A challenge that came up was the lack of diverse ways in which these crops could be used or consumed. Also, the factors that drive consumer food choices include;

- High cost of fruits and vegetables: High-cost fruits and vegetables are mainly due to the cost of transportation from the farm gate to market centers in cities.
- Others include high perishability, the safety of food, trust in the quality of produce, convenience, and social desirability.
- The improper practices by farmers such as the use of contaminated water in the irrigation of fruits and vegetables, the use of chemicals with disregard for the use of approved application rates, preharvest intervals before harvest is done to be sold in the markets, the indiscriminate use of agrochemicals on these crops. All these were said to reduce the trust consumers have in fruit and vegetable farmers.
- Unknown source of produce: It was also mentioned that if the source of the product is unknown, we are unable to verify the quality and safety of the produce. This discourages people from consuming such produce.
- High-cost technologies for proper handling and packaging of fruits and vegetables deter local consumers from purchasing and consuming.
- Lack of confidence in the safety of the produce of farmers (local) calls for education and awareness creation to help drive up the consumption of these crops. Even the safety of produce (fruits and vegetables that are indigenous) sold in the supermarkets and shopping malls are questionable.
- Another issue raised was food losses and wastage.

To prevent it, the representative of MOFA stated that the ministry is training farmers on how to increase production and at the same time help prevent or reduce food losses and wastage. He also stated that farmers must be educated on farming as a business. This will encourage farmers to produce food that meets the established or required standard of quality and safety.

There is a need to collect information on market trends in various regions to assist farmers in determining what to produce, in what amounts, when to produce it, and for how much. This would reduce postharvest losses and waste while also providing a secure market for their produce.

Another challenge was the availability and use of data management services to help farmers make informed decisions. It was also mentioned that it was up to the right bodies to monitor the activities of farmers to ensure and enforce the use of safe practices in the production of food crops. Another challenge discussed is the issue of certification. That there is a lengthy process that a farmer must go through to register and receive a license or certificate to authenticate his or her produce as organic or of high quality, and even after this, it is quite expensive. As a result, farmers are discouraged from obtaining one.

Research Opportunities and Way forward

The lack of information on the proper use of agrochemicals was mentioned and the opportunity in this is that researchers can generate or come up with the needed information and get it to the right stakeholders for implementation. Also, conducting good reviews, looking at the value chain and filling the gaps that are identified. In addition, the production of reports can be done and shared with government agencies for action and implementation. A participant from MoFA mentioned that there is currently no direct policy on the horticultural sub-sector and that the ministry is working on a document/ policy for the fruit and vegetable sub-sector.

Opportunities/Way forward

Collaborations between state agencies such as the Environmental Protection Agency (EPA), Food and Drug Authority (FDA), and MoFA are required to achieve a proper supervision or monitoring system to rid the system of malpractices and the use of unapproved agrochemicals. It was noticed that food safety was the main concern or the issue of most concern to the consumer. On how government agencies could work together, it was identified that the duties of these agencies overlap, and to solve this, the agencies need to come together to get a clear policy from their mother institution that would regulate all agencies to work in synchrony.

Alternatively, a clear division of labour and separation of powers should exist. Furthermore, the state must be prepared to support all of the agencies' functions adequately.

- Farmers must change their attitudes towards the production of such foods.
- The prices of these indigenous foods must be affordable to all.
- Knowledge of the health and nutritional benefits of indigenous foods must be readily available; this can be done by carrying out in-depth research into the composition of said foods.
- More research should be carried out into the rates of organic fertilizers which give optimum yields to help in easy use by farmers to discourage them from using inorganic fertilizers.
- Innovative ways to integrate the use of bio-pesticides into farming.
- The need to understand the effective communication channels available to farmers and the use of data management systems.
- Improvement in post-harvest and supply chain methods.

3. REGIONAL REPORTS

REGIONAL CONTEXT, OPPORTUNITIES AND CHALLENGES

GHANA

Context: The horticulture sector is important to the economy of Ghana as it provides income for farmers and the government. The sector is dominated by fruit and vegetable production. Ghana's fruit and vegetable production is among the highest in West Africa. Fruits and vegetables contributed to about 24 percent of the total value of non-traditional agricultural export in Ghana. Fruit export has grown by about 4 percent per year, exceeding vegetable export over the last decade. Commercial fruit production is concentrated in eleven regions spanning the middle belt to the south. Tomatoes, onions, green chillies, and pepper are mainly produced in Upper East, Northern, Brong Ahafo, Ashanti, Eastern, and Volta regions.

Opportunities and Challenges of the Horticulture Sector in Ghana

	Opportunities	Challenges
Input supply	-High demand for inputs -High potential for fertilizer production in Ghana -Proximity to input market (Morocco and Libya)	-Poor targeting of horticulture farmers for providing government input subsidy -Side selling of government-subsidized inputs
Production	-The rapid emergence of the middle-income class, fast-food joints, the hospitality industry, and supermarkets -High domestic and international market demand for fruits and vegetables in Ghana	-Use of poor seeds -Use of excess pesticides -Limited access to greenhouse technology -Low application of irrigation -Low supply of credit to farmers -Low supply of extension services
Trade and standards	Ghana has a good stand in fruit and vegetable export.	High importation of basic fruits and vegetables
Engineering and Technology	-Promotion of greenhouse technology by the government and private sector -Presence of higher education and research institutions	-There is minimal use of engineering and technology in horticulture production in Ghana. -Farmers practice irrigation using watering cans, buckets, knapsack sprayers, and small powered pumps. -There are no mechanized implements for weeding, planting, and harvesting horticulture crops. -Fruits and vegetables are sold on the open market without proper storage, processing, and packaging practices.
Research, Education and Training	-Most universities: The University of Ghana (UG), University for Development Studies (UDS), and Kwame Nkrumah University of Science and Technology are the only	-Lack of reliable data on the horticulture sector -Inadequate research into fruits and vegetables

	Opportunities	Challenges
	public universities majoring in horticulture programs -Ohawu, Kwadaso, Ejura, and Damango offer courses in Diploma and Certificates in agriculture Adidome, Wenchi, and Asuansi are farm institutes that train individuals in horticulture production in Ghana	

COTE D'IVOIRE

Context: The horticulture sector in Côte D'Ivoire is characterized by fruits and vegetables both for local market consumption and export. The local market comprises mainly smallholder farmers growing fruits and vegetables on a low technological level. Horticulture export consists mainly of bananas, mango, pineapple, and papaya. Cote D'Ivoire has a high production of bananas, followed by pineapple, and chillies. Horticulture exports are an important source of revenue for the country.

Opportunities and challenges of horticulture in Cote D'Ivoire

Sector	Opportunities	Challenges
Input supply	-High demand for chemical inputs and improved seeds -Good climatic conditions for commercial fruit and vegetable production. -Investment in inputs yields profitable outcomes. -There is increased potential for all-year-round production.	-Poor access to input (fertilizer, pesticide, and seed) markets due to poor road network. -Over-dependence on imports and low supplies of good fertilizers and pesticides. -Lack of mechanization, affordable loans, and cheap labour. -Poor land tenure security, limiting input application.
Production	-Cote D'Ivoire has a suitable climate for horticulture production -Horticulture products have better taste and high consumer demand. -More international demand than supply. -The high willingness of farmers to adopt improved technologies.	-Lack of effective pesticides for pest and disease control. -Inadequate credit provision to farmers. -Limited access to extension services. -Low adoption of irrigation farming. -Low government support.
Market and consumption	-High access to the urban market. -Rich customers purchase their fruits and vegetables from specialized shops and supermarkets. -Some Companies in Côte d'Ivoire, like Prosuma, buy fruits and vegetables from farmers and sell them to supermarkets.	-Supply is seasonal, with fluctuation in prices. -Inland distribution and marketing are a problem due to poor road networks. -High transportation cost. -Lack of proper storage facilities to ensure product quality.

Sector	Opportunities	Challenges
Trade and standards	-Proximity to Europe markets and North America. -Local and foreign markets for fruits and vegetables are rapidly growing.	-However, there are delays and congestion in exports at the port. -Lack of processing industries for value-added export.
Engineering and Technology	The use of greenhouses and netting is becoming a common practice to safeguard local production in Cote D'Ivoire.	Low dissemination and adoption of greenhouse technology by farmers
Research, Education, and Training	-The National Agricultural Research Department is into the development and commercialization of new varieties of vegetables and other crops. -Ongoing research and practical trials to improve and intensify the existing production systems are already carried out on a small scale	-Lack of reliable data on the horticulture sector -Inadequate research into fruits and vegetables

THE GAMBIA

Context: Horticulture occupies a major portion of The Gambia's Agriculture, accounting for 65% of the agricultural labour force. The Gambia produces more vegetables than fruits. Production of fruits and vegetables increased steadily between 2000 and 2020, but exports remained low and unstable. Less than 3% of the country's arable land is currently under fruit and vegetable production The Gambian horticulture farmers farm on One (1) hectare of land even though land area is increasing.

Opportunities and challenges in The Gambia

Sector	Opportunities	Challenges
Input supply	-The Gambia imports a lot of fertilizers and pesticides for agriculture. -Efficient domestic supply of inputs by the private sector.	Input application is minimal; 47%, 13%, and 21% of farmers use fertilizer, pesticides, and irrigation in agriculture respectively.
Production	-Good climate, -Labour availability increasing consumer market -Suitable land for cultivation	-Climate change -Poor yields -Low adoption of improved technologies -Lack of government support
Market and consumption	-High domestic and international market demand for fruits and vegetables.	-Postharvest losses remain high due to poor management practices and value addition. -Low consumption of fruits and vegetables
Trade and standards	Proximity to European markets and North America.	High importation of basic fruits and vegetables

TOGO

Context: The horticulture sector contributes more than 20% to the agricultural GDP and employs more than three workers per farm unit. Fruit and vegetable exports have been increasing in recent years. However, growth in fruits and vegetable export has remained stable in recent years.

Opportunities and challenges in Togo

Sector	Opportunities	Challenges
Input supply	-High potential for local production of organic fertilizer -An increasing number of input dealers in production zones.	-High importation of inorganic fertilizers and pesticides -High cost of inputs -Limited knowledge of pesticide application -Poor storage of chemicals
Production	The high market for fruits and vegetables both locally and internationally.	-Low yields, lead to low domestic supply. -Over-reliance on rainfall -Pests and diseases -Lack of government support and policy -Low adoption of improved technologies
Market and consumption	High demand for fruits and vegetables both locally and internationally	-Low fruit and vegetable consumption -Fruit and vegetable production in Togo only meets a quarter of domestic demand
Trade and standards	Proximity to the major export market	-Togo fruit and vegetable exports end in sub-Saharan Africa. -Low compliance with export standards for the international market

NIGERIA

Context: Nigeria is the leading producer of major fruits (pineapples, mangoes, and pawpaw) and vegetables (tomatoes, onions, and chillies) in West Africa. Horticulture represents a major sub-sector of agriculture in the country. Fruit and vegetable production and export are widely dispersed across Nigeria. The Middle Belt, which comprises the states of Kaduna, Kano, and Jos Plateau, produces over half of the country's tomatoes, onions, and potatoes. Except for mangoes, yields of several horticulture crops are lower than those in other West African countries.

Opportunities and challenges in Nigeria

Thematic areas	Opportunities	Challenges
Input supply	-Presence of the National Agricultural Seed Council (NASC) for the development and supervision of local seed production. -High demand for primary production inputs. -Emerging private commercial input producers (eg. Dangote Fertilizer)	-Low adoption of improved seeds, fertilizers, and pesticides. -High cost of primary inputs -Poor road network and transportation systems for input supply

Thematic areas	Opportunities	Challenges
Production	-Increasing domestic demand for fruits and vegetables due to population growth and urbanization. -High market value for horticulture products. -High international market demand for horticulture products in Nigeria. -Favorable climate for horticulture production	-Insect pests and diseases -Lack of knowledge about pesticide application. -Lack of irrigation facilities. -Low mechanization -Postharvest losses -Lack of access to credit -Land tenure insecurity
Market and consumption	-High demand for fruits and vegetables due to population growth -Local market for fruit and vegetable offers opportunities for women	Low fruit and vegetable consumption
Trade and standards	Proximity to major the European market	-Lack of policy -Absence of institutional support -Absence of agricultural extension -Poor technological infrastructure -Lack of credit facilities
Engineering and Technology	Greenhouse technology and artificial intelligence is fast emerging	Limited application of engineering and technology in the horticulture value chain in Nigeria
Research, education, and training	-The National Agricultural Research Institutes (NARIs) play a significant role in the production of seeds. -Nigeria has a large national agricultural research and extension service supporting farmers in the country	-Lack of data on horticulture -Low research on horticulture

SIERRA LEONE

Context: In Sierra Leone, the horticulture sector has developed very slowly, compared to other West African countries Horticulture accounted for less than 5% of the country's GDP in 2019. Onion, okra, pepper, eggplant, and tomato are the major vegetables produced in the country, while mango, pineapple, orange, lime, pear, and banana are the major fruits produced in the country.

Opportunities and challenges in Sierra Leone

Sector	Opportunities	Challenges
Input supply	-High demand for fertilizers and pesticides. -Potential for agribusiness exists at various points along the horticultural crops value chain from production to retail level.	-Supplies of fertilizers and pesticides are inadequate for domestic requirements. -In addition, these inputs are expensive and inadequate for the majority of fruit and vegetable farmers.

Sector	Opportunities	Challenges
	-Suitable land to expand production and increase the use of complementary inputs.	-Quality seeds of locally cultivated fruits and vegetable crops are not available.
Production	-High demand for fruits and vegetables by households, schools, hotels, restaurants, street food joints, and petty traders -High international market demand for fruits and vegetables	-Yields of major crops such as tomatoes, onions, and okro fall short of potential yields. -Low domestic supply improved seeds, fertilizer, and pesticides -Lack of access to credit, markets, and extension -Pests and diseases -Limited source of water for irrigation
Market and consumption	Fruits and vegetables have a high market demand in Sierra Leone.	-Daily fruit and vegetable consumption in Sierra Leone is below the FAO/WHO recommended amount of 400g/capita -Uncertainty of changes in prices of fruits and vegetables -Lack of access to a ready market is a challenge -Poor road network -Lack of proper distribution systems
Trade and standards	Proximity to the European market	Low compliance with food safety standards
Engineering and Technology	-Sierra Leone Agricultural Research Institute (SLARI) is the institution charged with the responsibility to develop technologies to enhance crop production in the country.	-Limited application of engineering and technology in the horticulture sector
Research, Education, and Training	Sierra Leone Agricultural Research Institute (SLARI), Njala University (NU), and the University of Sierra Leone (USL) are involved in horticultural research	-Lack of reliable data on horticulture -Low research on horticulture

SENEGAL

Context: Senegal is a net importer of food, including horticulture products such as onions. Fruit production has increased more than vegetable production over the last two decades. The region Niayes extending from Dakar to St. Louis produces more than 60% of onions, tomatoes, and pepper.

Opportunities and challenges in Senegal

Sector	Opportunities	Challenges
Input supply	-Senegal has a well-organized market for horticulture inputs. -Availability of certified seeds from Europe. -Domestic production of improved seed. -High demand for fertilizers, pesticides, and improved seeds.	-Local multiplication of improved seeds does not meet demand. -Supplies of fertilizers and pesticides are inadequate for domestic requirements. -Costs of importing primary production inputs are high, reducing input supply.

Sector	Opportunities	Challenges
Production	High demand for fruits and vegetables	Low yields of major fruits and vegetables High post-harvest losses
Market and consumption	Increasing urban demand for fruits and vegetables	-The Senegalese market is characterized by a low quality of horticulture products. -Lack of ready market in the local market -Lack of cold storage facilities -Low consumption of fruits and vegetables
Trade and standards	Proximity to major the European market High international market demand	Low compliance with international food safety standards.
Engineering and Technology	High potential for greenhouse technology	Engineering and technology for horticulture value chain activities are not yet developed in Senegal.
Research, Education and Training	ISRA / CDH has produced early maturity varieties of onions for Senegalese farmers.	-Lack of reliable data on horticulture -Low research on horticulture

MALI

Context: Mali is one of the largest producers of fruits and vegetables in West Africa. Primary production zones include Sikasso, Koulikoro, Mopti, Ségou, Kayes, and Bamako. Trade-in horticultural products represent more than half of total agricultural product exports to West Africa. Horticulture production accounts for between 21.6% and 35.9% of farmers' income. Fruit and vegetable production and export are high in recent years. Fruit exports are higher than vegetable exports.

Opportunities and challenges in Mali

Priority Areas	Opportunities	Challenges
Input supply	High demand for fertilizers, pesticides, and improved seeds.	Low domestic production of primary inputs (fertilizer, pesticide, and quality seed)
Production	High demand for fruits and vegetables	-Erratic rainfall -Poor soil fertility -Lack of access to land for production by women and youth -Limited application of irrigation
Market and consumption	-Horticulture products have a high market value -Domestic market trade transactions take place at farm-gate, village market, and urban markets	Fruit and vegetable consumption in Male is inadequate
Trade and standards	-Proximity to major the European market -High international market demand	Low compliance with international food safety standards

BURKINA FASO

Context: Fruits and vegetables play a crucial role in food security, nutrition and export earnings. Fruit and vegetable production is dominated by market gardens, of which 65% were managed by men in 2018.

Opportunities and challenges in Burkina Faso

Priority Areas	Opportunities	Challenges
Input supply	-High demand for fertilizers, pesticides and improved seed -Potential for organic inputs -Presence of local input dealers at the village level. -High dry season production	-Low supply of appropriate fertilizer -Low supply of local seed -Low supply of appropriate pesticides -Lack of appropriate storage facilities
Production	-Horticulture production provides more income to market gardeners in Burkina Faso. -This opportunity exists because of the high demand for fruits and vegetables both locally and internationally. -Fruits and vegetables have high market value in Burkina Faso -Most crops have a shorter maturity period	-Low yield -Water shortages -Declining soil fertility -Limited access to fertilizer -Pests and diseases -Lack of access to credit and extension services for horticulture farmers
Market and consumption	Consumption of fruits and vegetables is increasing over late Sales at farm-gate are high (>50%)	-Poor road networks -Lack of storage and processing facilities -Poor quality of vegetables leading to product rejection -The remoteness of production areas -High post-harvest losses
Trade and standards	-The domestic market is also growing with the installation of medium and large factories, especially for mangoes. -Export is also increasing in recent years	Farmers have a challenge meeting the export standards of the EU

4. PRIORITY RESEARCH AND DEVELOPMENTAL ACTIVITIES

Postharvest Technology and Food Safety

- Identify and develop appropriate postharvest technologies to reduce losses in quantity and quality of produce
- Development of a postharvest system to meet market demand and food safety standards
- Provide suitable post-harvest handling and safety information to all levels of value chains
- Improve post-harvest handling of fruits and vegetables in local markets in West Africa

Nutrition and Human Health

- Design programs to promote the production and consumption of indigenous, neglected, and orphan fruits and vegetables
- Establish a West Africa regional center to study and analyse disease risks of fruits and vegetables
- Develop selected indigenous horticulture crops and cultivars for their nutritional properties.

Youth, Gender, and Horticulture Development

- Empower youth and women in technology generation, transfer, adoption and capacity building through participatory methods
- Emphasize research on youth and women's participation in horticultural export production

Research and Development in Horticulture

- Food systems research from the respective countries in West Africa
- Commodity-based value chain analysis
- Research to assess the seed systems in various countries in West Africa
- Identify and develop varieties for local conditions, pests and diseases
- Develop local capacity to conduct advanced research and development and train the necessary extension personnel, private consultants, and industry leaders.
- IPM system for disease and pest problems

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APPENDIX 1: REGIONAL CONSTRAINTS ANALYSIS

CONSTRAINTS	Ghana	Togo	Nigeria	Mali	Senegal	Sierra Leone	Liberia	Gambia	Cote d'Ivoire	Burkina Faso
BIOPHYSICAL										
Input Supply	**	***	***	**	***	***	**	**	**	
Productivity and Production	**	***	**	***	**	**	**	***	*	
Improved Varieties	***	***	**	***	**	**	**	**	***	
Pests and Diseases	***	***	**	**	**	**	**	**	***	
NATURAL RESOURCES										
Soil	*	-	*	-	-	-	-		*	
Water	*	-	*	-	-	-	-		*	
Climate	**	-	*	-	-	-	-		*	
MARKET AND CONSUMPTION										
Market Access	**	*	**		**	**	**		*	
Value-addition (Processing)	***	***	***		**	**	**		***	
POSTHARVEST HANDLING, TRADE AND STANDARDS										
Standards	***	****	***		***	***	***		***	
Food safety	***	***	***		***	***	***		***	
Infrastructure	***	***	***		***	***	***		***	
Post-harvest Practices	***	***	***		***	***	***		***	
RESEARCH, EDUCATION AND TRAINING										
Extension	*	-	**		*	*	*		**	
Research	***	-	**		*	**	*		***	
Lack of Information	**	-	**		*	**	*		**	
SOCIO-ECONOMICS										
Women and Youth in Horticulture	**	*	***		*	*	***		**	
Indigenous Peoples in Horticulture	**	*	*		*	*	***		**	
ENGINEERING AND TECHNOLOGY										
Processing, Storage etc	***				**	**			***	
REGIONAL AND NATIONAL POLICY ENVIRONMENT										
Land/Capital	***	***	**		**	**	***		***	
Policy	***	***	**		**	**	***		***	

APPENDIX 2: RECAP OF DAY 1 PROCEEDINGS

- The conference was opened by Prof. Irene Egyir (Dean of the School of Agriculture) and she introduced the Chairman of the conference. The chairman was Prof. Boateng Onwona-Agyeman.
- The chairman gave his introductory remarks and introduced the speakers and country coordinators of the conference.
- The overview of the conference was given by Erin McGuire (Associate Director, Feed the Future Innovation Lab for Horticulture University of California, Davis)
- Dr Amissah gave the details of the 2-day conference
- Prof. Anna Lartey, a professor of nutrition moderated the panel discussion on:

    - **Theme 1**: "contribution of horticultural crops to healthy diets and improve nutrition",
    - **Theme 2**: "Food safety: post-harvest handling. And sanitation of horticultural produce in West Africa"
    - **Theme 3**: "challenges faced by smallholder horticulture farmers in west Africa"
- The speaker for **Theme 1** was **Ms Paulina Addy** (Deputy Director Ministry of Food and Agriculture; Women in Agriculture Development Directorate (WIAD)).
    - She emphasized the importance of horticultural crops; especially on their nutritive, health and economic benefits.
    - She mentioned high losses of horticultural produce making it expensive. She highlighted some opportunities in the horticultural sector and encouraged backyard gardens and urban agriculture.

- The speaker for **Theme 2** was **Prof Adewale Olusegun Obadina** (Federal University of Agriculture, Abeokuta, Nigeria).

    - He mentioned that the annual cost of treating food-borne diseases in SSA is about 10.5 billion dollars.
    - He also mentioned that horticultural produce could be contaminated by physical and biological harvest before, at harvest and cross contamination during transportation, handling, and storage.
    - He highlighted some safety challenges including indiscriminate use of agrochemicals, poor pre-harvest practices including untreated manure, poor harvesting methods and the use of contaminated water for cleaning food.

- The speaker for **Theme 3** was **Mr Emmanuel Owusu** (CEO of Global FARMRITE).
    - The recovery of the African economy will be through horticulture.
    - He highlighted some challenges within the horticultural sector including poor road networks to farmer fields, markets, poor quality of planting materials, high cost of inputs and high occurrence of pathogens and diseases.
    - He made some recommendations including the provision of adequate extension services, adequate sources of financial support for women and youth, and the protection of crops using nets and row covers.

- The keynote address of the conference was given by Mr. Emmanuel Asante Krobea (Technical Advisor to the Minister) on behalf of the Minister of Food and Agriculture, Dr Owusu Afriyie Akoto.
    - He indicated that some stakeholders have drafted and submitted a proposal to establish the horticulture development authority to help strengthen the sector.
    - He also mentioned that the youth are being trained in vegetable greenhouse production and introduced to exchange programs in Israel.

- Prof. Oduro Nkansah, a professor of horticulture and the Director of IAST moderated the panel discussions on
    - Theme 4: "Role of the youth and gender in transforming horticulture in West Africa",
    - Theme 5: "Horticultural Funding and Financing", and
    - Theme 6: "Role of Research for Horticultural Development in West Africa"

- The speaker for **Theme 4** was **Ms Gifty Kafui Mensah** (Executive business Director, Maphlix Trust Ghana Limited). She highlighted the need to create income-generating opportunities for the youth and women. She advised the youth to take advantage of training opportunities to add value to themselves and leverage the use of artificial intelligence to sustain horticultural crop production and marketing.

- The speaker for **Theme 5** was **Mr Kwesi Korboe** (Chief Executive Officer, Ghana Incentive-based Risk-sharing System for Agricultural Leading (GIRSAL Ltd.)). He advised participants on how to position their businesses for funding. He made a profound statement that "*in credit, character is everything*". He pointed out that the cost of loans is expensive and as a result, shareholders must be identified for equity's sake.

- The speaker for **Theme 6** was **Dr. Rosaine Yegbemey** (interim Regional Director, World Vegetable Centre). He spoke of the need to strengthen the horticultural, nutritional and functional value chains. He also emphasized awareness creation regarding the consumption of fruits and vegetables

- Several interesting questions and answers were raised during the panel discussion session. Some of the questions raised were:

    - "*who is a farmer*"? how do you manage the challenges with women and youth in agriculture?
    - do smallholder farmers get the finances budgeted for them?
    - are smallholder farmers able to meet the requirement of preparing a good business plan?
    - Are there training opportunities available for smallholder farmers?

- An online survey on "Horticulture innovation" was administered to participants, led by Erin McGuire

- Seven (7) Country coordinators from Ghana, Nigeria, Gambia, Sierra Leone, Liberia, Senegal and Mali gave presentations on the state of the horticultural sector in their respective countries, highlighting their challenges and opportunities.
    - Some of the challenges include inadequate inputs, poor access to funds, poor road network, and post-harvest losses.
    - Some opportunities include high international demand for fruits and vegetables, favourable weather, available training and research facilities.

APPENDIX 3: COUNTRY PRESENTATIONS

- Country Presentation – Ghana pdf
- Country Presentation – Nigeria pdf
- Country Presentation – The Gambia pdf
- Country Presentation – Sierra Leone pdf
- Country Presentation – Liberia pdf
- Country Presentation – Senegal pdf
- Country Presentation – Mali pdf
- Country Presentation – Togo pdf
- Country Presentation – Ivory Coast pdf
- Country Presentation – Burkina Faso pdf

Report on the Horticulture Sector in West Africa

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CONTENTS

ACRONYM

GDP	Gross Domestic Products
GoG	Government of Ghana
AfCFTA	African Continental Free Trade
AgSSIP	Agricultural Services Sub-Sector Investment Programme
CNRA	National Agricultural Research Department
CAADP	Comprehensive African Agricultural Development Programme
EC	European Commission
ECOWAP	Economic Community of West Africa Agricultural Policy
EMQAP	The Export Marketing and Quality Awareness Project
FAO	Food and Agriculture Organization
FASDEP	Food and Agriculture Sector Development Policy
FVO	Food and Veterinary Office
GEPA	Ghana Export Promotion Authority
GSC	Ghana Seed Company
GHPPP	Ghana Private-Public Partnership for Food Industry Development
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GSS	Ghana Statistical Service
IFPRI	International Food Policy Research Institute
ITA	International Trade Administration
MiDA	Millennium Development Authority
MOAP	Market Oriented Agriculture Programme
MOFA	Ministry of Food and Agriculture
NTE	non-traditional export
NES	National Export Strategy
PERD	Planting for Export and Rural Development
PFJ	Planting for Food and Jobs
PPRSD	Plant Protection & Regulatory Services
SRID	Statistics, Research and Information Directorate
TIPCEE	Ghana Trade and Investment Promotion for Competitive Export Economy
UNDESA	United Nations Department of Economic and Social Affairs
USAID	United State Agency for International Development
USAID	United State Agency for International Development
WA	West Africa

EXECUTIVE SUMMARY

INTRODUCTION

West Africa comprises of six English-speaking countries (Ghana, Liberia, Nigeria, Sierra Leone, The Gambia, and English-speaking part of Cameroon), eight French-speaking countries (Guinea, Togo, Burkina Faso, Cote D'Ivoire, Senegal, Mali, Niger, Benin), one Portuguese-speaking country (Guinea Bissau) and one Spanish-speaking country (Cape Verde). West Africa is largely agrarian, with agriculture accounting for about 30-50 percent of the region's GDP and up to 70-80 percent of total employment in Togo, The Gambia, and Burkina Faso. Horticulture also offers significant opportunities for economic development. For instance, in Togo, the sub-sector contributes more than 20% to the agricultural GDP and employs more than three workers per farm unit. Horticulture also occupies an important portion of farmers' income in Mali, ranging between 21.6% and 35.9%.

Horticultural products offer substantial prospects for export growth in West Africa due to its relative proximity to large and growing consumer markets in Europe and the Middle East. Indeed, fruits and vegetables imports into Europe are growing fast as consumers develop the taste for a wider variety of products such as tropical fruits which are not available in Europe and products that are 'off season' in the European growing cycles but are available all year-round from the tropical regions. International trade for horticulture products is growing at 7% per annum compared to 2% for staple food crops, providing an ever-increasing opportunity for West Africa. Additionally, several international trends are growing in favour of West Africa including the expansion of EU membership, which will increase horticulture product demand in the medium to long term, and the rising strategy of European retailers to diversify their geographical sourcing from beyond Europe and also from their traditional over-sea growers.

ASSESSMENT METHODOLOGY

This review is focused on identifying priority areas determined by stakeholders in the horticulture sector. The methodology used in the assessment is a combination of (i) desk reviews, (ii) stakeholders' surveys, (iii) focus group discussions, and (iv) key informant interviews. Desk research included extensive searches on websites of institutions for reports and documents of relevance. Organizations such as the Ministry of Food and Agriculture (MoFA), the Ghana Export Promotion Authority (GEPA), Ghana Statistical Services (GSS), Institute of Rural Economy (IER), National Institute of Agronomic Research (ITRA), the Ministry of Trade and Industry, and other relevant institutions from other countries were consulted for data. Published articles and reports on the horticulture sector were consulted.

Key informant interviews were conducted to gather information on challenges and opportunities for the horticulture sector. In the case of the research institutions and the universities, data was gathered on the research infrastructures, education, and training needs concerning the horticulture sector. The West African stakeholder inputs from ten (10) countries were considered. These key stakeholders included industry leaders, experts in horticulture production, crop handling between harvest and markets, gender equity, youth empowerment, nutrition, agri-policy, input suppliers, irrigation experts, value chain experts, climate experts, and farmer groups. Subsequent to this review, a two-day regional conference (West Africa Regional Horticulture Conference: Horticulture for Food, Nutrition and Livelihood) was organized from 31st May to 1 June 2022. The workshop was designed to elicit equitable and active participation of all major stakeholders in the horticulture sector in West Africa.

SUMMARY OF FINDINGS

West Africa has experienced a rapid growth in its horticulture sector in the last three decades. A transformation that is mainly driven by (i) urbanization, (ii) an increase in per capita income, (iii) growth in supermarkets, and (iv) an increase in export market opportunities. However, the smallholder producers, processors, and exporters still face several structural challenges. Constraints in the sector are identified under eight (8) categories across the region: Biophysical; Natural Resources; Socio-Economics; Market and Consumption; Trade, and Standards; Engineering and Technology; Research, Education, and Training; and Regional and National Policy Environment

Biophysical

Biophysical challenges include input supply, productivity and production, improved varieties, and pests and disease infestation.

Inputs Supply

Inputs such as fertilizers, seeds, pesticides, land, and labour play an important role in fruit and vegetable production in West Africa. Fertilizer consumption among smallholder farmers, who make up the majority of farmers in the region has increased in the past decade but it is still far below what is needed as farmers face numerous challenges that limit their effective fertilizer demand. The majority of these farmers have little or no experience with fertilizers and its potential to enhance crop yields. Of the farmers who may be aware of this, the majority do not know the right types and application rates of fertilizers they should use for their soils and crops. These farmers have limited access to finance which further affects their demand for fertilizer and other inputs. Markets in the region are fragmented and intra-regional trade is weak. The supply of chemical inputs is largely dependent on imports. West Africa imports its chemical fertilizers and pesticides from Morocco, Asia, and Europe to meet farmers' demands. Improved seeds are also imported into West Africa. Only a few countries, including Ghana, have subsidies on inorganic fertilizers and improved seeds in the agricultural sector. Farmers source their inputs from multiple channels, including the use of their own saved seeds, neighbours, informal markets, commercial input dealers and seed-producing companies. The high price of fertilizer, lack of improved seeds, and inadequate knowledge of pesticides for usage and application pose a major challenge in the sub-region. These challenges are similar across the sub-region.

Production and Productivity of Horticultural Crops

Horticulture, especially fruits and vegetables production support social and economic development in West Africa. West Africa's vegetable production is dominated by tomato, onions, and chili pepper, while fruit production is dominated by pineapple, orange, mango, pawpaw, and banana. Nigeria is the leading producer of major fruits (pineapple, mango, and pawpaw) and vegetables (tomato, onion, and chili pepper) in West Africa. Ghana is the leading producer of oranges and has the highest orange yield in West Africa. Mango yields in Nigeria are the highest in West Africa, while pineapple yields in Ghana are the highest in West Africa. Banana yields in Cote d'Ivoire are highest in West Africa. Yields of tomatoes, chilies, and onions in Niger are the highest in West Africa. The total area under fruit and vegetable production has increased over the last three decades. Production of fruits and vegetables has more than doubled since 1990, but the region is not self-sufficient in fruit and vegetable production due to low yields.

Improved Varieties of Fruits and Vegetables

For vegetables and most fruits, farmers use local varieties and informal seed sources. The formal commercial seed sector serves only a small portion of vegetable producers, more often supplying commercial markets with quality seeds and improved varieties, such as tomato, onion, and peppers. MD2, Smooth Cayenne, Sugar Loaf (Pan de Azucar), Red Spanish, Queen Victoria and Abacaxi are the dominant improved varieties of pineapple grown by farmers. For orange, Washington Navel, Crimson Blood Orange, Hamlim, and Late Valencia are among the major improved varieties cultivated by farmers. Kent, Keitt, and Springfield are the major varieties of mango grown. The major improved varieties of bananas grown in West Africa include Cavendish, Mysore (Alata Kwadu, local variety), and Gros Michel varieties are the widely grown and preferred bananas in Ghana. The main varieties of pawpaw planted in Ghana are Solo Dwarf, Hortus Gold, and Bluestem. Green Chilies, Scotch Bonnet, and Bird's Eye are widely grown in Ghana and Nigeria. Recent improved varieties of tomatoes in Ghana include Kwabena Kwabena, Kopia, Adope Shite Adopte, Mako Ntose, Pectomech, Power Roma, Techiman, Eva F1, Padma F1, COBRA, Sultan, Raja, and Gigantico. Bawku Red and Galmi are the two main varieties of onions grown in Ghana.

Food Safety: Postharvest Losses and Management of Fresh Products

Food safety in the horticulture sector is necessary because it has adverse effects on nutrition and human health. Horticulture produce (fruits and vegetables) could be contaminated by physical, and biological hazards before harvesting, during the harvesting period, and cross-contamination during transportation, handling, and storage mainly due to poor agricultural and hygienic practices.

Good pre-harvest, harvest, and post-harvest practices are essential in preventing fruits and vegetable contamination. Microbial contamination of fruits and vegetables in the field is more likely in West Africa where growing conditions are unhygienic and protective practices such as the use of plastic mulch that prevents contamination by soil-borne microorganisms are lacking. Harvesting methods also predispose fruits and vegetables to microbial contamination. In addition, the transportation of fresh produce from the farm gate to the primary and secondary collection centers using head loads, farm animals, wheelbarrows, carts, bicycles, motorcycles, and motor vehicles can be sources of contamination. At the collection centers, fresh fruits and vegetables are often heaped together in piles in the open without any form of protection.

Food safety is a critical issue and promoting good practices in the production, harvesting and post-harvest handling of fresh produce reduces the risk of food contamination and helps maintain quality. Poor handling practices along the fresh produce supply chain from farm to market, poor infrastructure including transport and market infrastructure, and lack of refrigeration capacity in a tropical environment (within West Africa), promote the growth of pathogenic organisms with adverse consequences for food safety and human health.

Post-harvest losses for fruits and vegetables are very high in Ghana. In 2021, post-harvest losses for fruits and vegetables were 38% compared to other crops such as cereals (22%), roots and tubers (25%), and meat and fish (15%). Food losses are highest in sub-Saharan Africa, between 15 to 50 percent compared to East and South-eastern Asia (with a maximum of 13 percent) and even lower in Central and South Asia (with a maximum of 7 percent). The high post-harvest losses are mainly caused by (i) unsuitable harvest timing (ii) unexpected harsh climatic conditions and environment (iii) insect and pest infestations (iv) poor harvest and handling practices (v) infrastructure and marketing challenges and (vi) lack of storage facilities. The main postharvest management practices of fruits and vegetables identified in West Africa include precooling, washing and disinfecting, sorting and grading, packaging, storage, and transportation. These management practices help maintain the quality and increase the shelf life of fruits and vegetables. Precooling is done with the help of refrigerators while cleaning and disinfection are done by washing the product in clean water and disinfectants. Sorting and grading are done to eliminate unwanted products from the harvest, and also to determine prices.

Pests and Diseases

Pests and diseases are major problems in fruit and vegetable production in West Africa, causing significant crop losses for farmers. This includes diseases such as anthracnose, powdery mildew, alternaria, stem-end rot, Pseudocercospora leaf and fruit leaf disease of citrus, Cape St Paul wilt (CSPWD) for coconuts, bacteria black spots (BBS) on mango and pests (fruit fly, mealybug, termites and mango bugs).

Natural Resources

Water for fruits and vegetable production is mainly from irrigation, rainfall or wastewater. However, farmers depend mainly on rainwater for fruit and vegetable production. Water quality and availability are a challenge to the development of the horticulture sector. Most urban farmers use wastewater, which carries microbial and chemical hazards. In West Africa, less than 10 percent of the fertile land is under irrigation.
West Africa has a diverse agroecology and climate. The region has several climate zones suitable for fruit and vegetable production. Forest ecology is characterized by bimodal rainfall patterns, while savannah ecologies have monomodal rainfall patterns. However, there is a continuous decline and fluctuation in rainfall in West Africa due to climate change. Most savannah areas experience a long dry period. Yet, there is limited adoption of climate-smart practices by farmers in West Africa. The soils in West Africa are relatively less fertile, compared to other regions of the world. Most soils contain abundant coarse materials either gravel and stone, or concretionary materials which affect their physical properties. The coarse sand particles limit the water retention capacity of the soils, which compromises the resistance to drought for the crops. Ferralsols, strongly weathered reddish or yellowish soils are the well-known soil groups in West Africa.

Socioeconomics

Gender and Youth in Horticulture

The global population is projected to reach 9 billion by 2050. The number of young people (aged 15-24) is also expected to increase to 1.3 billion by 2050, accounting for almost 14 percent of the projected global population. While the youth of the world is expected to grow, employment and entrepreneurial opportunities for youth particularly those living in developing countries remains limited. According to the Food and Agriculture Organization (FAO), the unemployment rate for youth is currently three times that of adults in all regions of the world. Youth participation in agriculture is generally low in West Africa.
The horticultural sectors offer potential income-generating opportunities for the women and youth.
In West Africa, women play a significant role in the horticulture industry, especially in the post-production side of the vegetable value chains – such as processing and marketing/sales. They are more active in the production of mostly leafy and indigenous crops. Women account for more than 50 % of the workforce in the horticulture sector in West Africa. In The Gambia, women constitute over 60 % of the workforce in the horticultural sub-sector. In Nigeria they account for 75% of the farming population. However, their ability to access land and other resources for production is dependent on their husbands or fathers. Women earn income from horticulture production for household upkeep and payment of school fees and health services. They should be encouraged to participate in agricultural training, use machinery and adopt new advanced technologies, to enable them engage in improved agricultural practices. In addition, there is a need to improve women's access to education, land, and finance.

Innovation among the youth in the sector is necessary to adopt new technologies such as greenhouse production, artificial intelligence (AI), remote sensing, and drone technology. The youth require the adoption of block-chain (forecast, recording, and tracking) and decision-making technologies to better understand produce supply chains and make informed choices for improving crop yield, to get higher prices. In Ghana, for instance, the youth are being encouraged to go into agri-business along the horticulture value chain and greenhouse farming (Greenhouse Village Initiative-MoFA). The idea of the greenhouse village is to establish strong agribusinesses in the vegetable sector to attract both Ghanaian youth and international investors. The government of Ghana's objective is to position the country as a key competitor in the export of fresh vegetables and cut flowers. The project trained about 537 youths including Degree, Higher National Diploma (HND) and certificate holders. The three-month intensive training session covered all aspects of greenhouse vegetable cultivation, starting from the nursery, crop production, fertigation, pest and disease management, handling, marketing, and branding.

Market and Consumption

Market Access

Fruits and vegetables produced in West Africa are destined for local and international markets. Locally, the marketing of fruits and vegetables is dominated by informal actors, operating largely in open markets. The local market comprises about 70 percent of the fresh fruit and vegetable market in Ghana and other West African countries. Farmers supply the fresh produce mainly to domestic bulk suppliers, itinerant suppliers, and other suppliers such as supermarkets, hotels, and restaurants. In addition to informal marketing outlets, which are smaller, street shops, hawkers, and well-built markets, formal retail outlets such as supermarkets and specialty stores also engage in selling fruits and vegetables.

Demand for nutritious fruits and vegetables

The demand for fruits and vegetables has grown steadily over the last decade in West Africa due to rising urbanization, population, and income coupled with the expansion of traditional markets, the hospitality industry, and fruit processing units. However, there are still disparities in the consumption of fruit and vegetables across West Africa and between income classes within countries. The consumption of fruit and vegetables is below the FAO/WHO daily recommendations of 400g/day. Ghana has the highest consumption of fruits (189kg/capita/yr), followed by Guinea (97kg/capita/yr), while Mali has the highest consumption of vegetables (97 kg/capita/yr), followed by Senegal (86kg/capita/yr). Vegetable consumption has increased for most countries in West Africa (Benin, Burkina Faso, Cote d'Ivoire, Ghana, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, and The Gambia), compared to fruit consumption. Benin, Ghana, Senegal, and Mali have witnessed some growth in fruit consumption over the last decade.

Value-added Horticulture Products

Fruits and vegetables are mostly sold fresh, limiting value creation and value addition by producers and marketers. Producers and traders engage in primary activities such as cleaning, sorting and grading with poor storage, contributing to high post-harvest losses, food safety problems and a low product shelf life.

Agribusiness Opportunities

This is an excellent opportunity for investors to help introduce disease-resistant varieties by using tissue culture technology. Greenhouse gardening, integrated pest management, and organic fertilizers also provide opportunities for farmers to produce safe fruits and vegetables in West Africa.

Trade and Standards

West Africa trades in a variety of fruits and vegetables. The major export markets for fruits and vegetables are Europe and North America. Exports of fruits and vegetables in West Africa have been unstable due to production and institutional challenges. In most cases, farmers are unable to meet food safety and sanitary standards set by foreign markets. Exports of pineapple, banana, and mango, especially in Ghana fell in 2020 due to restrictions imposed by COVID-19. However, exports of pineapple in Cote D'Ivoire have remained high in recent years. The volume of orange and pawpaw exports increased exponentially in Ghana. Nigeria exports just 10% of its fruits and vegetables. The main exported fruits and vegetables are the indigenous types consumed by Nigerians in the UK.

Engineering and Technology

There is minimal use of engineering and technology in horticulture production in West Africa. Most reviewers reported the low application of engineering and technology with regard to the production and supply of horticulture products. Nigeria, Mali, Liberia, Ivory Coast, Burkina Faso, Togo and Ghana provided no evidence to this effect. In recent years however, drones have been used in pest, disease, and weed surveillance, as well as water stress monitoring in agricultural production. However, most countries in West Africa are yet to adopt these new technologies.

Application of engineering and technology in postharvest packaging, cooling, storage and drying is low in West Africa. There is no evidence of post-harvest packaging, cooling, cold storage and drying of fruits and vegetables in Togo, Gambia, Liberia, and Sierra Leone. In Burkina Faso, only mango and cashew are processed. In Nigeria, although fruit and vegetable processing are at the infant stage, about nine (9) companies are involved in the processing of tomato, dried fruits, vegetable mix and dried spices. These factories are located in Kaduna, Kanu, Abuja, Legos, Ogun and Oyo states. Mali has a unit for storage of horticultural products (PLAZA). This is a modern refrigerated and packaging warehouse located in Bamako. Other infrastructures for fruit and vegetable processing are also located in the main producing regions such as Sikasso, Koulikoro, and Bougouni. Some private women's cooperatives also have postharvest packaging, cooling, cold storage, and drying equipment. In Ghana, for example, the major companies engaged in processing fruits such as mango, pineapple and coconut are Bomarts Ltd., Blue Skies and HPW Fresh and Dry Ltd. These companies apply engineering in fruits washing, peeling and cutting, removing and sorting and packaging. They also have PLC dryers for drying processed fruits. In addition, the construction of a refrigerated fruit export terminal (Shed 9 at Tema Harbor) also provides cold storage for pineapple and other horticultural produce.

Research, Education and Training

Horticulture is knowledge dependent and its success depends on research and development. A regional center for research and development in horticulture in West Africa does not exist. However, individual member states conduct research and training at public and private facilities available to them. In Ghana, there are three public universities and five agriculture colleges for teaching and training in agriculture and horticulture-related fields. The public universities are the University of Ghana (UG), the University for Development Studies (UDS), and Kwame Nkrumah University of Science and Technology (KNUST). In Sierra Leone, there are three institutions namely; Sierra Leone Agricultural Research Institute (SLARI), Njala University (NU) and the University of Sierra Leone (USL) that are mainly involved in horticultural research. Research and training in horticulture in Togo are carried out by Agriculture Schools (ESA/UL) and by National Institute of Agronomic Research (ITRA). The research conducted in these institutions are crop-specific. Similarly, several research institutions in Mali including (i) Rural Polytechnic Institute for Training and Applied Research (IPR/IFRA): considered one of the best agricultural engineering schools in the region (ii) Institute of Rural Economy (IER): agricultural research policies; approval and certification of agricultural inputs; and importation, testing and distribution of the latest crop varieties (iii) The DNA (National Directorate of Agriculture) Agricultural Learning Centers (CAA), University of Bamako (FSEG), (iv) Sahel Institute Permanent Interstate Committee for Drought Control in the Sahel (CILSS) CILSS): leads a common regional regulatory framework for pesticides as well as the approval process for new pesticides and (v) International Crops Research Institute for the Semi-Arid Tropics (ICRIS) (CGIAR network) International research institute actively conducting crop research in Mali and leading a world-class geographic information system (GIS) unit in partnership with IER are among few research institutions that undertake horticulture-related training. However, these public and private research institutions are confronted with challenges such as (i) lack of/or inadequate funding, (ii) lack of conducive research environment and infrastructure including laboratory space, basic laboratory instruments and chemicals, research gardens/stations/growth chambers, green houses, internet facility, unreliable electricity supply, (iii) lack of information due to poor access to electronic databases, e-journals, e-books, and lack of mentorship.

Role of Research for Horticultural Development

Several challenges confront the production and consumption of fruits and vegetables in West Africa. These include (i) low knowledge of good agricultural practices among producers (ii) high pests and diseases occurrence (iii) climate change (iv) poor soil quality (v) limited access to inputs and poor quality inputs (vi) the perception of vegetables to be as non-commercial crops (vii) poor postharvest handling practices (viii) limited knowledge/awareness on the benefits of fruit and vegetable consumption (ix) limited household income (x) price and availability of fruits and vegetables and (xi) consumers preferences (education, cultural beliefs, norms, etc.).

Potential areas for intervention include both the demand and supply sides. On the supply side, there are diverse varieties of safe vegetables that require (i) improving on-farm productivity (improved vegetable varieties, safe and sustainable pest management, protected cultivation) and (ii) ensuring that vegetables are safe to eat, (iii) reduce post-harvest losses and (iv) improve market access. The demand side entails increasing vegetable consumption to improve nutrition. This requires (i) increasing awareness of a balanced diet and concept of nutritional security (ii) behavioral change and better communication on vegetable consumption (iii) home gardens, rural vegetable consumption, school meals, and (iv) modifying food systems for better nutrition.

Research Priority Areas include (i) fruit and vegetable breeding research to improve variety performance (ii) raising peoples' interest in healthy eating through school and home gardens (iii) addressing access to fruits and vegetables through school meal provision (iv) analysis of seed policies affecting the fruit and vegetable seed sector; capacity strengthening of stakeholders (v) strengthening of business networks.

Regional and National Policy Environment

There is no regional policy for the horticulture sector in West Africa. Issues regarding horticulture in the sub-region are mainly addressed through the ECOWAP/CAADP. West Africa has unprecedented opportunities for growth in horticulture export. The review revealed that national agriculture policies are the main policies guiding the production, processing and export of horticulture products (fruits and vegetables). Various countries also implement programmes and projects in collaboration with donors to enhance the production, processing and export of horticulture products.

Horticultural Funding and Financing

Financing of horticultural production is attractive because horticultural products have a higher yield per acre compared to other value chains. This implies that the output per acre for most horticulture products is significantly higher than cereals and grains. In addition, the price per yield for horticultural products is higher than in other value chains. Due to their high value, they can be cultivated throughout the year under irrigation and greenhouse technology. The risk associated with cultivating horticulture products is mitigated because of the use of modern technology and good agronomic practices. In order to access funds from a financial institution, agribusinesses have to go beyond identifying the market for their products and understanding the details of quality standards. Additionally, there must be a clear indication of the various activities to be undertaken as part of projects. Agribusiness firms requesting funding must determine how much is needed for activities planned for funds to be made available to them as and when it is needed. Transparency is necessary for acquiring funds for business activities. Funding sources for the sector include long-term funding from the Development Banks or equity investors, family, and friends.

Challenges Faced by Smallholder Horticulture Farmers

The horticulture sector has been identified as the key driver for sustainable growth in West Africa. In recent years, there has been high demand for horticulture produce from domestic, export markets (the EU), and other emerging markets. However, horticulture crop production continues to be dominated by smallholders and farmer groups with about 80-95% of them having farm sizes less than 2 ha. The smallholder farmers in the sector are confronted with several challenges including (i) marketing challenges such as limited market information, poor quality produce, inadequate knowledge of food safety standards (ii) inadequate credit facilities (iii) poor quality and high cost of inputs (iii) poor agronomic practices (iv) limited access to recommended fertilizer because of the high cost (v) inadequate extension services (vi) poor knowledge of harvesting and post-harvest handling practices (vii) high pest and diseases infestation leading to crop failures.

To improve the challenges confronting the smallholders, the following strategies must be implemented:

(i) Improve accessibility to farms through the construction of farm roads
(ii) Private investment in nurseries in communities to sell good quality seedlings to farmers.
(iii) Provide continuous training in the nursery, Integrated Pest Management (IPM), and postharvest management to reduce pre-and post-harvest losses.
(iv) Motivate farmers to use certified planting materials through the provision of subsidies on agricultural inputs
(v) Harmonization and production of extension materials to be used by all trainers
(vi) Build the capacity of extension staff to provide efficient and effective extension services
(vii) Ensure ready markets for produce through contract farming arrangements.

Research Priority Areas

Research and Development

- Conduct Food systems research across the West Africa sub-Region
- Comprehensive data collection and management on horticultural crops to enable forecasting and predictions of the sector
- Map and strengthen the horticultural value chains across the West Africa sub region
- Assess and develop the fruit and vegetable seed systems in various countries in West Africa
- Develop improved varieties adapted to local conditions and IPM systems against disease and pest problems
- Establish a West Africa Horticultural Research Center

Youth, Gender and Horticulture Development

- Empower youth and women in technology generation, transfer, adoption, and capacity building through participatory methods
- Emphasize research on youth and women's participation in horticultural export production
- Research should also focus on documenting women's constraints and opportunities in the horticulture sector.

Postharvest Technology and Food Safety

- Identify appropriate postharvest technologies to reduce losses in quantity and quality of produce
- Develop a postharvest system to meet market demand and food safety standards
- Develop detailed post-harvest handling and safety information for fruits and vegetables

Nutrition and Human Health

- Profile indigenous horticulture fruits and vegetables, develop agronomic and postharvest practices to improve yield and storage life and create awareness and increased consumer demand through product development.

INTRODUCTION

The location, climate, and suitable soil conditions of West Africa (WA) make it ideal to become Europe's next largest supplier of horticulture products at a time when the EU imports large quantities of fruits and vegetables to meet growing demand and broadening taste for new, high quality, and ready-to-eat foods. Fruit and vegetable export growth has the potential to significantly boost economic growth in the West African countries, generate employment and income in rural areas, and create opportunities for smallholder inclusion into the value chain. In addition, the sector provides all-year-round sources of income in rural and urban areas for women, thus improving their standard of living. Women play an essential role in many aspects of the horticulture value chain.

Horticultural crops (fruits and vegetables) have a tremendous potential to contribute to food and nutrition security in West Africa by enhancing the nutritional quality of diets through, the provision of key minerals (zinc, iodine & iron), vitamins (A and C) and fibre. Micronutrient malnutrition as a result of the inadequate intake of fruits and vegetables has been known to cause serious disorders, especially in women and children. These nutrients are essential for pregnant and lactating women to ensure proper development of the brain of the unborn and breastfeeding child. They are also required for growing children to ensure normal growth. It is estimated that about 2 billion people globally who are mostly concentrated in developing countries suffer from micronutrient deficiency, referred to as hidden hunger[1]. Hidden hunger not only causes the lowering of a person's IQ but as well stunting and blindness, with children and women being especially vulnerable.

In WA, changing demographics, rising incomes and shifting consumer preferences have resulted in an ever-growing demand for food that is more varied, healthier and of higher quality. According to the IMF, by 2022, WA's per capita gross domestic product will increase from $1,753 in 2017 to about $2,122 in 2022. The region has an estimated population of 420.9 million people, with an annual growth rate of 2.63% percent, and it is projected to increase to 516.6 million in 2030 (World Bank, 2021). The region has become more urbanized with the urbanization rate being 44 percent in 2021, compared to 35 percent in 2000 (World Bank, 2021). The growing number of middle-class consumers in WA that are increasingly more affluent and educated will continue to shift their dietary preferences to include more protein, fruits, and vegetables. Additionally, market liberalization and a trend toward export diversification have played an important role in stimulating the exports of high-value horticulture crops in WA. Horticultural crops especially fruits and vegetables play a major role in food and nutrition security.

1.1 Global Performance of Fruits and Vegetables

Globally, fruit and vegetable production has increased exponentially over the past three decades. However, global production has been dominated by Asia which produced nearly 58.14% and 78.21% of fruits and vegetables in 2020 (Table 1.1). Africa produced nearly 13.51% and 7.41% of the world's fruits and vegetable output in 2020. Other major leading world producers of vegetables were Europe (7.36%), Latin America (3.66%), Northern America (3.08%), and Oceania (0.28%) (Table 1.1). Additional leading producers of fruits include Europe (9.34%), Latin America (15.31%), North America (2.78%) and Oceania (0.89%). West Africa's share of world production is relatively low accounting for 3.21% and 2.31% of global fruits and vegetable output in 2020 (Table 1.1).

[1] WHO (World Health Organization) and FAO (Food and Agriculture Organization of the United Nations), (2006). Guidelines on Food Fortification with Micronutrients. Geneva.

Table 1.1: Fruits and Vegetable Production Across Regions (2020)

Vegetables Production (MT)			Fruits Production (MT)		
Regions	**Quantity (MT)**	**Share (%)**	**Regions**	**Quantity (MT)**	**Share (%)**
Asia	898,151,797.00	78.21	Asia	515,770,210.00	58.14
Europe	84,577,939.00	7.36	Europe	82,853,809.00	9.34
Africa (excl. WA)	58,620,859.00	5.10	**Africa** (excl. WA)	91,368,938.00	10.30
West Africa	26,528,444.00	**2.31**	**West Africa**	28,514,991.00	**3.21**
Latin America	42,035,925.00	3.66	Latin America	135,864,415.00	15.31
North America	35,365,836.00	3.08	North America	24,673,541.00	2.78
Oceania	3,165,452.00	0.28	Oceania	7,981,472.00	0.89
TOTAL	1,148,446,252.00	100.00		**887,027,376.00**	100.00

Source: FAO, 2022

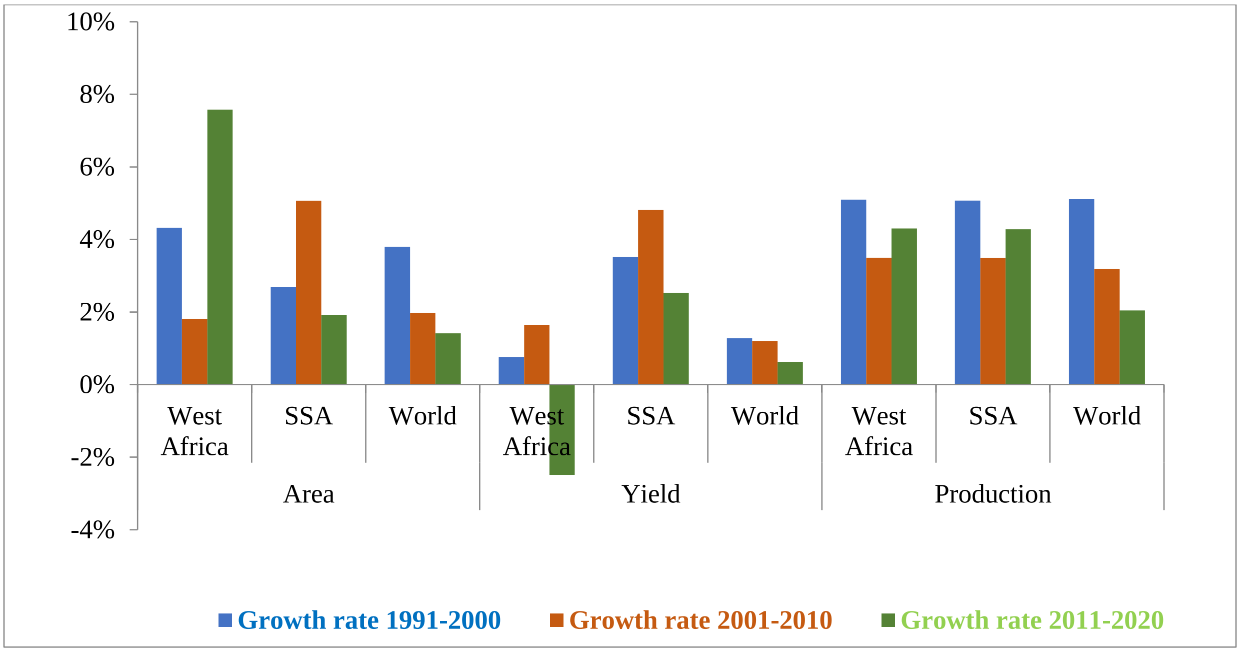


Figure 1.1: Fruit Production Across Regions
Source: FAO, 2022

Over the past three decades, the output of fruits and vegetables more than doubled. For instance, the global output of fruits increased from 420 million tons in 1990 to nearly 887 million tons in 2020. Similarly, vegetable output increased from 418 million tons in 1990 to 686.6 million tons in 2000. Production increased from 974.8 million tons in 2010 to over 1 million tons in 2020. The observed increase in global output is mainly driven by production from Asia. Production of fruits and vegetables remain relatively stable in other regions such as Africa, Europe, Latin America, North America and Oceania. The growth of fruits and vegetable production in West Africa declined over the past three decades. Estimated growth rates for fruits and vegetable were 5.11% between 1990-2000, 3.18% (2001-2010) and 2.04% (2011-2020) (Figure 1.1). Growth in production in WA is mainly driven by the expansion of land under cultivation (Figure 1.2).

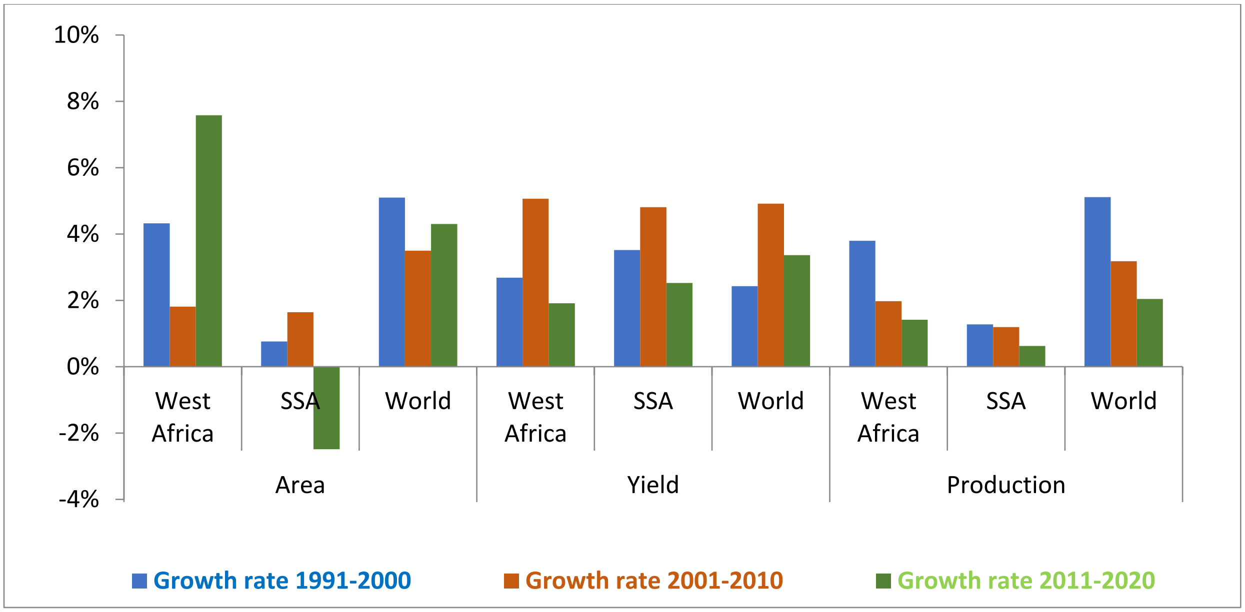


Figure 1.2: Vegetable Production Across Regions
Source: FAO, 2022

1.2 Regional Performance of Fruits and Vegetables

Pineapples are native to Central and South America, but they are grown in Asia, North America, and Africa. In West Africa, Nigeria, Ghana, and Benin are the top three producers of pineapples. Nigeria accounted for around 44% of the total production in 2020. However, yields of pineapples are very high in Ghana (63.1 Mt/ha) compared to Benin (59.8 Mt/ha), and Nigeria (8.2 Mt/ha). West Africa accounts for 2.3% of global banana production. According to FAO data (2020), about 13 countries in West Africa produce bananas. After Cameroon, Cote d'Ivoire, and Guinea, Ghana is the fifth largest banana producer. Banana yields in Cote d'Ivoire (44.7 Mt/ha) are higher than in Cameroon (12.3 Mt/ha), Ghana (11.2 Mt/ha) and Guinea (11.2 Mt/ha).

Nigeria and Mali are the top producers of mango in WA. Mango yields are particularly high in Nigeria (89.4 Mt/ha), and Mali (79.3 Mt/ha). Ghana ranked seventh in West Africa in mango production in 2020, with an average yield of 9.9Mt/ha. Pawpaw (papaya) is a popular fruit cultivated for local use and export in many West African countries. Nigeria produced nearly 81.5% of the region's output in 2020. Ghana was placed fifth in 2020, with a total production of 5,661 Mt. Ghana is the leading orange producer in West Africa, producing 52.1% of the region's oranges in 2020. In comparison to Mali (13.4 Mt/ha), Cote D'Ivoire (12.6 Mt/ha), and Senegal (38.8 Mt/ha), Ghana also has the highest yield (38.8 Mt/ha).

In West Africa, chilies, onions, and tomatoes are among the most widely grown and consumed vegetable crops. Nigeria, Niger, Ghana, Cote D'Ivoire, and Sierra Leone are the leading chili producers in the subregion, with Nigeria accounting for 45.6% of total production in 2020. Niger, on the other hand, has the highest yield (14.0 Mt/ha), followed by Sierra Leone (12.8 Mt/ha), Ghana (7.9 Mt/ha), Cote D'Ivoire (6.0 Mt/ha), and Nigeria (4.6 Mt/ha). Nigeria produces nearly half of the region's tomatoes (49.6%), but has the lowest yield (4.4 Mt/ha), compared to Niger (27.0 Mt/ha), Cameroon (12.3 Mt/ha), and Ghana (7.8 Mt/ha). In 2020, Ghana ranked fourth in West Africa for tomato production, with about 144,328 tonnes produced. Similarly, Nigeria leads the other countries in onion production but has the lowest yield (2.1Mt/ha), compared to Niger (35.0 Mt/ha), Senegal (30.7 Mt/ha), Cameroon (12.3Mt/ha), and Ghana (35.0 Mt/ha).

1.3 Growing demand for fruits and vegetables in West Africa

Demand for fruits and vegetable have grown steadily over the last decade in West Africa. Table 1.2 shows the per capita consumption of fruits and vegetables between 2010 to 2019. During the period per capita consumption of fruits increased for the five countries-Benin, Cameroon, Ghana, Mali and Senegal. Fruit consumption in Ghana is the highest in West Africa with consumption levels of about 189 kg/year. Similarly, vegetable consumption increased in most countries in West Africa. However, consumption increased significantly for Benin, Niger, Senegal and Mali (Table 1.2). Consumption of vegetables increased in Ghana by about 0.5% per annum.

Table 1.2: Per Capita Consumption of Fruits and Vegetables in West Africa (2010-2019)

Country	Fruits		Vegetables	
	(kg/year)	CAGR	(kg/year)	CAGR
Benin	48	2.0%	49	6.5%
Burkina Faso	5	-0.6%	16	0.04%
Cote d'Ivoire	69	-0.01%	34	0.6%
Ghana	189	1.1%	30	0.5%
Guinea	97	-1.4%	52	-1.6%
Liberia	43	-1.5%	28	0.8%
Mali	70	1.0%	97	4.1%
Niger	26	-0.8%	86	11.8%
Nigeria	59	-1.4%	72	1.0%
Senegal	18	2.3%	78	9.9%
Sierra Leone	34	-0.1%	49	1.1%
Togo	8	-0.8%	21	-0.8%
Gambia	5	0.0%	33	4.3%

Source: FAO, 2021; CAGR – Compound Annual Growth Rate

However, high demand for food safety and quality from consumers and traders imposes standards on smallholder producers, processors and exporters of horticultural products to deliver competitive products. The emergence of more rigorous international food and safety standards over the past decades presents challenges and opportunities for horticulture exporters in WA. European markets differentiate themselves from their competitors by offering fresh fruits and vegetables and cannot afford to offer inferior products that do not meet food safety standards. These standards are not based on superficial preferences of retail shops but have become formalized as legal and commercial necessities of brands and food standard management. EurepGAP is a private sector body that sets the voluntary standard for the certification of agricultural products. In addition, governments of Europe, North America, and other importing regions set maximum residue levels (MRLs) for pesticides and other potentially harmful chemicals. These requirements are applied to imported food products and those grown domestically.

West African countries have signed the African Continental Free Trade Area (AfCFTA), as a major strategy for regional integration and trade facilitation. This presents opportunities for the export-oriented horticulture sector and also requires an urgent need to improve the competitiveness of smallholder farmers. Access to finance, suitable land, markets and market information, technical assistance, input providers, research services, production technologies and sustainable farming systems is needed to operate effectively and contribute to the competitiveness of smallholder farmers in the horticulture sector. In addition, improving opportunities for smallholder farmers to export horticultural crops and improving the value chain can benefit domestic markets and regional markets.

The current review is to provide a general overview of the horticulture sector and also identify challenges and opportunities (biophysical, natural resource, socio-economic. engineering and technology, policy, training and technical capability) that affect the horticultural value chain in Ghana; recognizing their effects on productivity, product quality, profitability; and identifying what is required to achieve sustainable growth of the horticultural sector. Successful investments in programs aimed to enhance horticultural production in Ghana should be guided by the strategic assessment of the main constraints faced by small-scale farmers.

Thus, the ultimate goal of the West Africa horticulture review is to identify challenges and opportunities in areas for research and capacity development in the sector. This report focuses on the opportunities and challenges of the horticulture sector (fruits and vegetables) in West Africa and the capacity of local and regional institutions to conduct horticultural research and training to address the challenges.

1.4 About West Africa

West Africa is approximately 5 million square miles and located in the westernmost region of the African continent. It has an estimated population of about 420.9 million people in 2022, and this is projected to increase to about 490 million by 2030 and 736 million people by 2050 (UNDESA, 2011). Though the region has an abundance of natural resources such as gold, diamond, land, and untapped water resources, it is still confronted with several social challenges. The World Bank posits that the total number of people living in extreme poverty (those living on less than US$1.90/day) at the end of 2019 was 138 million. This number is expected to increase by approximately 18 percent (or 25 million persons). This pushed the sub-regional poverty headcount to 41.1 percent, up from 34.8 percent in 2019, with varying country statistics. Additionally, the number of people at risk of hunger in West Africa is estimated to rise from 30.1 million in 2010 to 32.5 million in 2030 and 33.5 million in 2050 (IFPRI, 2017).

West Africa's population is rapidly urbanizing. between 1980 and 2010, urban populations grew 4.5% annually, against 1.8% in rural areas. This trend is expected to continue between 2011 and 2050, with urban population growth projected at 3.7% per annum compared to only 0.5% in rural areas (UNDESA, 2011). Already by 2020, half of the projected 388 million people residing in West Africa will live in urban areas, and urbanization it is expected to reach 65% by 2050 (UNFPA, 2010).

Development of the agriculture sector offers significant growth potential for the region. Agriculture remains a central part of the West African economy, providing 30–50% of GDP in most countries, the major source of income and livelihoods for 70–80% of the population, food supplies and revenue from the export of cash crops. In addition, investment in the sector is necessary for economic growth and the attainment of sustainable development goals (1, and 2). The production of horticulture crops especially fruits and vegetables offer promising opportunities for income and food production in WA. These crops are important because of their economic and nutritive value and can be an avenue for diversification for small-scale farmers who can produce for local, regional and global markets.

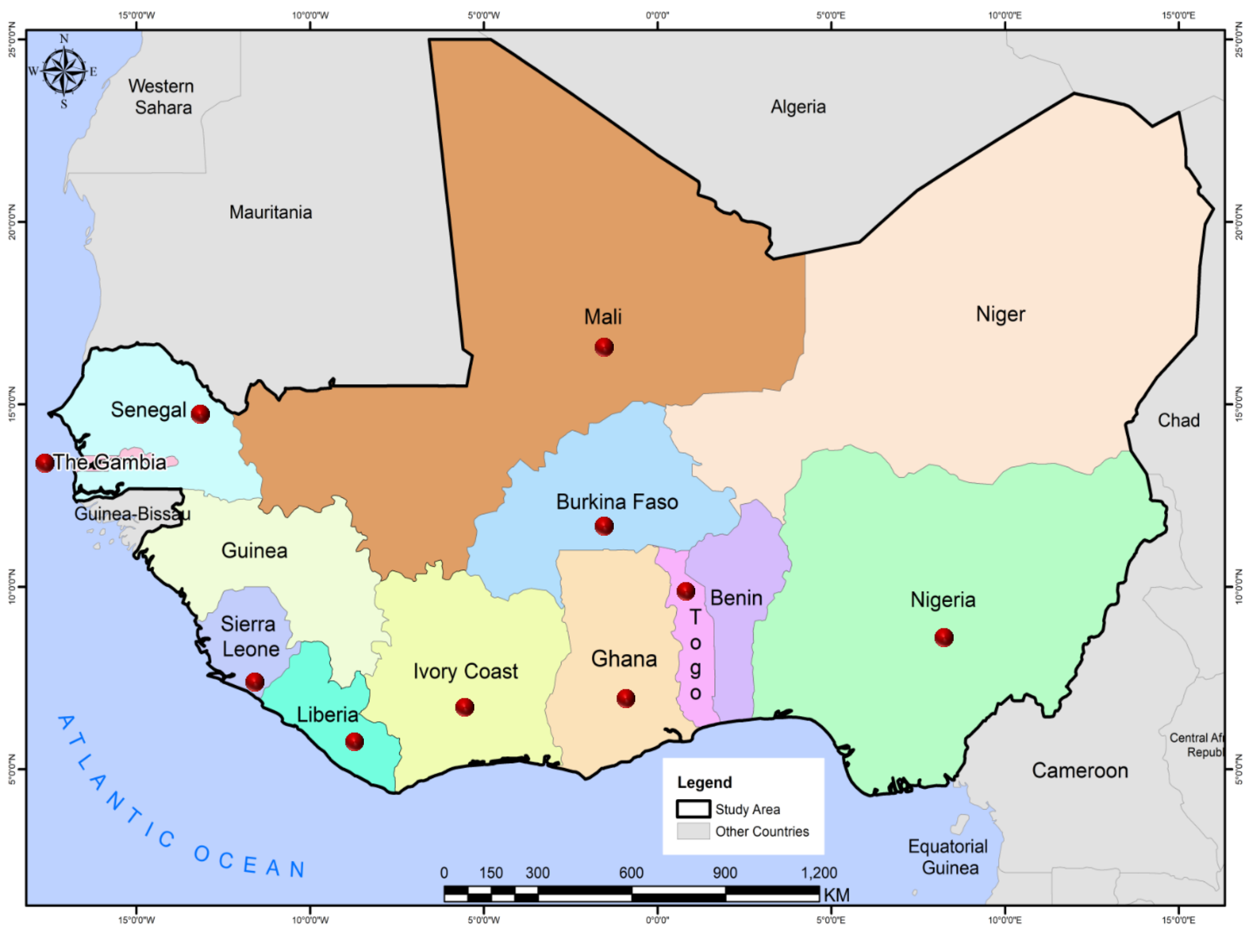


Figure 1.3: Study Area Map of West Africa Showing Participating Countries
Source: Authors Depiction

Increased production and consumption of fruits and vegetables are essential for achieving food and nutrition security in WA. Fruits and vegetables, due to their rich micronutrient content, play a key role in food and nutrition security. Recent statistics have shown that the prevalence of undernourishment has increased significantly over the past decades in WA (WHO, 2020). For instance, between 2005 and 2020, the prevalence of undernourishment increased from 14.2% to 18.7% while the number of people undernourished also increased from 38 million in 2005 to 75.2 million in 2020. Similarly, the level of food insecurity in WA has also increased exponentially within the same period. Severe food insecure levels increased from 8.6% in 2014 to 28.8% in 2020.

1.4 Methodology

West Africa Horticulture Sector Assessment is focused on priorities determined by stakeholders in the sector. Specific developments in the sector, capacity building and recommendations will be proposed. The assessment process included desk reviews, stakeholders' surveys, focus group discussions, and key informant interviews.

Desk Research: Desk research included extensive searches on websites of institutions for reports and documents of relevance. Organisations such as the Ministry of Food and Agriculture (MOFA), the Ghana Export Promotion Authority (GEPA), Ghana Statistical Services (GSS), the Ministry of Trade and Industry and the Peasant Farmers' Association were interviewed for relevant information and data. Published articles and reports on the horticulture sector were consulted. Other institutions in other West African countries were also consulted for relevant information.

Key Informant Interviews: One important qualitative method used in preparing this report involved key informant interviews with identifiable persons with relevant information on the subject. The interviews sought to gather information on challenges and opportunities for the horticulture sector. In the case of the research institutions and the universities, data was gathered on the research infrastructures, education and training needs of the horticulture sector.

Expert Group Discussion: West Africa Stakeholders input from ten (10) countries were considered in this review. These key stakeholders include industry leaders, experts in horticulture production, crop handling between harvest and markets, gender equity, youth empowerment, nutrition, agri-policy, input suppliers, irrigation experts, value chain experts, climate experts and farmer associations.

The review of the horticulture sector is done within eight thematic areas namely: Biophysical, natural resources, socio-economics, markets and consumption, trade and standards, engineering and technology, research, education and training and policy environment for horticulture.

Subsequent to this review, a regional conference was organized between 31st May to 1 June 2022. The workshop was designed to elicit equitable and active participation of all major stakeholders in the horticulture sector in West Africa. The participating countries were Benin, Burkina Faso, Cote d'Ivoire, Ghana, Guinea, Mali, Nigeria, Senegal, Sierra Leone, Togo and Gambia. In addition to in-country coordinators from these participating countries, other stakeholders in all the countries were invited to join the conference online.

The horticulture innovation lab will focus its efforts in four regions with a country region serving as a hub. This includes West Africa (Ghana), Eastern Africa (Kenya), Asia (Nepal) and Central America (Honduras). It aims to implement a locally-led, globally supported programme that will lead to improvement in the horticulture sector.

REGIONAL REPORTS

GHANA

2.1 Context

In the last two decades, Ghana has achieved robust economic growth averaging 7.0 percent annually. However, this growth was not accompanied by a reduction in poverty, the creation of jobs, and socio-economic transformation. This situation is further worsened by the Covid-19 pandemic, causing a decline in economic growth. As a result, in 2020, gross domestic product (GDP) grew by 0.4%, a substantial decrease from the rate of 6.5% in 2019. Industry (3.6%) and services sector (1.5%) both grew at lower rates in 2020 than in 2019; however, the growth in the agriculture sector was substantially faster. The agriculture sector grew by 7.4% in 2020 which was mainly driven by the crop subsector (8.7%) (Ghana Statistical Service, GSS, 2021).

The horticulture sector offers great opportunities for economic growth due to strong export market potential and growing domestic demand. High-value horticulture crops are more profitable than the alternatives such as grains. For instance, fruits and vegetable producers in India earned eight times more profit than cereal farmers (Subramanian, Varadarajan, & Asokan, 2000). In Ghana, the gross margins of vegetable producers are significantly higher than maize and rice farmers (Van Asselt, DI Battista, Kolavalli, Udry, & Baker, 2018). They also noted that horticultural crops such as pineapple, tomatoes, onion, carrot, and Scotch Bonnet generate more income for farmers than cereals, providing good opportunities for poverty reduction. This implies that the export-based horticulture sector has the potential to increase farmer income and create jobs. However, it required improved technology, infrastructure, pre- and postharvest management, finance and technical knowledge.

According to data compiled by FAO Stats in 2020, banana, citrus, mango and coconut production have been growing progressively since 2010 (Figure 2.1).

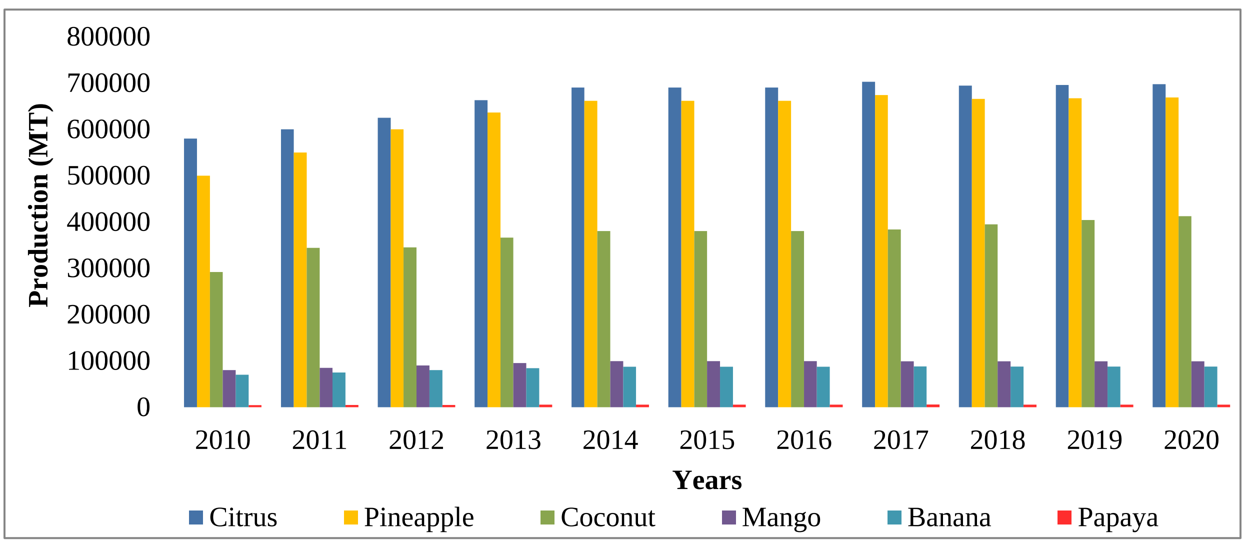


Figure 2.1: Production of Major Fruits in Ghana (Mt), (2010-2020)
Source: FAO, 2020

Pineapple production decreased drastically after the shift from the production of smooth cayenne to MD2. However, between 2010 to 2020, production increased from 500,000 Mt to 668,945 Mt (FAO, 2020). Production seems to be steady for the last five years with only a marginal increase within the period. Citrus production has also witnessed a significant increase. Production increased from 580,000 Mt in 2010 to

697,637 Mt in 2020 (FAO, 2020). Similar trends were also observed for coconut, mango and banana. Papaya production was on a smaller scale compared to other fruits.

Production of vegetables is not widespread in Ghana. In 2020, tomato production was approximately 368,920 Mt, green chilies and peppers were 119,405 Mt, and onions were 144,328 Mt (Figure 2.2). In addition, together, these vegetables were planted on less than 1.5 percent of the estimated 4.7 million hectares of cultivated land (MoFA, 2020)

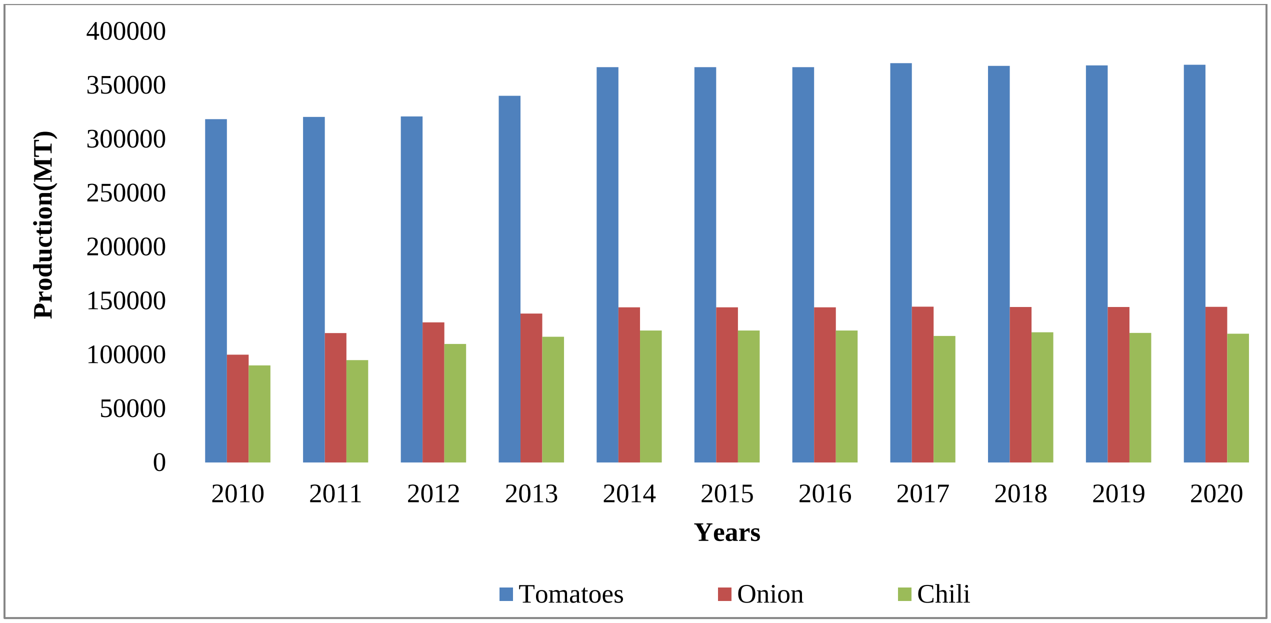


Figure 2.2: Production of Major Vegetables in Ghana (Mt), (2010-2020)

Source: FAO, 2020

In Ghana, fruit production is highly commercialized. More than 60% of farm produce is sold for both domestic and international consumption (Agyei-Sasu, Egyir, Osei-Asare, & Anaman, 2013; Asuming-Brempong, Anarfi, Arthur, & Asante, 2013), partly from pineapple, banana, and passion fruit, which are exported in greater quantities; about 35% of mango, citrus, and coconut are sold to buyers at the farm gate.

Data from FAO (2020) shows that the export of vegetables remained relatively stable over the past decade. Vegetable export values were 3,919Mt in 2010, however, decreased to 2,391Mt in 2012. Between 2015 to 2020, export remained relatively stable, accounting for 14,329Mt in 2020 (Figure 2.3).

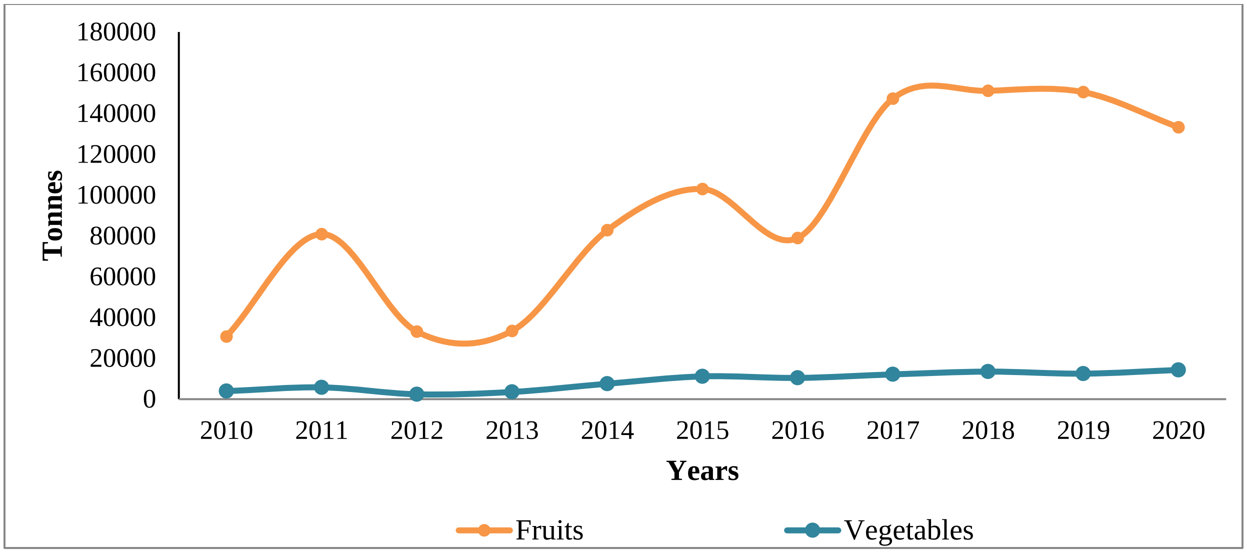


Figure 2.3: Export Volume of Fruits and Vegetables in Ghana (Mt)

Source: FAO, 2021

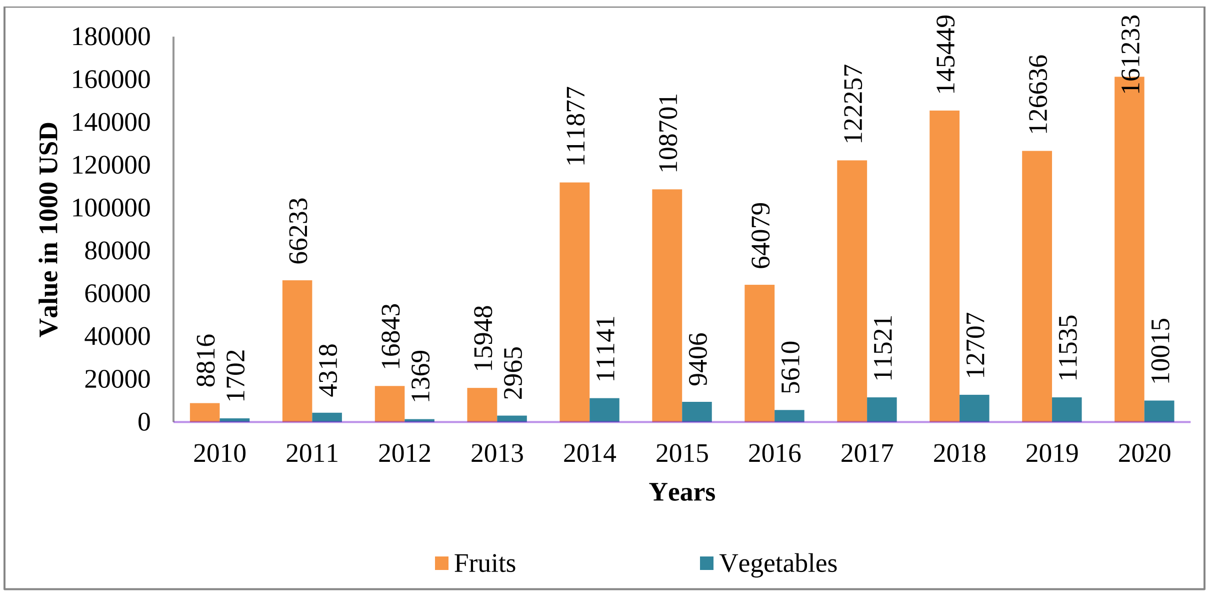


Figure 2.4: Export Value of Fruits and Vegetables in Ghana (in 1000 USD)

Source: FAO, 2021

Export of fruits fluctuates over the period. The average export volume of fruits in Ghana was 100,000 Mt for the period 2010-2020, with a yearly growth rate of about 4.14% (Figure 2.3). In 2010, the value of fruits was 31,000 Mt which increased to 80,911Mt in 2011 before declining to 33,427 Mt in 2013 (Figure 2.3). Export quantities increased to 82,812Mt in 2014 before reaching about 133, 263 Mt in 2020 (Figure 2.3).

2.2 Geography and Markets

Ghana is located between latitudes (4° 44'N and 11° 11'N) and longitudes (3° 11' W and 1 ° 11'E) respectively. The closeness of Ghana to the EU is a major opportunity for horticulture exporters. Currently, most fruits and vegetable products are exported into these regions.

The agroecology of Ghana is conducive to the cultivation of horticultural crops. However, due to differences in rainfall patterns, Ghana's fruit and vegetable production systems vary by agroecological zones. Aside from mango, commercial fruit production is concentrated in eleven regions spanning the middle belt to the south. Tomatoes, onions, green chilies, and pepper are highly produced in production in Upper East, Northern, Brong Ahafo, Ashanti, Eastern, and Volta regions (Robinson & Kolavalli, 2010; Saavedra et al., 2014). Holding irrigation constant, farmers in the forest savannah transition and coastal savannah zones have two production seasons because they enjoy bi-modal rainfall patterns (Table 2.1).

Table 2.1: Rainfall Distribution by Agro-Ecological Zones in Ghana

Agro-Ecological Zone	Mean Annual Rain (mm)	(Rainfall mode) Rainy Seasons	Growing Period (Days)		Dominant Horticultural Crops
			Major Season	Minor Season	
Rain Forest	2,200	**(Bimodal)** March-July Sept-October	150-160	100	Onions and shallots
Semi Deciduous Rain Forest	1,500	**(Bimodal)** March-July Sept-October	150-160	90	Onions and shallots
Transitional	1,300	**(Bimodal)** March-July Sept-October	200-220	60	cashew and vegetables
Coastal Savanna	800	**(Bimodal)** March-July Sept-October	100 - 110	50	Pineapple, mango, tomato, pepper, water melon
Northern Savana **Guinea Savanna** **Sudan Savanna**	 1,100 1,000	**(Monomodal) May-November**	 180 – 200 150 - 160	 * *	Shea, Mango, Tomato, Pepper, Dawadawa

Source: MOFA, 2021

Rainfall distribution is bimodal in the forest, transitional and coastal zones, giving major and minor growing seasons. Elsewhere (Guinea Savanna and Sudan Savanna), the unimodal distribution gives a single growing season. The Coastal Savanna belt covers the Coast - Winneba Plains, the Accra Plains and the Ho-Keta Plains. The Coastal Savanna is characterized by grassland, shrub and thicket. The major crops grown are cereal, fruit and vegetable crops. The Forest Agro-ecology is further to the north of the Coastal Savanna. It is made up of evergreen rainforest and deciduous forest. The major horticultural crops grown are citrus, coconut, fruit and vegetable crops.

The Transitional Zone is a mixture of forest and grassland and is located to the north of the Forest Zone. The major crops grown are cashew and vegetables. The Guinea Savanna Zone is to the north of the

Transition Zone. It is made up mainly of grassland with few trees. Major crops grown are vegetables and shea. Sudan Savanna is further to the north of the Guinea Savanna zone and has less vegetation. The main crops grown are vegetables and shea.

Table 2.2: Major Fruits and Vegetable Production areas in Ghana

CROPS	REGION
FRUITS	
Pineapple	Ashanti, Western North, Central, Eastern, Greater Accra, Volta
Citrus	Ashanti, Central, Eastern, Bono, Oti, Volta, Western, Western North
Mango	Ashanti, Bono East, Central, Eastern, Northern, Savannah, Upper East, Upper West, Volta, Western, Western North
Pawpaw	Ashanti, Central, Eastern, Oti, Savannah, Upper East, Volta, Western North
VEGETABLES	
Tomato	Ashanti, Eastern, Greater Accra, Volta, Bono East, Bono, Ahafo Kasena Nankana, Ahafo Tano South, Techiman North, Wenchi, Techiman, Dormaa Central Berekum West, Offinso North, Asante Akim North Ada East, Ada West, Ga South, Anloga, Agortime, Akatsi North
Onion	Ashanti, Eastern, Greater Accra, Volta, Bono East, Bono, Ahafo, Western, Northern, Upper West
Pepper	Ashanti, Eastern, Greater Accra, Volta, Bono East, Bono, Ahafo, Upper West, Northern, Western

Source: MOFA, 2022

2.3 Notable Production System and Practices

Horticultural production systems in Ghana are dominated by crops such as pineapple, pawpaw and exotic vegetables, which are mainly grown for export. About 90% of farm holdings are less than two hectares in size. Vegetable production in Ghana is produced on smaller plots of land of less than one hectare (Van Asselt et al., 2018). The average farm size for tomatoes, onion, and Scotch Bonnet is 0.66 ha, 0.42 ha, and 0.36 ha, respectively. However, there are some large farms and plantations, particularly for bananas, coconuts and to a lesser extent, pineapples. The main system of farming is traditional where hoe and cutlass are the main farming tools.
There are two systems for fruits and vegetables based on sources of water for production:

Rain-Fed Cultivation: In Ghana, many small-scale farmers rely on rainfall to produce their vegetables. A bi-modal rainfall pattern in the south allows for a long farming season from May to November (van Asselt et al., 2018). In Ashanti and some parts of Bono regions, selected vegetables such as tomatoes and onions are produced mainly under rainfed conditions. Most fruits such as pineapple, papaw, mango, citrus and coconut are mainly cultivated under a rain-fed system.

Irrigated Cultivation: Irrigated vegetable production is done in the North, Upper East and Volta whereas southern production is mainly rainfed. Farmers irrigate their plots using gravity-fed systems, whereas farmers in Upper East use irrigation pumps (Van Asselt et al., 2018). Tomato, onion and Scotch bonnet farmers in the Upper East have access to irrigation schemes. Other farmers also irrigate their vegetable plots using moto pumps.

Seed Sources and Varieties: Farmers obtain their seeds and planting materials through either informal or formal seed systems. In informal systems, farmers save seeds and planting materials from their crops, collect seeds from neighbour's seed stands or high performing trees, and purchase seed and planting materials from non-regulated local seed producers and traders. Under the formal seed system, farmers obtain their seeds and planting materials, whose traits and quality have been certified through a rigorous regulatory process. In Ghana, fruit and vegetable farmers use recycled seed or purchase seed from the local market for production (Van Asselt et al., 2018). About 42 percent and 64 percent of Scotch Bonnet seed and onion seed are purchased from the local market. However, 82 percent of carrot seed is purchased from private input dealers. Robinson and Kolavalli (2010), noted that about 20 percent of fruits and vegetable farmers in Ghana used recycled seeds.

Chemical Control: Chemical application remains the most common means to control pests and diseases on fruits and vegetable farms in Ghana. The main chemical inputs for fruit and vegetable production in Ghana are fertilizer and pesticides, including insecticides, herbicides, and weedicides. Famers use pesticides to control weeds and protect their plants against pests and diseases. Research shows that more than seventy percent of vegetable farmers use insecticides for pest control and nearly all vegetable farmers used chemical fertilizer in vegetable production. The use of pesticides is excessive, especially in urban and peri-urban vegetable farming, posing health and environmental hazards (Nchanji et al., 2017).

Greenhouse Technology in Vegetable Production

Greenhouse cultivation is the production of high-value crops in controlled environments using the advantages of technology, water conservation and environmental protection techniques while increasing yields and productivity with substantial income to investors. The Government of Ghana, in a bid to open up more opportunities for increased production and export of vegetables introduced greenhouse technology in vegetable production in 2017. The crops produced under this technology include tomato, cherry tomato, cucumber, sweet pepper, and hot pepper (Habanero). Three greenhouse centres were built in Akumadan (14,440 m^2) in the Ashanti Region, Bawjiase (14,440 m^2) in the Central Region, and Dawhenya (38,260 m^2) in the Greater Accra Region. The centre trained 537 youths in greenhouse vegetable production.

2.4 Biophysical

Inputs Supply

Fertilizer, pesticide, seed, labour, land, and water for irrigation are the key inputs for fruit and vegetable production in Ghana. Although no specific data on the volume of imported fertilizers used for horticulture crops are available, several surveys reveal that most fruit and vegetable farmers in Ghana use inorganic fertilizers and plant protection inputs such as pesticides to control pests and diseases, as well as increase crop yields. Ghana currently does not produce inorganic fertilizers and pesticides because there are no pesticide manufacturing and formulation plants in the country (Onwona Kwakye, Mengistie, Ofosu-Anim, Nuer, & Van den Brink, 2019). What is available locally is imported from across the globe.

Availability of Fertilizer

According to FAO data, imports of certain types of inorganic fertilizers for agriculture have been rising in Ghana in recent years. Recent flagship programs of the government such as the Fertilizer Subsidy Program (2008-2018) and Planting for Food and Jobs (2017-Date) are among the primary drivers of rising fertilizer imports. Under these programs, the Government of Ghana (GoG) provided a 50% subsidy on fertilizer prices, which are regulated seasonally with the agreement of importers.

Between 2016 and 2017, the total volume of inorganic fertilizer imports grew from 440,826 MT to 499,566 MT (Table 2.3). Except for phosphates, the number of imports of NPK, urea, muriate of potash, ammonia sulphate, nitrates, and potassium sulphate grew dramatically between 2016 and 2020. The import of liquid fertilizers more than doubled, rising from 651,211 MT in 2016 to about 1.4 million MT in 2020 (Table 2.3). Fertilizers are imported into Ghana from some parts of Africa, Asia, and Europe. In 2018, the top ten sources of fertilizer imports into Ghana in 2018 were Morocco, Finland, Estonia, China, Italy, Latvia, Libya, Belgium, Turkey, and Germany (AfricanFertilizer.org, 2018). Despite increased imports, Ghana's fertilizer application rates (8kg/ha) are lower than those of Malawi (22kg/ha) and Kenya (32kg/ha) (Fuentes, Bumb, & Johnson, 2012).

Table 2.3: Fertilizer Imports (2016-2020)

Fertilizer Type	Unit	2016	2017	2018	2019	2020
NPK	Mt	258,290	153,767	224,176	217,024	299,423
NPK (LIQUID)	Lt	127,565	14,351	-	99,334	734,325
Urea	Mt	16,353	78,591	42,005	77,011	90,025
Muriate of Potash	Mt	14,268	26,018	15,993	42,235	55,621
Sulphate of Ammonia	Mt	14,417	36,833	10,084	17,326	44,084
Phosphates	Mt	109,961	23,280	703	4,189	9,668
Nitrates	Mt	3,450	2,203	90,019	3,831	80,796
Potassium Sulphate	Mt	3,627	N. A	74	-	44,084
***Others: Solid**	Mt	20,459	178,875	-	63,494	119,326
Liquid	Lt	523,646	2,839,351	-	1,570,654	665,431
Total	Solid (Mt)	440,826	499,566	383,054	425,110	119,326
	Liquid (Lt)	651,211	2,853,702	-	1,669,988	1,399,756

Source: MOFA, 2021

The PFJ increased Ghana's fertilizer application rates to 20 kg/ha in 2019, but adoption remains low, particularly for millet, sorghum, yams, and cassava. But, according to FAO (2005), as cited in IFDC (2012), fertilizer application rates are highest for vegetables than those of maize and other cereals. The importation, distribution, and retailing of fertilizer goods are dominated by private enterprises. Chemico, Yara, AMG, Afcott, Omnifert, Macrofert, Macrofertil, Agricult Ghana, RMG, ETC Agro, and Jubaili Agrotech are also some of Ghana's major private fertilizer importers (MOFA, 2022). In 2020, Chemico, Yara, AMG, and Afcott alone accounted for 66% of total fertilizer imports in Ghana (MOFA, 2020). Fertilizer is purchased locally by farmers from these firms through their retail outlets which are located in all districts in Ghana.

Availability of Pesticides

The Environmental Protection Agency (EPA) and the Pesticides and Fertilizer Regulatory Division of the Ministry of Food and Agriculture (MoFA) are responsible for the registration and issuance of pesticide use permits. The volume of pesticide imports decreased from 43,396 MT in 2016 to 37,611 MT in 2020 (Table 2.4). Pesticides are brought into Ghana from China, India, the United States, Germany, France, Belgium, Israel, Singapore, Switzerland, and Cyprus (Fuentes et al., 2012).

Table 2.4: Pesticide Imports (MT) (2016-2020)

Types of Pesticides	2016	2017	2018	2019	2020
Insecticide	5,742	1,620	1,295	1,247	6,351
Fungicide	4,707	4,482	1,770	4,069	1,105
Herbicide	32,947	19,113	6,975	8,063	30,154
Total	43,396	25,215	10,040	13,379	37,611

Source: MOFA, 2021

However, China alone accounts for more than half of Ghana's pesticide imports (Onwona Kwakye et al., 2019). In Ghana, private players are also heavily involved in the importation, distribution, and retailing of pesticides (Onwona Kwakye et al., 2019). Pesticides are widely used in fruit and vegetable production. According to Dinham (2003), 87% of Ghanaian vegetable producers use chemical pesticides to control pests and diseases. Most vegetable farmers are unduly reliant on pesticides due to perceived economic effects, but they are unaware of which pesticides to use and how to apply them, putting the health of their customers in danger (Onwona Kwakye et al., 2019). There is also limited government capacity for pesticide registration, testing, and regulation enforcement to guarantee that registered pesticides are used responsibly throughout the country (Saavedra et al., 2014).

2.5 Production and Productivity of Fruits and Vegetables

Fruit and vegetable production is a thriving agricultural activity in Ghana, providing social and economic support to both urban and rural households. Tomatoes, onions, and chilies are the most common vegetables grown in Ghana (Saavedra et al., 2014). Pineapples, oranges, mangoes, pawpaw, and banana are also popular fruits produced in Ghana (IFDC, 2012). There is a difference in crop mix and area cultivated across the major agroecological zones. Tomatoes, chilies, and mangoes are grown in all agroecological zones. Onions and shallots are mostly grown in the forest transition savannah zone (FTSZ) and guinea savannah zone (GSZ). Pineapple is mainly grown in the coastal savannah zone (CSZ), the Central, Eastern, Greater Accra, and Volta regions, where the climate is favourable for fruit production.

The total area of fruits such as pineapples, mangoes, pawpaw, bananas, and oranges in 2019 and 2020 is 45,422 hectares and 45,498 hectares, respectively (FAOSTAT, 2020). Also, the total area under vegetable production such as chilies, onions and shallots, and tomatoes were 84,199 hectares and 84,207 in 2019 and 2020, respectively. According to Table 2.5, oranges have the largest land area and production in 2019 and 2020, followed by pineapples, tomatoes, chilies, onions and shallots. Mangoes, bananas, and pawpaw rank sixth, seventh, and eighth positions in both land area and production. Among the fruits, pineapples and oranges have the highest yields of 63.1 tonnes/ha and 38.8 tonnes/ha in 2020, respectively (Table 2.5). The yield of onions is higher (17.4 tonnes/ha) than tomatoes (7.8 tonnes/ha) and chilies (7.9 tonnes/ha).

Table 2.5: Total Production, and Yield of Horticultural Crops in Ghana (2019-2020)

	2019				2020			
Products	**Total Production (Mt)**	**Position**	**Land Size (ha)**	**Yield (Mt/ha)**	**Total Production (Mt)**	**Position**	**Land Size (ha)**	**Yield (Mt/ha)**
Fruits								
Pineapple	667,084	2nd	10,571	63.1	668,946	2nd	10,595	63.1
Mango	99,271	6th	7,586	13. 1	99,242	6th	7,590	13.1
Pawpaw	5,636	8th	1,612	3.5	5,661	8th	1,622	3.5
Banana	87,751	7th	7,813	11.2	87,832	7th	7,808	11.2
Orange	695,761	1st	17,840	39.0	697,637	1st	17,983	38.8
Vegetables								
Onions	144,242	5th	8,325	17.3	144,328	5th	8,294	17.4
Pepper	228,051	4th	28,874	7.9	227,636	4th	28,913	7.9
Tomatoes	368,383	3rd	47,000	7.8	368,920	3rd	47,000	7.8

Sources: FAO, 2021

Pineapple production grew by 10% in 2011, but growth has since remained stagnated in 2015 and 2016 (Figure 2.5). Production, however, stagnated in 2015 and 2016. After increasing marginally in 2017 by 1.9%, production declined by -1.2% in 2018. Orange production also grew from 3.4% in 2011 to 6.1% in 2013 but stagnated in 2015 and 2016, as did mangoes, pawpaw, and bananas. Oranges, pawpaw, and bananas experienced negative growth in 2018, except for mangoes. Generally, the production of the selected fruits declined much faster from 2013 to 2016 and 2017 to 2020, except for mangoes.

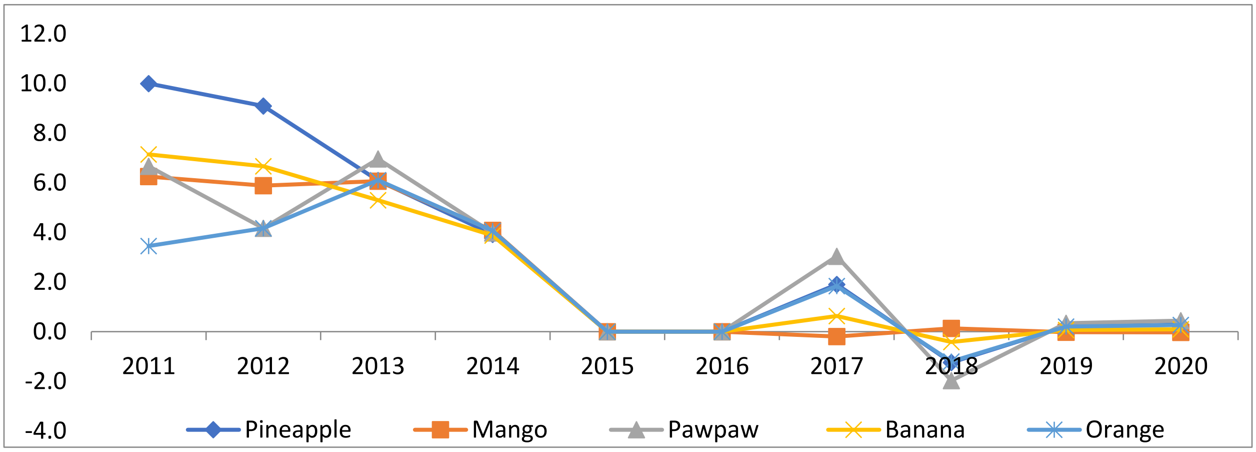


Figure 2.5: Growth rates of fruit production in Ghana (2011-2020)
Sources: FAO, 2021

In 2011, onion and shallot production grew by 20%, compared to 1.7% for chilies and 0.6 % for tomatoes (Figure 2.6). However, the increase in onion and shallot production has been low and declining since 2012. Chili production increased by 15% in 2012, but growth rates have remained low and falling since 2013. Chili production recorded negative growth in 2016, 2017, 2019, and 2020. Tomato production fell by 0.6-0.2 percent in 2012 but increased by 6.0% and 7.8% in 2013 and 2014.

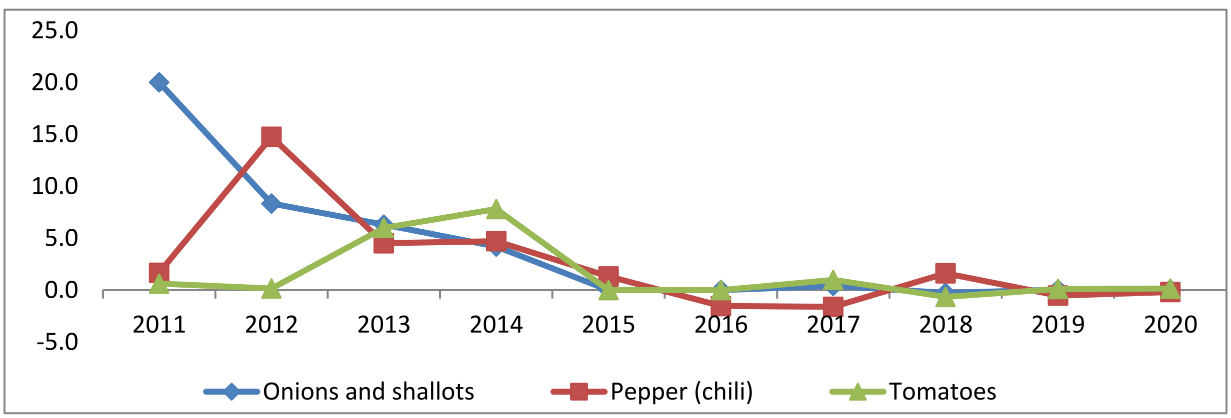


Figure 2.6: Growth rates of Vegetable Production in Ghana (2011-2020)
Sources: FAO, 2021

In 2003, the FAO and WHO launched the Global Initiative on the Promotion of Fruit and Vegetable for Health (PROFAV) to raise awareness, boost fruit and vegetable production and consumption for improving people's health and farmers' incomes. Despite increasing demand for fruits and vegetables in Ghana, production has been steadily declining in recent years. Demands for tomatoes and onions are met by massive imports, stifling production progress. Production shortfalls in fruits and vegetables are due to low yield and seasonality (Tsiboe, Asravor, & Osei, 2019; Van Asselt et al., 2018). Differences in soil fertility, climatic factors like rainfall and temperature, access to water, improved technologies, and market access account for variation in harvested output (Robinson & Kolavalli, 2010). There is also a lack of public and private investment in productivity-enhancing technologies, which is stifling the production of fruits and vegetables in Ghana (Tsiboe et al., 2019).

Improved Varieties of Fruits and Vegetables in Ghana

Pineapples

There are over one hundred pineapple varieties, but only six (MD2, Smooth Cayenne, Sugar Loaf (Pan de Azucar), Red Spanish, Queen Victoria and Abacaxi) are known and traded on the international market (Kpare, 2016; MoFA, 2022). Pernambuco, Variegated, and Baby are some of the other cultivars. Smooth Cayenne is the most common variety worldwide, both for processing and for eating. Smooth Cayenne and Sugarloaf are the most popular varieties in Ghana. However, MD2 is preferred for its sweet and savoury taste. It also has a higher vitamin C content and is less acidic (Danielou & Ravry, 2005). MD2 has excellent storage ability, making it ideal for shipment (Whitfield, 2010). However, MD2 adoption is low and farmers in Ghana have less preference for organic farming, compared to the traditional and robust varieties such as Sugar Loaf (Wuepper, Sauer, & Kleemann, 2014).

Oranges

Both local and exotic cultivars are grown in Ghana. Obuasi, Asuansi, Achiasi, Shama, Nkwanta, Anomabu, and Kwesi Nyarko oranges are among the local types of orange varieties. The appearance and flavour of these local cultivars have changed over time due to considerable natural crossbreeding. Washington navel, crimson blood orange, hamlim, and late Valencia are among the exotic cultivars.

Mangoes

The Portuguese were the first to introduce mangoes to Africa. Some of the varieties cultivated in Ghana are Keitt, Kent, Francine, Tommy Atkins, Palmer, Haden, Springfield and Irvin. However, Kent and Keitt are the major varieties grown ((MoFA, 2022; Okorley, Acheampong, & Abenor, 2014). About 85% of the mangoes produced in Ghana are of the Keitt variety. Kent and Springfield's varieties have gained attention in recent years because of their export potential.

Pawpaw

Pawpaw (papaya), also known as *Carica papaya* (Caricaceae) is a small tropical plant native to South America. Pawpaw is eaten fresh and ripe all around the country. The main varieties planted in Ghana are Solo dwarf, Hortus Gold, and Bluestem. These varieties were reintroduced in the 1990s, leading to commercial production (Akakpo, 2000). The Solo dwarf papaya, which is in high demand on the worldwide market, is the preferred Ghanaian export variety. Other varieties include Sunrise, Formosa, Amazon Red, Waimanalo, and Red Maradol (MoFA, 2022).

Bananas

There are over one hundred varieties of bananas growing around the world. However, Cavendish, Mysore (Alata kwadu, local variety), and Gros Michel varieties are the widely grown and preferred bananas in Ghana.

Chilies

Chili peppers (Capsicum spp.) are a common spice and condiment in Ghanaian cooking. Legon 18 is the most popular chili variety in Ghana (green chili). Other common varieties of chili are Scotch bonnet, Bird's eye, Demon, and CRI Shito Adope. According to (MoFA-IFPRI, 2020), Ghana's biggest export variety is green chili.

Tomatoes

In Ghana, the CSIR has played a key role in the development of novel tomato cultivars. Kwabena Kwabena, Kopia, Adope Shite Adopte, and Mako Ntose are some of the varieties released to farmers. Other varieties of tomatoes grown in Ghana are Pectomect, Power Roma and Techiman (Melomey et al., 2019). Other varieties include Eva F1, Padma F1, COBRA, Sultan, Raja, and Gigantico (MoFA, 2022).

Onions

Bawku Red and Galmi are the two main varieties grown in Ghana (MoFA-IFPRI, 2020). Despite their important varietal traits, Dayo, Trophy, Red-Creole, and Orient are not widely grown in Ghana (MoFA, 2022; Mohamed, 2018).

Underutilized Neglected & Indigenous Crops

Ghana is endowed with a lot of indigenous fruits and vegetables. However, the majority of these products are neglected. Aboagye, Amoatey, Asante, Obiri-Opareh, and Ofosu (2010) provide a summary of underutilized, neglected and indigenous fruits and vegetables (UNIFV) in Ghana. The findings are presented in the Table 2.6.

Table 2.6: Underutilised and Neglected Vegetables in Ghana

Vegetables	Indigenous Leafy Vegetables	Edible Wild Fruits
Trichosanthes cucumerina, Colocynthis edulis, Sechium edulis, Telfairia occidentalis, Lagenaria siceraria, Cucumeropsis edulis, Solanum aethiopicum, Solanum macrocarpon, Solanum torvum, Solanum pimpinellifolium, Bird's eye chili	*Celosia argentea, Corchorus olitorius, Cleome gynandra, Talinum triangulare, Vernonia hybridus, Amaranthus cruentus, Basella alba, Amaranthus hybridus, Moringa oleifera, Vernonia amygdalina, Wild lettuce, Hibiscus sabdariffa*	*Morinda morindiodes, Salacasia pyriformis, Dacryodes klaineana, Diospyros vigneri, Chrysophyllum albidum, Heisteria parvifolia, Irvingia gabonensis, Drypetes chevalieri, Diospyros soubreana, Solocia cornifolia, Cola millenii, Atocarpus utilis, Annona muricata, Velvet tamarind*

Source: Adopted from (Aboagye et al., 2010)

Postharvest Management of Fresh Products

Fruits and vegetables belong to the category of perishable foods. The quality (safety) and shelf life of these fresh products are influenced by postharvest management and handling procedures and treatments. Harvesting, precooling, washing and disinfecting, sorting and grading, packaging, storage, and transportation, according to (Arah, Ahorbo, Anku, Kumah, & Amaglo, 2016), play a crucial role in maintaining the quality and increasing the shelf life of fruits and vegetables. Fruit and vegetable harvesting in Ghana is done by hand and requires a lot of effort. Precooling helps minimize the effect of microbial activity, metabolic activity, respiration rate, and ethylene production as well as quick repining, dryness, decay, and water loss. Refrigerators are used in this manner. For tomatoes, however, many farmers in Ghana soak the fruits in cold water laced with disinfectants like thiabendazole and sodium hypochlorite (Arah et al., 2016). Cleaning and disinfection are a challenge due to the unavailability of clean water and disinfectants. To minimize the microbial load before packaging and marketing, fruits and vegetables are frequently treated with chlorinated water, vinegar, and salt solution after washing before sales. Onions and chilies are, however, not washed or disinfected in Ghana. One of the most significant stages in the packaging and selling of fruits and vegetables is sorting and grading. Sellers sort and grade their products to determine prices.

Processing and Packaging

Local processing of fruits and vegetables includes juicing and preparation of salads and fresh-cut products. However, there are just a few companies in Ghana that process fruits and vegetables. Table 2.7 is a list of Ghanaian fruit and vegetable processing companies, along with their year of operation, product category, and primary market destination.

Table 2.7: Companies Processing Fruits and Vegetables in Ghana

Company	Year of Operation	Type of Products Processed	Main Market Destination
Blue skies Holding Ltd	1997	Pineapples, banana, passion, mango, pomegranate, orange	Local and international
Taitapic Agrofood and Services	2017	Pineapple fruits, ginger roots, mango, orange, ginger, watermelon	Local
Nestle Ghana Ltd	1957	Fruits	Local and international
Frutelli Ghana Ltd	2000	Fruits; mango, pineapple, orange, and cocktail flavour	Local and international
Quin Organics	1995	Fruits; pineapple, coconut and herbs	Local and international
Pinora Food Processing Company	2008	Fruits; pineapple, orange, lime	Local
Multi-Pac Ltd	2009	Fruits; orange, strawberry, pineapple, apple, passion fruits, red berries, watermelon	Local
Mandis Ltd		Pineapple, mango, orange	
HealthLife Beverage Ltd	2008	Orange, pineapples, banana, coconut, mango, ginger	Local and international
Vineyard Exotics	2010	Herbs, flowers and fruits	Local
Bomart Farms	-	Dried Mango, Dried Pineapple Dried Banana, Dried Coconut	Local and international
HPW FRESH AND DRY LTD.	-	Dried mango, coconut	Local and international

Source: Ghana Export Promotion Authority, 2022

Packaging of fruits and vegetables as a postharvest handling method is rare in Ghana. Local market produce is frequently exposed to direct sunlight and flies, resulting in severe losses and damages.

Pests and Diseases

Pests and diseases are major problems in fruit and vegetable production because they cause significant crop loss for farmers. This includes diseases such as anthracnose, powdery mildew, alternaria, stem-end rot, Pseudocercospora leaf and fruit leaf disease of citrus, Cape St Paul wilt for coconuts, bacteria black spots (BBS) on mango and pests (fruit fly, mealybug, termites, and mango bugs).

2.6 Natural Resources

Water

Water for fruits and vegetable production is mainly from irrigation, rainfall or wastewater. According to Van Asselt et al. (2018), access to water for irrigation was a major constraint for farmers in Upper East. Forty-five percent of tomato farmers, 85 percent of onion farmers and 29 percent of Scotch bonnet farmers in the Upper East region reported inadequate water for watering as the biggest hindrance to vegetable production. Vegetable farmers in urban areas such as Accra use wastewater for the production of carrot, lettuce, pepper etc. However, using such sources of water has been reported to have contaminants such as heavy metals or microbial pathogens in the water which come in contact with fresh produce during irrigation, application of pesticides or washing produce after harvest. This is a concern for human health and market opportunities.

Climate

Climate is an influential factor that affects the growth of fruits and vegetables in rain-fed environments in Ghana. Most importantly, having the right rainfall, temperature and right amount of sunlight during the growing season is essential (Jost et al., 2016). Changes in rainfall and temperatures are expected to have negative consequences on horticultural production (Adade, Nyarko, Aheto, & Osei, 2017). Untimely rains during drought stress periods or above normal temperatures during flowering and fruit growth reduce yields and can cause physiological disorders (FAO, 2013).

Guinea and Sudan Savannah (Northern savannah) make up 62% of the land area of Ghana with an average growing period of 172 days where rainfed and irrigated fruits and vegetables can be grown with flexibility in planting and harvesting time. Rainfall statistics obtained from MOFA revealed that the national average distribution of rainfall declined from 1,276 mm in 2008 to 937 mm in 2020. The continuous decline in the volume of rainfall could affect agronomic practices and yields of crops, especially fruits and vegetables (MoFA, 2020). The Savannah agro-ecological zones experience the lowest rainfall (<1000mm) amounts in a year in Ghana. There is only one growing season, referred to as mono-modal rainy season. The rainy season starts in May/June and ends in September/October, followed by a long dry period from November to April.

The Forest agro-ecological zones, on the other hand, experience relatively higher rainfall amounts (>15000mm per annum) with a bimodal pattern. In the major season rains occur between March and mid-July with a peak in May/June. There is a short dry spell from mid-July to mid-August. The minor rainy season starts from mid-August to about the end of October with a peak in September. There is a long dry period from November to February with possibilities of occasional rains. The rains are well distributed throughout the year, with amounts considered adequate for crop production occurring in the two peaks. Due to the reality of climate variability change and increasing capacity building in Climate Smart Agriculture, more farmers are now increasing their investments in alternative irrigation devices/equipment to supplement their plant-water requirements to safeguard their investments.

Soil

The soils have predominantly light textured surface horizons in which sandy loams and loams are common. Lower soil horizons have slightly heavier textures varying from coarse sandy loams to clays. Heavier textured soils occur in many valley bottoms and in parts of the Accra Plains. Most soils contain abundant coarse materials; either gravel and stone, or concretionary materials which affect their physical properties.

Table 2.8: Fertility Status of Soils in the Ecological Zones of Ghana

Ecological Zones	Soil pH	(%) Organic matter	(%) Total Nitrogen	Available Phosphorus (mg/kg soil)	Cation Exchange Capacity
Coastal Savanna	4.40-9.50	0.00-8.00	0.07-0.37	0.00-6.62	0.00-9.28
Decidious Forest	4.40-9.50	0.00-13.83	0.00-0.52	0.00-3.48	0.00-9.62
Moist Evergreen	4.40-7.70	0.69-13.83	0.00-0.37	<0.02	0.00-1.21
Wet Evergreen	4.40-7.70	0.69-13.83	0.00-0.37	0.00-8.19	0.00-1.21
Trasitional Zone	4.10-7.70	0.00-10.3	0.00-0.52	0.00-2.00	0.00-9.62
Guinea Savanna	4.10-7.40	0.00-6.74	0.00-0.14	0.00-7.60	0.00-7.85
Sudan Savanna	4.10-7.40	0.54-5.89	0.00-0.10	0.00-3.62	0.00-7.72

Source: Soil Research Institute, CSIR-Kumasi, 2018

Table 2.9: Fertility Status of Soils in the Regions of Ghana

Region	Soil pH	(%) Organic matter	(%) Total Nitrogen	Available Phosphorus (mg/kg soil)	Cation Exchange Capacity
Ashanti	4.10-7.30	0.00-13.83	0.00-0.52	0.00-6.98	0.00-9.62
Western	3.80-7.10	1.03-5.70	0.06-5.40	0.35-11.25	0.00-1.21
Brong Ahafo	3.50-6.70	0.34-1.69	0.2-0.28	0.00-0.41	0.00-9.62
Greater Accra	5.40-8.20	0.10-1.70	0.05-0.90	0.00-6.62	0.00-9.28
Upper East	5.10-6.80	1.10-2.50	0.06-0.14	1.75-14.75	0.00-7.72
Upper West	6.00-6.80	0.50-1.30	0.01-0.07	2.00-7.40	0.00-4.79
Northern	4.50-6.70	0.60-2.00	0.02-0.05	2.50-10.00	0.00-7.85
Volta Region	4.10-7.80	0.00-5.63	0.00-0.02	0.00-6.62	0.00-9.28
Eastern Region	4.10-7.80	0.00-8.19	0.00-0.37	0.00-3.48	0.00-9.62
Central Region	4.40-7.70	0.00-4.30	0.00-0.37	0.00-9.80	0.00-2.40

Source: Soil Research Institute, CSIR-Kumasi, 2018

2.7 Socioeconomic

Women in Horticulture

In Ghana, vegetable production is mainly undertaken by women. Cultivation of onions, tomato, pepper, and water melon are some few crops mostly cultivated by women. Women also tend to engage more in the post-production side of the vegetable value chain – such as processing and marketing/sales. They are more active in the production of mostly leafy and indigenous crops. However, in Ghana, women lack access to productive input and lack power regarding decision making in the community. Major challenges facing women in the horticulture sector include inadequate access to credit, markets and land.

Women in horticulture are confronted with barriers such as access to markets and participation in large-scale and more remunerative value chains which require specialized vocational and technical skills in areas such as food safety, food conservation, packaging and product certification. They lack knowledge about trade standards needed particularly, in sanitary and phytosanitary measures which limit their involvement in other segments of the market. In Ghana, distribution, transportation processing and export of horticulture products especially fruits are mainly dominated by men.

Land ownership among women is low limiting their ability to acquire financial assets. In addition, difficulty in securing funding for their production activities is also a major hindrance to women in the horticulture sector.

Indigenous Peoples in Horticulture

Horticulture production in Ghana is mainly undertaken by indigenous people in most parts of Ghana. Cultivation of onions, shallots, pepper, water melon, and other leafy vegetable are done by indigenous people in parts of the Upper East Regions, Northern regions and Volta regions. Water for vegetable production is a major challenge, especially during the dry season. In addition, access to land can improve access to credit and provide incentives for making improvements to increase production.

Youth and Horticulture

The Youth are being encouraged in agri-business along the horticulture value chain, and greenhouse farming (Greenhouse Village Initiative-MOFA). As part of the government's efforts to open opportunities for increased production and exports of vegetables after the 2015 European Union export ban on selected vegetables, the concept of greenhouse villages was introduced in 2017. The idea of the greenhouse village is to establish strong agribusiness in the vegetable sector to attract both Ghanaian youth and international investors. The goal is to place Ghana as a key competitor in the export of fresh vegetables and cut flowers. The project trained about 537 youths including Degree, HND and certificate holders. The three-month intensive training session covers all areas in greenhouse vegetable cultivation, starting from the nursery, crop production, fertigation, pest and disease management, handling, marketing, and branding.

Market and Consumption

Demand for nutritious fruits and vegetables

Demand for high-quality fruits and vegetables for home consumption and export is increasing rapidly due to increased consumer income and awareness of food safety issues in Ghana coupled with the expansion of traditional markets, the hospitality industry, and fruit processing units, which is fueling the market growth for fruits and vegetables. Based on the WHO and the Food and Agriculture Organization (FAO) recommendations, there should be minimum ingestion of 400 g of FVs daily, which is equivalent to five servings (Ungar, Sieverding, & Stadnitski, 2013). Tomatoes, peppers (both sweet and hot chilies), onions, and okra are consumed a lot in Ghana. The market for tomatoes and peppers has boomed recently (IFPRI, 2020). Overall vegetable consumption in Ghana falls short of WHO/FAO recommendations, in comparison with other African countries like Kenya (Saavedra et al., 2014). Despite the inexistence of local production, consumers have heightened interest in food safety in vegetables due to their susceptibility to chemical and microbial contamination (Cobbinah, Donkoh, & Ansah, 2018).

Market Access

The main market for fruits and vegetables is dominated by open markets, which include smaller street shops, hawkers, and well-built markets. The local market comprises of about 70 percent of the fresh fruits and vegetables market in Ghana. Farmers supply the fresh produce mainly to domestic bulk suppliers, itinerant suppliers, and other suppliers such as supermarkets, hotels, and restaurants. Prices of pepper, onion, tomato and other fruits remain relatively stable during the period (Figure 2.7).

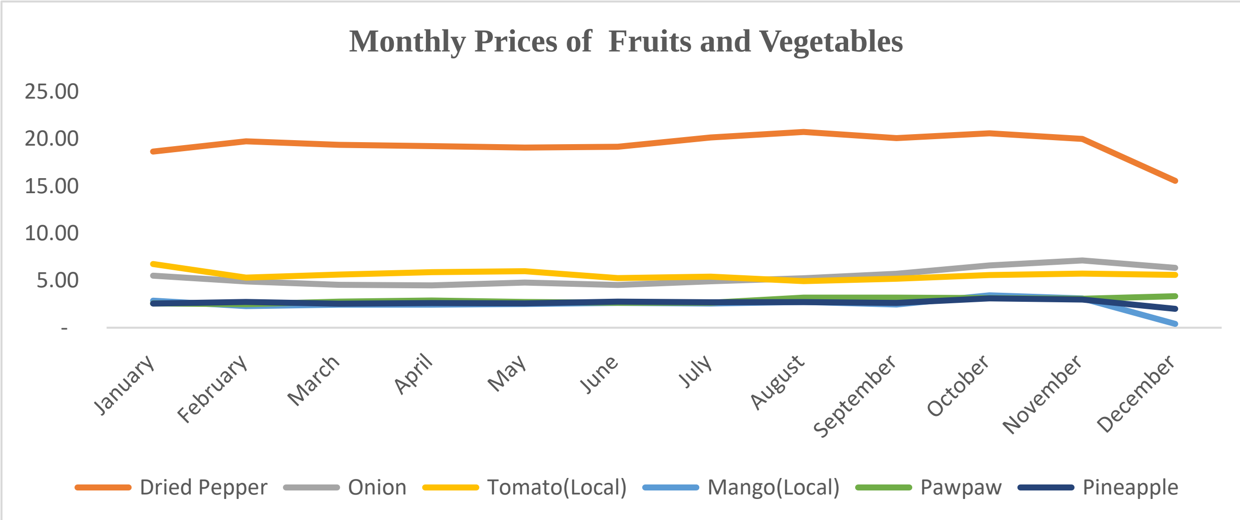


Figure 2.7: Monthly prices of fruits and Vegetables (2020*)*

Source: MOFA, 2022

Value-added Horticulture Products

Value creation and value addition in fruits and vegetables is minimal. Producers and marketers engage in primary activities such as cleaning, sorting, grading, and storage. However, local market centres encounter high post-harvest losses, food safety problems and a low product shelf life. Most fruit and vegetable products sold on the market are exposed to direct sunlight due to a lack of good storage and cooling systems. In some instances, vegetables get sold on the bare floor or tarpaulins. Good packaging is essential to maintain quality throughout the chain. In Ghana, suppliers use large sacks or wooden crates to store and carry huge amounts of produce. This method leads to significant market losses. Post-harvest losses in Ghana exceed 20% of the total value of the produce (Ridolfi, Hoffman, & Baral, 2018).

2.8 Agribusiness Opportunities

Production Opportunities

Healthy Orchards and Planting Materials

This is an excellent opportunity for investors to help introduce disease-resistant varieties by using tissue culture technology. Tissue culture is a technology which helps in producing true to type planting materials which are also disease-free. There is also a business opportunity in exploring the development of early maturing varieties for farmers.

Mango

The current plantations have several pest and disease challenges. Infestation of Bacteria Black Spot Disease is a major challenge in the sector leading to post-harvest losses. This offers opportunities for agro-input supply companies to identify effective management practices to ensure disease-free orchards.

Citrus

Majority (85–90%) of citrus orchards in Ghana are planted using the Late Valencia variety. This offers business opportunities for breeding and introducing other varieties into the sector.

Improved Fruit Handling, Transport and Storage

Post-harvest losses in the fruit sector are high. Value chain actors who are into storage facilities operation and pack house activities can explore business opportunities to enhance the activities of the farmers, wholesalers and retailers of fresh produce.

Marketing Opportunities

Investment in value-added processing of fresh fruits to juices and concentrates will offer potential market.

2.9 Trade and Standards

Export and Import of Fresh Fruits and Vegetables

In the last two years, Ghana's total fresh fruit exports have decreased but overall fruit and vegetable exports increased. Between 2019 and 2020, the volume of orange and pawpaw exported increased by 211.8% and 149.7%, respectively (Table 2.10). Exports of pineapples, bananas, and mangoes, on the other hand, fell by 76.7%, 18.2%, and 96.1%, respectively (Table 2.10). Despite the impact of CoVID-19, the export of onions, chili and tomato increased respectively (Table 2.10).

Table 2.10: Export of Fresh Fruits and Vegetables in Ghana (2019-2021)

	Volume (Tonnes)			Value ($000)		
Commodity	**2019**	**2020**	**% Change (2019-2020)**	**2019**	**2020**	**% Change (2019-2020)**
Fruits						
Pineapples	18,992,351	4,427,318	-76.7	51,174,151	5,786,740	-88.7
Bananas	97,424	79,732	-18.2	32,582,000	67,296,00	106.5
Mangoes	20,013,322	778,273	-96.1	67, 217,484	4,140,802	-93.8
Pawpaw	1,453,589	3,629,581	149.7	5,130,300	3,515,119	-31.5
Oranges	1,660,975	94,200,000	211.8	10,122,513	3,222,077	-68.2
Vegetables						
Onions	568283.1	1,197,071	110.6	669,424.6	872,688	30.4
Pepper (Chili)	2	47	2250	2,000	105,000	5150
Tomato	10,356	11,013	6.3	6,657	6,656	0

Source: Ghana Statistical Service, GSS, 2021

The total volume and value of export of processed fruits (pineapples) in 2019 was 18, 992,351 tonnes and $51,174,151.00. The majority of Ghana's tomato paste is exported to West African countries including Niger, Mali, Togo, and Burkina Faso. Cameroon, South Africa and Zambia. Japan, the United States, the United Kingdom, and France are among the minor export destinations. Ghana's largest export market for processed pineapples is the United States.

Import of Fresh Fruits and Vegetables

Table 2.11: Imports of Fresh Fruits and Vegetables (2019-2020)

Commodity	2019 Volume (Mt)	Value (Ghc)	2020 Volume	Value	Five Top Countries
Pineapples, fresh or dried	6,746.57	41,894.37	271	734	Spain, UK, The Netherlands, South Africa, United Sates
Mango	19525.75	38012.04	316.45	5,931.22	Togo, UK, The Netherlands, UAE
Pawpaws	5.33	35.52	2,790	42,012	Lebanon, The Netherlands
Oranges	92,066.84	207,606.13	358,772	797,270	Spain, Egypt, South Africa, Morocco, France
Onions and shallot	4,066,203.8	4,338,133.4	78,793,991.2	52,213,749.7	Niger, UK, Morocco, The Netherlands, UAE
Tomatoes	4,154,334.7	4,432,342.6	-	-	Burkina Faso, The Netherlands, Italy, Morocco, Luxembourg,

Source: GSS, 2022

Table 2.12: Import of Processed Horticulture Products (Tomatoes) in 2019

Top Ten Country	Volume (kg)	Value (GHS)
China	63,653,434.6	195,462,725.0
Italy	3,789,646.9	12,480,667.8
Cote D'Ivoire	461,668.2	1,429,830.9
Togo	465,519.0	1,381,215.1
USA	82,349.4	487,238.9
UAE	153,654.2	391,666.0
UK	103,789.7	362,819.6
Niger	55,786.4	173,371.8
South Africa	23,315.8	84,225.3
The Netherlands	21,806.3	69,329.3
Total Import	**68,895,939**	**212,556,611**

Source: GSS, 2022

The majority of Ghana's fresh fruits and vegetables, on the other hand, are exported to Asia, Europe, and Cote D'Ivoire. The top three importers of Ghanaian pineapples are France, Lebanon, and Switzerland (Table 2.12). The United Arab Emirates (UAE), the United Kingdom (UK), and Kuwait are the top importers of Ghanaian mangoes. Ghana's top three export destinations for pawpaw are Cote D'Ivoire, the United Kingdom, and the Netherlands. Cote D'Ivoire, the Netherlands, and Italy are the top three importers of Ghanaian oranges. The United Kingdom, the Netherlands, and Cote D'Ivoire are Ghana's top three onion importers (Table 2.13).

Table 2.13: Principal Export Destinations of Fresh Fruits and Vegetables from Ghana

	Major Export Country					
Products	**First Leading Country**	**Volume Exported in 2021**	Second Leading Country	**Volume Exported in 2021**	**Third Leading Country**	**Volume Exported in 2021**
Pineapples	France	2,052,562 (3,698,553)	Lebanon	100,873 (158,632)	Switzerland	97,649 (145,150)
Mangoes	UAE	287,166 (871,260)	UK	5,572 (655,006)	Kuwait	96,935 (242,758)
Pawpaw	Cote D'Ivoire	788,101 (3,100,502)	UK	52,531 (143,846)	The Netherlands	20,937 (107,666)
Oranges	Cote D'Ivoire	6,502,700 (938,589,658)	The Netherlands	93,860 (1,587,641)	Italy	30,720 (411,765)
Onions and shallots	UK	140,638 (476,903)	The Netherlands	18,025 (94,302)	Cote D'Ivoire	9,866 (52,836)

Source: GEPA, 2022 **Note: Value of export are in parentheses**

Private Sector Participation in Horticulture Export

Private sector participation in the export of fruits and vegetables is increasing in Ghana. Companies and individuals like AB Farms Ltd, A.T. Mahli Farms Ltd, Agrigold Resource Development Ghana Limited, Akafad-Pa Company Limited, Albe Farms Limited, Albert Agbeko, Albert Mills Agbeko, Alexandr Atuobi, Alhaji Awudu Karim Enterprise Ltd, and Ayaawan Harrison are involved in the export of multiple products.

Engineering and Technology

Production Technology and Supplies

There is minimal use of engineering and technology in horticulture crop production in Ghana. Smallholder farmers employ basic farm implements under a rainfed system (Osei et al., 2022), which increases the vulnerability of production to climate change. At the nursery and early field establishing stages, supplemental irrigation is delivered using traditional tools such as watering cans, buckets, knapsack sprayers, and occasionally small powered pumps, or a mix of these methods. Manual labour dominates in seedbed preparation, fertilizer and pesticide application, weeding, and harvesting. This farming method is, however, labour intensive and time-consuming. Farmers have limited access to mechanization services such as tractors, planters and harvesters, posing a challenge to vegetable production (Nyo, 2016). In recent years, drones have been used in pest, disease, and weed surveillance, as well as water stress monitoring in agricultural production (Osei et al., 2022). However, most developing countries such as Ghana have yet to adopt these new technologies.

Postharvest Packaging, Cooling, Cold Storage, Drying

Facilities such as harvesting and collection tools, containers and packing, rapid and cold chain transportation, and commercial storage are key to a successful vegetable postharvest value chain. The lack of appropriate storage conditions contributes to post-harvest losses in vegetable production. Apart from a few supermarkets that keep fruits and vegetables in refrigerators, fruits and vegetables are sold in the open market, exposing the produce to harsh weather conditions. Most farmers and traders are obliged to sell their products at low rates due to a lack of storage (cooling) facilities.

Processing of Horticultural Products

Processing of horticultural crops is important to add value to the products that are unsuitable for the fresh market, because of their size, shape, and superficial imperfections (Perera & Perera, 2019).

Some processing techniques for fruits and vegetables include:

- Preservation by removing moisture; e.g., drying and dehydration
- Preservation by concentration (e.g., Concentration by Freezing, Concentration by Vacuum Evaporator, Solar Concentration, Flash Evaporators, Thin Film Evaporator, Ultrafiltration and Reverse Osmosis/Hyperfiltration)
- Preservation by Sugar
- Preservation by Fermentation
- Preservation by Food Additives
- Preservation by Chemicals (e.g., Sodium bicarbonate)
- Preservation by Heat Treatment (e.g., Pasteurisation, Sterilization)

Research, Education and Training

Education and Training Needs in Horticulture

Ghana has three public universities and four agriculture colleges, teaching agriculture and horticulture-related courses. The public universities include the University of Ghana (UG), the University for Development Studies (UDS), and Kwame Nkrumah University of Science and Technology. These public Universities offer courses in BSc. Agriculture with specialization in horticulture, Masters and PhD Degree programmes in Agronomy, Horticulture and Crop Breeding. The four agriculture colleges include Ohawu, Kwadaso, Ejura, and Damango which offer courses leading to a Diploma and Certificate in Agriculture. Though these agriculture colleges do not specialize in horticulture, they offer courses in crop production. There are three farm institutes which are located in Adidome, Wenchi, and Asuansi and offer mainly certificate programmes in general agriculture.

There is a lack of connection between research conducted by these universities and agriculture colleges concerning on the ground agricultural issues affecting small-scale producers. This includes, among other things, a lack of operational capacity among small-scale producers which results in low-quality products, low productivity, inadequate production practices, and reduced access to formal markets. Fruits and vegetable farmers also lack training in well-accepted best practices for horticultural crop production and handling for export. Research in postharvest activities, such as postharvest handling, indigenous crops with export potential, and improved crop management to optimize postharvest quality and ensure food safety and standards are identified as priority areas for research.

Research Capacities of Universities and Research Institutions

Agricultural research is fundamental to enhancing Ghana's agricultural productivity in the horticulture sector. Ghana has a National Agricultural Research System (NARS) that includes research institutes, tertiary educational institutions, and other organizations. The main agency for agricultural research and development is the Council for Scientific and Industrial Research (CSIR) and its 13 research institutes, of which 10 are engaged in agricultural and related research activities. Research in the fruits and vegetable sector is mainly conducted at Food Research Institute (FRI), Crops Research Institute (CRI), Soil Research Institute (SRI), Plant Genetic Resources Research Institute (PGRRI), and Savanna Agricultural Research

Institute (SARI). The public universities such as UDS, UG and KNUST also conduct research in the horticulture sector. The major challenge confronting these research institutions is the lack of funding.

Extension Capacity in Public and Private Sector

Extension service activities in the fruits and vegetable sector are mainly undertaken by the public sector. The extension agents who work under the Ministry of Food and Agriculture, train small-scale and commercial fruits and vegetable producers in good production practices, pest and disease control, post-harvest management practices (handling, washing, packaging, transportation etc.), and food safety standards. However, in recent years, there has been concern about private sector driven technical support in fruits and vegetable sector. GhanaVeg, conducted a survey to explore private sector driven technical support services in Ghana's vegetable sector. Below are the main technical support needs based on the value chain actors.

Commercial growers: (i) Production and investment planning (assessing qualitative and quantitative demands; financial planning and funding; dealing with uncertainties) (ii) Cultivation (irrigation, pest and disease management, soil fertility) (iii) Product handling (preservation, sorting, grading, handling, packing) (iv) Quality assurance and traceability

Input suppliers (wholesale/large scale): Trends and opportunities in the sector, soil fertility management, and crop protection.

Handling agents and logistical service providers: (i) Quality management systems and traceability (ii) Handling of vegetables (sorting, grading, processing and packing fresh vegetables).

This requires technical expertise such as Local GAP advisors for smallholder fruits and vegetables. Growers and fruits and vegetable business development coaches for large-scale commercial growers and wholesale traders/exporters.

2.10 National Policy and Regulatory Environment for Horticulture Sector in Ghana

National Level Horticulture Policies

The Ministry of Food and Agriculture (MOFA) is the main policy institution responsible for promoting agricultural development in Ghana through the creation of an enabling environment for sustainable growth in the agricultural sector. The horticulture sector falls directly under this ministry. The horticulture sector for decades lacked a single comprehensive policy framework for growth and development in Ghana. Policies aimed at promoting the sector were implemented through agriculture sector policies such as FASDEP 1 &2, METASIP etc. and other donor-funded programmes and projects. During the FASDEP period, the sector was expected to grow by between 6% to 8% per annum within four years, while the crop sector was expected to grow at 6% per annum. FASDEP was built essentially on the five key elements of the AAGDS, with a focus on strengthening the private sector as the engine of growth.

The FASDEP I provide a framework for modernizing the agricultural sector and making it the catalyst for rural transformation. The objectives include (i) Ensuring Food Security (ii) Facilitating the Production of Agricultural Raw Materials for Industry (iii) Facilitating the Production of Agricultural Commodities for Export (iv) Facilitating Effective and Efficient Input Supply and Distribution Systems (v) Facilitating Effective and Efficient Output Marketing Systems (vi) Formulating and Coordinating Policies and Programmes for the Food and Agriculture Sector. Under FASDEP I, selected fruits and vegetables were targeted for food security, raw material for industry and export. MOFA supported the production and marketing of fruits and vegetables such as tomatoes, pepper, onions, mangoes, citrus, pawpaw and banana. The policy targeted service provisions such as market intelligence and communication, adequate financing,

efficient handling and transportation, good port facilities, grading, standardization and strong export marketing associations as strategies to promote the export of these selected horticulture crops.
FASDEP II was formulated based on six objectives: (i) food security and emergency preparedness; (ii) improved growth in incomes; (iii) increased competitiveness and enhanced integration into domestic and international markets; (iv) sustainable management of land and environment; (v) science and technology application in food and agriculture development; and (vi) improved institutional coordination. The key strategies include accelerating the provision of irrigation infrastructure, enhancing access to credit and inputs, promoting selective crop development, and increasing access to extension services. Horticulture crops such as mango, cashew, citrus and vegetables were targeted for production for domestic and international markets.

In 2008, the Tree crop policy was formulated based on the objectives of FASDEP II. The policy is to provide a comprehensive approach for the sustainable development of the tree crop sub-sector and for proper targeting of support to the tree crop value chains. It aimed to achieve the following objectives (i) support increased production and productivity (ii) promote investment and increase processing capacities (iii) improve marketing through value chain development (iv) promote sustainable practices for environmental protection (v) support research and development (vi) improve coordination and management of the policy. The policy also targeted some selected fruits and vegetables across different agro-ecological zones.
(i) Forest Zone: Citrus, Kola, Avocado
(ii) Transitional Zone: Cashew, Mango
(iii) Northern Zone: Cashew, Shea, Dawadawa, Baobab, Tamarind
(iv) Coastal Savanna: Coconut and Mango
The policy was to increase the share of locally processed products to generate added value to the sector, create jobs, and establish new marketing channels for farmers.

The National Seed Policy started on 1st August 2013. Quality seed is an essential input for increasing agricultural productivity and achieving food self-sufficiency. The National Seed Policy is to support the development and establishment of a well-coordinated, comprehensive and sustainable private sector-driven seed industry through systematic and strategic approaches which would continuously create and supply new and improved varieties for use by farmers. The Ghana seed industry started in 1958 with the establishment of a Hybrid Maize Seed Multiplication Unit within the then Ministry of Agriculture. The Unit produced only hybrid maize seed until 1961 when it was converted into a Seed Multiplication Unit (SMU) which included other crop seeds in its portfolio. The SMU eventually became the Ghana Seed Company (GSC) in 1979 with the mandate to produce all classes of seed except breeder seed which was under the mandate of research centres. The horticulture crops targeted by this policy include pineapple, plantain, papaya, banana, tomato, pepper, onion, okra and garden egg.

Ghana's Irrigation Policy (Lamptey, Nyamdi, & Minta, 2011), is designed to open up the investment space for intensified and diversified irrigated crop production in Ghana where there is a clear comparative advantage. The policy recognizes three main categories of irrigation in Ghana, namely (i) informal irrigation, (ii) formal irrigation, and (iii) large-scale commercial irrigation. Informal Irrigation comprises traditional and community-initiated schemes, which are typified by the cultivation of about 2,000 ha of shallots in the Southeastern coastline of Ghana, informal irrigation around the hundreds of small reservoirs in the North, and informal irrigators cultivation in inland valleys, groundwater irrigation e.g., near Bawku and irrigated urban and peri-urban agriculture. Formal irrigation may be defined as one that is reliant on some form of permanent irrigation infrastructure funded by the public sector. This includes Dawhenya, Afife, Mankessim, Okyereko, Tono and Vea and Bontanga schemes. Large scale commercial irrigation is usually export-oriented and comprises farm sizes of between 25 ha and 1,000 ha or more. High-value fruits and vegetables are usually the main crops cultivated under these irrigation schemes.

Under the Planting for Food and Jobs (2017-2020), the GoG intends to enhance the productivity of crops of significance for food and feed in Ghana through integrated services in farming and marketing. The PFJ program provides a framework for engaging farmers through a private sector-led agricultural value chain development. The Program was implemented by the Ministry of Food and Agriculture (MoFA) in partnership with public and private stakeholders. The project aimed to achieve the following i)immediate and adequate availability of the selected crops in Ghana through improved productivity and intensification of food crops, and extended support to private sector service providers ii) to provide job opportunities for the teeming unemployed youth in the agriculture and allied sectors, and iii) to create general awareness for all formal workers to either have farms and grow some cereals or vegetables or establish backyard gardens, when enough land is not available and accessible. The programme focused on the four thematic areas, namely fertilizer, seed, extension services, and e-agriculture. Some priority horticultural crops under the programme include tomato, onion and chili pepper.

Ghana's National Export Strategy (NES) is to develop the potential of the non-traditional export (NTE) sector to enable it make maximum contributions to GDP growth and national development to consolidate and enhance Ghana's middle-income status, create formal decent job opportunities and ensure high standards of living for the people. The NES is situated within the context of the Medium-Term Development Policy Framework, Ghana Shared Growth and Development Agenda (2010-2013), Trade Policy, and Industrial Policy which has identified the private sector as the main agent of change and a key actor in developing the non-traditional export sector. The strategy is to achieve a significant increase in the share of Non-Traditional Exports (NTEs) in total exports as a major step towards structural transformation of the export sector for spearheading growth and diversification of the economy. The horticultural crops targeted by the strategy include fresh and processed fruits and vegetables including fresh pineapples, banana, mangoes, papaya, citrus, chilies, melons, cut fruit, and tomato paste. Other sector policies are the Crop Protection Policy in Ghana (2001), National Plant Protection Policy (2004) and Fertilizer Policy (2013).

International Support Projects and Programmes for Horticulture in Ghana

In the last three decades, the institutional support efforts for horticulture have expanded rapidly, and continue to grow. In 2003, a cooperative agricultural-development project led by MoFA, and funded by the World Bank, known by its acronym AgSSIP, identified horticulture as a sector of enormous potential for growth in Ghana. Thus, emerged the MoFA's Horticultural Export Industry Initiative **(**HEII) in the late 2004, funded by the World Bank.

HEII has been at the center of many rapid developments including product-specific efforts such as MD2 cultivar sourcing, development and distribution, and programs to support mango out-growers to coordinating the development of Ghana's cold-chains, developing and spreading planting materials, improving food and quality management; the establishment of a definitive pesticide list for all fresh produce export crops; international certification of the Ghana Standard Board laboratories as an ISO 17025 accredited laboratory; supporting the implementation of Good Agricultural Practices by small-scale farmers and strengthening the '*cluster dynamics'* among industries that support the horticulture sector.

Supporting these efforts has been a priority for donor partners especially U.S Agency for International Development (USAID). Funded by USAID and the GoG, (2005–2009) with a budget of $30 million, the Trade and Investment Programme for a Competitive Export Economy (TIPCEE) was implemented to achieve "exponential" growth in sales of agricultural exports by increasing the competitiveness of Ghana's private sector in international and regional markets. Other donor-funded initiatives like the German Technical Corporation's Market-Oriented Agricultural Programme (MOAP), and the EU's regional Pesticides Initiative have significantly contributed to the growth of the horticulture sector. Though these programmes seem to overlap in their task, however, support for the agribusinesses in the private sector was the main mode of implementation.

In August 2006, the government of Ghana signed a five-year Millenium Challenge Account pact with the U.S government. The Ghanaian government created Millennium Development Authority (MiDA) to implement the projects. A large portion of MiDA resources was devoted to developing the horticulture sector and its related infrastructure, such as roads. MiDA's approach was to look at the entire horticultural supply chain in an integrated way and target resources to the most promising geographical intervention areas and links in the production, transport, and processing chain. Additionally, MiDA devoted about $200 million to the construction of horticulture cold-chain system and spent $66 million on the development of farmers' commercial skills by engaging 1,200 Farmer Based Organizations (FBOs), 120 agribusinesses and 60,000 farmers.

In 2005, funded by the African Development Bank (AfDB), the implementation of the Export Marketing and Quality Awareness Project (EMQAP) started with an amount of $28.6 million. The five-year project established 'demonstration farms' for training in GAPs and the creation of manuals with GAP protocols and requirements for the international markets. Among other things, the project achieved the following: (i) trained Agricultural Extension Agents (AEAs) in post-harvest handling of pineapple and mango (ii) trained 400 farmers in post-harvest handling of mango (iii) trained 100 farmers and farm workers in GlobalGAP/Other International Standards (iv) a total of 114 Agriculture Extension Agents were trained in the post-harvest handling of vegetables (chili, garden egg/aubergine, okra and Asian vegetables). The project also built the capacity of farmer and agriculture extension agents.

The HortiFresh West Africa programme funded by the Embassy of the Kingdom of the Netherlands in Ghana is being implemented by a consortium of 5 partners: WUR (the lead), SNV, Resilience, Advance Consulting and SENSE. The programme seeks to achieve its overarching goal of "a sustainable and internationally competitive fruit and vegetable sector that contributes to inclusive economic growth, food and nutrition security''. The main results areas are aligned with the Dutch Development Policy and include: (i) A competitive and innovative high-value fruit and vegetable sector; (ii) An inclusive and sustainable fruit and vegetable sector; (iii) A conducive business climate that facilitates the development of the fruit and vegetable sector.
The programme employed instruments to engage the sector through enhancing the enabling environment, stakeholder business meetings, trade promotion activities, technical assistance in agronomy and business management and financial support services.

Other ongoing projects and programmes being implemented by the government and donors in the horticulture sector include:

i. Mainstreaming Market-Oriented Livelihood Improvement through the Smallholder Horticulture Empowerment and Promotion Approach (SHEP) for Horticulture Extension (MOFA-JICA 2022-2027).
ii. Ghana CARES "Obaatan Pa" Programme (Tomato Initiative). Seeks to boost local tomato production and support effective marketing and processing (2021-2023).
iii. Ghana Peri-Urban Vegetable Value Chains Projects: Sought to improve productivity and access to the market by the beneficiary vegetable farmers in selected peri-urban communities in Ghana (2016-2021).
iv. GhanaVeg
v. Ghana Green Label Scheme Initiative

These specific projects and programmes are meant to **(i)** ensure **s**ound implementation of sanitary and phytosanitary (SPS) measures (ii) investments in applied horticultural research (iii) maximize the state's horticultural potential and increase the production of all horticultural crops.

Policies, projects and programmes implemented in the Horticulture sector over the last two decades can be summarized in five thematic areas: production and export, access to improved seed, fertilizer access and water for crop production. Through these projects and programmes, the Government of Ghana seeks to expand international trade in high-value horticulture commodities, in which the country has a comparative advantage. The government has introduced major initiatives to enhance the competitiveness of the non-traditional export sub-sector, and the horticulture sector in particular is the country's focus on agricultural export diversification. This is being done in collaboration with local and international development partners.

The major horticultural crops that have been the focus of successive policies and programmes over the last three decades include pineapple, mango, papaya, banana, citrus, chili pepper, tomatoes, onion, okra, garden eggs, and Asian vegetables. Production of exotic (European) vegetables such as lettuce, cabbage, cauliflower, onion, spinach, tomato, carrot, French bean, turnip, cucumber, beet, and radish is concentrated in and around the principal towns and cities of the country have been promoted alongside.

NIGERIA

3.1 Context

Nigeria is a multi-ethnic and culturally diverse federation of 36 autonomous states and the Federal Capital Territory (FCT). Agriculture is the mainstay of the economy, employs about 35% of the country's total workforce (WorldBank, 2020) and contributes approximately 24% to the country's gross domestic product (GDP) (NBS, 2020). In 2021, the sector experienced a growth of 3.4% and an inflation rate of 15.9% (NBS, 2020). The majority of the agricultural value is generated from arable crops.

Nigeria has an estimated population of 206 million people which is the largest in Africa and this is growing at a rate of about 2.6% annually (WorldBank, 2022). Nigeria is also the biggest oil exporter in Africa, with the continent's largest natural gas reserves. The oil and gas sector accounts for 86% of the total export revenue (Organization of the Petroleum Exporting Countries (OPEC), 2022). Despite its significant natural resources, poverty and unemployment remain widespread in Nigeria. According to the National Bureau of Statistics, an estimated 40 percent of Nigerians (83 million people) live below the poverty line of ₦198,000 (or US$360 per annum) (NBS, 2020) with an estimated 50 million youth unemployed.

There are two seasons in Nigeria, namely the rainy season and the dry season. Though Nigeria's climate varies across different regions, it is mostly tropical. More than 67% of its regions have an abundance of rainfall throughout the year. As a result of this favourable climatic condition, the country has the potential for increased agricultural productivity (Federal Ministry of Agriculture and Rural Development (FMARD, 2016).

Nigeria is the world's largest producer of cassava, yam and cowpea; yet it is a food deficit nation and depends on imports of grains, livestock products and fish. Of the total land size of 910,770 km^2, about 75% (70 million hectares) is considered agricultural land. Only half of this land is currently used for arable farming in 2018 (FAOSTAT., 2022). There is similar potential for an expansion of irrigation, which now only covers 7 percent of irrigable land with most farmers relying on rainfed production (Xie, You, & Takeshima, 2017). In 2017, the area equipped for irrigation was 331,200 ha. However, only 66% of the land equipped for irrigation was actually irrigated because of the need to rehabilitate most schemes (FAOSTAT., 2022).

Most of the rural population cultivate at a subsistence level, using small plots and depending on seasonal rainfall. Pressure from growing populations has resulted in diminished resources, further threatening food production. Over-farmed land, deforestation and overgrazing are severe in many parts of the country. Drought has become common in the north, while erosion and flooding are major problems in the south.

3.2 Geography and Markets

Nigeria has a range of climate zones that are relevant for horticulture crop production. International Köppen classification groups these into three; (i) the Sahelian climate in the northern part of the country, (ii) a tropical savannah/steppe climate in the middle and (iii) a tropical wet climate in the south. The mountainous areas of Jos and Adamawa, close to the Cameroon border, have a more temperate climate (Table 3.1, Figure 3.1). The various climates have the following key characteristics.

Kano, in northern Nigeria, has a dry semi-arid climate suitable for agriculture. The regional landscape is defined by semi-arid plains. The zone has several rivers, the most important being the Kaduna River flowing from the Jos plateau to Lake Chad. In Kano, there is also a major irrigation scheme, the Kano River Irrigation Scheme, which consists of 22,000 ha of irrigated land.

Table 3.1: International Köppen Classification of Nigeria's climate

Area	Climate type	Köppen classification	Designation
South	Tropical rainforest	**Af** – tropical wet – no dry season	Guinean
Central	Tropical Savannah/steppe	**Aw** – tropical and dry – winter dry season (Jos Plateau 1520 m is temperate, AwH Highland)	Sudanic or Savannah
North	Sahel Climate	**Bsh** – Subtropical dry semi-arid – evaporation exceeds precipitation on average	Sahelian

Source: Van der Waal (2015)

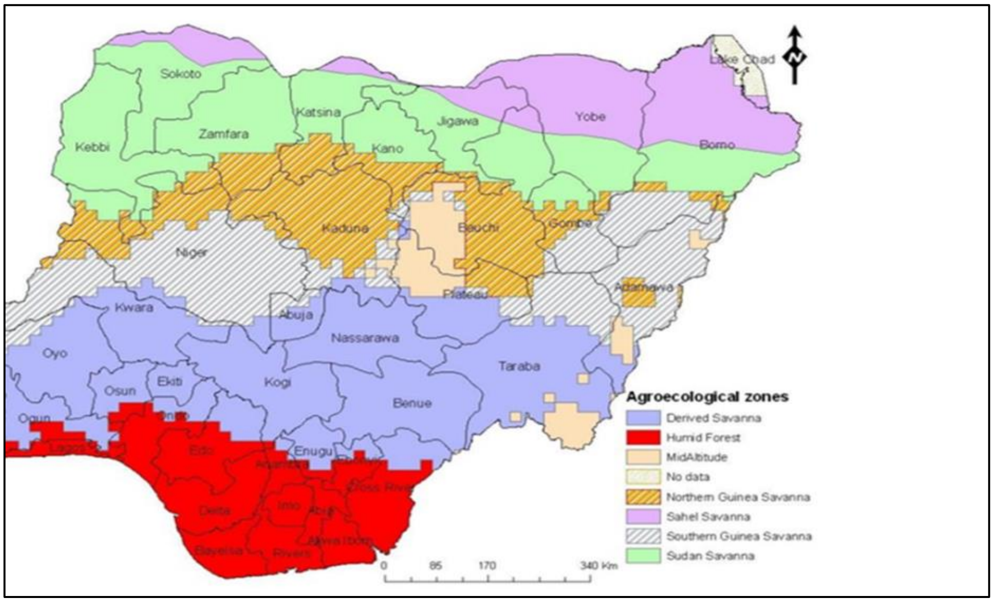


Figure 3.1: Map of Nigeria with different states and agroecological zones
Source:Alamu, A., Nwokedi, Oke, and Lawa (2013).

The main source of water for the irrigation scheme is provided by the Tiga Dam. Another major dam is the Challawa Gorge Dam in the northwest of Kano state (close to Makoda), which irrigates an estimated 10,000 ha (Van den Broek, Steemers, & Bagu, 2021).

Kaduna, in central Nigeria, is characterized by a tropical climate. The central area of the country is an interface between the dry and arid north and the tropical rainforest of the south. The climate is considered tropical wet and dry because a dry (in winter) and a wet season are distinguishable. Vegetation is divided into a variety of forests, steppes and savannahs: a tropical savannah or steppe, the Guinean savannah and the Sudan savannah. Kaduna is located within this climatic area.

The south is characterized by a tropical wet climate with relatively high temperatures. Vegetation is abundant as the region is divided between a tropical rainforest and a mangrove swamp. The southern part of the country is a delta region crossed by two important rivers namely the Benue River and Niger River.

3.3 Notable Production Practices

Production areas and main farming systems

In Nigeria, especially in the Middle Belt, the states of Kaduna, Kano and Jos Plateau, produce over half of the tomatoes, onions and potatoes. Figure 3.2 presents the share of production of some crops for each state. Data was collected by the National Agricultural Statistics Service in 2011 (NASS, 2011). The data presents the share of the total volume produced by the sample size of 18 million farmers. Despite the data being 10 years old, it still gives a representative overview of the relative differences between the states today.

For fruit production, there is no data available on the division per state. In the northern production zones of Nigeria, the main farming system is the smallholder mixed crops and livestock system, with seasonal irrigation. In Kaduna State, the average land size of irrigated dry season production is 0.7 ha (Van den Broek et al., 2021). Estimations for the typical farm size range between 1-3 ha Plaisier, Dijkxhoorn, van Rijn, Bonnand, and Talabi (2019), but there are also some larger-scale farmers, however, their share is limited (estimated at less than 5%). In the southern production zones, farmers rely more on rainfed production.

In addition to the mixed crops and home gardening, which provide an opportunity for people in different backgrounds to provide extra food for themselves and their families, these small-scale farming have a limited commercial outreach. However, the production of fruit and vegetable has been on the rise in Nigeria. Home gardening is also being increasingly recognized as a strong contributor to household food security.

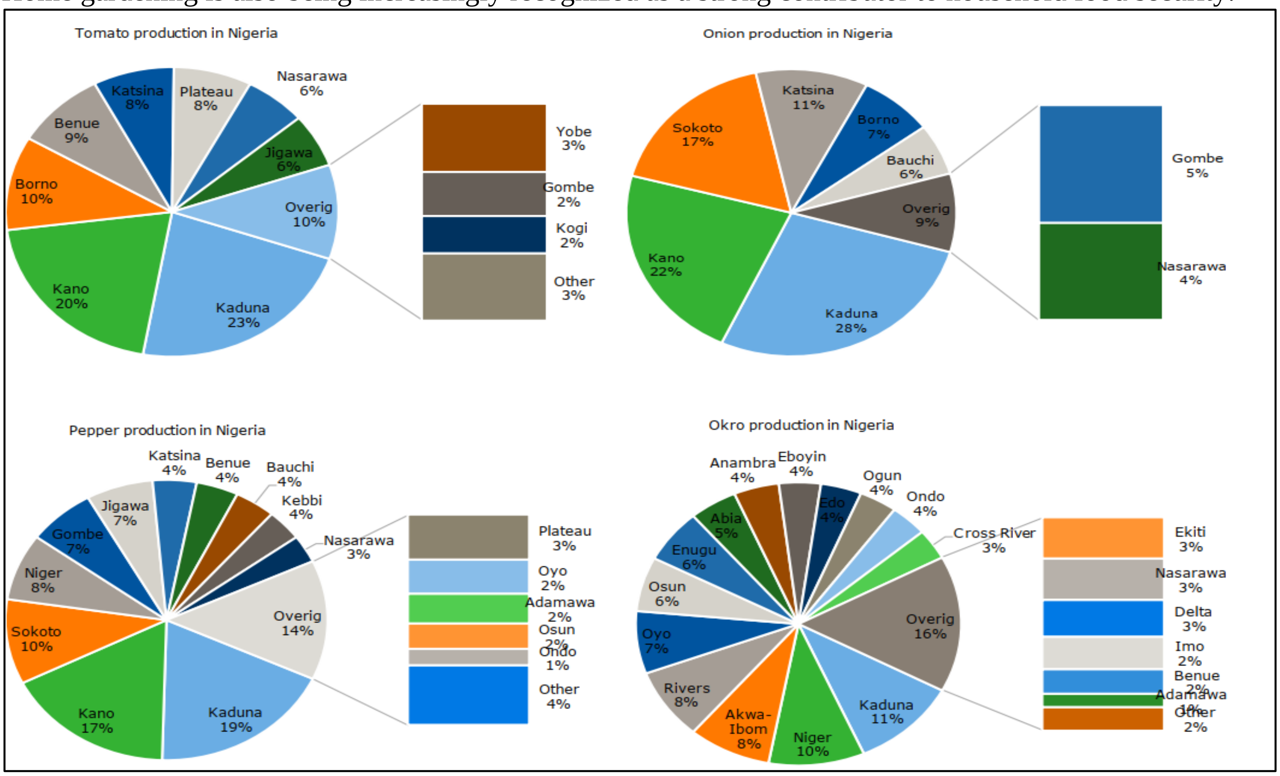


Figure 3.2: Division of different vegetables produced per state, in % of total tonnes
Source: NASS (2011)

Table 3.2: Overview of the different sub-groups for fruits and vegetables commonly consumed in Nigeria

Sub-Group	Sentinel Foods	Health and Nutritional Benefits
Green leafy vegetables	Jute leaves, pumpkin, bitter leaves, garden eggs, sweet potato, cowpea leaves	Contributes to iron, vitamin c, vitamin A and folate intake Reduce dietary risk for heart disease, stroke etc.
Orange and yellow vegetables	Carrots, pumpkin, squash	Contributes to iron, vitamin c, vitamin A and folate intake
Cruciferous vegetables	Cabbage	Reduce dietary risk for cancer
Other vegetables	Tomatoes, garden eggs, okra, cucumber, green pepper or green beans	No specific richness in relevant nutrient
Red, orange, yellow fruits	Mango, papaya, yellow melon	Vitamin C, vitamin A, and folate intake
Apples, pears	Apples	Reduces dietary risk for cardiovascular disease, stroke
Fruits	Banana, guava, pineapple, and avocado	No specific richness in relevant nutrient

Source: Dijkxhoorn, Talabi, and Eunice (2021)

Table 3.2 presents an overview of the different groups of fruits and vegetables that are consumed by a large share of the population in Nigeria.

Tomato

Tomato production in Nigeria is estimated to be about 3,816,000 tons/year and is a major food that is consumed in every household. It is an important part of the Nigerian daily diet (Plaisier et al., 2019) and used for stews or soups. Small-scale processing, packaging and retail of fresh and processed tomatoes are dominated by women.

Onion

Like tomato, onion is one of the most consumed vegetable crops in Nigeria. Retailers are also often women. The vegetable is available throughout the year, as farmers and upstream actors often use storage. There is also a strong regional and global export market.

Amaranth

Amaranth is widely produced and consumed in Nigeria. It is consumed with most dishes such as pounded yam, amala and fufu(Akin-Idowu, Odunola, Gbadegesin, Oke, & Orkpeh, 2013). Amaranth is an adaptable crop, it resists various weather conditions, and the short production cycle present amaranth as a high potential vegetable of importance (Hoidal, Jacobsen, Odone, & Alandia, 2020). The amaranth value chain is largely dominated by women, especially the retail end. Amaranth is consumed mainly for health and nutritional benefits and it is the main source of iron, vitamin C, vitamin A and folate.

Pawpaw

Pawpaw production accounts for 855,581 tonnes per year. Women largely carry out the aggregation of pawpaw from rural communities and sell it to consumers. From a consumption perspective, mango is high in fiber and an important source of vitamin A, vitamin C and folate intake. Consumption of papaya also decreases the risk of coronary heart disease.

Citrus

Various citrus fruits are produced in Nigeria, including oranges, lemons and grapefruits. Orange is a significant crop produced in Nigeria with an annual production of 4.2 million tonnes per year. The citrus value chain is equally dominated by both men and women.

Table 3.3: Selected fruit and vegetable supply chains

Selected fruits and vegetable supply	Focus production area	Economic opportunities	Opportunities for women
Amaranth	Nation wide	Easy to cultivate	Women dominate supply chain
Tomato	North (Kano, Kaduna, Sokoto and Jos)	One of the most consumed vegetables	Women dominate retail
Onion	North (Kano, Kaduna, Sokoto and Kebbi)	One of the most consumed vegetables	Women dominate retail
Mango	North/South	Improved varieties; processing can make it more profitable	Women dominate retail
Pawpaw	Nation wide	Improved varieties; processing can make it more profitable	Women dominate trade and retail
Citrus	North/South	Improved varieties; processing can make it more profitable	Women dominate trade and retail

Source:(Dijkxhoorn et al., 2021)

Table 3.3 presents an overview of some selected fruit and vegetable supply chains in Nigeria. The Middle Belt is the main production area for onion and tomato. Fruits are also widely grown in these northern production areas, although they are grown in more significant quantities elsewhere.

Mango

On average, about 946,695 tonnes of mangoes are produced every year. In the mango value chain, retail, processing and packaging are largely dominated by women. Mango is high in fiber and an important source of vitamin A, vitamin C and folate intake.

Major markets

The Nigerian food system is divided into two main market channels: the formal and informal markets. Figure 3.3 provides a simplified overview of the actors involved in both the formal and informal fruit and vegetable supply chain. In the following sections, the various actors will be discussed in more detail.

Farmers

Production of fruits and vegetables is mainly undertaken by smallholder farmers (Dijkxhoorn et al., 2021). Traditional mixed vegetable cropping systems are the most common production systems. Onions, tomatoes and amaranth are often produced in mixed crop and livestock farming systems. Tomatoes and onions are grown to a large scarlet in Fadama (seasonally irrigated flood plains) in the Northern savannah. Amaranth is produced across Nigeria and throughout the year.

Wholesale traders

Wholesale traders have a dominant position in connecting farmers to consumers. The majority of farmers sell to travelling collectors, with only a small minority taking their produce directly to the market. Traders provide an important intermediary service for both farmers and consumers. Exploitative behaviour, and high levels of informality, are significant challenges for the fruits and vegetables supply chains in Nigeria. This hinders marketing efficiency because they do not keep records of day-to-day financial activities, and this prevents traders from obtaining loans from formal financial institutions (Reardon, 2015).

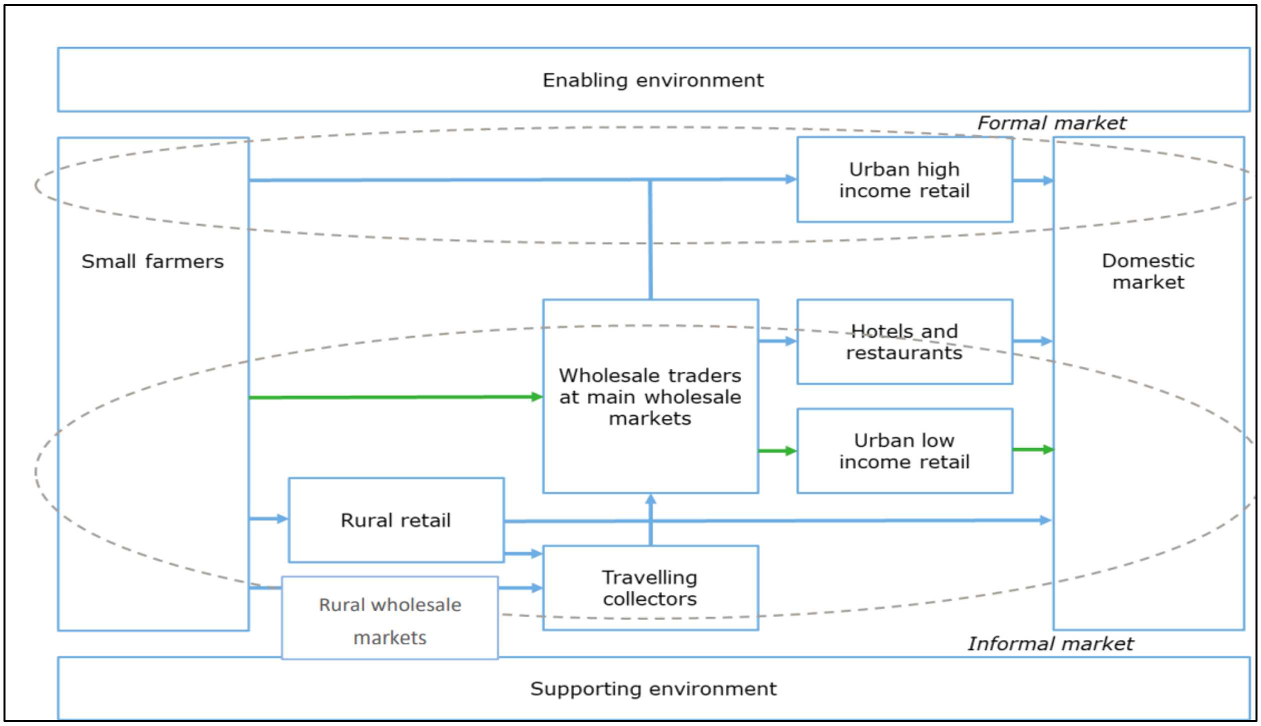


Figure 3.3: Vegetable and fruit supply chain, distinguishing the formal and informal chain
Source:(Dijkxhoorn et al., 2021)

Retailers

The Nigerian food retail sector is divided into two main market channels: the formal and informal markets. Two different types of urban market segments can be distinguished: urban high income and urban low income. Dijkxhoorn et al. (2021) noted that about 95% of the informal market mostly sells food. There is the emergence of supermarkets in Lagos and Ibadan that serve the higher-income classes and middle-class consumers. The lower-income classes purchase fruits and vegetables in informal wholesale and retail markets (corner shops).

In Lagos alone, there are more than 30 informal (wholesale) markets located in neighborhoods where fresh fruits and vegetables are sold. The markets are often private but are supported by the (local) government. However, the main wholesale market in Lagos is Mile 12. The market is located along the Ikorodu Road and serves as the main distribution center for vegetables and fruit arriving in Lagos.

Sourcing of fruits and vegetables often occurs at rural informal wholesale markets. Key markets for the different crops are:

- For tomato and onion, these are Kwanar Gafan tomato markets and Karfi yan Albasa respectively in Kano while notable markets in the south-west are Total market in Akure, Ondo State, Sasa/Akinyele and Bodija markets in Ibadan, Oyo State, Sabo market in Abeokuta in Ogun State, and Ilepo and Mile 12 in Lagos State
- Amaranth is picked up everywhere since it is an easy-to-produce crop and produced virtually in every region in substantial quantity.
- Citrus and mango are produced and traded in Benue State. For these crops the main markets are Makurdi market and Railway market both in Makurdi LGA, Wurukum market and Agidi market both in Konshisha LGA, and Austoma market in Gwer LGA in Benue.
- Pawpaw markets in the south-west can be found in all major fruit and vegetable markets. The notable urban markets are Oje market in Ibadan, Oyo State, and Ketu market in Lagos.

3.4 Horticulture Biophysical

Inputs

Seed Systems in Nigeria

The production of seeds is supervised by the National Agricultural Seed Council (NASC). However, there is a large presence of local government in seed production and distribution. As a Federal State, the NASC oversees the production of seeds. At the State level, Agricultural Development Projects produce foundation seeds and improved seeds to be sold to seed companies and farmers. Every State has its own Agricultural Development Projects that play a role in the development and production of seeds, especially for the staple crops. The National Agricultural Seed Council of Nigeria is a specialized agency overseeing the Nigerian seed industry to assure affordable access for farmers to improved quality seeds. The seed industry is organized into the seed association of Nigeria, with its office in Zaria.

For vegetables and fruits, farmers use local varieties and informal seed sources. There are many varieties of fruits and vegetable seeds often adapted to specific locations, and various farmer and customer demands. The formal commercial seed sector serves only a small portion of vegetable producers, more often supplying commercial markets with quality seeds and improved varieties, such as tomato, onion, and peppers. The informal sector remains particularly important for other vegetables (including especially African leafy vegetables) and fruits. The private sector now constitutes 13% of variety releases in the seed market, with the public seed sector constituting the remaining 87%.

There are several national and global seed companies in Nigeria. According to the NASC, there are 157 registered seed companies in Nigeria. Seed sector reform in Nigeria has led to the development of seed companies, but at a much slower pace than in Asia, and Eastern and Southern Africa.

Farmers growing fruits and vegetables use multiple seed sources. These sources include farmer-saved seed or planting material (fruit crops) from neighbours or informal markets or nurseries. Fruits and vegetable seeds are mostly imported into Nigeria. Vegetable farmers purchase small packs of seed from regional or national companies, opting for quality seed that may be open-pollinated varieties (OPVs). There is low adoption of hybrid seed varieties among vegetable and fruit farmers. Smallholders currently prefer OPVs as they lend themselves to on-farm seed saving.

Most vegetable farmers in Osun, Ogun, and Oyo States use improved seed while about 60% use seed collected from previous harvests and 30% purchase from seed dealers. Improvement of cultivars with better storage and transport capability, better resistance to diseases and drought tolerance, presents an important business opportunity for seed enterprises. Seed companies can invest significantly in local research and demonstration facilities.

Premier, one of the leading seed companies produces its own inbred lines for hybrid maize. Premier also produces seeds of OPV maize, rice, soybeans, cowpeas, groundnuts, sorghum, pearl millet, cotton, okra and various local leafy vegetables, such as tete (*Amaranthus hybridus*), soko (*Celosia argentea*) and ewedu (*Corchorus olitorius*). Premier imports seeds of tomato, watermelon, cucumber, carrot, onion, sweet pepper, cabbage and lettuce. Other companies are Alheri Seed, Nagari Seed, Maslaha Seed (Van der Waal, 2015).

Fertilizer

These are external inputs used for soil fertility conservation in Nigeria. Improving soil fertility maintenance is therefore of the greatest importance. Farmers use organic and inorganic fertilizers in fruits and vegetable production. A major reason for the high soil nutrient deficiency is the low level of fertilizer use in Africa compared to the rest of the world.

Among the factors influencing the effectiveness of fertilizer usage are the poor road and transportation systems. This increases the farm gate prices of fertilizers (Liverpool-Tasie, Omonona, Sanou, & Ogunleye, 2017). Where rain-fed agriculture is dominant, and improved seeds are not present, farmers find it too risky to adopt fertilizer use (certainty to increasing cost price, uncertainty to have higher yield, hence higher risk of lower economic return). Additionally, the low level of education of farmers affects the proper use of fertilizers. Fertilizer application (type, dosage, timing) needs to be carefully adapted to the type of soil, type of crop and the condition of the soil.

Production

Horticultural products in Nigeria are mostly manually cultivated by subsistence farmers on a small scale. The production of horticulture crops is not done with irrigation systems, it is rather dependent s on the use of water from wells, boreholes and rainfall (FAO, 2016). Results from (Kainga & Johnson, 2012) established that small-scale farmers engage more in horticultural production. This limits their capacity to access the international market.
Poor control of insect pests and diseases was identified as a constraint to horticultural production (Ibeawuchi et al., 2015). Farmers still rely on traditional methods to control pest infestations, because these methods are cheaper. Farmers lack knowledge of pesticide usage in Nigeria. As indicated by Ugwu, Omoloye, Asogwa, and Aduloju (2015), many of the farmers need to be educated on appropriate pest control measures to improve the yield and quality of their products.

Processing and packaging

The fruit and vegetable processing industry is still in its infancy and is uncoordinated. A key processing challenge is the lack of tomato varieties suitable for processing. The import of raw materials from abroad also jeopardizes the competitiveness of the domestic processing sector. Another issue is the volatile supply and the high cost of raw materials.

Table 3.4 Processing companies of fruit and vegetable in Nigeria

Processor	Location	Classification
Tomato Jos	Kaduna	Large scale, tomato
Dangote	Kano	Large scale, tomato
Dangi foods	Abuja	Large scale, tomato
Nature's Bounty Health products	Legos	Medium, dried fruits
Dansa holdings limited	Legos	Large-scale, fruits and beverages
Gunni royals tomato paste and allied company	Oyo	Medium focused on tomato
Frutta juice and service limited	Legos	Large-scale, fruits juice
Mystrose limited	Abuja	Small scale, vegetable mix
AACE foods and processing	Ogun	Medium-scale, dried spices

Source: (Dijkxhoorn et al., 2021)

For example, processors need a constant supply of raw material at an affordable price to be able to offer a competitive product to consumers. Some studies (Plaisier et al., 2019; Ugonna, Jolaoso, & Onwualu, 2015) also confirmed some of these challenges faced by the Nigerian processing industry. To overcome some of these barriers, some large processing company has set up dedicated out-grower schemes and provided farmers with technical support and inputs.

Table 3.4 lists the key processing companies active in the fruit and vegetable supply chains. In recent years there has been a small increase observed in companies processing fruit juices on a small scale, possibly due to the ban on imported fruit juices and juice concentrates. Some processors, mostly at the downstream end, are focused on value addition using innovative approaches. One company is producing a pasteurized tomato, pepper and onion mix which is used as a ready-to-cook product for stew making. A big player like Dangote Tomato Processing also makes tomato concentrate and puree. For mango, there is a small and medium-sized enterprises (SME) making mango chips. Some SMEs also specialize in dry food mix packaging destined for retailed markets in urban areas (e.g. ReelFruit in Lagos).

3.5 Natural Resources

Water

Water availability and quality are a challenge to the development of the horticulture sector in Nigeria. Although the northern parts of the country (Kano and Kaduna) have access to water through dams, water is a relatively scarce resource in Nigeria. Agricultural intensification will require good irrigation and water conservation methods to ensure its sustainability. Investments in improving the water system is required ((FMARD, 2016). In 2015, only half of the fertile land was used for farming activities and only 7% is grown under irrigation (Van der Waal, 2015).

Soil

The soils in Nigeria are comprised of various soil types, such as listed in Table 3.5. Ferralsols is the well-known, strongly weathered reddish or yellowish soil of the humid tropics. They have good soil physics with a high percentage of clay minerals and are rich in iron and aluminium oxides, which cause the red colour, but have a poor nutrient holding capacity, especially phosphate. Their acidity requires frequent liming and fertilization.

Table 3.5: Major Soil Types in Nigeria

Agro-Ecological Zone	Major Soil Types
Humid forest	Ferralsols, Nitisols, Gleysols
Coastal Savannah	Ferralsols, Luvisols, Nitisols, Arenosol, Acrisols, Lithosols
Guinea savannah	Ferralsols, Luvisols, Acrisols, Lithosols
Central Savannah	Ferralsols, Nitisols,

Source: Salako (2004)

Nitisols are well-drained, weathered soils with high percentages of clay minerals. They have a good structure and a high cation exchange capacity, allowing them to keep nutrients. They are neutral to alkali and have favourable characteristics. They are considered to be the most fertile and productive soils in the tropics, especially when phosphorus is added. Acrisols are strongly weathered acidic soils with low fertility. Luvisols are heavy fertile soils, where water logging may be a problem. Lithosols are rock soils with very low fertility.

The quality of soils on the savannahs seems to be generally fragile, with shallow top soils, relatively acidic, and relatively coarse particles. The coarse sand particles limit the water retention capacity of the soils. This compromises the resistance to drought for the crops that are grown.

Climate

Climate change is an important factor affecting the mainly rain-fed agriculture in Nigeria. Ogungbenro and Morakinyo (2014), studied weather station data over a 90-year period and found that in the three climate zones, marked shifts in average rainfall could be observed. Figure 3.4 clearly show how the climate zones have become drier, with peaks in the curves shifting to the left, towards lower amounts of rainfall. As some of the curves also become wider, this shows that the variability also increases. There are no climate-smart practices or effective resilience policies developed.

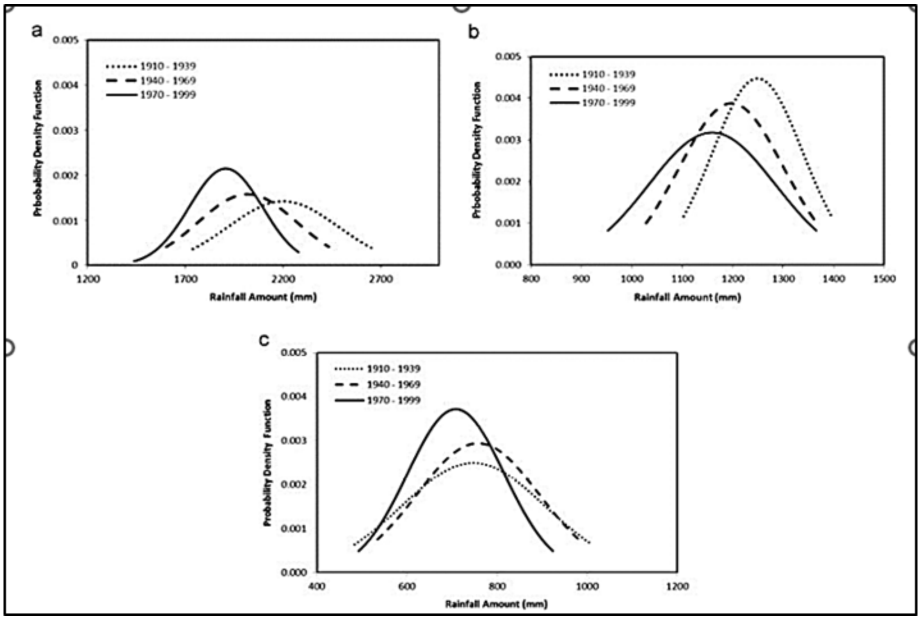


Figure 3.4 A shift in average annual rainfall in the main climate zones: a = Guinea zone, b = Sudanic zone, c = Sahelian zone from 1910-1999;
Source: Ogungbenro and Morakinyo (2014).

In conclusion, for the Sahelian zone, farmers need to adopt farming techniques that are resilient to poor rainfall patterns. Crops with a short growing cycle, drought-tolerant crops and cultivars will be important to decrease the risk of failed harvests. Irrigation can also be an important strategy to reduce dependence on rain.

3.6 Socio-economic

Women in horticulture

Women account for 75% of Nigeria's farming population, yet, women's overall productivity and capacity in the different parts of the value chain remain low (Olakojo, 2017). Women farmers and entrepreneurs continue to face disadvantages, including lower mobility, less access to training, less access to market and information, and less access to productive resources such as credit, land and labour-saving processing technologies. Increasing access to food production provides opportunities for them to earn extra income that would enable women to spend more money on health care, nutrition, and education for their children – investments that could produce long-term, positive results for families that are dependent on the fruit and vegetable value chain(Gustavsson, Cederberg, Sonesson, Van Otterdijk, & Meybeck, 2011).

Women have more prominent roles in post-harvest activities and their ability to have access to land for production depends on their husbands or fathers. Vegetable production continues to be a profitable enterprise for women despite challenges that constrain them. Fruit and vegetable value chains provide women with economic opportunities as producers, and value-addition activities from production to marketing.

Traditional green leafy vegetables (GLVs) are important crops in Nigeria and are a major source of income for women entrepreneurs (Kelechi & Dorothy, 2015). The nutrient-rich and inexpensive amaranth vegetable value chain is largely dominated by women, especially at the retail end of the value chain. Amaranth possesses tremendous potential for income generation among women because it is mostly purchased by consumers, easy to grow, highly affordable for the consumer, easily available, and requires minimum production inputs. Unlike staple crops like cassava and yams – which need large parcels of land, take a long time to mature and whose value chains are traditionally managed by men – amaranth can be produced on small parcels of land and is culturally acceptable for women to produce. Since women are likely to have access to less land than men, GLVs such as amaranth are an easier crop for women agri-preneurs to produce (Umar, Sadiq, & Suhasini, 2019). The fresh onion retail trade is dominated by men due to gender barriers at the production level that make it difficult for women to access land and other production resources (Kaka, Gindi, & Magaji, 2021). In the tomato sector, small-scale processing and packaging are often dominated by women.

In the fruit value chain, women are key actors in retail (Ocholi, Nyiatagher, & Ayila, 2020), and in processing activities. For example, mango processing and consumer-targeted trading is largely dominated by women. Similarly, for pawpaw, the downstream supply system is largely dominated by women. However, in the citrus value chain, both men and women are involved in retail activities. Agricultural development research needs to highlight the roles, contributions and gender-specific challenges that women in Nigeria face in different fruit and vegetable value chains. Addressing sociocultural factors such as cultural norms, that serve as barriers women's agribusiness initiatives can also enhance their profits.

Market and consumption

Demand for nutritious fruits and vegetables

Many consumers in Nigeria are focused on consuming affordable sources of energy instead of nutrient-rich food. As a result, intake of fruits and vegetables remains under the daily recommendation of 400g. According to Olatona, Onabanjo, Ugbaja, Nnoaham, and Adelekan (2018) only about 27% of respondents reported adequate daily intake of fruits and vegetables as recommended. Other studies in Nigeria reported much lower percentages such as 5.5% among Junior Secondary School students in Surulere, Lagos, 12% among adolescents in Ibadan, Nigeria (Ilesanmi, Ilesanmi, & Ijarotimi, 2014). However, reliable data on food intake in developing countries (including Nigeria) are scarce and limited.

The available information on expenditure reveals that the consumption of fruit and vegetables remains insufficient to meet daily recommendations. The Global Burden of Disease Murray et al. (2020) provided estimates of daily per capita consumption of 238 g vegetables and 84 g for fruits per day per person. Six disparities are observed in the consumption of fruits and vegetables across the country and between income classes. As a result, this study specifically differentiates between different consumer groups: urban high-income classes, the middle classes, and low-income classes.

Trade

In Nigeria, horticulture export is almost non-existent (EuropeanCommission, 2015; FAOSTAT, 2016a ; UNCTAD, 2016) unlike in Egypt and Kenya. Nigeria is the main African country producing mangoes in large quantities and one of the top mango producing countries in the world.

According to Thomas (2012), several horticultural crops such as lettuce, cucumbers, spring onions, amaranth and eggplants are produced in Nigeria.

Major constraints affecting the development of the horticulture sector are a lack of policy, absence of institutional support, absence of agricultural extension practices, poor technological and marketing infrastructure, a lack of credit facilities, a lack of land (in urban areas) and water (Thomas, 2012). Food safety and health certification issues, low economies of scale, a lack of organic farming techniques, infrastructure and an enabling national regulatory framework are the constraints that have prevented Nigeria from accessing international markets.

Import and export trade

According to the Federal Ministry of Agriculture and Rural Development FMARD (2016), there are serious annual demand gaps for vegetables, including tomatoes (1.4 million tonnes). This is a result of low yields, high post-harvest losses and increasing demand (FMARD, 2016). In addition, vegetable production has not been able to keep pace with Nigeria's increasing population; the high demand is met by import. Food imports have more than quadrupled in the past decades, from a value of US$ 964 million in 1995 to US$ 4,566 million in 2016 FAO (2019), resulting in a substantial trade deficit for the agri-food sector.

3.7 Research, Education and Training

Education and training needs in horticulture

Farmers have very limited knowledge of plant diseases and pests. The extension services are not able to accurately advice farmers. Advice is usually given by chemical sellers, but that advice may not be appropriate. This leads to frequent overdosage of pesticides and the application of the wrong pesticides. Training of farmers, training of extensionists and intensifying land use leading to higher yields can help develop the fruit and vegetable industry and mitigate social tensions and pressure on the land.

Research capacity of technical vocational institutes, universities and research institutes

National Agricultural Research Institutes (NARIs) play a significant role in the agriculture sector. NARIs, among others, produce foundation seeds. Nigeria has a large national agricultural research and extension service; however, their research has traditionally not been focused on fruits and vegetables, but mainly on other crops such as cereals. Public agricultural research institutes are critical for varietal development, however public investment in the development of vegetable and fruit varieties is inadequate. NARIs are made up of 17 commodity-based research institutes, a specialized national agricultural extension institute, 18 faculties of agriculture in regular federal universities, and three specialized agriculture universities (Van der Waal, 2015). Moreover, the Consultative Group on International Agricultural Research (CGIAR) is an important player in Nigeria, with ongoing activities, particularly through the International Institute of Tropical Agriculture (IITA) in Ibadan.

Most of the States have universities which in many cases have an agricultural faculty. They provide research for development. The study by Van der Waal (2015) shows that much useful research is done at these institutions, in many cases with limited means, but often of high relevance. The trick will be to turn the research into policy and practice, so that research leads to development.

The National Horticultural Research Institute is located in Ibadan and is part of the Agricultural Research Council of Nigeria. Ibadan hosts the International Institute for Tropical Agriculture (IITA), a CGIAR branch, focusing mainly on food staples, such as maize, rice, yam and cassava, but also on plantain and banana. Table 21 lists the most important Nigerian universities with agricultural colleges and schools, as well as the major research institutes.

An important agenda for research could be the further study of the relation between different interventions or strategies for improved production, yields, quality and hence food security. While there are ample studies into the effect of single improvement strategies, such as fertilizer application, there are limited studies where the relation between more than one is taken into account, like e.g., fertilizer and irrigation, or irrigation and improved seeds use. Horticulture is a multi-factorial production system, where inputs are complimentary. The absence of one factor may render useless the increase of another factor (Takeshima, 2011).

Table 3.6: Nigerian Universities with Agricultural Colleges and Research Institutes

University/College	Location	State
Federal College of Horticulture	Dadin Kowa	Gombe
Landmark University	Omu-Aran	Kwara
Ahmadu Bello University	Zaria	Kaduna
Federal College of Animal Health and Production Technology	Moor Plantation	Ibadan
Feral college of agricultural Produce and Technology	Kano	Kano
Federal College of Agriculture	Ibadan	Ibadan
Federal College of Agriculture	Ishiagu	Ebonyi
Kwara State University	Ilorin	Kwara
Ladoke Akintola University of Technology	Ogbomosho	Oyo
Feral University of Technology Oweri	Owerri	Imo
Michael Okpara University of Agriculture	Umudike	Abia
Obafemi Awolowo University	Yola	Adamawa
Federal University of Agriculture	Ile-Ife	Osun
University of Agriculture	Abeokuta	Ogun
University of Ibadan	Makundi	Benue
University of Nigeria	Nsukka	Enugu
National Horticulture Research Institute	Ibadan	Oyo
Agricultural Research Council of Nigeria	Abuja	FCT
International Institute for Tropical Agriculture	Ibadan	Oyo

Extension Capacity in Public and Private Sector

Extension activities are important for the development of the horticulture sector. All the States have Agricultural Development Projects, which provide agricultural infrastructure and the main vehicle for agricultural extension. It has already been mentioned how important extension services are to improve the quality and productivity of horticultural production.

3.8 Policy and Horticulture

The enabling environment for agriculture development in Nigeria is improving but is still very challenging. The Agriculture Transformation Agenda in Nigeria is and has been, the key to agricultural development.

Food security, import substitution, job creation and economic diversification are priorities of the new agricultural promotion policy.

The Federal Government concentrates on supporting the development of a conducive enabling environment. Policy emphasis is on providing a conducive legislative and agricultural knowledge framework, macro policies, security, enhancing physical infrastructure and institutional mechanisms for coordination and enhancing access to adequate inputs, finance, information on innovation, agricultural services and markets. However, in general, policies are considered to be ineffective and lacking enforcement.

The formal seed sector is run by FMARD, and the National Agricultural Seeds Council (NASC), which works under FMARD, and is a member of the Crop Varieties Registration and Release Committee (CVRRC). The CVRRC is responsible for varietal evaluation, release and registration in the national catalogue of registered and released varieties. NASC is a statutory government agency with the responsibility of coordinating and regulating the seed industry. It advises the government on seed-related programs and is responsible for quality control through certification procedures and enforcement of quality standards. Before varieties are officially released, NASC forms part of the committee that evaluates the technical procedures and parameters.

CÔTE D'IVOIRE

4.1 Context

The horticulture sector in Côte d'Ivoire is characterized by fruits and vegetables both for local market consumption and export. The local market constitutes of a multitude of smallholder farmers growing fruits and vegetables with low application of modern technology. Old varieties and extensive techniques are used. The markets are scattered, and no independent cool chain is employed, other than supermarkets. The quality of the products is generally low, which compel the supermarkets to import high-quality fruits and vegetables, mainly from Morocco and France. The fruit export consists mainly of banana, mango, pineapple, and papaya. The banana sector is dominated by two companies who control the sector by vertical integration. Little opportunities exist in this banana sector for other players. The mango exports are done by independent exporters from mostly medium-sized farms. Only a few bigger ones exist. The main export of destination for mango is Rotterdam.

Opportunities for improvement of the horticulture sector in Côte d'Ivoire exist. High-quality seeds, soil analysis services, plant protection products, and good quality fertilizers are needed. Intensification of production practices can improve quality and yields per ha enormously and enhance the income of the farmers. For the export crop specifically, the main challenge is the high number of notifications of phytosanitary interceptions in Europe of Quarantine organisms that can ultimately lead to an embargo for export into the (whole) European Union. Opportunities exist for the adoption of best practices in phytosanitary and the establishment of highly specialized companies active in biocontrol of those organisms. The establishment of independent cold chains for individual and smallholders' fruit and vegetable could as well reduce post-harvest losses and improved the quality of fruit and vegetable.

4.2 Landscape Challenges and Opportunities of Fruits and Vegetables

Diagnostic

The production and area cultivated increased between 2000–2020, sometimes even by 100%, with extraordinary growth in the case of dry chilies and peppers. Although the income of farmers has improved over the past two decades, there are still poor and vulnerable groups, living mainly around big cities. Those people are the cheap labour reservoir for the urban economies. They often don't own land but a lot of them produce vegetables on very small plots and sell them at the urban market via middlemen. The money earned is mainly used to buy staple foods and pay their children's school fees. To maximize profits, a very intensive production is needed with multiple harvests per year. Around Abidjan, we see a high percentage of immigrants from Burkina Faso, or the north of Côte d'Ivoire involved in vegetable production on small plots of land.

Table 4.1: Fruit and vegetable production and cultivated area in Côte d'Ivoire

	Year 2000		Year 2010		Year 2020	
Item	**Cultivated Area (ha)**	**Production (tonnes)**	**Cultivated Area (ha)**	**Production (tonnes)**	**Cultivated Area (ha)**	**Production (tonnes)**
Avocados	4770	20032	4878	30077	5332	35415
Bananas	7800	305300	7760	314270	13990	625981
Beans, dry	22988	20689	38725	33102	44300	37849
Beans, green	970	3269	1500	4436	1674	4969
Chilies and peppers, dry	14285	18000	21000	95000	25045	127642
Chilies and peppers, green	4015	23283	4200	25000	3857	26522
Coconuts	35000	230000	30000	150816	41154	105660
Cucumbers and gherkins	3874	16245	4500	19607	4272	20721
Eggplants (aubergines)	4914	63667	11881	83983	20879	109052
Fruit, citrus nes	2633	31074	3000	37754	3412	43251
Fruit, fresh nes	1550	9000	3500	18000	3986	20947
Fruit, tropical fresh nes	30789	44105	35579	46240	39555	49857
Mangoes	50331	23655	84000	45206	169921	103420
Okra	39644	92685	47000	125748	67285	188736
Onions, shallots, green	717	5130	850	7300	845	7980
Oranges	2619	29248	2900	35797	3208	40558
Papayas	2095	3981	4958	11626	5662	13992
Pepper (piper spp.)	977	1079	588	480	124	63
Pineapples	7663	238000	1194	68212	800	50893
Pumpkins, squash, gourds	1753	16030	2050	19635	1978	19297
Tomatoes	2331	23026	3300	31241	4550	47283
Vegetables, fresh nes	11772	95891	16577	136222	17858	147241

Source: FAO, 2020

Production Areas

Fruit and vegetable producers are mindful of the distance to the market and the climate. Nearly everywhere in West Africa, highly perishable vegetables like lettuce and other leafy vegetables are grown in urban areas. For instance, at the end of runways of airports, you will always find them and Abidjan is no exception. The logic is that the land is close to the market, but forbidden for building structures, so perfect for vegetables. Further away, less perishable vegetables and often fruits are grown. Being close to a highway speed up the development of these production areas. Highways such Abidjan–Yamoussoukro-Bouake have boosted the production of fruits and vegetables as transport prices have reduced significantly. Storable and transportable crops like onions mostly come from Sahelian countries like Niger, Mali, Burkina Faso etc. The onions can be stored for a while when dried properly. A big part of the harvest is transported to the coastal urban areas of the richer, neighbouring countries like Ghana.

Climate Zones

Côte d'Ivoire has several climate zones suitable for vegetable growing:

- A narrow coastal zone is suited for 'European' vegetable growing during the dry seasons because of the temperate influence of the sea.
- More inland temperatures are higher and more suitable for tropical fruits and vegetables. During the rainy season, vegetable growing can become difficult because of too heavy showers and high relative humidity, causing bacterial and fungus diseases. Fewer insect problems occur in this season.

- In the north with less rainfall, irrigation is needed. The relative humidity is lower and gives fewer problems with diseases, but pests can become a nuisance. In the cooler ‘winter’ period, onions and other ‘European’ vegetables can be grown.

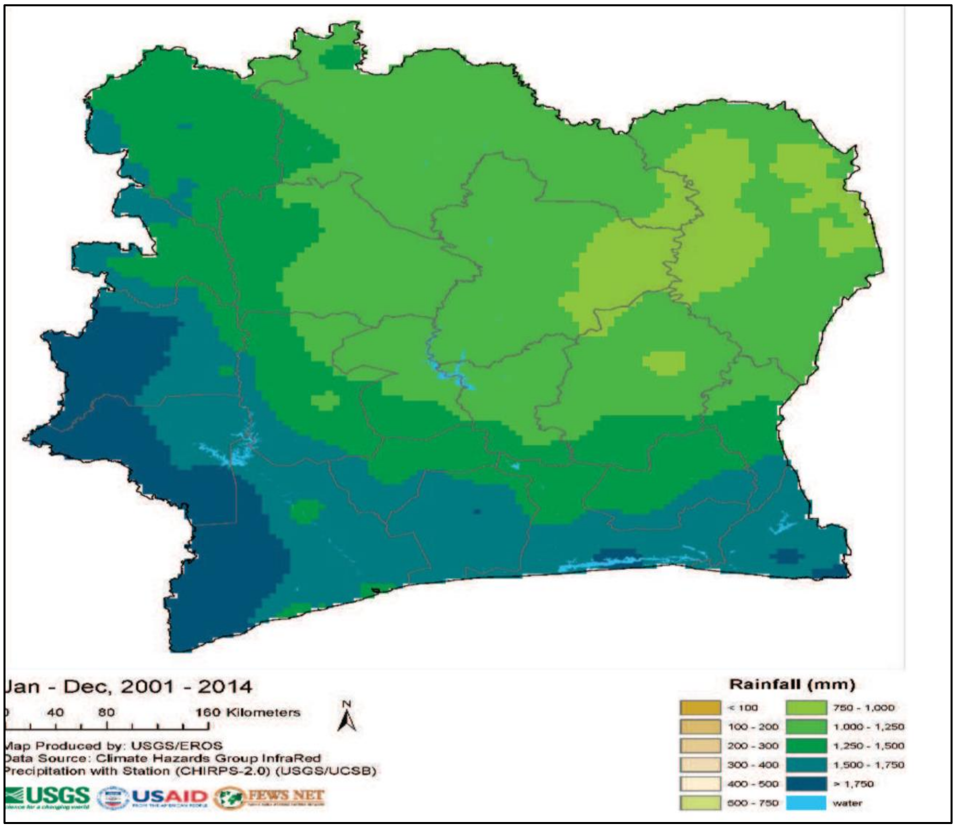


Figure 4.1: Historical Average Rainfall (mm/year) in Côte d’Ivoire

Vegetables produced can be divided into exotic or European types including lettuce, onion, garlic, tomato, cabbage, carrot, string bean, cucumber, bell pepper, European eggplant etc.) which are grown in Africa at lower temperatures during ‘winter’ time and tropical vegetables which require higher temperatures (African eggplant, chili pepper, okra, bitter leaf, jute leaf, cowpea leaf, amaranth, hibiscus leaf etc.). Growing these ‘European’ vegetables in the hot season ('off season'), will consequently lead to problems related to temperature (too high); rain (too little, too much, not well distributed, too high relative humidity etc.); pests and diseases (as a result of non-adapted varieties and adverse climatic conditions); non-adapted genetics.

Markets

The main markets for fruits and vegetables are the traditional open markets in the urban centers of Côte d’Ivoire. The customers have some purchasing power and are mindful of their diet. It is estimated that 90% of the fruits and vegetables produced for the local market are sold at the farm gate by the farmer to the middlemen (or women), transported to towns and sold to wholesalers at certain large wholesale markets, mostly in the outskirts of towns.
In Côte d’Ivoire, the retail market women come to buy their supply for their daily sales in smaller markets. These markets are highly seasonal. When products become rare and thus expensive, they disappear from

the market. The middle- and higher-class customers purchase their fruits and vegetables in specialized shops and supermarkets. This sector is growing fast.
Companies in Côte d'Ivoire, like Prosuma, buy fruits and vegetables from local farmers and sell them to supermarkets (Casino excluded). Prosuma's main problem is to ensure constant availability of the same vegetables all year round, regardless of the season. Buying fruits and vegetables from Morocco, South Africa or Europe is much easier as most products are available the all year round. In supermarkets in Côte d'Ivoire, we do see a lot of products from abroad at huge prices difference. Adoption of technology such as irrigation might contribute to reducing the seasonality variability in the supply of fruit and vegetable in Côte d'Ivoire. The features of fruits and vegetables growing in Côte d'Ivoire as a whole can be summarized in table 23 below.

Table 4.2: SWOT Analysis of markets in the Horticulture Sector in Côte d'Ivoire

Strengths	Weakness
• Good climatic conditions for commercial fruit and vegetable production. • Profitable activity for growers • Employment for young and old along the whole value chain • Motivated growers and entrepreneurs available • Good access to urban markets • Growing need for fruits and vegetables in the urban areas • Ongoing research and practical trials to improve and intensify the existing production • Systems are already carried out on a small scale	• Scarcity of land in and near urban areas • Climate change can give rise to unpredictable heavy showers or dry spells • Poor soils • Lack of access to soil laboratories • Lack of more efficient irrigation and drainage systems • Lack of affordable loans for investment • Inadequate technical know-how and education • Lack of cheap labour close to the consumption areas • Lack of mechanization • Handling and transport are suboptimal • Road network is not yet optimal but improving a lot!
Opportunity	**Threats**
• Intensification: the use of improved seeds, specialized fertilizer, biocides, better techniques etc. on a smaller area is already being practiced and can be improved further on • All-year-round production of vegetables • Organic fruits and vegetable niche market • Commercial vegetable growing is lucrative and creates employment • Offers opportunities for enterprising young people.	• Wrong and excessive use of biocides giving the local product a bad image

Fruit export sector

The fruit export sector in Côte d'Ivoire is important as it generates foreign currency and employment. In general, this sector has experienced some challenges in recent years, but it is starting up strongly again. The world market for exotic fruits is growing fast. Côte d'Ivoire has an advantage in the European market over Latin America because of its shorter distance to Europe.

Table 4.3: Main features of the fruit export sector in Côte d'Ivoire

Main features of the fruit export sector in Côte d'Ivoire					
	Banana	**Mango**	**Pineapple**	**Papaya**	**Others**
Area of production in Côte d'Ivoire	South and Central	North	South and Central	South	Anywhere
Production scale of companies	Large	Medium Small	Medium Small	Small	Small
Ranking main export destination countries	1. France 2. Belgium 3. UK	1. Netherlands 2. Belgium 3. France 4. UK	1. France 2. Belgium 3. Netherlands 4. UK	France	Hardly any export yet

a. Banana

The banana production and export are the main fruit business of Côte d'Ivoire. Banana is grown mainly in the coastal and central areas of Côte d'Ivoire. After the eighteen years of 'Banana wars' between Europe (with preferential customs tariffs for African bananas) and the Americas via the WTO, the production and market has changed considerably. Latin America is the main competitor for the Côte d'Ivoire banana sector. Some changes that are observed lately is that the north American buyers try to protect their position in Latin America against European buyers. This makes the Côte d'Ivoire banana production more important for Europe. The export crop is grown on large plantations, owned by two French companies: i) SCB: mother company in France: 'Compagnie Fruitière', exploits 4000 ha ii) SCAB: mother company in France: Canavese; exploits 1900 ha. Both companies have a large number of expat personnel and control the whole value chain: growing, packing, transport to port, loading on specialized vessels for transport to Europe.

Table 4.4: Exports of bananas into the EU countries from Côte d'Ivoire in tons

Exports of bananas into EU (tons)				
Country	2017	2016	**2015**	**2014**
France	166828	136468	120234	126861
Belgium	82709	99745	88794	81052
UK	74969	43247	40893	37724
Netherlands	0	40	0	0
Total EU	324507	279500	249921	245637

Over-dependence on a single crop is risky, and the large French companies are trying to diversify. Large trials with sweet corn (for the Dutch market) have been undertaken by SCB. Attempts of SCB to diversify with pineapple were also not very successful. SCB has become involved in mango export from the north which has turned out to be more profitable.

Table 4.5: SWOT Analysis of the Banana fruit sector

Strengths	Weakness
• Vertical, top-down, organized value chain (from farm to arrival port in Europe) assuring good quality and profitability. • Access to European and Latin America markets. Côte d'Ivoire is 2000 km from Europe. Latin America is at least 5000 km from Europe.	• The civil war in Côte d'Ivoire has negatively influenced the production, economy, investment and export of bananas since 2009. • Inland transport is difficult because of poor road networks. • Lack of processing industry for bananas. However, there is a growing market for banana powder and banana chips in the EU and USA. • Phytosanitary inspections at the port of Abidjan can take a long time (up to 72 hours instead of the stipulated 24 hours) and are not necessarily effective. • Congestion in the Port of Abidjan.
Opportunity	**Threats**
• The Eastern European and Russian markets for bananas are growing fast with tariff advantages for both. • Bananas can be grown year-round in Côte d'Ivoire which is an advantage compared to countries where traditionally it can only be grown during the rainy season. • Drip irrigation can help banana plantations to overcome drought periods which appear to occur more frequently with climate change. It does require very high investments. • Companies are looking into the installation of plantations more to the north into Côte d'Ivoire where the rainfall is less, less drainage is needed and there are fewer problems with harmful fungal diseases. • Growing bananas up north create a possibility for organically certified banana production since fewer fungus attacks can be expected. This is a niche market where other parties than the traditional ones, might come in. • New highways are under construction. Together with the new bridge in Abidjan this is improving the logistic situation a lot. However, there is still a lot to be done.	• With the apparent climate change, rains are less regular. Periods of drought are alternated by heavy rains. Both phenomena come with problems. • The occurrence of pests and diseases forms a threat to banana production in Côte d'Ivoire. • Production and transport costs need to be decreased. Otherwise, in time Côte d'Ivoire will not be competitive in the EU-market. • Being dependent on one crop is a financial hazard.

b. Mango

Mango production is highly seasonal. This is why there is no real competition between the Asian, West African and Latin American mango growing areas. Large international fruit companies buy mangoes year-round, switching between different countries and continents depending on the period of the year. Having all-year-round mangoes production will help serve the supermarkets. The main production is in Asia. Mango crops prefer drier areas than banana and pineapple. The Ivorian mango area is part of a greater growing area consisting of the north of Côte d'Ivoire, the south of Mali and south of Burkina Faso and the north of Ghana. The nature of the borders between those countries makes all statistics on production difficult. The ‘pisteurs’, small businessmen who go buy and harvest the mangoes from medium-size farmers (mostly between 5 and 20 ha per farmer) sell them to exporters at packing houses. The exact origin of those mangoes may be unknown, although the certification mentions a distinct place.

A few larger growers like ‘Nembel Invest’ with 340 ha, export themselves. They often buy extra mangoes from surrounding smaller farmers. This can be a lucrative business to have higher efficiency in the packing house, etc., but it can easily turn into a headache when the situation in the port turns out into a disaster like in 2017, when reefer containers with mangoes were delayed for long periods in the Port of Abidjan.

Mangoes are prone to pests and diseases. Some have Quarantine-status and are forbidden to enter the EU. Interceptions made by phytosanitary services when these mangoes are entering the EU led to a direct loss for the owner of the container (Soro, Amao, Adjiri, & Soro, 2019). When it happens too often, an embargo on Ivorian fruits into the EU is a possibility. There are 3 Quarantine-organisms in mango that are not allowed to enter the EU: specific fruit flies, mango stone weevil and a fungus, commonly called ‘anthracnose’.

Table 4.6: Exports of mangoes into the EU countries from Côte d'Ivoire in tons

Exports of Mangoes into the EU countries (in tons)				
Country	2017	2016	2015	2014
France	6222	2959	1638	1483
Belgium	6495	4704	4051	5424
UK	4407	7135	2980	1889
Netherlands	10860	13283	11896	10322
Total EU	27984	28081	20565	19118

Little is done with second and third-grade mangoes. The second-grade mangoes are sold at local and regional markets. Opportunities to export second-grade mangoes to Morocco and Algeria should be investigated, possibly together with second-grade banana and pineapple. Moroccan orange exporters bring their first-grade products to Europe but decided, with success, to penetrate the markets of Senegal, Mali, Burkina Faso and also Côte d’Ivoire for second-grade oranges.

Processing: Mango drying is often still done at an artisanal scale with small solar dryers at the village or cooperative level or at a semi-industrial scale. In recent years, new initiatives for mango processing have started producing ultra-frozen chunks, juices and concentrates. Two major exporters investing in processing equipment and training. In this way, they hope to stay in business and keep their trained personnel employed within the company throughout the embargo period.

Table 4.7: SWOT Analysis of the Mango Fruit Sector

Strengths	Weakness
• The climate is perfect for the production of mangoes. • There are larger farms and existing trees with a very high production capacity. • According to professionals, the taste of the West African mango is the best. • Farmers are open-minded to adopting new varieties when market demands it. • Harvest occurs right into a time slot with less other suppliers on the world market. • If all systems work, the shipping time is short so more mature mangoes can be picked without spoiling. This results in a better taste at the destination. • Two factories produce packaging material locally.	• Lack of affordable loans for investment for producers leading to low yields and low quality. • The mango season is very short due to lack of early varieties. Additionally, the problems with fruit flies and anthracnose are limiting the growing season. • The control of pests and diseases is not yet effective, resulting in notifications by the EU phytosanitary authorities at arrival in Europe. • Very little is done with second and third grade mangoes. • Processing of mangoes (dried strips) is done but often still on an artisanal or semi-industrial scale.
Opportunity	**Threats**
• The use of growth hormones or early varieties (e.g., Tommy Atkins) can increase the season by 1,5 months. • Faster transport means could bring back the better tasting varieties into the market in Europe. • Biological control of the pests and diseases of the crop (especially of the 3 EU Quarantine organisms) should be priority number one, to avoid an embargo for export to the EU. • There is more international demand than supply in the specific months that Côte d'Ivoire is on the market. Local and regional markets are also emerging, providing opportunities for increased export. • Côte d'Ivoire is relatively close to Europe. • There is a lack of cold storage facilities offering opportunities for investors. • The processing of mangoes is still at an artisanal or semi-industrial scale. There is a growing demand for dried mango in the EU and its production pays off.	• The inadequate control of pests and diseases in mango-production, resulting in notifications by the EU phytosanitary authorities might lead to an embargo. • The inadequate logistics in the congested port.

c. Pineapple

The climate in the south of Côte d'Ivoire is very favourable for pineapple growing. It is grown all year around. Even small farmers have good yields and a low amount of second and third grades. The production is close to the port which makes inland transport costs are relatively low. Transport for export however is expensive and not reliable. Pineapple exports reached 200,000 tons per year in the year 2000. Production and export dropped dramatically because of the introduction of the MD2 variety in Latin America (Table 4.8). Currently, only 22,000 tons is exported. From importers in Europe, MD2 fruit quality from Costa Rica is superior to the MD2 from Côte d'Ivoire. This can be attributed to the professionalism of the growers and/or better climatic factors.

Table 4.8: Exports of pineapple into the EU countries from Côte d'Ivoire in tons

Exports of pineapples into EU countries (in tons)				
	2017	2016	2015	2014
France	12747	8474	10784	9635
Belgium	9109	8664	9995	11119
UK	2035	1365	1501	961
Netherlands	3528	2235	1438	736
Total EU	27419	20738	23718	22451

Apart from mango and banana, the pineapple value chain has a juice company in Côte d'Ivoire. In an attempt to diversify, this company has also brought other juices and mixtures onto the market but with little success yet. In a marketing study, especially the packaging was criticized by the respondents. Only one size cans are available which get them only one place on the supermarket's shelves. In recent years, imported juices have had several stands because of different bottle and/or can sizes. A small factory has started in Grand Bassam, processing organic pineapple into fresh-cut pieces, frozen 'carpaccio', 'kebab' and chunks. The production is exported to France. Sustainability is very important to the owners and management: only organic fruits are used. Regeneration of heat and bio-generation of the produced waste materials to generate electricity is part of the factory design. They are also expanding now into coconuts and other fruits for processing.

Table 4.9: SWOT Analysis of Pineapple Fruit Sector

Strengths	Weakness
• The climate in the south is very good for pineapple production. • Year around production is possible. • Producers have adopted the MD2-variety with its cultivation practices. It also seems to be more adapted to climate change. • There are no important pests and diseases. • Production is close to the port. • Prices on the national and regional markets for second and third grades are good. • The activity is profitable for all involved in the value chain.	• Farm gate prices are high compared to other production areas. There is room for negotiation with the farmers. Currently, farmers make some 50% margin (Van den Broek et all, 2016). • Small farmers have left the pineapple cultivation during the political crisis. • Availability of quality planting material is still limited. • Irrigation facilities are poor on small farms. • Cold storage is lacking in the packing stations. • Export is dominated by many smaller, less professional exporters. Their working capital is also often limited. • Airfreight is expensive and is therefore prohibitive for the pineapple export by air.
Opportunity	**Threats**
• Good possibilities for growth on the European market especially with the MD2-variety. • The crop is very profitable when managed by well-trained, commercial farmers. • If producers accept lower sales prices, the organic market could become a more important niche market. • Processing of second and third-grade pineapples into juice, frozen, cut or dried pineapple can be extended, both for the West African market as well as for the export to Europe.	• International competition on the world market on production and logistics efficiency • Climate change forms a challenge. The majority of farms still rely on rainfall only. • Alternative crops like rubber and oil palm are competitive on land use.

d. Papaya

It is difficult to find figures on the papaya export from Côte d'Ivoire, but considerable quantities were shipped in the 80s and 90s of the last century. The main commercial variety is 'Solo Sunrise' developed in Latin America. In 2010, heavy infestations of the Papaya Ring Spot Virus (PRSV) were observed in de main production area around Azaguié. These days, papaya is only produced for the Abidjan market but on a low level. Small quantities are exported to Mali, mainly from the north of Côte d'Ivoire. Until some 8 years ago, the European market only wanted this small 'Solo Sunrise' variety, but lately, there is a movement toward larger papayas in Europe. This opens the way to replace the 'Solo Sunrise', which is very susceptible to this PRSV, with bigger fruited modern hybrids. The latter varieties often produce 10 times more kg per ha, have a better shelf life, good taste and larger fruits.

Table 4.10: SWOT Analysis of Papaya Fruit Sector

Strengths	Weakness
• The climate in Côte d'Ivoire is ideal for papaya. • The growing market for papaya in the EU • Distance to the European market is relatively short. • Strong demand for good-tasting papayas in the urban areas of Côte d'Ivoire itself.	• Still 100% old varieties in use. • Papaya is a fragile fruit which has to be handled with care. • The shelf life of papaya is short, so international transport has to be by air.
Opportunity	**Threats**
• The introduction of new PRSV-resistant or -tolerant hybrids can revitalize the sector. • The international papain market is growing fast. Papain is a natural meat tenderizer. There exist special varieties for papain production.	• Climate change: most papaya is grown rain-fed. With irregular rain patterns, drip irrigation will become necessary making production more expensive. • PRSV is spreading all over the country. Local varieties are highly susceptible.

There was a reduction in demand for exported fruit, leading to a reduction in income for both exporters and producers. Challenges are mainly related to exports to Europe. There are three main areas of concern when it comes to exporting to Europe; (i) contractual difficulties due to travel restrictions, (ii) cash flow difficulties due to the decline in prepayments and the closure of the main French markets (namely, Rungis) during the peak of the COVID-19 pandemic. The pandemic exposed the inherent risks regarding supplying a region. There were staff reductions (for example, in treatment and cooling centres). It is difficult to comply with all measures for combatting COVID-19, such as reducing the number of employees per packaging facility, social distancing and curfew.

4.3 The organizational overview of fruit and vegetable production in Côte d'Ivoire

In Côte d'Ivoire there are many organizations (international, governmental and non-governmental including cooperatives) that stimulate fruit and vegetable production. The most important are mentioned in this chapter with their main activities and fields of intervention in the horticultural sector. Also, cooperative organizations of producers are mentioned.

International organizations

PARFACI *(French Development Cooperation)*
Mainly irrigation activities in rural areas. These irrigated plots can also receive ownership titles which are normally not available in rural areas. The association of farmers organizations ADCVI installs drip irrigation on-demand for individual farmers or groups of farmers to intensify agriculture. Nearly all projects are in the vegetable sector.

FAO
The FAO is also active in Côte d'Ivoire. The representative is in dire need of reliable figures on horticultural production in Côte d'Ivoire. These figures which form the basis of decision-making by governments and companies are either not available or, if available, extrapolations of earlier extrapolations. He explains the absence of these figures as being caused by the unrest of the last years and is hopeful that new, reliable figures will be published.
Agricultural programs financed by FAO include:

- HORTIVAR, the CNRA program on Horticulture
- SNDCV (mainly on manioc)

- PND (National Development Program)
- Agricultural production on wetlands

GIZ
This German development organization is active in Côte d'Ivoire on various subjects. It started as a development organization of the German Government. Nowadays, it is also open to collaboration with companies to improve the situation of the local population. Training 'out-grower' farmers is part of their business. In the north (Ferkesedougou) a program to include small mango farmers into the Export Value Chain of a large company is ongoing.

IFDC *(International Fertilizer Development Center)*
IFDC originated in the USA as a development organization for fertilizers. Today it executes agricultural development projects all over the world. In Côte d'Ivoire, the organization was absent during the past period of political instability.

Governmental organizations

CNRA *(National Agricultural Research Department)*
Apart from agricultural research, CNRA also develops, produces and commercializes new varieties of vegetables and other crops. This was done in other countries by governmental organizations as well but this activity has been abandoned a long time ago. Modern breeding techniques take huge investments in equipment and laboratories. Governments are rarely willing to make these investments. These activities are now left to the commercial sector instead of being performed by state or parastatal organizations. In the 'Plan Directeur,' these activities are planned to be transferred to the private sector. Useful research on the hydroponics method of growing vegetables by Dr Lassina Fondio are available at the Bouake branch of CNRA.

ANADER
This governmental organization is coordinating activities of donor organizations that aim to develop agricultural production by small farmers. On the horticultural side, ANADER is supporting several ongoing projects.

Non-governmental organizations and cooperatives
In general, cooperatives have been misused in West Africa for political reasons. Mismanagement of funds has further weakened the image of a cooperative in the perception of the farmers. Fruit and vegetable growers are often more individualists. In general, co-operatives that are necessary for the lives of their members are viable. The central pumping installations, canalizations and filtration systems need maintenance daily and renewal at the end of their economic life. Watering schemes have to be respected by the farmers. Without efficient association and management of these irrigated schemes, it can collapse.

Some recently started organizations of producers are;
- 'Interprofession de l'Oignon': An organization where members of the whole Value Chain of onion are represented: producers, input dealers, buyers, retailers, importers etc.
- 'Interprofession de la Mangue': An organization where all actors in the Value Chain of mango are represented. This association has been set up recently.
- OBAMCI (Organisation des producteurs-exportateurs de Bananes, d'Ananas, de Mangues et autres fruits de Côte d'Ivoire) : This is a lobbying organization. Only the budget for lobbying at the EU in Brussels is considered to be more then EUR 300.000 annually. The biggest member of OBAMCI (by far) is SCB, market leader in banana production in Côte d'Ivoire. SCB is a company of the multinational.

- OCAB (Organisation Centrale des producteurs exportateurs d'Ananas et Bananes de Côte d'Ivoire). This also a lobbying organization like OBAMCI. The other big banana producer of Côte d'Ivoire, Canavese, is member of OCAB.
- SCOPACI-SCOOPS is a successful organic pineapple export cooperative of small farmers around Bonoua. Pineapple exports from Côte d'Ivoire have been in decline in the last decades. This group of pineapple farmers joined forces with a (Dutch) importer to export certified organic pineapple to The Netherlands. Without the cooperative, this would not have been possible.
- ADCVI (Association pour le Développement des Cultures Vivrières Intensives). This association has been started as a Swiss-financed NGO. The main activity is conceiving and constructing irrigation systems for small and medium farmers (mainly vegetable producers) and guiding the farmers into a more intensified production system. The association has installed irrigated schemes all over Côte d'Ivoire.

4.4 Research Priority Areas

Adoption of improved seeds

There is an urgent need to adopt new varieties of seeds that are resistant to local diseases and climate. The Ivorian horticultural sector needs better varieties to develop the sector and solve some of its problems. About 90% of the varieties are traditional. These varieties are low-yielding and lack resistance to pests and diseases. They are mostly Open Pollinated Varieties (OPV) which the farmers grow often from self-saved seeds. These varieties have low potential and prevent farmers from obtaining good income even when weeding, fertilizing, and watering is done. Hybrid varieties are rarely found in Côte d'Ivoire.

Adoption of irrigation

Less than 1% of the land in Côte d'Ivoire is irrigated and this thus tremendously affects the productivity of fruits and vegetable productions. There is a need for irrigation and drainage to cope with climate change.

Increase use of greenhouse and netting

Greenhouse structures and netting material might become an interesting market for smallholder farmers in fruits and vegetable production. Small net houses are very useful as nurseries because the plants are already infected by viruses at a young stage, so there is little chance for a good yield. However, when plants are attacked at an older age there still is yield reduction, though much less than when attacked early. In Senegal, a lot of farmers, including small ones have a 'net house nursery'. Plastic-covered greenhouses have been tried a lot (all over West Africa) but are seldom successful. It may be possible to adapt these greenhouse structures to provide shadow or insect netting.

Greenhouse structures and netting material might become an interesting market but now will still be small because of the high investment costs involved. When intensification increases, these innovative techniques will come within reach of a larger number of farmers. The adoption of greenhouse and netting is constrained by their non-availability at scale and the cost.

Improved access to credit

Small farmers have no access to credit facilities to invest in their farms. Financial institutions do not accept land as collateral. This has to do with the non-transparent land tenure system in rural areas, and as a result, production for the local and export markets suffer. The use of credit guarantee could be a useful instrument to leverage much financing to the sector.

Adoption of post-harvest technologies and packing material

After the harvest, products have to be collected and transported to the urban areas. They are packaged in bags or wooden boxes, resulting in high losses and quality reduction. Provision of better, smaller boxes and other packing material to maintain the quality of the products could help reduces losses.

Cooling and storage

With the extra efforts of the government improving road transport, the need is higher for more better packaging and cooling equipment. However, as we see in other emerging countries, some extra cooling at wholesale markets in urban centers could be profitable. In Abidjan, this is not yet a reality, but developments might go fast with the current spirit of rebuilding the nation.

Processing

In most West African countries, development agencies and governments have tried to start up tomato paste factories. Except for Senegal, where the conditions are positive for this industrial tomato crop, it has failed nearly everywhere.

Functioning markets

A non-functional market can make the financial result of a nice crop turn to nothing. Direct links between farmers and supermarket suppliers might lead to a win-win situation. The quality of the product and a reliable supply chain will be an advantage for the supermarkets while a guaranteed sale of products against fixed prices is advantageous to the farmers. Marketing strategies will help to make sales a success.

Logistics

The Ivorian government is very active in building roads and bridges. The new highway between Abidjan and Yamoussoukro (at the moment extended to Bouake) is a very positive contribution to the vegetable sector. Products can be transported on longer stretches at lower prices.

Intensification of the production system

The need for high production levels on small fields becomes evident to keep down investment costs per unit of product. This brings us to the main theme of improving this sector, which is intensification. The development of intensive farming will give much more profitability. Weed suppression becomes expensive and crop protection becomes difficult. Investments in irrigation and drainage systems have become very expensive on large fields with low yields. Some research and practical improvements have already been tried out in Côte d'Ivoire to intensify the production system. Five examples that exist in Côte d'Ivoire include completely 'hors sol'; 'greenhouse' with 'pasteurized' soil in bags

THE GAMBIA

5.1 Context

Agriculture is the most important sector in the Gambian economy, accounting for roughly 20 percent of GDP in 2017 (International Trade Administration (ITA), 2020). Agriculture accounts for approximately one-quarter of GDP and employs 75 percent of the labour force (Fatty, Ode, & Ogbe, 2017). Horticulture has long been recognized as a means of diversifying the production and export base of the Gambian economy and improving self-sufficiency and improving the food security situation of the country. The sub-sector makes up 65% of the agricultural labour force in the Gambia (FAO, 2021). The sub-sector contributed 4% of the country's GDP in 2009 (Sanyang, Kao, & Huang, 2009). Since 2000, fruit and vegetable output has been continuously growing (Figure 5.1). Fruit production increased from 5,866 tonnes to 9,503 tonnes between 2000 and 2020. Vegetable production also increased from 9,000 tonnes in 2000 to 12,828 tonnes in 2020. Fruit production has however remained lower than vegetable production.

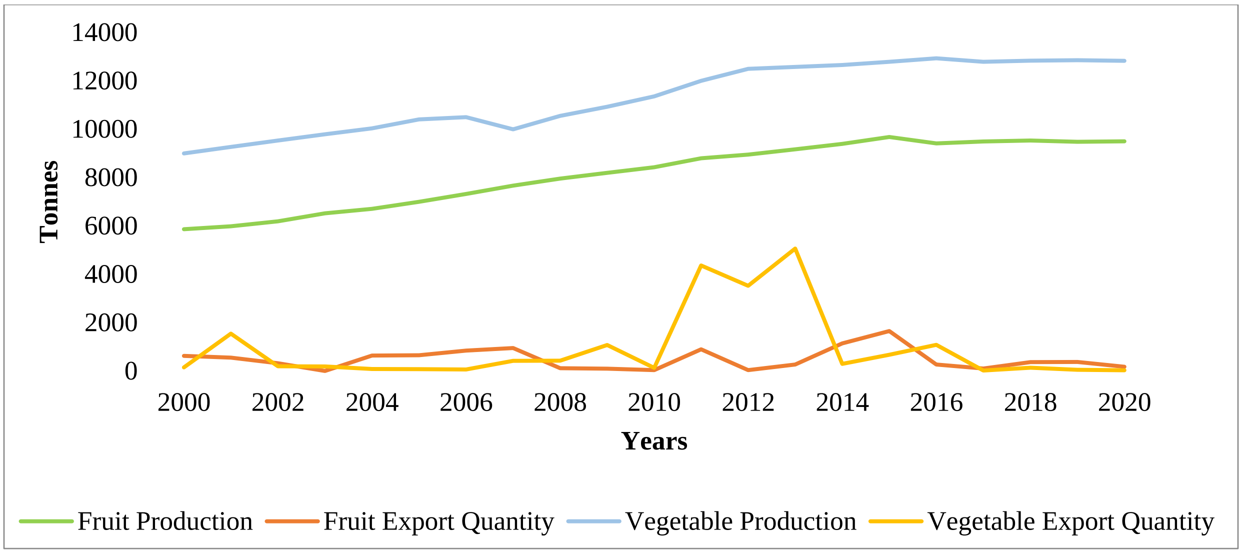


Figure 5.1: Production and export of fruit and vegetable production in The Gambia
Source: FAO (2022)

Furthermore, the country's annual fruit and vegetable exports have averaged less than 1000 tonnes. Fruit and vegetable exports have been fluctuating during the last two decades. Vegetable exports increased exponentially in 2011 and 2013 but then fell drastically in 2014 and subsequent years.

The Gambia's proximity to Europe (approximately 6 hours flight to the UK) and its ability to produce during the off-season winter months when demand and prices for fresh produce are relatively high in Europe holds promise for the country. Horticulture production is concentrated in the West Coast region of the country (Fatty et al., 2017). The West Coast region has a favourable climate for horticulture production. Production in this region is based on community gardens organized and managed by smallholder farmers and women's groups. Smallholder horticulture offers considerable potential to increase women's income-earning capabilities, promote food security, alleviate poverty, generate employment and diversify export markets. In the Gambia, the horticulture sector primarily consists of fruits and vegetables. Production is largely confined to the dry season when plant growth can only be sustained through reliable irrigation. For the most part, gardens depend for their water on relatively shallow, hand-dug wells, and therefore sites are located in low-lying areas where the water table is near the surface and borehole drill with reservoir displayed in all four corners of the garden. ,Chicken wire attached on metal poles and stock-proof fencing is another essential for successful crop production in the country. The women gardeners have become skilled in growing horticultural crops but post-harvest handling, distribution, and marketing activities are less well developed. Produce that is surplus to domestic needs finds an outlet through tourist hotels and local markets, but gluts frequently occur and attempts are being made to overcome this problem. One approach has been to stagger production by advancing planting dates, although this has often proved difficult as women are not usually available to start work on their gardens until the completion of the rice harvest. A spread in production could also be achieved by planting a suitable range of early and late cultivars, but this depends heavily on a timely supply of high-quality seeds. Overall, the gardens make a useful contribution to the country's economy and the health of its people and represent an important focus for development (Fatty et al., 2017).

5.2 Geography and Markets

Fruit and vegetable production covers a small land area in The Gambia. Consequently, individual farmers' and community farms' average fruit and vegetable farm sizes are 1 hectare and 5 hectares, respectively. The area dedicated to vegetable cultivation is greater than that dedicated to fruit production. However, the area under fruit and vegetable production is increasing gradually both for domestic consumption and export (Fatty et al., 2017).

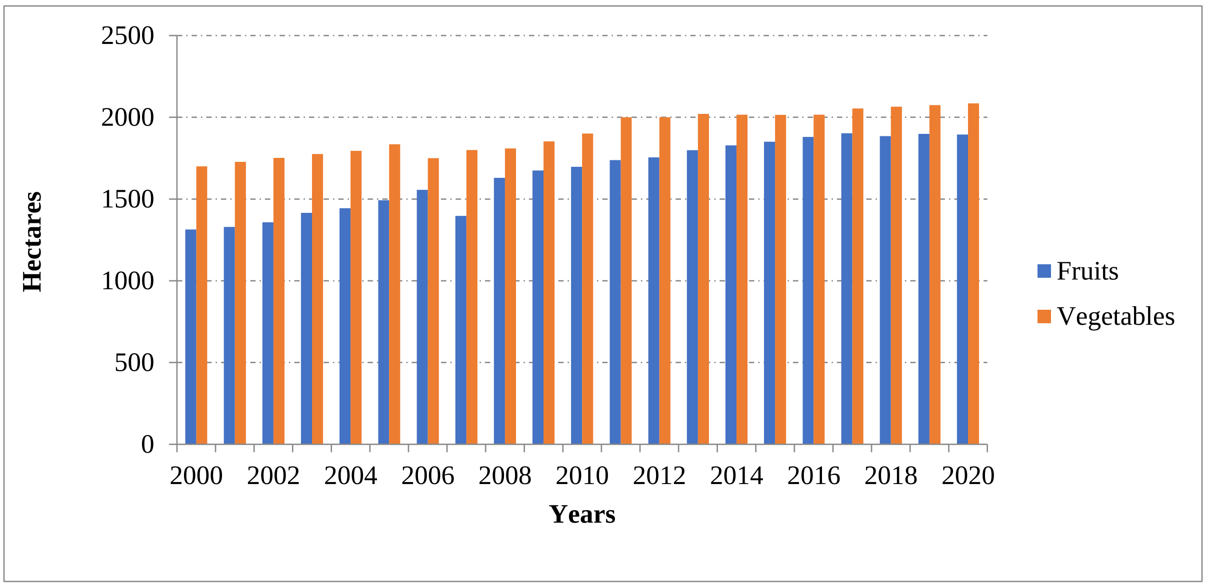


Figure 5.2: Area under fruit and vegetable production in The Gambia
Source: FAO (2022)

Between 2000 and 2020, the area under fruit production increased from 1,314 hectares to 1,895 hectares, while the area under vegetable production increased from 1,700 hectares to 2,085 hectares (Figure 5.2).

It is estimated that 23% of the total arable land in the Gambia, which is about 117,329 hectares is suitable for horticulture, however only 3,519.9 ha (i.e. less than 3% is currently under production). The Gambia is divided into seven agricultural regions namely, West Coast Region (WCR), North Bank Region (NBR), Central River Region North (CRR/N), Central River Region South (CRR/S), Lower River Region (LRR), Upper River Region (URR), and URBAN agriculture.

West Coast Region is the region that plays a major role in horticultural production and trade. The region is the largest and most populated. According to the Gambia Bureau of Statistics (2013), it has a population of 699,704 people and a total land size of 1764 SQ KM. Temperatures range between 21^0-30^OC (Department of water resources, 2012). Rainfall is seasonal. It has a minimum temperature of 14.3^0C recorded in January and a maximum temperature of 41.7^{0}C and April is usually the hottest month (Department of Water Resources, 2012).

Women dominate the production of vegetables (Fatty et al., 2017). The soil type of the region is sandy loamy. Major sources of water for vegetable production in the region are rivers, wells, and boreholes. The main socio-economic activities of the region include crops and livestock production with vegetable production largely dominant. The region holds the largest commercial fishing activities and serves as a business center for both agricultural and non-agricultural products.

The sector is favoured by reasonably good growing conditions and presents high economic value to the country. If the potential of the river Gambia is tapped, this would allow for the spread of horticultural production throughout the year and in all parts of the country. Improved marketing opportunities are required to spur production. The Serekunda market in KMC, Divisional Administrative Headquarters Brikama, Farafenni, and Basse market are where the majority of the vegetable farmers sell their products at a wholesale price to retailers whol in turn sell them to consumers within the various regions and municipalities. The pricing of the vegetable products depends on the availability of the products in the various markets' when vegetables are scared the prices will be high and when a glut occurs, the prices drop.

5.3 Biophysical

Input Supply: Fertilizer and Improved Seed

Limited agricultural inputs such as fertilizers, pesticides, improved seedlings, and insecticides are a major challenge to the productivity of the sector. Both organic and inorganic fertilizer is available in the market for farmers. Nationally, about 47% of small-scale farmers use fertilizer in the Gambia. Only 13% of farmers use pesticides while 21% have access to irrigation. The supply of input is mainly done by the private sector.

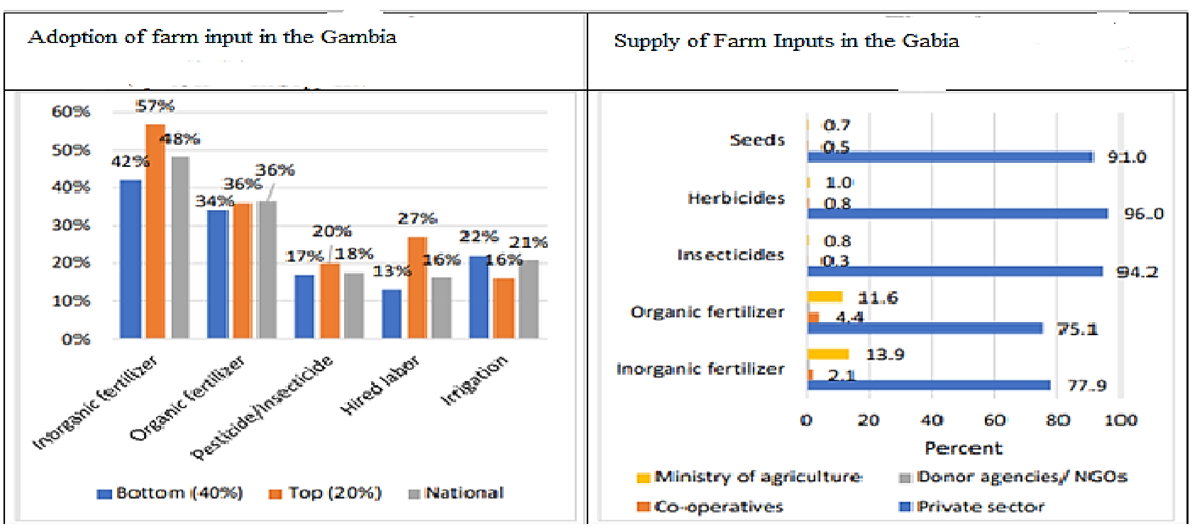


Figure 5.3 Adoption and Supply of Farm Inputs in the Gambia
Source: World Bank, 2019

Production and Productivity of Horticulture Crops

The Gambia is not self-sufficient in fruit and vegetable production. Throughout the country, mango and onions are the most predominant horticultural crops grown by farmers. Mango production has increased in the last three decades. The area under mango production and yield of mangoes has also increased in the country. However, the area under mango production witnessed the highest growth from 1991 to 2000, then from 2001 to 2010, and from 2011 to 2020.

Table 5.1: Production and Productivity of Mangoes in The Gambia

Year	Area (ha)	Yield (tonnes/ha)	Production (tonnes)	The growth rate of Area	The growth rate of Yield	The growth rate of Production
1991-2000	114.4	4.7	536.0	22.2%	-10.0%	24.0%
2001-2010	177.0	4.9	876.6	5.6%	1.6%	7.2%
2011-2020	253.9	5.4	1380.8	1.8%	0.0%	1.7%

Source: FAO, 2022

Fruits and Vegetable Producer associations like National Women Farmers Association (NAWFA) can serve as an important outlet that provides a guaranteed and fair price market for the women's produce and takes the risk off the women producers. It can also purchase inputs in wholesale quantities thus bringing down the cost of inputs which can enhance women's access to inputs. The association is also better positioned than individual growers to negotiate credit arrangements with development banks and other credit institutions. Projects also support their interventions sites with inputs and the non-intervention areas purchase their inputs from the inputs dealers within the country. Small scale farmers who cannot afford to purchase their inputs from the right source (dealer) visit the weekly market and purchase from retailers. These dealers usually re-package the vegetable seeds in small plastic bags and that can reduce the viability of the seeds and cause poor germination rates.

Improved Varieties

The Gambia has numerous varieties of fruits and vegetables. Table 5.2 below shows the improved varieties of major fruits and vegetables.

Table 5.2: Improved Fruit and Vegetable Varieties in Gambia

Crop	Variety
Onions	1. Texas Grano, 2. Red creole 3. Violet de galmy 4. Red Bombay
Tomatoes	1. Moneymaker 2. Roma 3. Tropics 4. Manmade 5. xina 6. Mongal 7. Nadira

Indigenous and Neglected Species

Indigenous and underutilized crops are fruits and vegetables with high nutritional, economic and market value which include, beetroots, radish, carrot, and Irish potato.

Postharvest Management Practices

Postharvest management of fresh products practices includes; sorting, grading, cooling, and cleaning (washing). Some losses occur during handling at the farm gate and final destination at the market, with the majority of the post-harvest losses occurring during storage. There are no standard storage facilities for fresh products which lead to a lot of losses or selling the products at giveaway prices and there are no standard vehicles for transporting harvested product from farm gate to the final destination (market).

Processing and Packaging of Fruits and Vegetables

Processing and packaging are done locally in the Gambia by using locally available materials. For packaging vegetables, farmers normally used locally made bamboo baskets and plastic containers, and for processing, processors used cooking pots, and blenders wooden spoons.

5.4 Natural Resources

Physical Resource: Climate and Soils

Fruit and vegetable production is dependent on natural processes and resources, including rainfall and soils. Fruit and vegetable production is largely rain-fed and suffers the brunt of climate change. Farmers do not have access to irrigation systems but depend on waterlogging areas to produce vegetables. Soils in The Gambia are generally infertile. Farmers rely on crop residue or animal waste to increase soil fertility. Farmers adopt the following climate-smart varieties and practices to increase productivity:

- Heat tolerant varieties, Flood tolerant plant varieties, fast-maturing varieties, etc.
- Intercropping, crop diversity, container gardening, micro gardening, rainwater harvesting, efficient irrigation, mulching, composting, water management, shade house, and boundary trees.

Human resource: Women in horticulture

The Gambia is predominantly dominated by women. Women occupy a good stand in the country's horticulture. Women constitute over 60% of the workforce in the horticultural sub-sector (Fatty et al., 2017). Women are largely involved in production and marketing activities. Youth participation in horticulture is minimal (Fatty et al., 2017). Presently, youth are venturing into horticultural production but in the form of individual gardens.

Market and consumption

Demand for fruits and vegetables are very high in the Gambia, yet farmers are unable to meet this demand. Scarcity does occur and the motive behind it is that vegetable farmers are not active during the rainy season due to some reasons.

Market access for horticultural products is an issue, as fruits and vegetables are easily perishable. Farmers need to have a ready market or standard cool stores for storage of the harvested products which is inadequate in the Gambia.

Value-added horticulture products are done through the processing of fruits and vegetables into finished products and that will help to increase the shelf-life of the products and the market prices as well.

Agribusiness Opportunities in The Gambia are through cooperatives, as different farmer groups come together and form cooperatives. The different groups will be contributing depending on what they agreed on either monthly, quarterly, or yearly. The money generated will be used to purchase inputs and resell the inputs among members at a cheaper price or give it out to members as a credit until after harvest they pay back. Cooperatives will also help members to sell their products in bulk and distribute the money.

Horticultural farmers use available local materials for packaging such as bamboo baskets, plastic containers, and recycled bags to package their harvested products. The cooling process is conducted either in the garden or at home before packaging, cooling immediately after harvest will remove the heat. Storage is done at home using their local available stores which are not up to standard for storing fruits and vegetables and that leads to a lot of losses. Processing of horticultural products in the Gambia is done on a small-scale, hence there are no processing plans for farmers to process on large scale. They use the available local materials to process on small scale.

5.5 Trade and Standards

The Gambia exports few vegetables. The volume of export of fruits and vegetables is small. According to FAO data, mangoes are the dominant export products, followed by tomatoes, chilies, and onions.

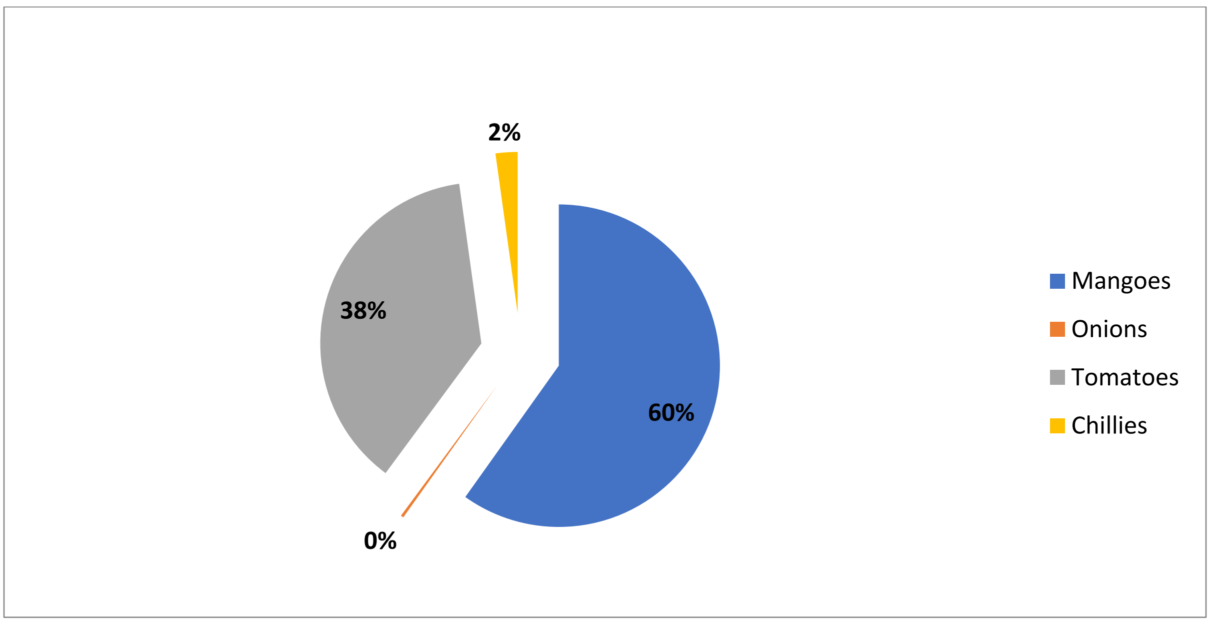


Figure 5.4: Percentage Fruit and Vegetable Exported from The Gambia

Source: FAO, 2020

Inputs such as fertilizers, seeds, pesticides, and fungicides are key to enhanced productivity. In the Gambia, there are four categories of inputs suppliers for horticulture, namely:

- Commercial suppliers such as GHE: One-stop shop for all agricultural inputs for farmers (seeds, farming implements, garden equipment, milling machines, irrigation equipment, fencing materials);
- Small scale suppliers in urban centers, selling vegetable seeds (tomato, cabbage, onion, cucumber, etc.); fertilizers (N.P.K & Urea); chemicals (pesticides, fungicides, nematicides, insecticides, herbicides, etc.), and garden equipment (watering can, spade, hand fork, knapsack sprayer etc.);

- Village shops: often stock a limited range of pesticides and other garden materials; and
- Loumos: weekly markets in various locations throughout the country and neighbouring regions in Senegal where farmers can also access inputs.

There are 480 communal gardens country-wide –Table 5.3 for distribution. They are mostly sponsored by government and development partners through projects such as FASDEP, NEMA/CHOSSO, GCAV, FAO, LHDP, GALDEP, RED CROSS, United Purpose, etc. It is important to stress that horticulture is often only one component of these projects, and there is as yet no major project entirely dedicated to the horticulture sector.

As reported in the National Horticulture Master Plan

Membership in these groups ranges between 100 and 300 persons, with each allocated an average of twenty or more beds. They benefit from government or donor support that takes the form of technical advice, training, grants of seeds and fertilizer, fencing material, concrete-lined wells, or boreholes.

Table 5.3: Distribution of Communal Garden Schemes[2]

Region	Total Number of Communal Garden Schemes	Area (Ha)	Membership		
			Male	Female	Total
West Coast	116	508.9	353	13,550	13,903
North Bank	84	114.9	1043	14,537	15,580
Lower River	82	112.4	592	11,963	12,555
Central River/South	38	25	231	3,610	3,841
Central River/North	48	52.5	242	3,658	3,900
Upper River	86	54.4	277	9,337	9,614
Total	454	868.2	2738	56,655	59,393

Commercial Farms

These are medium-sized to large farms, with farm sizes between 40 to over 100ha. Although only a limited number of enterprises are under this category - Radville Farms, GHE, Kharafi, Kura’s Garden, they are responsible for supplying over 90% of total horticultural exports. Vegetable crops grown include Hot pepper (Chilies); Green fine beans; Okra; Baby corn; Squash; Butternut; Eggplant.

Typically, they employ capital-intensive means of production with modern farming tools, machinery, and equipment as their land is big and has sprinkler or drip irrigation systems. These farms are distinguished by the following features[3]:

- They are often vertically integrated with their customers and are close to the market, react to market demand, and can organize production accordingly.
- Have a high level of professionalism in production by the mastering of the agronomy and post-

harvest of all crops of interest

- Will buy from smaller growers through contract farming for export purposes
- Make substantial investment and funds for further investment
- Have good leadership and business management skills.

Small Scale Horticulture Producers' Organizations

With the support of partners, communal garden producers have organized themselves into six marketing federations (one in each agricultural region) and an apex body:

i. Fangsoto (West Coast Region)
ii. Khewal (Central River Region – North)
iii. Nematulai (Upper River Region)
iv. Sofaniama (Lower River Region)
v. Fangkaso (Central River Region – South)
vi. Solicita (North Bank Region)
vii. Sosolaso (National Apex Body)

These federations can potentially play many useful roles such as:

i. Generally representing the voice of horticulture farmers in policy circles;
ii. Assisting farmers collectively bargain to purchase critical inputs such as fertilizers, pesticides, seeds, etc, and collectively market their produce;
iii. Conducting training, especially on good agronomic practices, and business development;
iv. Advocating to improve access to finance; and
v. Linking producers with exporters and other buyers.

These organizations can also be building blocks for the setting of agriculture cluster models as a way to modernize and catalyze production.

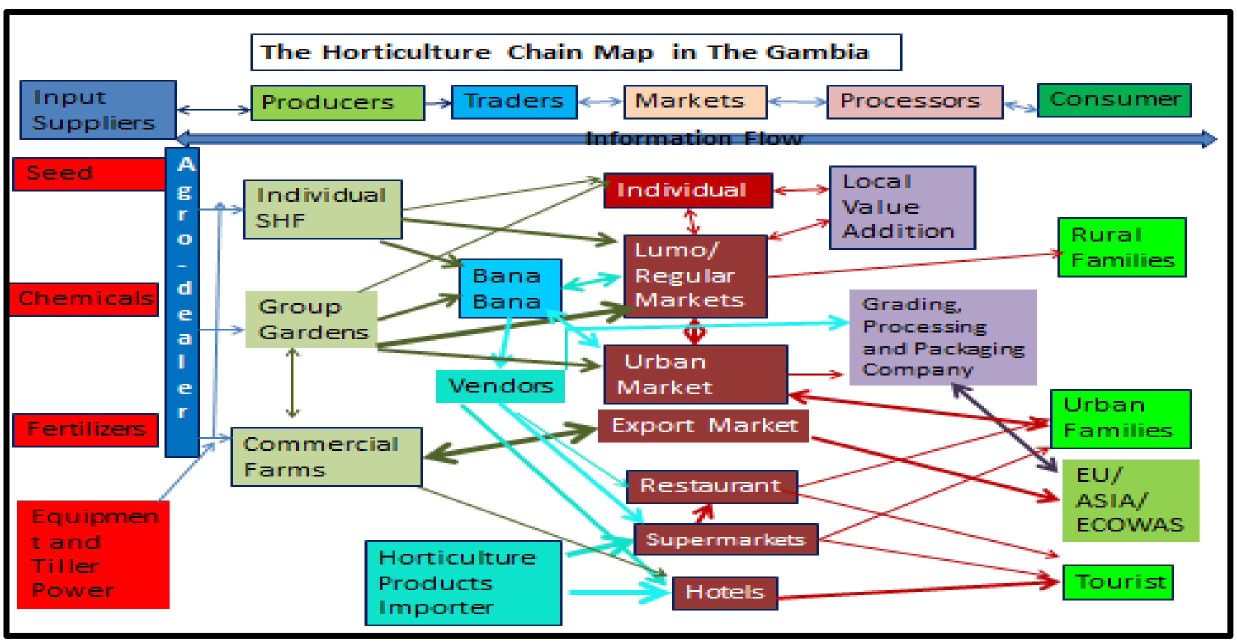


Figure 5.5: The inter-linkages between the various actors and processes

MALI

6.1 Context

In Mali, cereals such as millet, sorghum, corn, and rice constitute the staple food. However, for more than a decade, horticultural crops have become one of the spearheads of the policy of diversifying income sources for farmers and the country. Horticulture occupies an important portion of farmers' income, ranging between 21.6% and 35.9% (INSTAT, 2020). The government has demonstrated interest in horticultural crops since the unprecedented drought. The development of the horticultural sector can improve the food security of the population because of their nutritional quality. Food security remains a positive impact of fruit and vegetable crops in the diet and nutrition of urban and rural populations. Fruit and vegetable consumption in Bamako has increased from 15 to 70 kg/inhabitant/year and 20 to 97 kg/inhabitant/year between 2000 and 2020 (FAO, 2020). Horticultural production, especially market gardening, is a remunerative activity undertaken largely by women. Women are present at all points of the horticulture value chain. Horticulture remains a significant source of income for women, who invest in the education and health of their families (Diakité, Dramé, & Sidibé, 2014).

The horticultural sector is dominated by informal activities. Horticultural production is geographical dispersed across Sikasso, Koulikoro, Mopti, Ségou, Kayes, and Bamako (Diakité et al., 2014). Mali's horticultural products are mainly fruit trees, vegetables/leaves, vegetables/fruits, bulbs, and tuber vegetables (CPS/SDR, 2019).

Mali is one of the largest producers of fruits and vegetables in West Africa. Fruit and vegetable production in the country has seen tremendous growth over the last three decades. Between 1990 and 2000, fruit production increased from 351,008 tonnes to 534,481 tonnes. In 2020, fruit production was 2,350,297 tonnes, which is an increment of more than 300%, when compared to what was achieved in 2000.

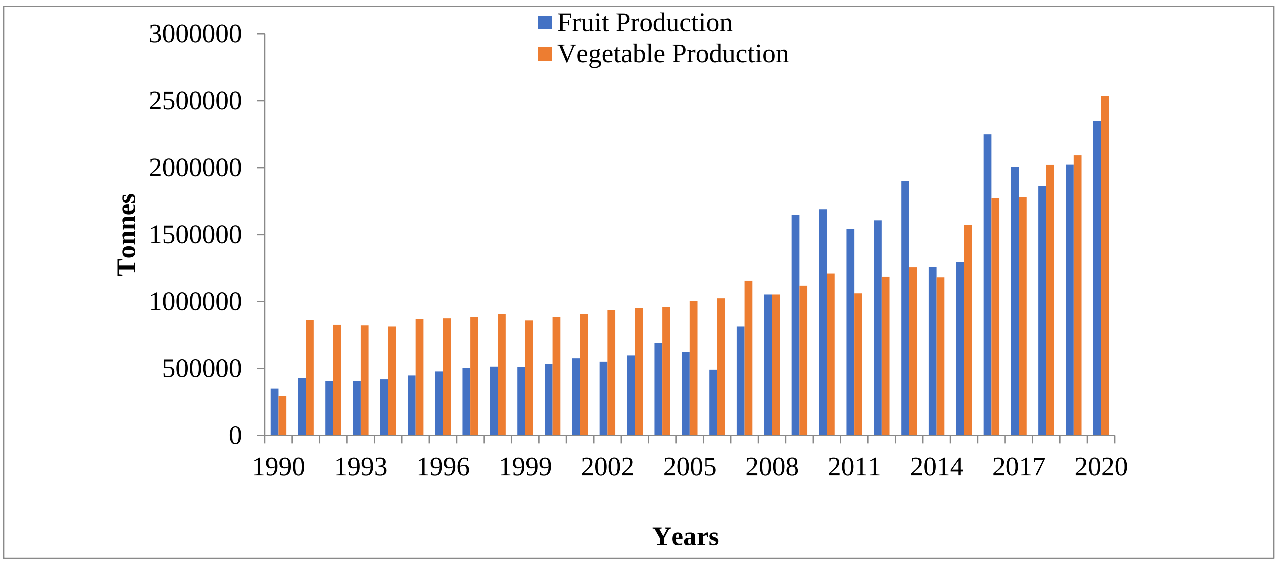


Figure 6.1: Fruit and vegetable production in Mali (1990-2020)
Source: FAO (2020)

Vegetable production also increased more than fruit production (Figure 6.1). Production increased from 296,290 tonnes in 1990 to 2,535,287 tonnes in 2020. However, major fluctuations persist. Vegetable production declined in 2008, 2011, and 2014. Production has increased steadily since 2015.

Export of vegetables has been relatively stable. However, vegetable export increased significantly in 2017. Just like vegetables, fruit export increased drastically to 21, 060 tonnes in 2012, but fell to 8,034 tonnes in 2013. This trend was also observed in 2014-2015, 2017-2018, and 2019-2020.

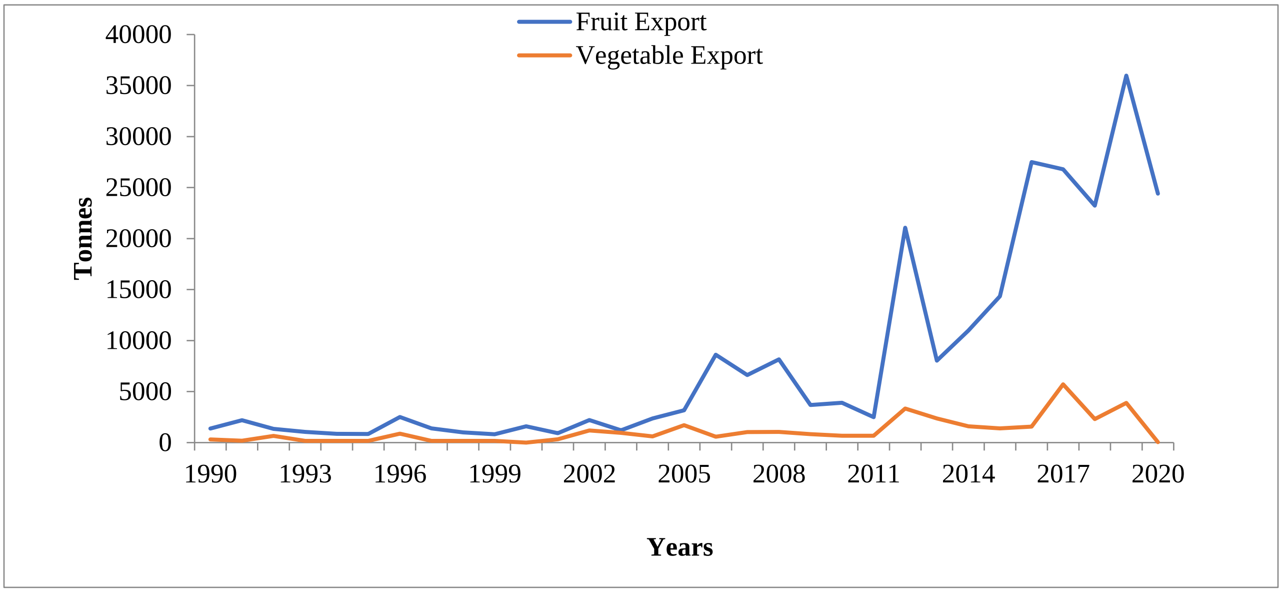


Figure 6.2: Fruit and vegetable Export in Mali (1990-2020)
Source: FAO (2020)

Mali's horticultural products are intended for local, sub-regional (UEMOA countries), and European Union (EU) markets (Key informant survey, 2022). According to Diakité et al. (2014), the analysis of exports of Malian horticultural products in the WAEMU countries reveals that (i) before the crises (financial and food), most of the trade-in products takes place within the community area (78% in 2007); (ii) exports fell in 2008 (-63.2%) and 2009 (41.2%) before growing again in 2010 (63.2%). This can be explained by the combined effects of the financial and food crises observed during this period; (iii) despite the crises, trade-in horticultural products represent half, if not more, of all agricultural product exports in WAEMU; (iv) the challenges to be met by Mali to exploit these sub-regional niches are: a better knowledge of the characteristics of these markets and the creation of efficient distribution mechanisms. New EU regulations, Brazilian competition, and the proliferation of private standards limit access to EU markets for horticultural products from Mali. The problems of reciprocity also constitute a challenge to the export of horticultural products from Mali.
In general, there is a problem with the organization and management of horticultural sub-sectors in Mali, limiting their access to short- and medium-term financing. Specifically, there are constraints at all the stages of the horticulture value chains in Mali. Production techniques are obsolete and unsustainable (Key informant survey, 2022).

6.2 Landscape challenges and opportunities

Horticulture – Biophysical

Inputs (including seed supply)
Horticultural producers source their inputs (fertilizer, seed, and agrochemicals) on the market or use self-supply seeds and fertilizers (organic fertilizers). Through programs and projects, farmers can benefit from small subsidies to produce horticultural products. However, there are no subsidies for the horticultural sector.

Production

The horticultural sector in Mali is mainly dominated by the following sub-sectors: fruit trees, vegetables/leaves, vegetables/fruits, and bulb and tubercle vegetables(CPS/SDR, 2019). For the sub-sector of fruit trees, the production of mango occupies the first place (754892 MT) followed by that of orange, banana, and cashew with 487794 MT, 191228 MT, and 119,761 MT, respectively (Table 6.1). However, the region of Sikasso occupies the first place in terms of production (74.8%) followed by the region of Koulikoro, the district of Bamako, and the region of Segou with 11.54%, 7.67%, and 3.54% respectively.

Table 6.1: Production of fruit trees by region

Products		Kayes	Koulikoro	Sikasso	Segou	Mopti	Tombouctou	Goa	Kidal	Bamako	Total
Cashew	Production (mt)	213	25384	93695	469	0	0	0	0	0	119761
Orange tree	Production (mt)	3167	14524	463462	5008	2	69	0	0	1562	487794
Mandarin	Production (mt)	1305	3638	6002	1027	0	14	0	0	1200	13186
Lemon	Production (mt)	1762	4797	25342	2895	460	144	33	0	98	35531
Grapefruit	Production (mt)	5	278	533	153	0	0	0	0	0	969
Mango	Production (mt)	8597	71385	527716	22240	9210	244	0	0	115500	754892
Papaya	Production (mt)	1919	15767	25563	18720	2088	18	0	0	3816	67891
Guava	Production (mt)	780	2545	2796	1608	6900	15	0	0	280	14924
Banana tree	Production (mt)	2357	55099	118208	6790	1769	5	0	0	7000	191228
Grafted jujube	Production (mt)	0	820	0	225	30	0	0	0	0	1075
Date palm	Production (mt)	0	0	0	620	30	2	0	6	0	658
Apple Cinnamon	Production (mt)	215	653	27	88	0	0	0	0	128	1111
Total Production (mt)		20320	194890	1263344	59843	20489	511	33	6	129584	1689020
Percentage Production (%)		1.2	11.54	74.8	3.54	1.2	0.03	0.002	0.0004	7.67	100

Source: Author calculation from CPS/CDR data

For the vegetables/leaves sub-sector, cabbage production ranks first (69,072 MT), followed by lettuce, and cowpea leaves 64,395 MT, and 6,722 MT, respectively (Table 6.2). However, the district of Bamako ranks first in terms of production (31.44%) followed by the region of Sikasso, the region of Koulikoro, and the region of Segou with 25.13%, 21.67%, and 7.88%, respectively.

Table 6.2: Production and yield of vegetables/leaves by region

Products		Kayes	Koulikoro	Sikasso	Segou	Mopti	Tombouctou	Goa	Kidal	Bamako	Total
Lettuce	Production (mt)	1509 (10480)	11505 (8960)	5277 (5555)	5739 (14593)	5407 (12782)	1547 (11050)	881 (9904)	180 (15000)	32350 (16015)	64395 (11804)
Cabbage	Production (mt)	3691 (17011)	17800 (15936)	29636 (18171)	5254 (18698)	2986 (15635)	504 (14410)	580 (10733)	200 (20000)	8420 (29034)	69072 (18053)
Parsley	Production (mt)	104 (7990)	1271 (5450)	61 (2329)	46.8 (18700)	5.3 (10568)	0 (0)	0 (0)	2 (2000)	201 (8040)	1691 (5612)
Cowpea leaf	Production (mt)	2208 (6835)	214 (3057)	576 (4202)	248 (8267)	29 (699)	30 (4250)	0 (0)	8 (8000)	3410 (11000)	6722 (7307)
Potato leaf	Production (mt)	0 (0)	259 (2698)	451 (5858)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	660 (13200)	1370 (6144)
Total Production (mt)		7512	31049	36001	11288	8427	2081	1461	390	45041	143250
Percentage Production (%)		5.24	21.67	25.13	7.88	5.88	1.45	1.02	0.27	31.44	100

NB: () represents the Yield measured kg/ha

Source: Author calculation from CPS/CDR data

For the vegetables/leaves sub-sector, the production of Okra occupies the first place (254545 MT), followed by Tomato, Eggplant, and squash 175577 MT, 96943 MT, and 67 921 MT, respectively (Table 6.3). However, the Koulikoro region ranks first in terms of production (48.84%) followed by the Sikasso region, the Segou region, and the Kayes region with 27.24%, 12.26%, and 4.15% respectively.

Table 6.3: Production and yield of vegetables/fruits by region

Products		Kayes	Koulikoro	Sikasso	Segou	Mopti	Tombouctou	Goa	Kidal	Bamako	Total
Squash	Production (mt)	5242 (9496)	21972 (15695)	19314 (18625)	16122 (16203)	891 (17479)	630 (14000)	119 (6635)	0 (0)	3630 (22975)	67921 (15959)
Green bean	Production (mt)	0 (0)	262 (5574)	719 (5789)	371 (8433)	0 (0)	70 (5000)	0 (0)	0 (0)	475 (9500)	1897 (6794)
Melon	Production (mt)	7053 (29760)	9926 (10639)	8898 (13380)	13085 (22599)	2461 (12494)	185 (10250)	207 (9202)	0 (0)	5556 (17363)	47371 (15942)
Eggplant	Production (mt)	3910 (11637)	22834 (14017)	52811 (28953)	5742 (12760)	8166 (17448)	117 (11720)	490 (10000)	0 (0)	2874 (21605)	96943 (19788)
Jaxatu	Production (mt)	949 (14598)	17830 (11943)	8103 (15464)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	26882 (12912)
Tomato	Production (mt)	6191 (11380)	53784 (15451)	48467 (14268)	49520 (22550)	10671 (20760)	2794 (15350)	698 (12243)	252 (18000)	3200 (19162)	175577 (16639
Pepper	Production (mt)	842 (8000)	5637 (11382)	4664 (13065)	344 (10104)	0 (0)	32 (8000)	114 (7500)	0 (0)	495 (16500)	12128 (11653)
Okra	Production (mt)	8497 (7635)	98030 (11578)	93313 (11635)	32996 (12990)	9533 (5928)	8186 (11812)	221 (3803)	80 (5000)	3690 (11903)	254545 (11152)
Pepper	Production (mt)	482 (4189)	2999 (3447)	14092 (2742)	9812 (5610)	1766 (3463)	42 (5250)	44 (3167)	0 (0)	299 (9328)	29536 (3501)
Cucumber	Production (mt)	2690 (8706)	30909 (15562)	20933 (15224)	7712 (14550	2344 (14744)	469 (10668)	193 (8283)	56 (7000)	3576 (28381)	68882 (15104)
Watermelon	Production (mt)	10276 (26830)	278483 (24237)	31349 (18205)	477 (25107)	6918 (10627)	931 (19000)	237 (11167)	0 (0)	722 (27500)	329413 (22934)
Total Production (mt)		46132	542666	302663	136181	42750	13456	2323	388	24517	1111076
Percentage Production (%)		4.15	48.84	27.24	12.26	3.85	1.21	0.21	0.03	2.21	100

NB: () represents the Yield measured kg/ha

Source: Author calculation from CPS/CDR data

For the vegetables/leaves sub-sector, the production of Shallot occupies the first place (401,285 MT) followed by the potato, Onion, and Carrot 251,558 MT, 111,385 MT, and 15,790 MT, respectively (Table 6.4). However, the region of Ségou occupies the first place in terms of production (39.71%) followed by the region of Koulikoro, the region of Sikasso, and the region of Mopti with 21.37%, 18.11%, and 10.43% respectively.

Table 6.4: Production and yield of bulb and tubercle vegetables by region

Produits		Régions									Total
		Kayes	Koulikoro	Sikasso	Ségou	Mopti	Tombo uctou	Goa	Kida l	Bamako	
Pomme de terre	Production (mt)	759 (14588)	91866 (20111)	106329 (19930)	40631 (32847)	3560 (20000)	3420 (20000)	4698 (23609)	0 (0)	295 (29500)	251558 (21409)
Carotte	Production (mt)	167 (7275)	3257 (9840)	1763 (16177)	1100 (12083)	861 (10125)	100 (11090)	239 (9207)	0 (0)	8303 (25546)	15790 (15805)
Betterave	Production (mt)	257 (1190)	1595 (13749)	864 (13190)	269 (10596)	526 (11442)	134 (11200)	363 (11346)	0 (0)	2640 (17600)	6649 (14150)
Navet	Production (mt)	0 (0)	38 (1924)	114 (8127)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1428 (21962)	1580 (15938)
Oignon	Production (mt)	2921 (12020)	40059 (17609)	14299 (19642)	10856 (24956)	3851 (20057)	26263 (17370)	10706 (21939)	0 (0)	2428 (22391)	111385 (18622)
Echalote	Production (mt)	2601 (15124)	34056 (14859)	21201 (18812)	257361 (28105)	70697 (30778)	14395 (16192)	684 (10529)	0 (0)	290 (19300)	401285 (25058)
Ail	Production (mt)	0 (0)	393 (4471)	544 (12952)	8079 (17756)	4099 (13754)	0 (0)	0 (0)	0 (0)	84 (7000)	13199 (14748)
Total Production (mt)		6705	171264	145114	318296	83594	44312	16690	0	15468	801443
Percentage Production (%)		0.84	21.37	18.11	39.71	10.43	5.53	2.08	0	1.93	100

Postharvest management of fresh products

With regards to the phytosanitary requirements for the marketing (local and export) of agro-food products, particularly horticultural products, the survey reveals that there are a certain number of services (public and private) involved: Central Veterinary Laboratory (LCV), National Health Laboratory (LNS), National Food Safety Agency (ANSSA), Malian Agency for Standardization and Quality Promotion (AMANORM), and PROSLABS.

Central Veterinary Laboratory (LCV) is involved in phytosanitary requirements through the Toxicology, Control and Environmental Quality Laboratory (LTCQE) which is equipped and adapted for the analysis of pesticide residues in water, soil, fruits and vegetables, and other foodstuffs. It analyzes fruits and vegetables for national exporters.

National Health Laboratory (LNS) was created to preserve the well-being of the population. The LNS's mission is to control the quality of food, drugs, and drinks. The LNS is responsible for taking and analyzing samples in any unit producing, importing, distributing, or storing food products (Mali, 2017).

The National Food Safety Agency (ANSSA) is responsible for ensuring food safety. As such, it is responsible for: coordinating all actions related to food safety; providing technical and scientific support to control structures; providing the technical and scientific support necessary for the development of food safety regulations; assessing the health risks that food intended for humans and animals may present; water intended for human and animal consumption; the processes and conditions for the production, processing, preservation, transport, storage and distribution of foodstuffs; food additives; residues of veterinary and phytosanitary products and other contaminants; residues of fertilizing materials and crop supports; the

packaging and materials intended to be in contact with the elements mentioned above; support the activities of surveillance systems and epidemiological networks; ensure risk communication.
Agence Malienne de Normalisation et de Promotion de la Qualité (AMANORM) is the national standards body of Mali. AMANORM coordinates and carries out work, studies, and research related to standards, promotion of quality, certification, and accreditation. Its main functions are: assist companies with production and product certification; provide assistance to laboratories, inspection and certification bodies with accreditation; manage and distribute documentation on standardization and quality promotion; provide information, assistance, and advice to companies and laboratories on standardization, quality assurance, management quality, and quality tools, certification and accreditation; training and development related to standards, promotion of quality, certification and accreditation; creation and management of the national logo of conformity to standards. AMANORM is a member of ISO, ECOSHAM (program for harmonization of standards of ECOWAS[4]), ECOQUAL (quality policy of ECOWAS and UEMOA[5]).
PROSLABS is a private laboratory that does a lot of analysis, in particular, agro-food analyzes for the marketing authorization of agri-food products, and their periodic monitoring.

b. Natural resources: This is both in terms of natural resources as a resource and as a limiting factor (climate change) for horticulture production.

Water– availability, quality, accessibility

Market gardening, which is one of the major components of horticultural production in Mali, is an off-season activity that mainly uses irrigation (key informant survey, 2022). Wells and boreholes are the main sources of irrigation water. Water availability is limited from April to June because the water table is getting deeper and deeper (key informant survey, 2022). This problem is linked to the proliferation of boreholes which are multiplying in an anarchic way without regulation. Added to this problem is also the problem of lack of monitoring and quality control of drilling equipment, limited depth of drilling, lack of geophysical study when drilling, and lack of qualified personnel to repair the pumps water (key informant survey, 2022).

Soil – fertility (fertile areas for crop production)
More and more mineral fertilizers are used because the soils are less fertile. The vegetables and fruits were the sectors that used fewer fertilizers but because of the production intensity, their productions are very small without fertilizers and agrochemicals (key informing survey, 2022).

Climate – rainfall patterns, climate-smart crops, climate-smart agricultural practices in place

The data from the meteorological service of Mali shows that the rainfall trend has been unstable from 1991 to 2021 (Figure 6.3). The environment and natural resources continue to deteriorate under the effects of increasing pressures related to climate change, socio-economic development, and population growth. The key informing surveys also revealed that farmers are using resilient and improved seeds in vegetable and fruit production.

[4]Economic Community of West African States
[5]West African Economic and Monetary Union

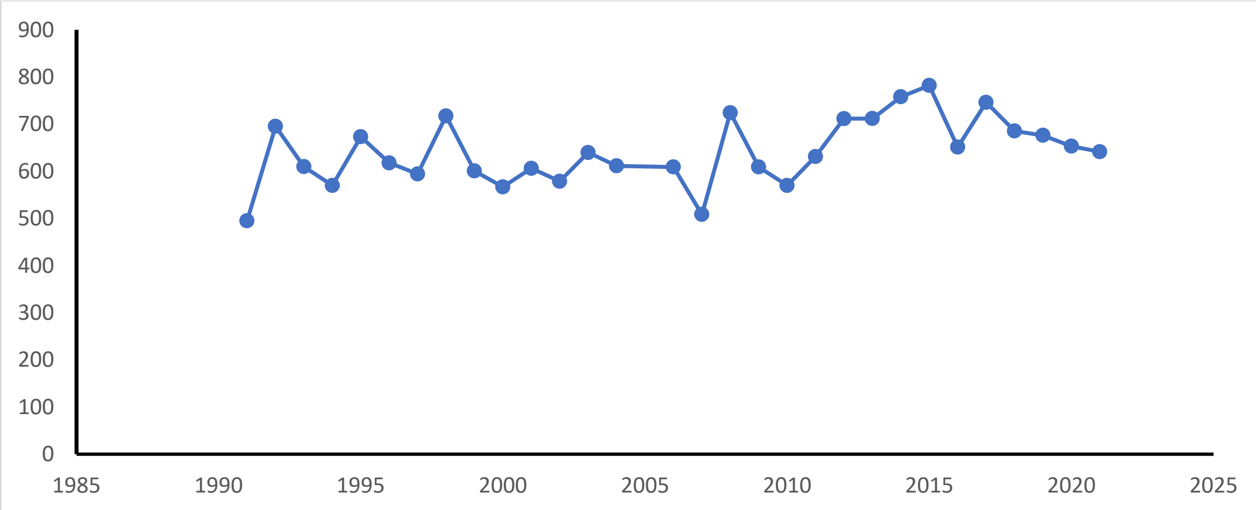


Figure 6.3: Rainfall patterns in Mali from 1991 to 2021

6.3 Socioeconomic

Women and youth in horticulture

Often seen as women's crops, horticultural products offer considerable economic opportunities for women and young people (Key informant Survey, 2022). First, access to plots for dry season production is easier than for the rainfall crops, such as cereals and cotton, crops typically grown by men. In addition, the size of the farms of horticultural products are very small, on average 0.1 ha per farm. The rental of irrigated plots in developed areas such as the Office du Niger benefits tenants and those who rent. Given the small plots, the high demand for labor, and the high value of yields, many women and young people see the production and marketing of horticultural products as a means of achieving economic independence from the head of household (Key informing Survey, 2022). According to different studies, women account for 40% to 80% of the horticulture production labor and around 80% of traders in horticultural products (Drame, Moumouni, & Traore, 2018).

Market and Consumption

Demand for Nutritious Fruits and Vegetables

In Mali, according to FAO data, fruit and vegetable consumption was estimated at 74.89 kg/inhabitant/year and that of vegetables at 93.3 kg/capita/year (Figure 6.4). In 2019, fruit consumption fell to 66.26 kg/capita/year, but vegetable consumption increased to 115.81 kg/capita/year.

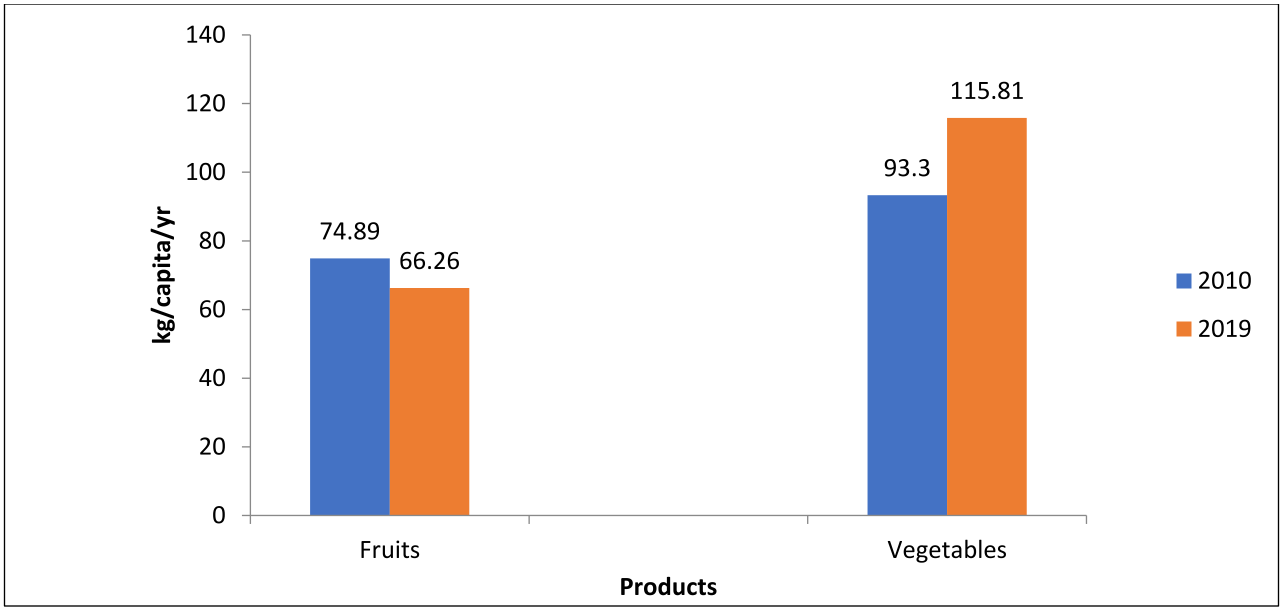


Figure 6.4: Fruit and Vegetable Consumption in Mali
Source: FAO (2019)

The Household Food Diversity Score (SDAM) shows households in Mali consume fruits, vegetables, and leaves in the respective order of 11.8%, and 65.2% (ENSAN, 2018). These statistics show that there is a potential domestic demand for fruits and vegetables. From a nutritional point of view, horticultural products provide considerable benefits. With high nutritional intensity, they offer farming households as well as urban consumers an important source of vitamins, fiber, and micronutrients (Key informing Survey, 2022).

Market Access

Most of the horticultural production is intended for sale. The main customers are women resellers, processors, exporters, etc. Transactions take place either in the field or at the market (Key informing survey, 2022).

In most cases, the sale is made by the number or the heap except in the case of bananas, potatoes, onions, and shallots which are sold by the kilogram. According to a study carried out by the FAO in 2000 in Mali, in the market gardening sector, 31% of small producers declare that they market their products themselves. This percentage decreased to 7 and 2% respectively for medium and large producers. Direct marketing is carried out by the farmers' wives who are in charge of the retail sale in the markets. Most of the production is sold on the farm (from 69% for small producers to 98% for large ones). Seasonal commodity price fluctuations reflect agronomic and climatic constraints as well as underdeveloped marketing infrastructure (Diakité et al., 2014).

Value-added horticulture products

Horticultural products are mostly sold fresh for domestic consumption and export (CPS/SDR, 2019). There are few processed and semi-processed products from these specific value chains, which are geared toward export.

Trade

Imports are mainly vegetable seeds, bananas, plantains, yams, onions, potatoes, garlic, and processed products. The cooperatives of planters and market gardeners organize the marketing of their members both for the internal market and for the external market. Some exporters have organized themselves to create associations while others work independently. Generally, all these exporters collaborate with development structures to organize production. According to Diakité et al. (2014), the products are generally exported to neighboring countries such as Burkina, the Ivory Coast (potatoes, onions, fresh and dry peppers), Mauritania (watermelon, squash, mango), Senegal (dry peppers, mango, watermelon) and Europe (mainly mango and green beans but also eggplant, fresh and powdered okra).

6.4 Engineering and Technology

Production technology and supplies
Faced with the depletion of the soil and the intensification of production, more and more producers are turning to Microdosing and the use of chemical fertilizers and biological fertilizers such as fertinova (Key Informant Survey, 2022).

Postharvest packaging, cooling, cold storage, drying
Units specializing in the storage of horticultural products (PLAZA: Modern refrigerated and packaging warehouse located in the Bamako area, other logistical infrastructures in the main producing regions Sikasso, Koulikoro, Bougouni), exporters, processing units such as Large Cereal Distributor in Mali (GDCM), and some women's cooperatives have postharvest packaging, cooling, cold storage, and drying equipment (Key Informing Survey, 2022).

Processing of horticultural products
Most of the processing of horticultural products is dominated by women's cooperatives, which are generally semi-industrial or artisanal units. Alongside these cooperatives, there are a few very well-equipped industrial units with a large capacity for processing, packaging, and sales at the national and sub-regional levels (Key Informant Survey, 2022). These horticultural product processing and marketing units are found in all regions of the country (Key Informing Survey, 2022). One of these agri-food processing units is the Laboratory of Agro-food Technology (LTA) of IER.

Research, education, and training
Education and training needs in horticulture
Education and training needs in horticulture are done along the value chain from the production techniques, storage techniques, processing, management technique, and marketing technique (Key informing survey, 2022).

Research capacity of technical vocational institutes, universities, and research institutes
According to the key informant survey (2022), the institutions of education, research, and technical assistance existing in Mali are:

- Rural Polytechnic Institute for Training and Applied Research (IPR/IFRA): considered one of the best agricultural engineering schools in the region
- Institute of Rural Economy (IER): agricultural research policies; approval and certification of agricultural inputs; and importation, testing, and distribution of the latest crop varieties
- The DNA (National Directorate of Agriculture) Agricultural Learning Centers (CAA),
- University of Bamako (FSEG)
- Sahel Institute Permanent Interstate Committee for Drought Control in the Sahel (CILSS) CILSS): leads a common regional regulatory framework for pesticides as well as the approval process for new pesticides
- International Crops Research Institute for the Semi-Arid Tropics (ICRIS) (CGIAR network) International research institute actively conducting crop research in Mali and leading a world-class geographic information system (GIS) unit in partnership with IER

- Laboratories: several laboratories are equipped to conduct quality research and analyzes (SEP, IPR IFRA, LCV, etc.)
- PLAZA: Modern refrigerated and packaging warehouse located in the Bamako area, other logistics infrastructure in the main producing regions (Sikasso, Koulikoro, Bougouni).

Extension capacity in the public and private sector
Extension service are undertaken by public such as DNA and NGOs such as European Cooperative for Rural Development (EUCORD), Association Malienne d'Eveil Au Développement Durable (AMEDD), Association Malienne pour le Développement Durable (AMDD), FASO JIGI, Association Malienne pour la Sécurité et la Souveraineté Alimentaires (AMASSA), Mali Agricultural Market Development Trust (MALIMARK), etc. (Key Informant Survey, 2022).

6.5 The National Policy Environment for the Horticulture Sector

The state intervenes in the horticulture sector through development projects and programs, including the West African Agricultural Productivity Program (WAPP), the Proximity Irrigation Program, and the Strengthening of Irrigated Agriculture -Strengthening of Irrigated Agriculture (IPRO-REAGIR), a Support program for the local irrigation sub-sector – Strengthening of Irrigated Agriculture (PASSIP-REAGIR), GIZ projects, World Vegetable Center projects, DARWIN INITIATIVE, the JEKE NI JABA Project, USAID horticulture scaling project to improve nutrition and hygiene in Mali, etc. (Key Informant Survey, 2022). The policies, legislation, and strategies supporting the development of horticulture in Mali include the strategic framework for growth and poverty reduction (CSCRP 2012-2017), the agricultural orientation law (N° 06-40 /AN-RM), the Master plan for the Rural Development sector, and trade policy (key informant survey, 2022).

BURKINA FASO

7.1 Context

Agriculture is an important sector in Burkina Faso, contributing about 80% of the country's labour force and 16-30% of gross domestic product (Carrico et al., 2021). Agriculture also contributes significantly to food security and the income of agricultural households. Fruits and vegetables play a crucial role in food security and income generation for the rural population. In West Africa, horticultural production is particularly important in the Sahel countries (Burkina Faso, Niger, and Mali). Indeed, these countries are subject to climatic variability (drought, flooding) which means that horticultural production, particularly fruit and vegetables, is a way out for rural and peri-urban populations. The fruit and vegetable sector occupies a prominent place among sectors selected by the Burkinabe authorities. According to the Ministry of Agriculture (2018), there were approximately 698,682 market garden producers in Burkina Faso in 2018, of which 445,091 (65%) were managed by men and 244,592 (35%) were women. The largest market gardening regions are Centre-West (19%), Boucle du Mouhoun (14%), Centre-North (14%), North (10%), Centre-East (10%), Hauts-Bassins (8%), Centre (5%), Cascades (5%), and South-West (2%). The total area sown under market gardening in 2019 is 54,678.4 hectares.

The average area per region is 4,206 hectares. The major production regions in terms of area are Boucle du Mouhoun (9,759.0 ha), Hauts-Bassins (7,762.5 ha), Centre-North (7,558.5 ha), Centre-South (5,909.9 ha), and North (5,904.2 ha). The regions where market gardening is less practised are the South-West (480.9 ha), the Sahel (563.8 ha), and the East (1,623.7 ha). The sources of water mostly used by farmers are dams (30%) of market gardeners) and traditional wells (26% of market gardeners). After these sources come market garden wells (18%) and rivers (17%). Boreholes are the least used by farmers, with 5% of market gardeners using them.

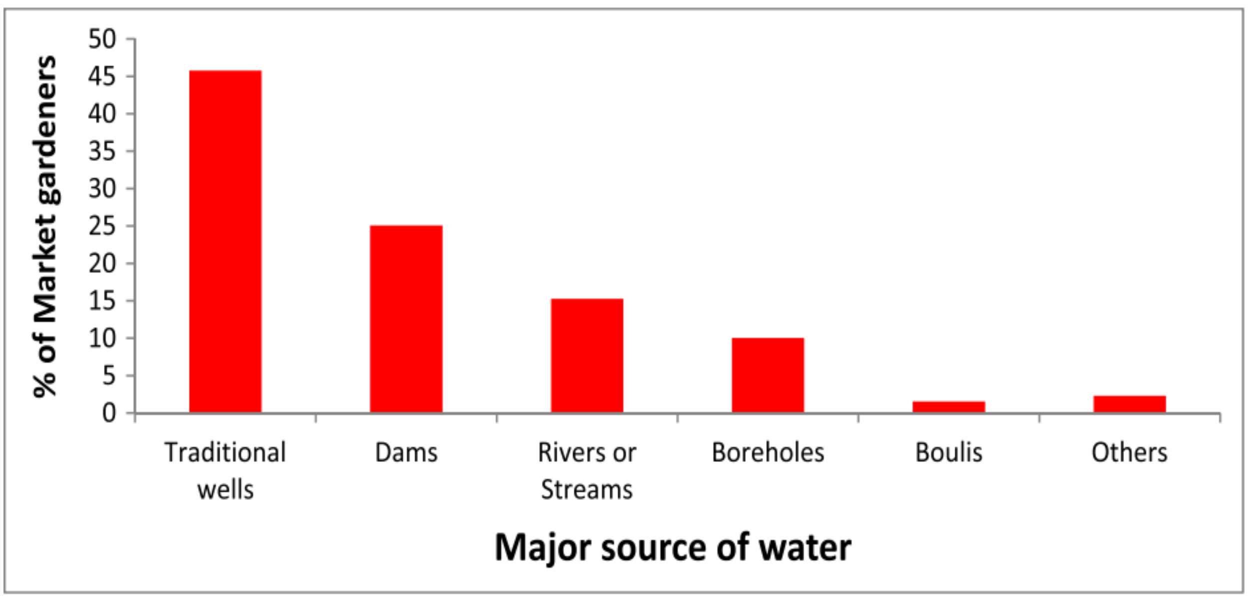


Figure 7.1: Number of market gardeners (%) by a major source of water
Source: (Sanfo, Barbier, & Zangre, 2017)

According to the FAO (2022), the volumes exported by Burkina Faso from 2016 to 2020 are more than 33, 000 Mt. Shea nuts, sesame seed, mangoes, and cashew were the dominant exported commodities (see Table 7.1).

Table 7.1: Volume of Commodities Exported by Burkina Faso (2016-2020)

Commodities	2016	2017	2018	2019	2020	Grand Total
Cashew nuts shelled	3676	2185	2032	2368	2514	2555
Cashew nuts, with shell	90360	98127	127011	96554	59669	94344.2
Eggplants (aubergines)	71	40	102	69	100	76.4
Shea nuts		135002	114933	150482	104740	126289.25
Mangoes, mangosteens, guavas	10334	7329	8941	8931		8883.75
Onions, shallots, green	8163	5345	5700	5486	12990	7536.8
Sesame seed	159837	110490	163559	72210	60770	113373.2
Soybeans	383	1159	2959	8790	15377	5733.6
Tomatoes	12610	8678	19160		0	10112
Vegetables, fresh nes	600	3000	3000	2200	5000	2760
Grand Total	**28603.5**	**37135.5**	**44739.7**	**31553.81818**	**26116.6**	**33589.11765**

Source: FAO, 2022

The revenue from this export is about $27.9 million. Cashew nuts, sesame seeds, shea nuts, and mangoes provide more revenue to Burkina Faso (Table 7.2).

Table 7.2: Value of Commodities Exported by Burkina Faso (2016-2020)

Commodities	2016	2017	2018	2019	2020	Grand Total
Cashew nuts shelled	9,362	10,497	13,086	14,247	14,961	12,431
Cashew nuts, with shell	103,209	144,759	198,732	81,028	53,262	116,198
Eggplants (aubergines)	36	9	14	8	9	15
Shea nuts		27,692	41,447	66,334	45,727	45,300
Mangoes, mangosteens, guavas	14,053	15,052	24,097	23,352		19,139
Onions, shallots, green	620	442	595	651	693	600
Sesame seed	113,363	96,774	128,540	70,589	64,468	94,747
Soybeans	230	699	1,777	4,196	6,399	2,660
Tomatoes	1,272	928	1,754		-	989
Grand Total	**24,217**	**29,696**	**41,024**	**26,049**	**18,576**	**27,912**

Source: FAO, 2022

7.2 Geography and Markets

According to MAAH (2018), there were an estimated 698,682 market garden producers in 2018 in Burkina Faso, comprising about 445,091(65%) men and 244,592 (35%) women. The largest market gardening regions are respectively Centre-West (19% of producers), Boucle du Mouhoun (14%), Centre-North (14%), North (10%), Centre-East (10%), Hauts-Bassins (8%), Centre (5%) and Cascades (5%). The other regions accounted for less than 5% of market gardeners each, notably the South-West (2%). Similar spatial distribution is also found by (Sanfo et al., 2017) by type of commodities (Figure 7.2).

According to the Ministry of Trade (2020), the main destinations of horticultural commodities from Burkina Faso are Cote d'Ivoire, Ghana, Togo, Benin, Senegal, and other countries such as Nigeria, Morocco, South Africa, and Egypt. Indeed, Sesame seeds, shea nuts, and cashew are mainly exported to Asia (China, Singapore, and India). Also, dried and fresh mangoes are exported to Germany, France, and the UK. For vegetables such as tomatoes and onions, are exported to Ghana and Cote d'Ivoire. The domestic market is also growing with the installation of medium and large[6] factories, especially for mango processing (juice and dried).

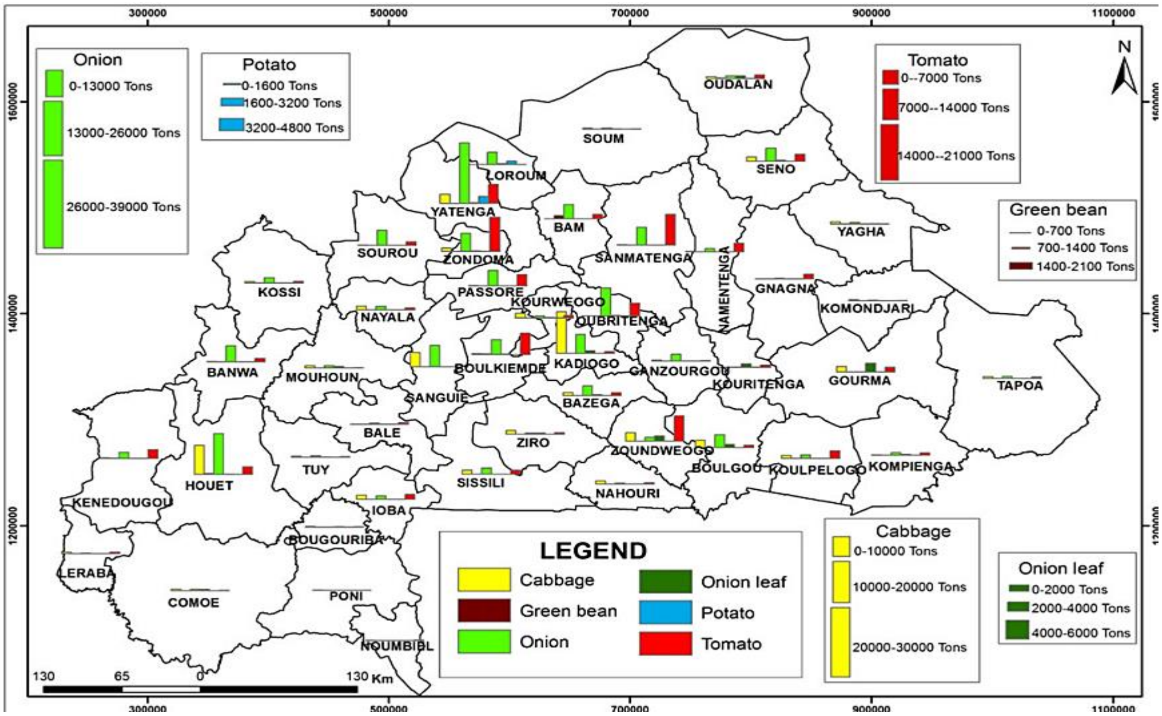


Figure 7.2: Comparison of horticultural crop harvested areas
Source:(Sanfo et al., 2017)

The horticultural products from Burkina Faso are mainly sold at the farm gate (more than 50%) and marketplace (49%). Due to the perishability of the products, storage is very challenging (Figure 7.3).

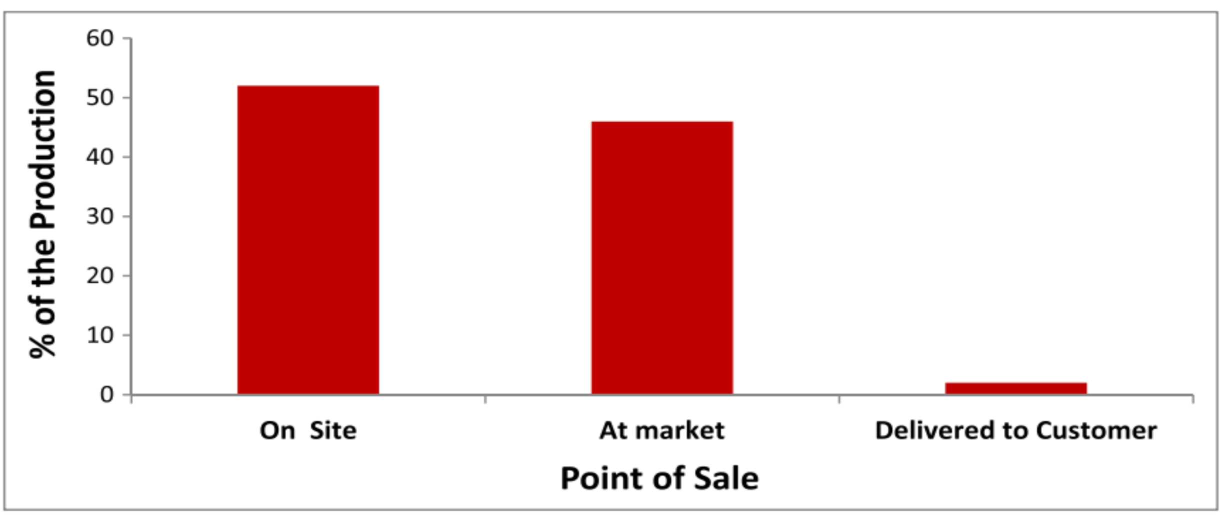


Figure 7.3: Percentage of production by point of sale
Source: Sanfo et al. (2017)

[6]https://burkina24.com/2021/12/21/burkina-faso-jus-de-fruits-malia-le-bon-gout-de-lafrique-produit-a-bobo/

7.3 Landscape Challenges and Opportunities

Horticulture-Biophysical

Inputs (including seeds supply)

According to the literature review and the key informants, the main inputs challenges include production, inputs supply, processing, and trade of horticultural products.

❖ **Inputs for horticulture production**

- Low supply of appropriate fertilizer;
- Low supply of local seed (90% of the seed is imported by Nankosem SA);
- Low supply of appropriate pesticides;
- Low supply of appropriate storage facilities
- Low supply of mangoes flies' pesticides

❖ **Challenges for horticulture Production**

- Small production plots;
- Water scarcity at certain times of the year (March-May);
- Low supply of storage facilities;
- Non-respect for technical itineraries by producers;
- Training manuals in French, whereas producers only speak local languages;
- The presence of pesticide residues prevents good marketing of fruit and vegetables;
- Poor access to finance due to climatic risks;
- Drought and floods

Production

The total area sown under market gardening in 2019 is 54,678.4 hectares. The average area per region is 4,206 hectares. The main production regions in terms of area are Boucle du Mouhoun (9759.02ha), Hauts-Bassins (7,762.50 ha), Centre-North (7,558.45 ha), Centre-South (5,909.86 ha) and North (5904.17 ha). The regions where market gardening is less practised are the South-West (480.89 ha), the Sahel (563.75 ha), and the East (1,623.66 ha).

The national onion yield is 19 tonnes per hectare. This level remains well below the maximum achievable yield of 40 tonnes/ha. The Cascades and South-West regions have the highest yields (26t/ha), while the Centre-East and Centre-South have the lowest yields (14t/ha) (Figure 7.4).

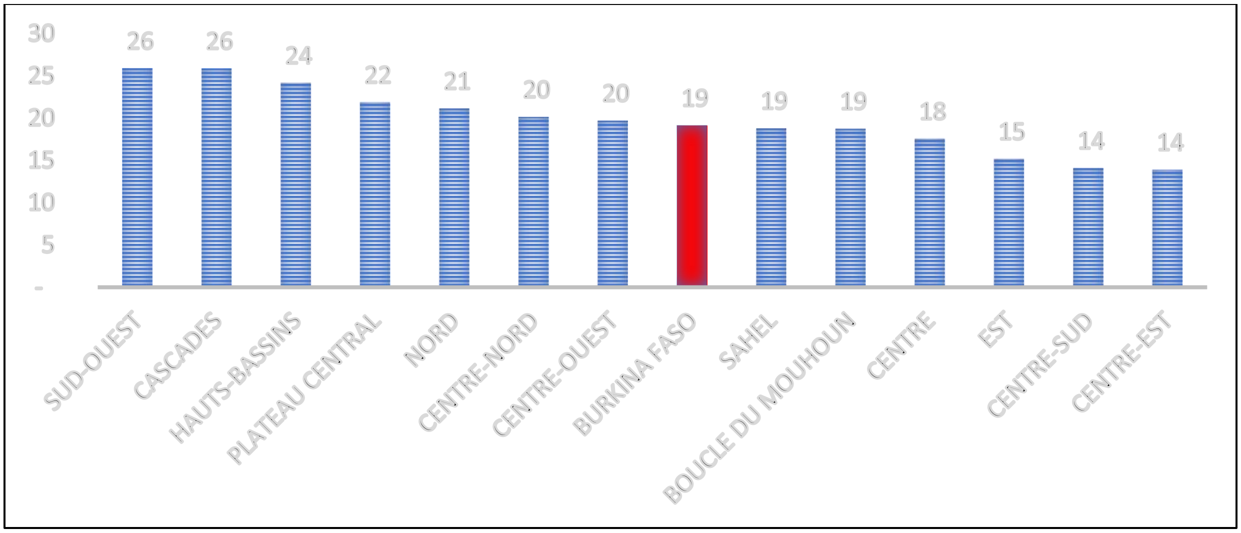


Figure 7.4: Onion yield (in t/ha) per region
Source: DGESS/MAAH, 2019.

The graph (Figure 7.5) shows the yield of cabbage. It shows a national yield of 24 tonnes/ha. This value is generally low compared to the threshold yield of 50 tonnes/ha. The highest yield is achieved in the Hauts-Bassins (37 tonnes/ha), followed by the South-West (32 tonnes/ha) and the Centre-East (30 tonnes/ha). The Centre region has the lowest yield (11 tonnes/ha).

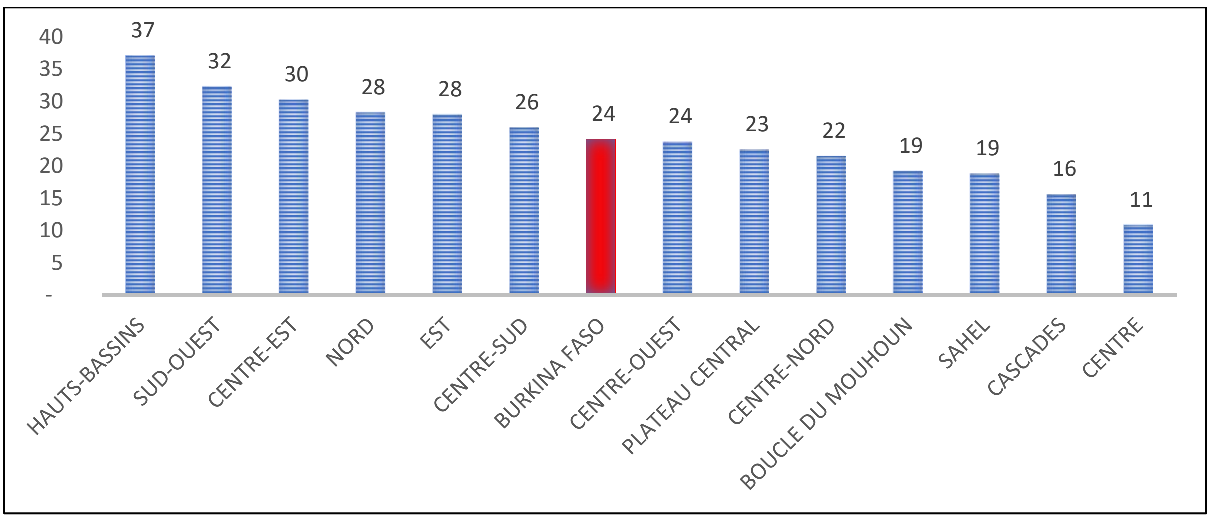


Figure 7.5: Cabbage yields by region (in t/ha)
Source: DGESS/MAAH, 2019

For tomatoes, the graph below shows that the national yield is 21tonnes per hectare, about 2.5 times lower than the maximum achievable yield of 50 tonnes per hectare. The Sahel region has the highest yield (33 tonnes/ha), followed by the North (28 tonnes/ha) and the Boucle du Mouhoun (24 tonnes/ha). The lowest yield is obtained in the Centre-South (9 t/ha) (Figure 7.6).

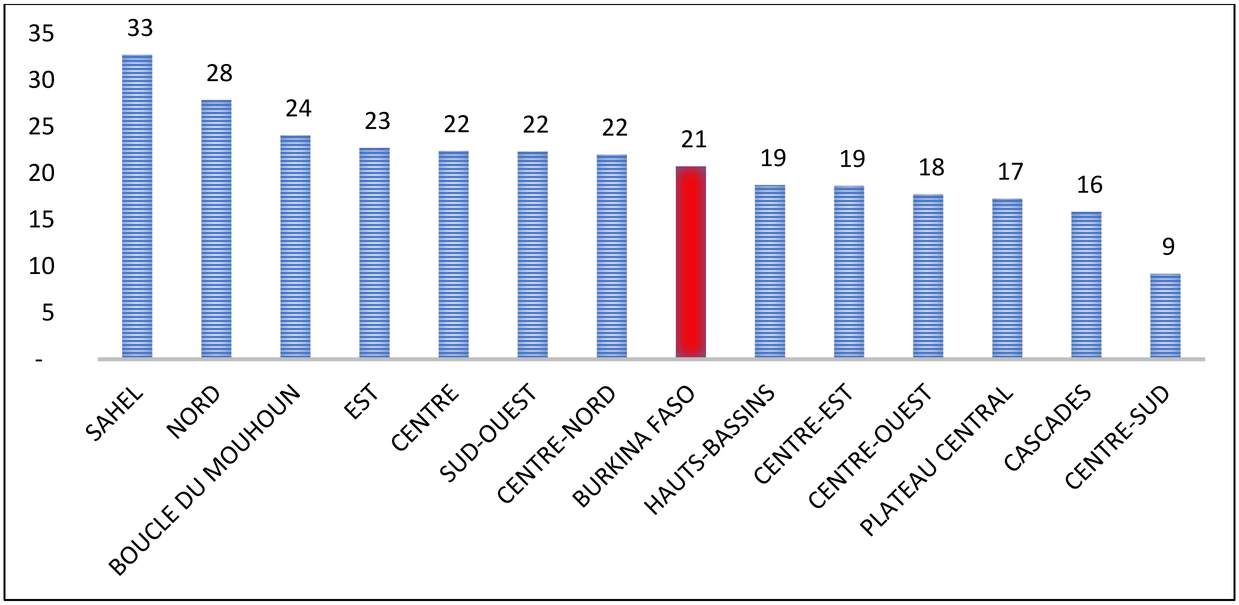


Figure 7.6: Tomato yields by region (in t/ha)
Source: DGESS/MAAH, 2019.

Income generated from some vegetables

The cultivation of onions, tomatoes, cabbage, and local aubergines in the dry season provides more than 123 billion, 48 billion, 78 billion, and 20 billion francs respectively to market gardeners in Burkina Faso (Table 7.3). For onions, the Boucle du Mouhoun region appears to be the most affluent with more than 36 billion CFA francs in income from the sale of onions by their market gardeners. It is in the South-West region that the sale of onions provided less in monetary terms to market gardeners (259 million).

The sale of tomatoes brought in more than 78 billion at the national level, including more than 5 billion in several regions: the Mouhoun loop, the center, the centre-east, the center-west, the center-south, the high basins, and the north. Cabbages are grown more in the high basins, the sale of which has enabled these market gardeners to earn more than 12 billion CFA francs. This speculation has enabled market gardeners in each region to earn at least 3.7 billion.

Local aubergines are sold more in the Centre-North region, where sales are estimated at 12.5 billion CFA francs. In the Centre Region, the production of local aubergines for sale is smaller, with sales estimated at around CFA 56 million. The sale quantities of stored produced after the harvest is sold later and will provide producers with additional income compared to the amount obtained at harvest time.

Table 7.3: Income from sales of vegetable crops (in millions of FCFA)

Region	Onion	Cabbage	Tomato	Local Eggplant	Okra
Boucle Du Mouhoun	36 521	3 004	7 950	814	908
Cascades	361	4 878	2 533	527	19
Centre	2 464	1 260	11 128	56	35
Centre Est	6 477	2 267	9 304	913	162
Centre-Nord	11 475	2 552	13 863	12 588	88
Centre-Ouest	17 187	3 786	6 987	2 518	138
Centre-Sud	4 479	3 257	5 156	355	88
Est	3 068	4 373	3 260	180	112
Hauts Bassins	11 116	12 277	8 672	789	455
Nord	24 027	8 432	5 134	737	257
Plateau Central	4 427	411	2 964	528	294
Sahel	1 824	1 509	815	493	1 692
Sud-Ouest	259	789	1 081	226	135
BURKINA FASO	**123 685**	**48 794**	**78 848**	**20 723**	**4 384**

Source: DGESS/MAAH, 2019.

Market gardening production is mainly intended for marketing. Indeed, more than 80% of the production of each of the four main vegetable crops is intended for sale. At the national level, 83% of onion production is sold. This marketing rate varies from one region to another. In the Centre and Centre-South, almost all of the production is destined for sale. The lowest rates are recorded in the Cascades and the Central Plateau, at 59% and 58% respectively.

The marketing rate for tomatoes and cabbage is at least 70% in all regions. Similarly, the marketing rate for local eggplant varies between 67% and 99% in the regions. Except for the Centre-West region, where the marketing rate is 67%. These sales are those that take place at the time of harvest.

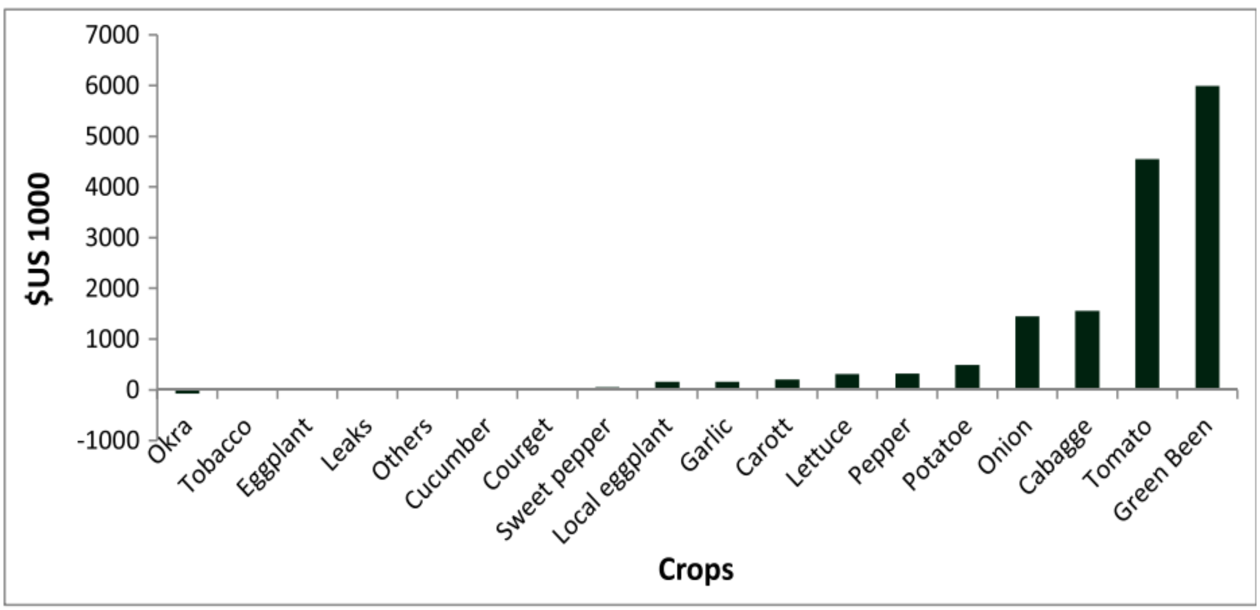


Figure 7.7: Net incomes in main crops per hectare
Source: Sanfo et al (2017)

Water access
The essential inputs for fruit and vegetable production are the natural resources of land and water. Burkina Faso has a large potential of irrigable land reaching 233,500 ha, of which about 12-14% is currently exploited (AFC, 2015). There are 54,678 hectares of irrigated vegetable plots (DGESS, 2018), and 8% of the 142,500 hectares of fruit trees are irrigated.

Irrigated vegetables include onions, tomatoes, cabbage, and lettuce, which covered 75% of the 27,000-30,000 ha in 2008. Fruits and vegetables are also grown on 500 ha of lowland where water lowlands where water accumulates in wells and reservoirs during the rainy season (Ouédraogo et al., 2019). Overall, the production period for vegetables, which depends largely on water availability varies from 3 to 10 months between September and July

Market gardening in Burkina Faso is practised in its entirety in small areas. At the national level, the area under vegetable production is between 4,000 and 6,000 hectares depending on the season. There are three types of vegetable farms:

Urban farms, are located within cities, either along the waterways (such as the market gardens on both banks of the Houet in Bobo-Dioulasso), or downstream and around the dams built inside the cities.

Peri-urban farms are located in the suburbs of cities around wells, boreholes, and dams, within a radius of 30 km of the towns. Near Ouagadougou, peri-urban farms exist in Saaba, Koubri, Loumbila and Boulbi. Bama is an important area for peri-urban agriculture near Bobo-Dioulasso, as well as Bobo-Dioulasso as well as Goinre for the city of Ouahigouya.

Rural farms, located in rural areas, often near dams and water reservoirs. Examples include the market garden sites of Guiedougou, Kongounsi, and Lake Dem. Also, the main challenges for the market include parasite attacks, water shortage, and pest control.

Improved varieties
Although the country attaches great importance to horticulture, national research remains low, especially in the field of seeds and specific inputs. The input sector is largely dominated by the following specialized companies: INERA, NANKOSEM, KING AGRO, SOPAGRI, SEMAGRI, SAPHYTO, EXOTIMEX, TIGRE AGRO. The focus on Burkina Faso is mainly on Tomatoes, Green beans, Onions, Cabbage, Potatoes, Peppers, Green peppers, and Carrots for vegetable farming. As for fruits, Burkina Faso is more focused on mango, cashew nuts, bissap (BARRO, Nanama, Coulibaly, Dieni, & Cordea, 2021).

The main varieties developed by National Research Institute (INERA) from 2007 to 2020 are five papaya varieties which include FBPA-1; FBPA-2; FBPA-2; FBPA-3; FBPA-4 and FBPA-1-13-1. Also, tree crop varieties such as mangoes and cashew have been developed by the National Research Institute. They include the following varieties: Brooks, Kent, Lippens, Amelie, Keitt for mango (MRSI[7], 2014).
Although vegetable varieties are also developed by national research, farmers are more focused on imported seeds, of which NANKOSEM is the leader in Burkina Faso. It is also known that NANKOSEM has an efficient distribution network covering the whole country with 11 distribution shops unlike INERA, whose seeds are very little multiplied by firms and distributed. The image below shows the varieties available at NANKOSEM[8] Burkina Faso.

[7] National Catalogue of Agricultural Species and Varieties of Burkina Faso (http://fagri-burkina.com/Docs/BF_2014_Catalogue_especes_varietes_agricoles_BF_Final.pdf)
[8]https://nankosem.com/plans/

Underutilized Neglected & Indigenous crops

Marginal crops in Burkina Faso include okra, garlic, strawberries, lettuce, aubergine, squash, watermelon, and tobacco.

Postharvest management of fresh products

Post-harvest management of horticultural products remains a challenge in Burkina Faso. Indeed, the lack of appropriate infrastructure and logistics means that tomato, green bean, lettuce, fresh mango, and chili farmers suffer huge losses at each production cycle. Only onions, cashew nuts, and shea nuts are products that producers manage to preserve before the sale. Recently, with the advent of drying technologies, dried mango and chili are beginning to be better preserved before sale.

Processing and packaging

Packaging horticultural products remain difficult in Burkina Faso. Indeed, there are very few local packaging factories. Most packaging needs to be improved, especially for freshly harvested products. According to MAAH (2019), only mangoes and cashew are processed in Burkina Faso. The other horticultural products are mainly used as raw materials (exports and national consumption). For mango, for example, there are nearly 15,000 producers, 14 international exporters, 76 drying units, one industrial unit (DAFANI), 5 packaging centres, 1,255 ha of orchards, and a total of 1,500 ha of fruit. units, an industrial unit (DAFANI), 5 packaging centres, 1,255 ha of modern orchards, 6ha of orchards, and 6ha of nurseries.

7.4 Natural resources

Water

According to the Ministry of Agriculture (2018), 58% of farms have a permanent water supply and 86% of sites are permanent. Regarding the permanence of the site, the Cascades region has the highest proportion of permanent sites (94%), followed by the East, Centre, and Central Plateau regions (86%). The proportion of permanent sites in the North is the lowest (56%).

Soil–fertility

The majority of producers combine organic and mineral fertilization. However, the Ministry of Agriculture states that the dose remains insufficient, especially for organic fertiliser. Indeed, the volume of fertilizer used was estimated at 6,411 tonnes, of which 65% was nitrogen, phosphorus, and potassium (NPK), 30.3% urea, and 4.8% phosphate. Fertilizer use is satisfactory for NPK and urea, as the average rates used are 635 and 296 kg/ha for NPK and urea, respectively. However, for organic fertilizer, farmers applied a rate of 2.7t/ha which is below the recommended rate of 10-20 t/ha. Furthermore, the majority of fertilizers available on the market are not for fruit and vegetable production.

Climate

Most of the horticultural crops are produced during the dry season. Water shortage, drought, flood, and wind are the main climate factors faced by farmers concerning fruits and vegetable production. For mango and cashew, pest attacks, and flies are the obstacle in the production sector (Nebie, Dabire, Fayama, Zida, & Sawadogo, 2021).

7.5 Socioeconomic

Women and youth in horticulture

Market gardening is most important in the Centre-West, followed by the Centre-North, Boucle du Mouhoun, North, Centre-East, Hauts-Bassins, Centre, Cascades, and East. Market gardening was little practised in the South-West, Sahel, Central Plateau, and Centre-South regions. However, some regions stand out for the strong presence of women among market gardeners, notably the Sahel region where 83% of market gardeners are women, although the activity is relatively small. The Centre-North and Centre-East regions follow with 63% and 59% of market gardeners being women respectively. In the other regions, women represent less than 44% of market gardeners.

According to MAAH (2018), the majority (55.52%) of Burkina Faso's vegetable producers in 2018 are over 35 years old. The Eastern region is the one with the youngest people aged 35 and under, who account for 60.59%. The Centre region concentrates more producers aged over 35, whose proportion reaches 75% of the total for the region. Similar results were found by Sanfo et al. (2017) when analysing market gardeners in Burkina (Figure 7.8).

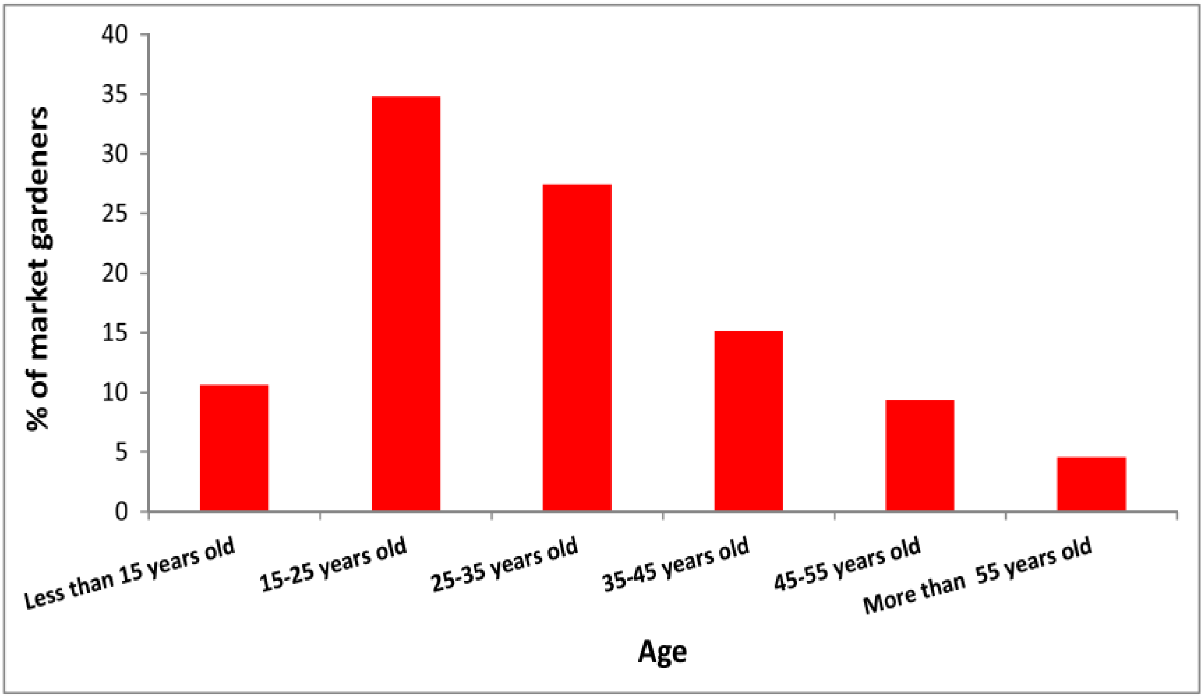


Figure 7.8: Percentage of market gardeners by age group
Source: Sanfo et al. (2017)

Marginalized groups in horticulture

Crops such as sorrel, Kenaf, Urena, potato, sunflower, sesame seed, and fonio are the most marginal in Burkina Faso. Admittedly, the sesame market is developed but varietal creation and other aspects are neglected.

Market and consumption

Burkina Faso has a growing market for fruits and vegetables both locally and internationally. It supplies the West African sub-region with mangoes, onions, and tomatoes. Niger, Ghana, and Côte d'Ivoire are the main African mango, onions, and tomato destinations. The transport to the sub-region is by truck. Burkina Faso's mango exports represent 0.5% of world mango exports, placing it in 31st place in the world exports, making it the 31st largest exporter in the world after Mexico, the Netherlands, Peru, Brazil, and India. According to MAAH (2019), the value of Burkina Faso's mango exports amounted to US$15.1 million, representing 7,322 tonnes of mango exports in 2017. The annual growth rate in value between 2013 and 2017 is 26%. It was 6% between 2016 and 2017. Burkina Faso's main buyers of mango are the Netherlands (33%), the UK (19%), Germany (19%), Germany (17%), France (9%), Italy (6%), USA (6%), Spain (3%).

Horticulture contributes significantly to food security, employment, social inclusion, and the creation of green spaces. Despite these benefits, the sector is bedevilled with many challenges. Farmers are subject to the scarce and contentious availability of land and water resources as well as to the rudimentary nature of the equipment used, the poverty of the soil, and the health risks incurred by the use of untreated wastewater, chemical fertilizers, and pesticides.

Agribusiness opportunities

The interviews identified business opportunities in production, processing, and marketing.

- **At the production level**, cooperatives and individual producers stressed that they have difficulties in accessing biopesticides and pesticides that can effectively treat fresh mango. This is therefore an opportunity for any company that can make mango-friendly pesticides and biopesticides available. Also, for tomatoes, there are serious problems with storage and transport to client countries (Ghana and Cote d'Ivoire). Any company that can offer adapted storage and logistics technologies is therefore welcome.
- **At the processing level**, there are almost no factories that process tomatoes or onions. There is only processing of mango and cashew nuts. It is therefore important for entrepreneurs who can process tomatoes and other vegetables. Of course, mango and cashew nuts are processed, but their waste (cashew apple, mango skin) is still very little used by agribusinesses. In addition, there is a severe lack of packaging suppliers for horticultural products in Burkina Faso. This is therefore a business opportunity according to the actors we met.
- **At the marketing level:** the rejection of mangoes linked to the fruit fly, for example, is one of the causes of rejection of the Burkinabe mango abroad.

7.6 Horticulture Research Priorities

Farmers and Farmers Organisations' opinions

- Improvement of plant material to increase yield.
- Update data on production, raw cashew nut yields by region
- Assess the quality of raw cashew nuts
- Improvement of plant material to increase yield.

Researchers 'opinions on research priorities

- Genetic characterization of a collection of accessions of local species (black nightshade, great nightshade or gboma, amaranth, squash)
- Characterization of fungi responsible for Solanaceae fungal diseases in Burkina Faso
- Selection and creation of high-performance tomato and onion varieties adapted to market needs
- Selection and creation of local eggplant varieties resistant to the most pathogenic fungus in Burkina Faso.

Inputs providers' opinions on research priorities

- Comparative effect of pheromone traps and foliar insecticides on fruit flies
- Selection of resistant and early varieties
- Creation of local varieties of vegetable seeds
- Comparative studies of the adaptation of existing varieties to different seasons

Processors' opinions on research priorities

- Research on equipment that consumes less electricity
- Research on types of technologies for the preservation of fruits and vegetables
- research on sustainable packaging for fruits and vegetables

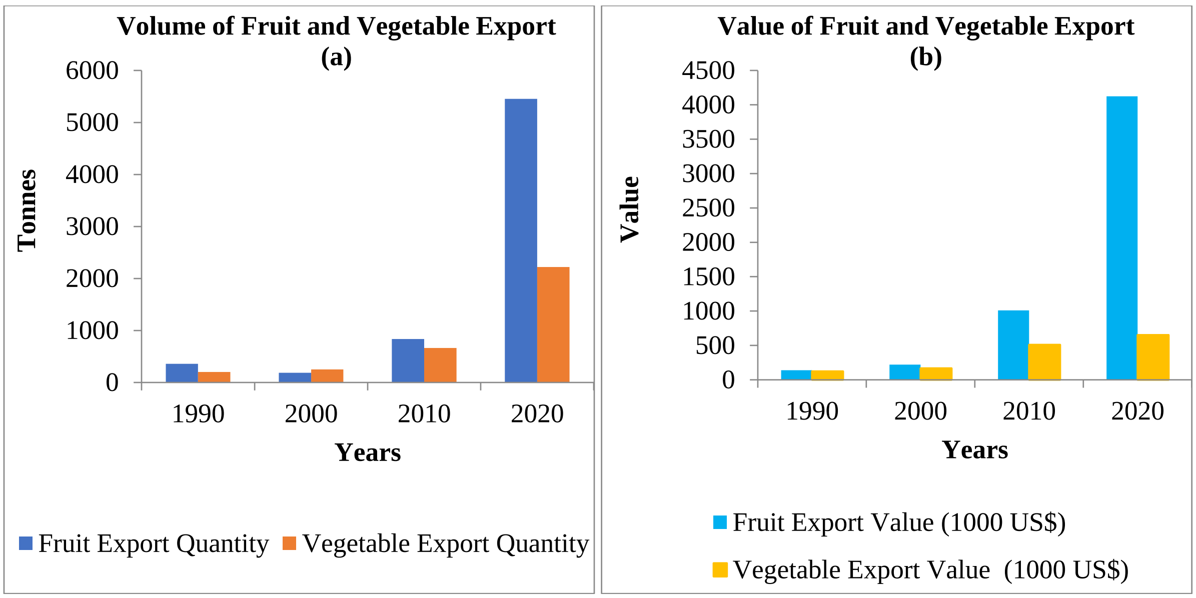
Exporters 'opinions on research priorities

- Renew orchards
- Control of these diseases and pests

TOGO

8.1 Context

Togo is an agrarian country. Agriculture employs the majority (70%) of the country's labor force and contributed about 40% of the GDP (Julien, Kossi, & Aklésso, 2021). The fruit and vegetable sector contributes more than 20% to the agricultural GDP and employs more than three workers per farm unit (Radji and Kokou, 2017). Horticulture production plays a significant role in poverty reduction and the welfare of agricultural households (Radji and Kokou, 2017). Togo accounts for 0.07% of exports of fruits and vegetables from the West African Economic and Monetary Union (WAEMU) zone to the European market. However, the export of fruits and vegetables has been increasing over the last few decades. Vegetable export remained low and stable from 1990 to 2000. However, it increased significantly in 2010 and 2020 (Figure 8.1a). The value of vegetable export in 2020 was also higher than that of 2010 (Figure 8.1b).



Figures 8.1a and 8.1b: Volume and value of fruit and vegetable exports
Source: FAO (2020)

Fruit export remained higher than vegetable export. Fruit export has had significant increases in recent years. The export of fruits increased from 188 tonnes in 2010 to 5,455 tonnes in 2020. Similar trend was observed for the value of fruit exports. The area under fruit production increased from 7,221 hectares in 1990 to 9,823 hectares in 2020. Vegetable production area also increased slightly from 24, 550 hectares to 29,431 hectares in 2020. As a matter of fact, between 1992 and 1994, the area dedicated to vegetable production was more than 30,000 hectares.

Between 1990 and 2020, fruit production increased from 46,358Mt in 1990 to about 66,823Mt in 2020. However, vegetable production has been declining over the last three decades. Vegetable production declined from 158,700 tonnes in 1990 to 149,504 tonnes in 2020.

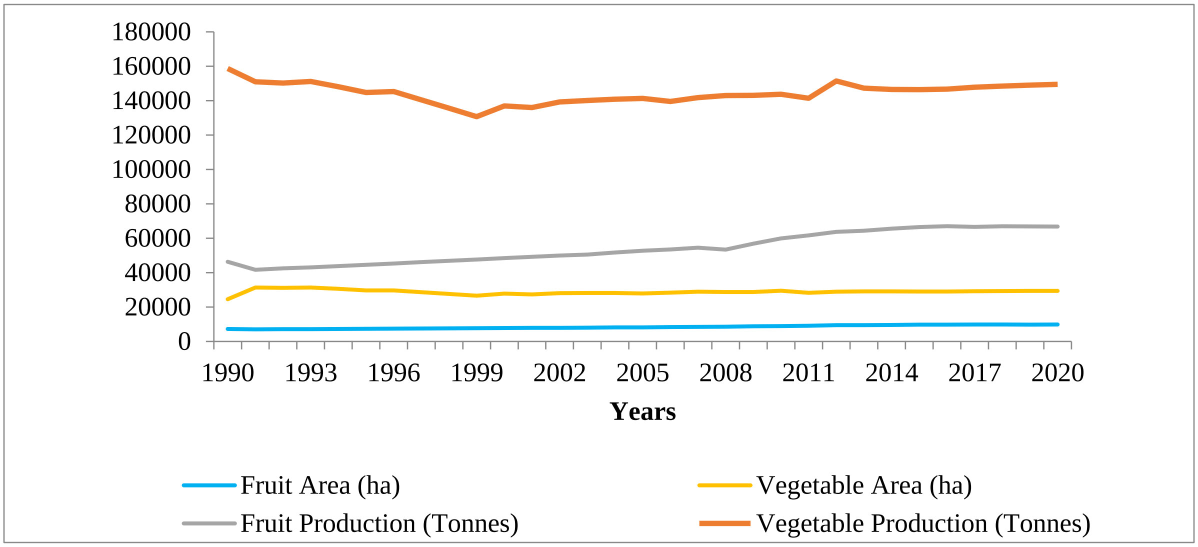


Figure 8.2: Production of Fruit and Vegetable Exports
Source: FAO (2020)

8.2 Biophysical

Production and Productivity of Major Fruits and Vegetables in Togo

Bananas, oranges, pineapples, and tomatoes are among the major fruits and vegetables produced in the country. In 2020, oranges ranked first in land area under cultivation, followed by bananas. This is because banana has a higher yield (12.1Mt) than orange (4.6 tonnes/ha). The area under pineapple production and yield of pineapples remained unchanged between 2019 and 2020 (Table 8.1).

Table 8.1: Production and Productivity of Major Fruits and Vegetables in Togo

Crops	Area (ha)			Yield (tones/ha)			Production (tones)		
	2019	2020	% change	2019	2020	% change	2019	2020	% change
Bananas	1996	2018	1.1	12.2	12.1	-0.8	24383	24398	0.1
Oranges	3227	3237	0.3	4.6	4.6	0.0	14873	14925	0.3
Pineapples	230	230	0.0	8	8	0.0	1843	1847	0.2
Tomatoes	1262	1257	-0.4	4.2	4.1	-2.4	5250	5214	-0.7

Tomato land area, yield and output declined by 0.4%, 2.4%, and 0.7% between 2019 and 2020.

Chemical Inputs

Inputs used in horticulture production are fertilizer, seeds, and agrochemicals. The fertilizer application for vegetables and fruit is done with chemical and organic fertilizers. Chemical fertilizers are imported, while organic fertilizers are locally produced. There is a general subsidy for targeted smallholder farmers in the country for chemical fertilizer.

Most of the vegetable crops are produced at the small scale and can be produced throughout the whole country. Fruits such as pineapple can only be produced in the maritime and plateaux regions by about 4,000 producers where the climatic conditions are favourable. Most of the production is sold fresh and about 12,000 tons are processed into juice (organic and conventional).

The major farming seasons of vegetable crops are the rainy seasons. Currently, a large part of the vegetable and fruit production are rainfed. There is also the production of vegetable crops using manual irrigation during the dry season where investments have been made to achieve a year-round water supply, these consist of small dams along regional streams and basic pump and pipe surface irrigation. Savana and Kara regions are the major production area of tomatoes, onions and melons during the dry season because of special climatic conditions in these regions.

Post-harvest

The main post-harvest problems, on the international market, are the presence of insects in the crops. For example, there have been occasional interceptions of batches of cassava leaves with whiteflies (*Bemisia tabaci*) and recent interceptions of eggplants with various pests, mainly shoot moth (*Leucinodes orbonalis*) as well as flies' fruit, moths and thrips which also affect mangoes and leafy vegetables. The local market, is careless about the presence of these insects.

Processing and Packaging

Vegetable processing is not well developed in Togo. Processing is done only to traditional vegetables such as ademe and okra which are dried. Fruits processing into juice (orange, pineapple and mangoes) or dried (pineapple and mangoes). The most important companies involved in food processing in Togo include Tropic Bio, Junabio, Agro-Food, Julado Rehoboth, Rimouski, Allbio Togo etc, Safleg, Setrapal, Pronatura. The processing of pineapple in juice is developing in Togo, like the Jus Délice factory located in Gbatope, 47 km north of Lome. The construction of this factory began in November 2018 and it was inaugurated at the end of April 2019. It was developed with an investment of 1.7 billion CFA francs (nearly 2.6 million euros) from the support of the European Union and German cooperation. Jus Délice is produced from "organic" pineapple juice. It aims to obtain ISO 22000 certifications to continue to develop its export market, particularly the European Union.

Natural Resources

Most vegetable crops are irrigated manually with watering cans, but fruits such as mangoes, oranges and pineapples are mainly rainfed. The waters used in the irrigation of vegetables are either underground water (wells) or surface water (reservoir or lowland water), that is why more vegetables are produced close to the lowlands. The fruits are more produced not only on fertile soils but also on suitable soils. It is thus noted that the region of the plateaux (the most fertile zone of the country) is the region where various types of fruit (bananas, mango, orange avocado etc) are more produced.

8.3 Socioeconomic

Women in Horticulture

The horticulture sector is one of the few income-generating opportunities for women in rural and urban areas in Togo and therefore has a huge impact on development. Rural women represent 56.4% of agricultural workers and 43% of goods processors. They are important in the horticulture value chain.

Market and Consumption

Fruit and vegetable consumption in Togo, which has been only around 100g per person per day in recent years, is significantly lower than the WHO recommended intake of 400 g of fruit and vegetables per day. The supply of fruit and vegetables has fallen by around a third since 1990 after an increase in the early 1990s proved unsustainable. Fruit and vegetable production in Togo only meets a quarter of domestic demand.

Trade

Togo mainly exports its horticulture product to sub-Saharan Africa (52%), East Asia (37%) EU (9%) and Nort America (2%) (Figure 8.3).

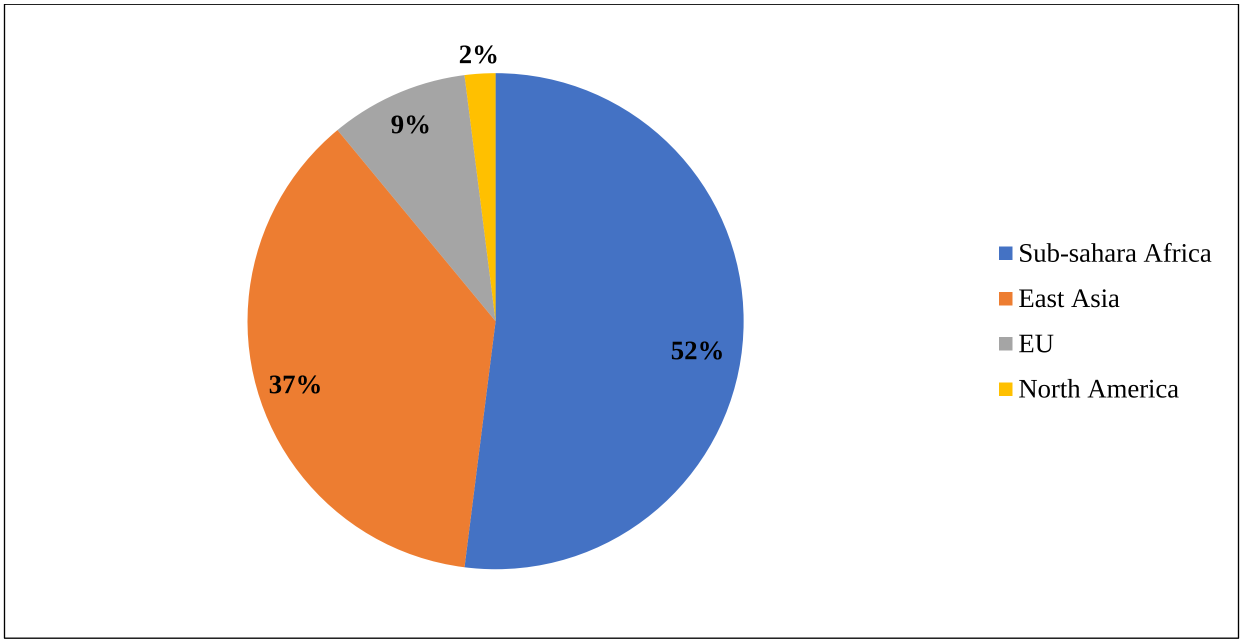


Figure 8.3: Distribution of export countries for Togolese horticultural products

Research, Education and Training

Research in the horticulture sector is conducted by School of agriculture (ESA/UL) and by National Agronomic Research Institute (ITRA). Most of this research is conducted on a crop-by-crop basis.

The higher school of agronomy trains its learners in horticulture. Farmers, for their part, receive capacity building from ICAT and NGOs.

SENEGAL

9.1 Context

Senegal, located the westernmost part of West Africa, covers an area of 196,722km with an estimated population of 16.7 million people in 2020. The GDP of Senegal was $24.64 billion with per capita GPD of $1,471.8 (World Bank, 2020). About 58% of the population is under 20 years old, with 55.7% has formal education. Service, agriculture and industrial sector contribute 49.94%, 17.03%, and 23.22%. Horticulture production is a backbone of the Senegalese economy due to production of food, income for rural people, employment and foreign exchange through exports. The importance of the added value of its products and the existence of a potential market both domestically and internationally make very attractive and profitable.

Senegal is endowed with favorable climatic conditions for horticultural production in different areas of the country: Cape Verde region, the Niayes, the Senegal River valley, eastern Senegal, Casamance, center of Senegal. Moreover, the practice of horticultural crops has become a tradition in the northwestern part of the country which practically serves as a learning zone for the rest of the other regions. The growing urban demand for fruit and vegetables and the development of exports of these products to Europe with the presence of international airport infrastructure in the capital are remarkable factors supporting the growth of this sector. The sector is steadily increasing despite the difficulties that still remain despite goals set by the State.

9.2 Geography and Markets

Senegal's closeness to EU makes the country a potential hub for horticultural crop production in West Africa. The country is appromxiately 5,139.3 kilometers from EU coupled with favourable climatic and soil conditions for horticultural production in different areas of the country including the Niayes, Senegal River Valley, eastern Senegal, Casamance, and Valley in Saloum (center of Senegal). The main markets are exports of products such as melon, cherry tomatoes, sweet corn, green beans, squash, sweet potatoes, etc. There is the national market and the countries of the sub-region, which absorb a very good part of this national production.

Notable production practices

The region Niayes extending from Dakar to St Louis, is credited with more than 60% of crops, and provides onions, potatoes, carrots, kale, cherry tomatoes, eggplants, lettuce, pepper. The Senegal River Valley specializes in industrial tomato production (90 000 tons in 2010), onions (between 30 000 and 60 000 tons) and sweet potato (more than 60 000 tons/year).

- Valley of Lower Saloum, where African vegetable types are sold (Bisap, okra, Jaxatu).

Fruit crops are including:

- In Lower Casamance (mangoes, bananas, citrus fruits) and
- The medium Casamance area (Bananas), other production clusters are
- The Dakar-Pout - Mboro, and Dakar- Mbour with productions of mango, citrus, papaya.
- Eastern Senegal Tambacounda with the area around the Gambia valley (bananas and mangoes).
- The future potential expansion areas of fruit crops are:
- The Senegal River Valley with the axis Dagana - Podor
- Bakel for Banana
- Kolda for mangoes and bananas.

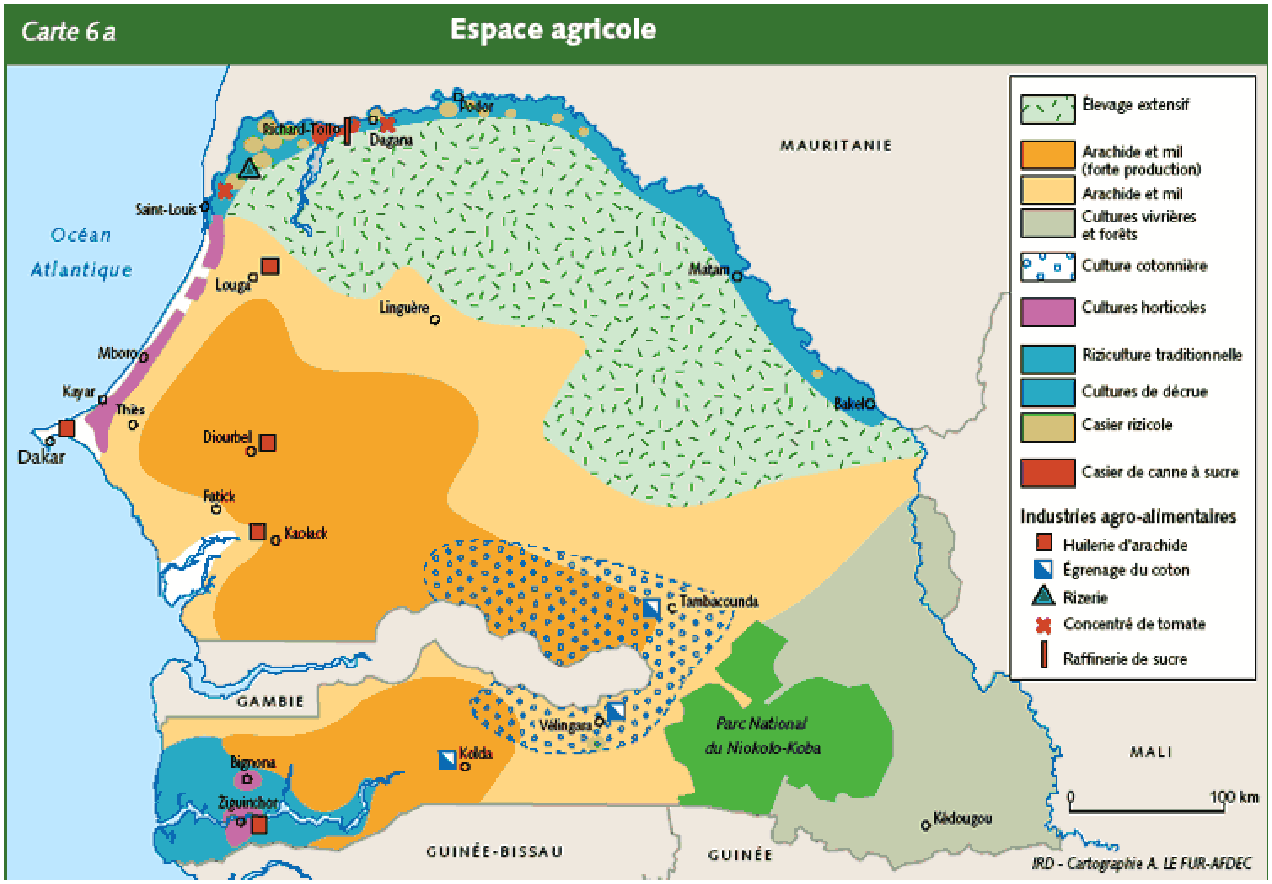


Figure 9.1: Agricultural Areas in Senegal

The Senegal River Valley region and the Niayes are the main production areas for onions in Senegal. These locations account for 85% of annual production. Exponential growth in demand for onions locally has led to new smaller production regions. In 2016, Thiès, Kaolack, Touba and Kolda produced approximately 15% of overall production. The large size of the onion market has also attracted interest from large scale industrial agriculture with a few important investments having been made in the recent years. Farmers pump water from the river, and use gravity irrigation or pumps to irrigate their fields.

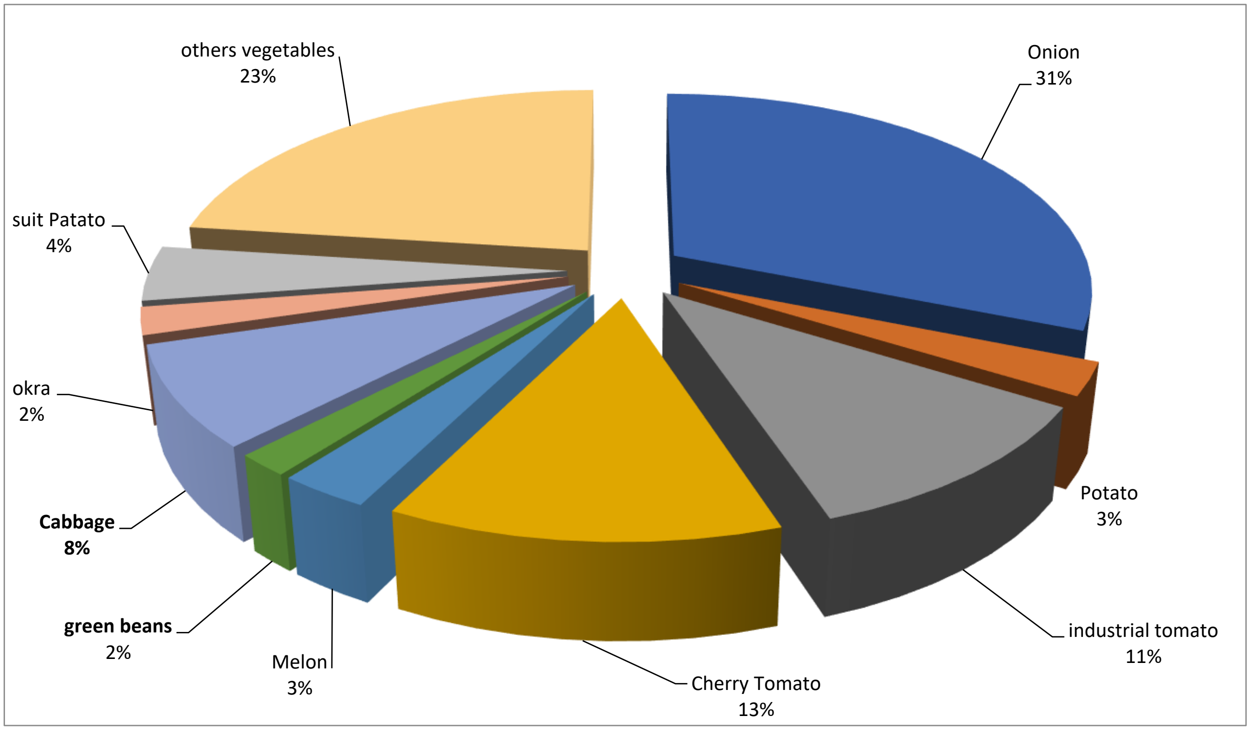


Figure 9.2: Distribution of vegetable production in Senegal (%) in 2012

Source: DH Data 2012

9.3 Challenges and opportunities in Horticulture Sector

Horticulture – Biophysical

Inputs (including seed supply)

The market for horticultural inputs and seeds is very well organised in Senegal. Most inputs such as seed and fertilizers are imported. The producers source various fruits and vegetable seeds from international private sector companies. Quality seed is supplied by companies such as Bejo Seeds, who have a strong working relationship with these firms. For the more vertically integrated producers who produce in multiple countries, inputs in general are sourced for the entire group, rather than for their Senegal locations alone. Pesticides certified for use in the EU are not available in Senegal. Local multiplication of vegetable seed is only done on a very small scale by cooperatives in the sector. Even small-scale producers typically access green bean and sweet corn (and other vegetable crops such as tomatoes, aubergine, squash etc) seed via input suppliers.

Production

Table 9.1: Fruits and Vegetable Production in Senegal (2012-2019)

Commodities	2010/2011	2012	2013	2014	2015	2016	2017	2018	2019
Onion	190 000	210 000	230 000	245 000	367 500	393 225	400 000	434 112	444 871
Potato	12 500	15 000	20 000	29 680	52 230	67 485	118 783	140 000	158 875
Industrial tomato	110 000	80 000	50 000	97 513	57 700	32 000	70 000	77 000	73047,6
Cherry tomato	50 000	80 000	110 000	83 000	82 500	70 000	68 000	71000	78 396
Melon	15 000	20 000	18 000	20 000	19 000	21 500	28 000	24532	25 632
Green been	10 500	10 000	14 000	10 500	15 500	15 000	18 700	18815	20 879
Cabbage	50 000	55 000	55 000	51 182	55 500	60 000	76 116	105096	189 618
Okra	13 000	15 000	15 000	15 000	15 000	15 000	14 500	14000	22 185
Sweet potato	35 000	30 000	30 000	28 350	35 000	70 000	72 000	89397	96 360
carrot	-	-	9 500	10 500	11 500	12 000	16 000	17085	24 600
Hibiscus sabdariffa	-	-	1100	1 200	1 200	1400	1300	1500	1678
Other vegetables	15 400	160 000	168 000	160 500	185 800	207 700	200 000	209751	215 875
Vegetables	**640 000**	**675 000**	**710 000**	**741 925**	**886 930**	**953 310**	**1 083 399**	**1 202 288**	**1 349 016**
Mango	120 000	125 000	130 000	131 500	125 000	130 000	132 000	128 450	130 000
Banana	30 000	35 000	35 000	35 575	36 500	37 000	30 000	31 422	33 110
Citrus	50 000	45 000	40 000	50 000	50 000	50 000	45 000	48 500	52580
Other fruit products	20 000	25 000	35 000	36 000	35 000	36 500	30 000	35 700	59 750
Total Fruits	**220 000**	**230 000**	**240 000**	**253 075**	**246 500**	**253 500**	**237 000**	**244 072**	**275440**
Total fruits and vegetables	**680 000**	**905000**	**932000**	**995 000**	**1133430**	**1206810**	**1 320 399**	**1 446 360**	**1 624 456**

Improved varieties
Farmers in Senegal source seeds largely from the private sector. A variety of seeds are available in Senegal that allows for production in both the cold season and the early part of the hot season. Importers form the cornerstone of this portion of the onion value chain. Tropicasem is a major player, importing seeds that have been tested for being suitable for local conditions.

Postharvest management of fresh products
In Senegal, there is lack of infrastructure for large production areas. For example, the region of Casamance region, which provides 55% of the national mango production, has no cold storage infrastructure.

- Since 2000, the state has started a conservation program for cold storage in Rao, in the north of the country, with 9 cold rooms, a total capacity of 2500 tons, but this infrastructure is currently facing a problem with the management of the structure
- High Cost of rental: 30 million FCFA / month
- High Cost of electricity and water
- Another challenge is post-harvest losses due to pest infestation. For example, due to fruit flies, Senegalese mango farmers loss up to 30-40% of national production across the country.

Problems in postharvest industry

- No access to appropriate technologies
- Product quality failure to transform
- No access to finance for marketing and processing
- No access to technological and business information
- Insufficient technical and commercial partnerships
- Processing industries, are facing equipment problems;
- The high cost of the raw material.
- Lack of managerial and commercial building technical capacity

Processing and packaging – value addition to horticultural crops

The processors are faced with high cost of raw materials, which makes it difficult to expand. Regarding packaging, a lot of effort remains to be done to be competitive.

Natural resources

Water

The main water for horticulture production is mainly rainfed. Other major rivers which provide water for irrigation include;

- The Senegal River which is 1,770 km long and its watershed extends over 337,000 km^2, 60,000 of which are in the national territory. The current inter-annual flow of this river is around 410 m^3/s per year on average.
- The Gambia River is 1,150 km long, of which 477 km are in Senegalese territory. Its average annual flow at Gouloumbou is 135 m^3/s (1970-1995) and 70 m^3/s at Kédougou. Its watershed covers an area of 77,100 km^2.
- Lake Guiers: The volume of Lake Guiers is estimated at 601 million m^3, when the body of water reaches the dyke at 1.80 IGN. It is fed by the Senegal River from the Taouey Canal. This lake is a particularly vital ecosystem for the entire northwestern part of the country, but also a very important permanent freshwater reserve.

Soil

Soils can be grouped into four main types include sandy soil, loamy soil, clay soil. and humus soil.

Farm that observed increase yield are planted on soils are deep, well aerated, rich, free of obstacles, with little relief, low slopes, a suitable water regime and other natural factors. Most horticultural soils are not hydromorphic.

Climate

The climate is of the Sudano-Sahelian type characterized by the alternation of a dry season from November to May and a rainy season from June to October. The average annual rainfall follows an increasing gradient from north to south of the country.

9.4 Socio economic

Women in Horticulture

Women ownership of horticultural land are very rare. These lands are registered in the name of their husbands. They however invest in the purchase of seeds, and agricultural inputs, to be paid in kind at harvest. Women are mainly involved in the marketing of harvested products; they buy at farm gates and supply most retail markets in large cities.

Youth and Horticulture

Most of the workforce on horticultural farms is made up of young people. About 60% mostly engage in manual irrigation. Young girls and women of working age are mainly involved in harvesting and packaging fruits and vegetables.

Market and Consumption

Demand for Nutritious Fruits and Vegetables

The fruit and vegetable sector offers an example of the dynamism displayed by this type of activity. Upstream there is a very diversified production of fruits and vegetables extended in space and time.

Market Access (including product forms and price trends)

Currently in Senegal, horticulture production is very profitable business. However, transportation, processing, installation around these processing plants, input supply are areas that require significant investment.

Value-added horticulture products

Horticultural products are sold on the field, however entrepreneurs (men and women) come to buy and added value to them, by processing, packaging and transporting them to distant markets.

Trade

The export campaign for horticultural products starts immediately in January of each year for cold off-season speculations such as vegetables. For mango, exports start in May. Export volumes has increased significantly in recent years, ranging from 65,778 tons in 2012 to 107,977 tons in 2019.

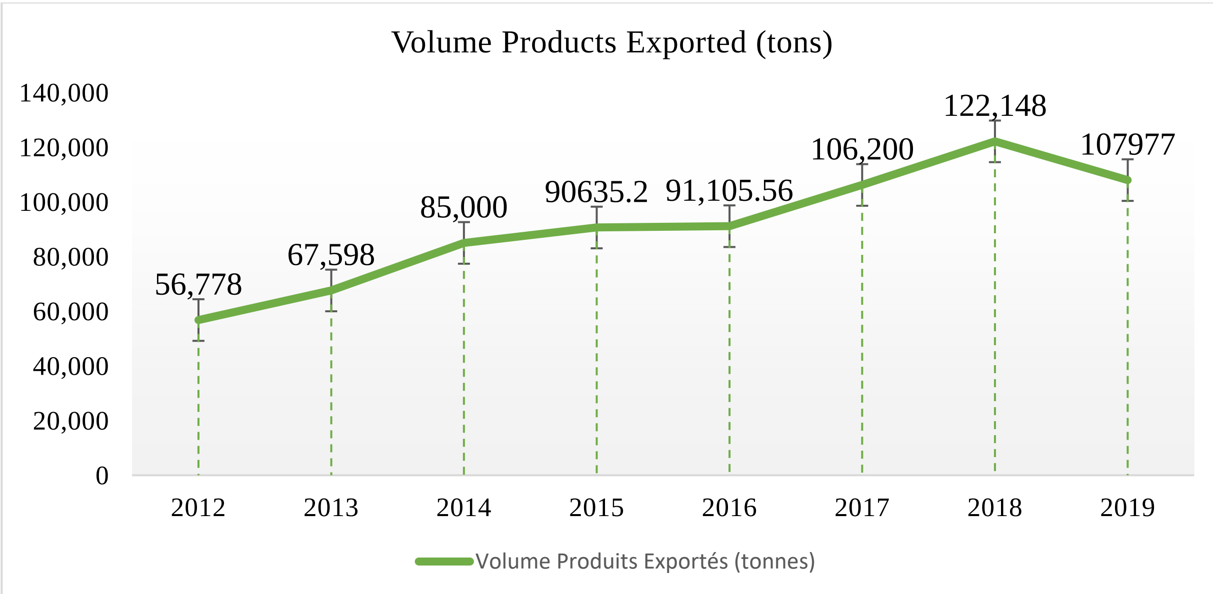


Figure 9.3 Volume of products exported from 2012- 2019 in MT

Engineering and technology

Senegal has a very high level of technology, who have learned all the facets of modern agriculture, from irrigation to harvesting, including other technical production routes; now remains to disseminate it on a fairly generalized level.

Production Technology and Supplies

Production technologies and supplies of inputs and equipment exist in Senegal, but the availability of credit necessary for their acquisition these technologies remains a challenge.

Postharvest packaging, cooling, cold storage, drying

In recent years, there has been a sustained development of agro-food processing activities with the emergence of small and micro enterprises most in urban areas.

In Senegal, post-harvest losses of variable amplitude ranges from 30% for cabbage, 50%, for onion, to over 40% for the mango.

- For the cabbage, cold storage at 4-5 degrees for 2-3 weeks is necessary.
- Mango, with marmalade, syrup and dried mango slices, jam, drink nectar.
- For the onion, there is the dried onion, onion powder made primarily with white varieties, to season gri lled meats.

Apart from direct consumption at the household level, cabbage undergoes no further processing for the moment. It is mainly used in rice and fish, but tends to return to the main Senegalese dishes. 92% of households in Dakar use at least once a day cabbage but this high frequency of use does not correspond to a large cabbage consumption per household. Purchases are made through unit (42%) or single tranche (24%).

There were cabbage processing technologies sponsored by the Association of Unions of vegetable Niayes (AUMEN) in 2014, with the Food Technology Institute (ITA) in Senegal.

The marketing of cabbage is through urban and rural markets. Distribution channels are mainly oriented towards local demand.

Research, education and training

Agricultural research (which has developed fact sheets production for all these speculations), the National Agency for Agricultural and Rural Council (ANCAR), and direction of horticulture are currently carrying out plans for lead producers to be competitive in the national and international market, producing healthy vegetables of impeccable quality.

Education and training needs in horticulture

Education in horticultural professions needs to be strengthened. They require capacity building for producers.

Research capacity of technical vocational institutes, universities and research institutes

Agricultural research is well established in Senegal; Within this structure, horticultural research, with the creation of the Center for the Development of Horticulture (CDH), founded in 1972, has even trained a very good part of the executives of the sub-region. This center with all the specialties aims to take care of all the issues related to horticulture on a national scale. Senegal has all the training structures related to horticulture; indeed, the various 5 universities are inserted within the departments of agriculture / horticulture. In addition, there are training centers for horticultural technicians and senior technicians at all levels.

Extension capacity in public and private sector

At the national level, we have a rural extension structure, the National Agency for Agricultural and Rural Advice (ANCAR). This is a competent structure, which has specialized personnel at all levels, yet suffers from a lack of workforce and logistical resources, to better respond to requests from producers. At the NGO level, there are several structures working in rural development, which also do agricultural and horticultural extension at the national level.

Policy and Horticulture

Since 2000 the state has adopted new policies and strategies, for the modernization and intensification of agriculture, crop diversification, food security, poverty reduction, access to foreign markets and rising incomes.

SIERRA LEONE

10.1 Context

Sierra Leone is a small country located on the west coast of Africa between Latitudes 7^{o}N and 10^{o}N and Longitudes 10^{o}W and 13^{o}W. It is bordered on the Northwest by the Republic of Guinea, on the Southeast by the Republic of Liberia and on the southwest by the Atlantic Ocean. Sierra Leone is divided into Northern, North-western, Eastern and southern regions with fourteen districts (Bombali, Karene, Kabia, Portloko, Tonkolili, Koinadugu, Fabala, Kenema, Kono, Kailahun, Bo, Bonthe, Moyamba and Pujehun) and the Western Area (Figure 10.1). The climate is characterized by the wet season (May-October) and dry season (November-April). The country has a conducive agricultural environment consisting of optimum temperature conditions, an abundance of rainfall and many rivers with great irrigation potential to support year-round horticulture production.

The country has a land area equivalent to 72,300 km^2 with the uplands and lowland occupying 60,650 km^2 and 11,650 km^2 respectively. About 5.4 million (ha) (74%) are fertile arable lands which have great potential for crop production (Population and Housing Census, 2015). These attributes, coupled with the relatively all-year-round normal temperature conditions and the abundance of rainfall and rivers, makes the production of diverse crops including vegetables and fruits possible in most parts of the country.

The economy of Sierra Leone is dominantly agrarian. About 89% and 58 % of the population engaged in farming in 2004 and 2015 respectively. The agriculture sector contributes the largest share of the gross domestic product (GDP) during the period 2010-2019 (Figure 10.2). Although a decline from 54.6% in 2011 to about 48% in 2013 was reported, it employs more than 70% of the country's labour force (Population and Housing Census, 2015; World Bank, 2019). The crop subsector's contributions to agricultural GDP ranged from 29-37 %, of which horticultural crops contributed between 3-4 % during 2010-2013 (Figure 10.3). The agriculture sector in Sierra Leone is still dominated by smallholder subsistence farmers who use traditional tools, with limited farm inputs.

Figure 10.1: Map of Sierra Leone showing regions and districts.
Source: IFAD, 2020.

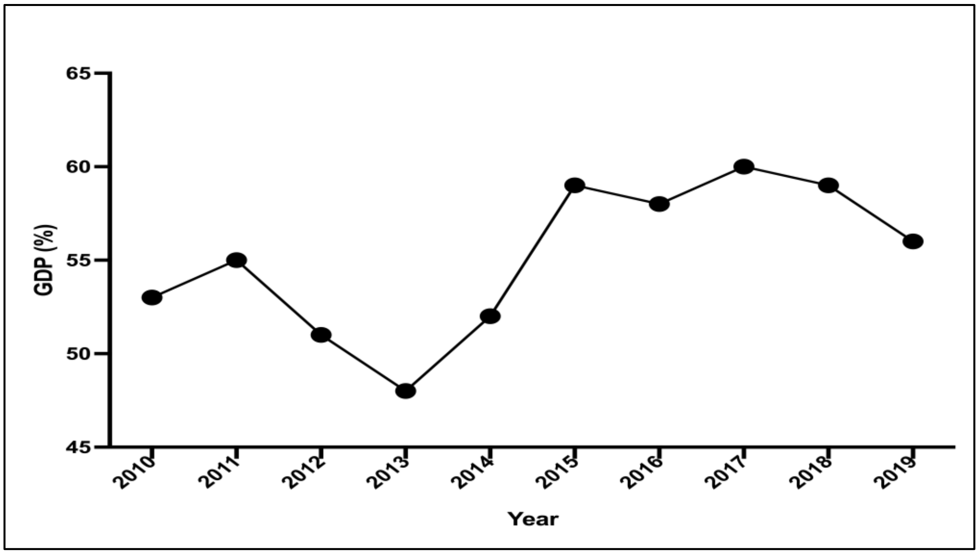


Figure 10.2: Trend analysis of the contribution of the agriculture sector to Sierra Leone's GDP (%) from 2010-2019

Horticultural crops are cultivated in all the regions of Sierra Leone in both the upland and low land ecologies. However, the production of horticultural crops is more concentrated in certain regions /districts. For instance, the cultivation of pepper is predominantly carried out in both the northern and southern regions; Okra cultivation is done in the northern and the eastern regions. The cultivation of pepper is done in Koinadugu, Port Loko and Tonkolili districts in the north and Pujehun in the south, while okra is cultivated in Bo district in the south (Figure 36).

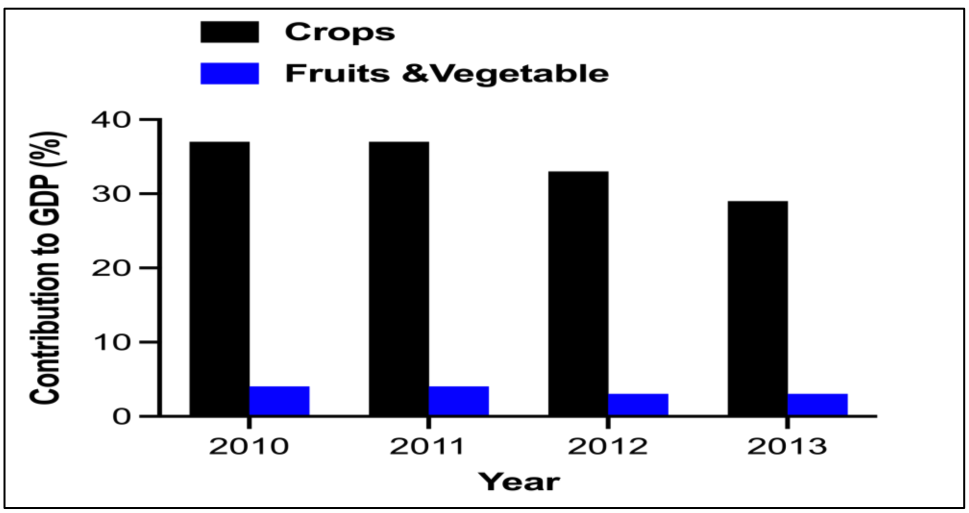


Figure 10.3: Trend analysis of the contribution of the vegetable and fruit subsector to Sierra Leone's GDP (%) between 2010-2013 **(Source PEMSD 2015)**

However, okra yields are relatively low in all districts (Figure 10.4), despite variations in the cultivated area at regional and district levels. Except for pineapple, which is concentrated in the Moyamba district, south of the country (Head of Horticulture division, MAFFS), the cultivated area and yield data are not available.

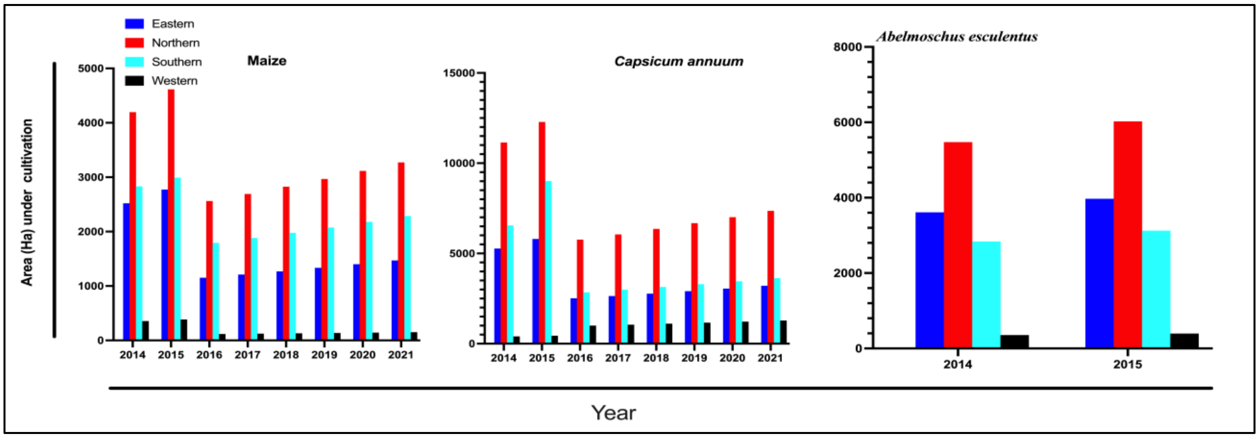


Figure 10.4: Area (Ha) under *Zea mays*, *Capsicum annuum* and *Abelmoschus esculentus* cultivation by region from 2014 -2021. **(Source: PEMSD of MAFFS).**

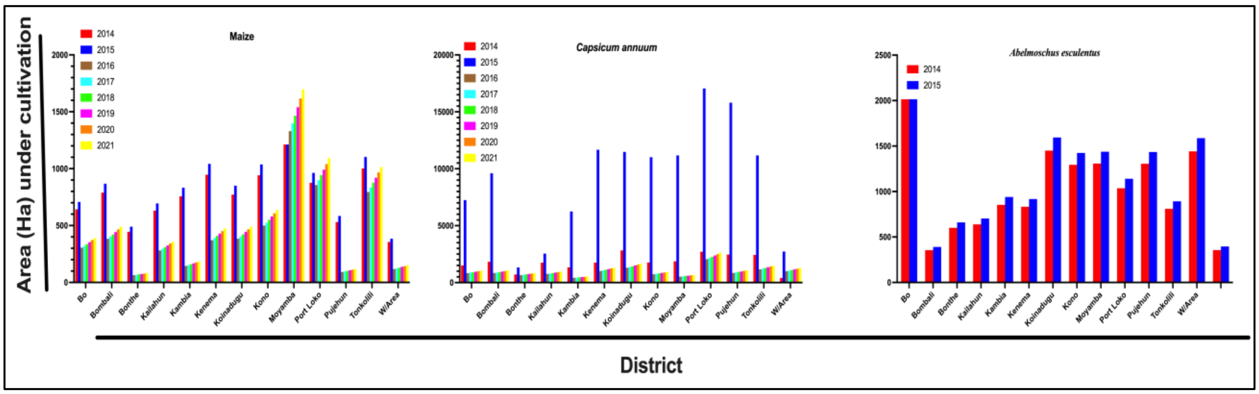


Figure 10.5: Area (Ha) under *Zea mays*, *Capsicum annuum* and *Abelmoschus esculentus* cultivation by district from 2014 -2021.

Source: PEMSD of MAFFS

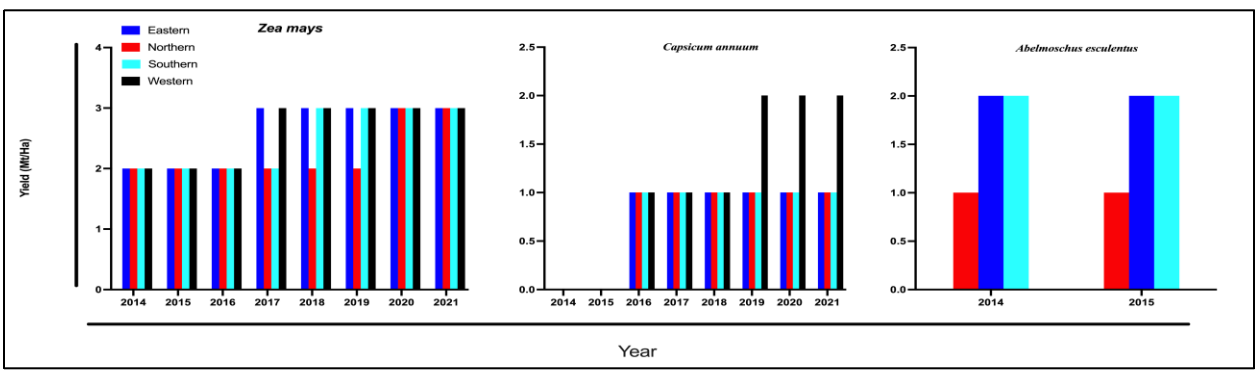


Figure 10.6: Yield (Mt/Ha) of *Zea mays*, *Capsicum annuum* (2014 -2021) and *Abelmoschus esculentus* 2014 -2015 by region.

Source: PEMSD of MAFFS

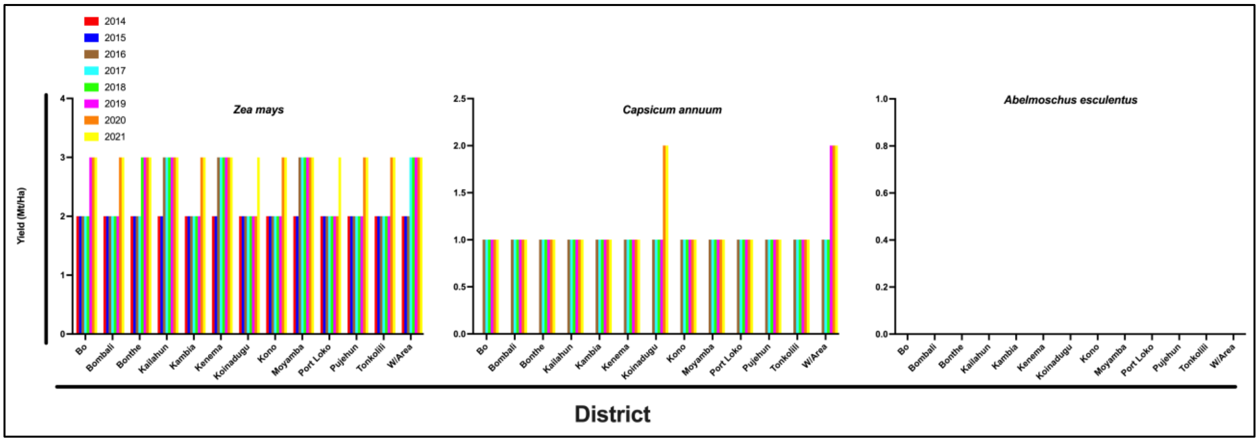


Figure 10.7: Yield (Mt/Ha) of *Zea mays, Capsicum annuum* (2014 -2021) and *Abelmoschus esculentus* (2014 -2015 by district).

Source: PEMSD of MAFFS

In the vegetable subsector, the main crops include exotic types such as onion (*Allium cepa*), okra (*Abelmoschus esculentus*), pepper (*Capsicum annuum*), eggplant (*Solanum melongena*) and tomato (*Solanum lycopersicum*) (Head of Horticulture division MAFFS). Other widely grown and consumed indigenous vegetables include the leafy greens i.e. cassava (*Manihot esculenta*), sweet potato (*Ipomoea batatas*) and krain krain (*Corchorus olitorius*) which are often neglected and corn (*Zea mays*). Exotic vegetables that are less widely grown and consumed include cabbage (*Brassica oleracea*), lettuce (*Lactuca sativa*), and carrot (*Daucus carota*). In the fruit subsector, the popular fruits include mango (*Mangifera indica*), pineapple (*Ananas comosus*), orange and lime (*Citrus species*), pear (*Persea americana*) and banana/plantain (*Musa species*).

In Sierra Leone, the development of the horticulture sector is very slow. The sector lacks a well-organized growers association, and research. In addition, women's access to productive inputs (seeds, fertilizer and agrochemicals), finance and markets is a major barrier to production. Vegetables produced by farmer associations are purchased by hotels, restaurants and petty traders. However, vegetables produced by individual farmers do not have real markets. The horticulture subsector in Sierra Leone is underdeveloped and has several challenges.

10.2 Challenges and Opportunities

Horticulture-Biophysical

Inputs

Supplies of fertilizers and pesticides are inadequate for domestic requirements and are mainly sourced from imports as there are no local fertilizer/pesticide manufacturing industries in the country. In addition, these inputs are expensive and inadequate for the majority of growers of vegetables and fruits.

Quality seeds (hybrids/improved seeds) of locally cultivated fruits and vegetable crops are not available. Seeds of vegetables are sourced from imports (exotic). Seeds of exotic vegetable crops including those of lettuce, cabbage, onion and carrot are very expensive.

Improved varieties

No locally developed/bred/improved variety/cultivar of horticultural fruits and vegtables has been released. A catalogue of locally bred crop varieties so far released included cereals (rice), tubers (cassava and sweet potato) and legumes (cowpea and soybean and groundnut).

Underutilized Neglected and indigenous crops

The green leaves including cassava, sweet potato and krain krain (*Corchorus olitorius*) are rich in minerals and have high economic and market demands. They form part of the daily intake of vegetables for most Sierra Leoneans. Thus, estimation of the area of cultivation, yield/ha and production values and market price trends for varieties/cultivars of cassava, sweet potato (exclusively consumed as green leaves) and krain krain are hitherto, not determined.

Postharvest Management of Fresh Products

- Postharvest losses are high due to a lack of appropriate postharvest management techniques such as controlled ripening, edible coating, temperature management, and chemical treatment methods.
- There is a total lack of cold-chain from farm gate to market centres due to the absence of cooling vans or cool storage centers for harvested horticultural products.
- Food quality control is a major problem. Both export and locally consumed vegetable and fruit products are supposed to be sanitized prior to their release for export or to local markets. Due to the high cost and unavailability of agrochemicals, smallholder farmers cannot afford to fully adhere to phytosanitary requirements for their products. For export markets, exporters are required to obtain a quality certificate from the Ministry of Agriculture, Forestry and Food Security.

Processing and Packaging

- Processing and packaging of horticultural products are challenging issues in Sierra Leone, especially for rural smallholder vegetable farmers which are indicated by the high level of postharvest wastage.
- There are limited processing (with exception of drying chili pepper and canning of pineapple), packaging and storage facilities in the country, as such most vegetables and fruits are harvested and consumed fresh and producers are not able to benefit from value addition.

10.3 Natural Resources

Water (availability, quality and accessibility)

Sierra Leone has two main seasons-wet season and dry season. Since the horticulture crop production system in the country is exclusively rainfed, water availability, accessibility and quality are major challenges during dry season cultivation even though the country is blessed with nine rivers.

Soil

- Due to increased pressure on arable lands as a result of population increase and a decrease in the land fallow period, there is an overall decrease in soil fertility levels especially in upland resulting in overall low crop yield.
- The upland soils - the most dominant - are generally ferralitic, shallow and susceptible to low fertility with high aluminium contents. The remaining lowland soils, which are relatively better in fertility, are subjected to seasonal or permanent water logging, inadequate drainage and again have related problems of high iron and aluminium content.

Climate

At the global level, Sierra Leone's contribution to global warming is negligible. However, Sierra Leone is likely to be disproportionately affected by the impacts of climate change as a result of limited adaptive capacity and widespread poverty. Rising sea levels and increased risk of flooding, changes in rainfall and temperature patterns, and intermittent droughts are among the already experienced effect of climate change reported by key actors of the horticultural crop value chain. These are reported to negatively impact horticultural crop production through damages to crops, delay in product transport and crop/product loss.

10.4 Socioeconomic

Women in Agriculture

The horticulture sector is dominated by smallholder farmers mostly women. Leo (2015), reported that women accounted for about 85% of the total labour. Despite that, they tend to handle the less labour-intensive tasks in the value chain including nursery establishment, planting, ongoing management and the majority of the postharvest activities. Women are also essential as aggregators and are exclusively the main actors of the retailer component of the horticultural value chain.

Youth and horticulture-roles of youths in horticulture, barriers

The government of Sierra Leone, in a bid to mainstream youth in development planning, developed the National youth policy in 2003, which is anchored on the notions of youth empowerment and the creation of responsible citizenry. Although generally, agriculture and specifically horticulture have the potential to employ youths, MAFFS has not developed a specific policy to mainstream youth in the horticulture subsector. This serves as a major barrier to identifying the specific roles of the youth in the horticulture industry.

10.5 Market and Consumption

Demand for nutritious fruits and vegetables

The roles of fruits and vegetables in maintaining health are well acknowledged and seen as important. Vegetables and fruits are important sources of minerals such as phosphorus, iron and calcium, vitamins A, B and C and sometimes proteins (Nutrition data, 2015). In 2014, the trade database reported significantly more imports than exports for vegetables (ComTrade, 2015). The total reported vegetable import amounted to $8.65 million while reported export in the same year amounted to $217,733. This suggests that local vegetable production is not adequate to meet the local demand. Although export and import data for fruits are not reported in this review, fruits such as pineapple, banana, pear, citrus (lime and orange) have high local demand, indicated by their prices at the retail level on the Freetown market. For instance, a single pineapple cost about $1.5 while a single pear cost about $1 (Key informant, 2022).

Market Access

Vegetables and fruits can be found in markets of all sizes, with the primary vegetables being onion, leafy greens (cassava, sweet potato and krain krain), okra, eggplant, chili pepper, and onions and fruits being banana, pear, pineapple, orange, mango. However, access to markets by the producers is a major constraint due to poor road infrastructure. Both fruit and vegetables are often sold as fresh products. Prices are not constant throughout the year. Although there are no market survey reports indicating price trends of horticultural crops, vegetables are most expensive in the dry season and are least expensive in the rainy season while fruit prices are more expensive during the offseason and least expensive when in season.

Value-added horticultural products

The transformation of fruits and vegetables is generally very underdeveloped/very limited in Sierra Leone, except for drying chili pepper and canning of pineapple. The lack of processing and refrigerated storage facilities are the major bottlenecks. Thus, the majority of the country’s horticultural products are exposed and consumed fresh.

Agribusiness opportunities

Potential for agribusiness exists at various points along the horticultural crop value chain from production to retail. Major constraints of the horticulture sector are the lack of modern technology and mechanized equipment for use in the cultivation of crops. Supplying labour-saving agricultural equipment like tractors, power tillers, ploughs, and harvesters are opportunities for investors. Adding value to horticultural products through processing and manufacturing presents an opportunity for investors from both domestic and international markets.

Trade

Vegetable and fruit exports are minimal. However, ComTrade (2015), reported vegetable exports to the Gambia. Although export data are not available, Guinea and Liberia are potential regional markets for horticultural products given their proximity to Sierra Leone. Additionally, chili pepper and eggplant exports to Austria were reported in 2014, and chili pepper exports to Canada, Bahrain and Germany in 2012. However, the value and volume of exports were not reported for these periods., Information on exports of fruits and vegetables to regional and international markets are difficult to access locally. This can be attributed to either key players involved in the trade of horticultural products not taking record of their transactions or are not willing to release relevant information upon demand by researchers. This was evident during information gathering exercise for the current review and is a serious impediment to institutions and researchers engaged in horticultural products trade and could serve to obscure the country's output/performance for the horticultural sector.

10.6 Engineering and technology

Production technology and supplies

Sierra Leone Agricultural Research Institute (SLARI) is the institution charged with the responsibility to develop technologies to enhance crop production in the country. However, given the limited resource (financial) base of the institution, very little is being done in the area of technology development to enhance horticultural crop production, although greenhouse production at the Kabala horticultural research centre in the Koinadugu district is at its earliest stage of development. Development of climate-smart horticultural crop varieties (hybrids) is also a big challenge since no locally bred and improved horticultural crop variety/cultivar has ever been released in the country.

Postharvest packaging, cooling, cold storage

These are among the main challenges facing the horticulture sector since there are limited or no post-harvest packaging materials, cold storage centres, cooling van/refrigerated vehicles in country.

Processing of horticultural products

There are limited processing facilities in the country. Among the horticultural crops, chili pepper is processed through drying whilst pineapple is canned into fruit juice. Due to the limited availability of postharvest processing and packaging, and cooling/cold storage facilities in the country, huge quantities of the harvested products are lost.

10.7 Research, Education and Training

Education and training needs in horticulture

To improve the horticulture sector in Sierra Leone, the need for training horticulturists is paramount. Training needs in the following areas were identified: postharvest management and value addition. In addition to horticultural products, disease management, pest management, nutrient management, marketing of horticultural produce, nursery management, packaging of horticultural products, land management, transplanting, orchard management, raising seedlings, greenhouse/protected cultivation and horticultural crop genetic resources development and conservation are needed.

Research capacity of technical vocational institutes, universities and research institutes
Research is a critical component of higher education systems. Research creates new knowledge or utilizes existing knowledge to bring about innovative applications directed towards specific practical aims and objectives. Universities/research institutions with high research output are ranked high in terms of academic standards. In Sierra Leone, there are three institutions: Sierra Leone Agricultural Research Institute (SLARI), Njala University (NU) and the University of Sierra Leone (USL) mainly involved in horticultural research. The research capacities of these institutions are not strong and research outputs are low. Several obstacles hinder these institutions' efforts toward the research capacity building which include: lack of or inadequate funding, lack of conducive research environment and infrastructure including laboratory space, basic laboratory instruments and chemicals, research gardens/stations/growth chambers, greenhouses, internet facility, unreliable electricity supply, lack of information due to poor access to electronic databases, e-journals, e-books, and lack of mentorship.

Extension capacity in the public and private sector
An efficient horticultural extension service is crucial to increase the knowledge of agronomic techniques and skills of smallholder farmers to improve productivity, food security and livelihoods. Due to major challenges including the lack of resources, poor knowledge of improved horticultural technologies, high illiteracy levels among the farmers, the extension capacity of the public sector workers is very weak. Furthermore, most of the extension staff in the MAFFS are males who find it difficult to work with exclusive women groups since women dominate the horticulture sector.
Local, regional and national government policy intervention to improve the horticulture sector
There are no clearly outlined local, regional and national policy interventions to improve horticulture in Sierra Leone.

Policy and horticulture
There is no policy specially targeting horticulture development in Sierra Leone.

Opportunities for horticulture sector development in Sierra Leone

- Strengthening the research capacity of research institutions to develop and conserve horticultural crop genetic resources including climate-smart (short duration, temperature and drought resistant, hybrid, disease resistance) crops as well as in various aspects of horticultural crop production including greenhouse/protected cultivation, postharvest management and food safety, pests and disease control, nutrient management, market systems and market channels, gender and women empowerment.
- Strengthening of the capacity of extension staff of the MAFFS and NGOs to facilitate training of horticultural crop producers and other value chain actors.
- Establishment of solar-powered cold storage facilities and provision of refrigerated vehicles to minimize postharvest losses of horticultural crop products during storage and transport.
- Establishment of modern irrigation systems for dry season cultivation of horticultural crops
- Establishment of greenhouse facilities to enhance the production of quality horticultural crop products.
- Establishment of fertilizer and packaging materials production industry and agri-processing and packaging facilities.

10.8 Horticulture Research Priories

The diversity of horticultural crops (local) in this country is enormous but little or no efforts are being made to tap their potential and improve food security and nutrition. It is necessary to investigate the horticultural crop genetic resources base of the country to facilitate their development and conservation.

To promote ongoing horticultural production, it is imperative to conduct a needs assessment of horticultural crop producers and other actors in the horticulture value chain to enhance production, processing and packaging, storage and transport, and minimize post-harvest losses.

Key identified challenges associated with the horticulture subsector include

- Lack of policy for horticulture development
- Inadequate and high costs of agricultural inputs such as fertilizers, pesticides, and quality seeds
- High postharvest losses due to the lack of appropriate postharvest management techniques, cold storage centres and refrigerated vehicles, processing and packaging facilities
- Poor extension services
- Poor rural road infrastructure
- Lack of modern irrigation technology for dry season cultivation

Key areas of possible interventions/opportunities for horticulture development

- Strengthening the research capacity of research institutions
- Strengthening the extension capacity of the public and private sector
- Establishing solar-powered cold storage, greenhouse, agri-processing and packaging facilities, and provision of refrigerated vehicles
- Establishing modern irrigation facilities

SUMMARY AND CONCLUSIONS

BIOPHYSICAL

Inputs Supply: Conventional inputs such as fertilizers, seeds, pesticides, land, and labour play an important role in fruit and vegetable production in West Africa. Inorganic fertilizers and pesticides are widely used in fruit and vegetable production in West Africa, but fertilizer application rates are still lower than those of Asia and Latin America. Most farmers are unaware of which pesticides to use and how to apply them, putting the health of their customers in danger. However, almost all the countries do not engage in commercial production of inorganic fertilizers and pesticides but import them from Morocco, Asia, and Europe to meet farmers' demands. Improved seeds are also imported into West Africa. However, there are few seed-producing companies and public research institutions in Ghana and Nigeria. Farmers source their inputs from using multiple channels, including their own saved seeds, neighbours, informal markets, commercial input dealers and seed-producing companies. Only a few countries, including Ghana, have subsidies on inorganic fertilizers and improved seeds in the agricultural sector.

Production and Productivity of Horticultural Crops: The horticultural sector in West Africa is mainly dominated by fruits and vegetables. Production and marketing activities are largely informal. However, the sector supports social and economic development in West Africa. Vegetable production is dominated by tomatoes, onions, and chilies, while pineapples, oranges, mangoes, pawpaws, and bananas are the main fruit produced. The total area under of fruit and vegetable production has increased over the last three decades. Production of fruits and vegetables has more than doubled since 1990, but the region is not self-sufficient in fruit and vegetable production due to low yields.

Improved Varieties of Fruits and Vegetables: For vegetables and most fruits, farmers use local varieties and informal seed sources. The formal commercial seed sector serves only a small portion of vegetable producers, more often supplying commercial markets with quality seeds and improved varieties, such as for tomato, onion, and peppers. MD2, Smooth Cayenne, Sugar Loaf (Pan de Azucar), Red Spanish, Queen Victoria and Abacaxi are the dominant improved varieties of pineapples grown by farmers. For orange, Washington navel, crimson blood orange, hamlim, and late Valencia are among the major improved varieties cultivated by farmers. Kent, Keitt, and Springfield are the major varieties grown. The major improved varieties of bananas grown in West Africa include Cavendish, Mysore (Alata kwadu, local variety), and Gros Michel varieties are the widely grown and preferred bananas in Ghana. The main varieties of pawpaw planted in Ghana are Solo dwarf, Hortus Gold, and Bluestem. Green chilies, Scotch bonnet, and Bird's eye are widely grown in Ghana and Nigeria. Recent improved varieties of tomatoes in Ghana include Kwabena Kwabena, Kopia, AdopeShiteAdopte, Mako Ntose, Pectomech, Power Roma, Techiman (CSIR, 2022), and Eva F1, Padma F1, COBRA, Sultan, Raja, and Gigantico. Bawku Red and Galmi are the two main varieties of onions grown in Ghana.

Postharvest Management of Fresh Products: The main postharvest management practices of fruits and vegetables identified in West Africa include precooling, washing and disinfecting, sorting and grading, packaging, storage, and transportation. These management practices help maintain the quality and increase the shelf life of fruits and vegetables. Precooling is done with the help of refrigerators are used in this manner. Cleaning and disinfection are done by washing the product in clean water and disinfectants. Sorting and grading are done to eliminate unwanted products from the harvest, and also to determine prices.

Pests and Diseases: Pests and diseases are major problems in fruit and vegetable production because they cause significant crop loss for farmers. This includes diseases such as anthracnose, powdery mildew, alternaria, stem-end rot, *Pseudocer cospora* leaf and fruit leaf disease of citrus, Cape St Paul wilt for coconuts, bacteria black spots (BBS) on mango and pests (fruit fly, mealybug, termites, mango bugs).

NATURAL RESOURCES

Water: Water for fruits and vegetable production is mainly from irrigation, rainfall or wastewater. However, farmers depend mainly on rainwater for fruit and vegetable production. Water availability and quality are a challenge to the development of the horticulture sector. Most urban farmers use wastewater, which carries microbial and chemical hazards. In West Africa, less than 10 percent of the fertile land is grown under irrigation.

Climate: West Africa has diverse agroecology and climate. The region has several climate zones suitable for fruit and vegetable production. Forest ecology has bimodal rainfall patterns, while savannah ecologies have monomodal rainfall pattern. However, there is a continuous decline and fluctuations in rainfall in West Africa due to climate change. Most savannah areas also experience a log dry period. Yet, there is a limited adoption of climate-smart practices by farmers in West Africa.

Soil: The soils in West Africa are relatively less fertile, compared to other regions of the world. Most soils contain abundant coarse material either gravel and stone, or concretionary materials which affect their physical properties. The coarse sand particles limit the water retention capacity of the soils, which compromises the resistance to drought for the crops. Ferralsols is the well-known, strongly weathered reddish or yellowish soil in West Africa.

SOCIOECONOMICS

Women in Horticulture: In West Africa, women play a significant role in the horticulture industry, especially in the post-production side of the vegetable value chain – such as processing and marketing/sales. They are more active in the production of mostly leafy and indigenous crops. Women account for more than 50% of the workforce in the horticulture sector in West Africa. In The Gambia, women constitute over 60% of the workforce in the horticultural sub-sector (Fatty et al., 2017). However, their ability to access land and other resources for production is dependent on their husbands or fathers.

Indigenous Peoples in Horticulture: Horticulture production is an indigenous activity in West Africa. Horticulture production takes place throughout every country in West Africa. It is mainly undertaken by all ethnic groups for home consumption and export. However, there are spatial distributions of fruit and vegetable production among ethnic groups across the region.

Youth and Horticulture: Youth participation in agriculture is low in West Africa. The Youth are being encouraged in agri-business along the horticulture value chain, and greenhouse farming (Greenhouse Village Initiative-MOFA). As part of the government of Ghana efforts to open opportunities for increased production and exports of vegetables after the 2015 European Union export ban on select vegetables, the concept of greenhouse villages was introduced in 2017. The idea of the greenhouse village is to establish strong agribusiness in the vegetable sector to attract both Ghanaian youth and international investors. The objective is to place Ghana as a key competitor in the export of fresh vegetables and cut flowers. The project trained about 537 youths including those with degrees, HND and certificate holders. The three-month intensive training session covers all areas of greenhouse vegetable cultivation, starting from setting up a nursery, crop production, fertigation, pest and disease management, handling, marketing, and branding of the produce.

MARKET AND CONSUMPTION

Demand for nutritious fruits and vegetables: Demand for fruits and vegetable have grown steadily over the last decade in West Africa due to rising urbanization, population, and income coupled with the expansion of traditional markets, the hospitality industry, and fruit processing units. However, there are still disparities in the consumption of fruit and vegetables across West Africa and between income classes within countries. The consumption of fruit and vegetables is below the FAO/WHO daily recommendations of 400 g/capita. Ghana has the highest consumption of fruits (189kg/capita/yr), followed by Guinea (97kg/capita/yr), while Mali has the highest consumption of vegetables (97kg/capita/yr), followed by Senegal (86kg/capita/yr). Vegetable consumption increased for most countries in West Africa (Benin, Burkina Faso, Cote d'Ivoire, Ghana, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, and The Gambia), compared to fruit consumption. Benin, Ghana, Senegal, and Mali have witnessed some growth in fruit consumption over the last decade.

Market Access: Fruits and vegetables produced in West Africa are destined for local and international markets. Locally, the marketing of fruits and vegetables is dominated by informal actors, operating largely in open markets. The local market comprises about 70 percent of the fresh fruits and vegetables' markets in Ghana and other West African countries. Farmers supply the fresh produce mainly to domestic bulk suppliers, itinerant suppliers, and other suppliers such as supermarkets, hotels, and restaurants. In addition to informal marketing outlets, which are smaller, street shops, hawkers, and well-built markets, formal retail outlets such as supermarkets and specialty stores also engage in the sale of fruits and vegetables.

Value-added Horticulture Products: Fruits and vegetables are mostly sold fresh, limiting value creation and value addition by producers and marketers. Producers and traders engage in primary activities such as cleaning, sorting, grading, and poor storage, contributing to high post-harvest losses, food safety problems and a low product shelf life.

Agribusiness Opportunities: This is an excellent opportunity for investors to help introduce disease-resistant varieties by using tissue culture technology. Greenhouse gardening, integrated pest management, and organic fertilizers also provide opportunities for farmers to produce safe fruits and vegetables in West Africa.

TRADE AND STANDARDS

West Africa trades in a variety of fruits and vegetables. The major export market for fruits and vegetables are Europe and North America. Exports of fruits and vegetables in West Africa have been unstable due to production and institutional challenges. In most cases, farmers are unable to meet food safety and sanitary standards set by foreign markets. Exports of pineapples, bananas, and mangoes, especially in Ghana fell in

2020 due to restrictions imposed by COVID-19. However, exports of pineapples in Cote D'Ivoire have remained high in recent years. The volume of orange and pawpaw exports increased exponentially in Ghana. Nigeria exports just a little of its fruits and vegetables. The main exported fruits and vegetables are the indigenous types consumed by Nigerians in the UK.

ENGINEERING AND TECHNOLOGY

There is very little use of engineering and technology in horticulture production in West Africa. Most reviewers reported low application of engineering and technology when it comes to the production and supply of horticultural products. Nigeria, Mali, Liberia, Ivory Coast, Burkina Faso, and Togo provided no evidence to this effect. Though, in recent years, drones have been used in pest, disease, and weed surveillance, as well as water stress monitoring in agricultural production. However, most countries in West Africa are yet to adopt these new technologies.

Application of engineering and technology in postharvest packaging, cooling, storage and drying is low in West Africa. There is no evidence of post-harvest packaging, cooling, cold storage and drying of fruits and vegetables in Togo, Gambia, Liberia, and Sierra Leone. In Burkina Faso, only mango and cashew are processed. In Nigeria, though fruits and vegetable processing is at the infant sage, about 9 companies are into the processing of tomato, dried fruits, vegetable mix and dried spices. These factories are located in Kaduna, Kanu, Abuja, Legos, Ogun and Oyo states. Mali has a unit for storage of horticultural products (PLAZA). This is a modern refrigerated and packaging warehouse located in Bamako, and other infrastructures for fruits and vegetable processing are also located in the main producing regions such as Sikasso, Koulikoro, and Bougouni. Some private women's cooperatives also have postharvest packaging, cooling, cold storage, and drying equipment. In Ghana, major companies engaged in processing fruits such as mango, pineapple and coconuts are Bomarts, Blue Skies and HPW FRESH AND DRY LTD.. These companies apply engineering in the washing of fruits, peeling and cutting, removing and sorting and packaging. They also have PLC controlled dryer for drying processed fruits. In addition, Shed 9 at Tema Harbor, a world-class, dedicated fruit terminal, also provides cold storage for pineapple and other horticultural products in Ghana.

RESEARCH, EDUCATION AND TRAINING

Horticulture is knowledge-dependent and a highly integrated activity whose success depends on research and development activities. Findings from the review revealed that there is no regional centre for research and development in horticulture in West Africa. However, individual member states conduct research and training based on public and private institutions and facilities available to them. In Ghana, there are three public universities and five agriculture colleges for teaching and training in agriculture and horticulture-related fields. The public universities include the University of Ghana (UG), the University for Development Studies (UDS), and Kwame Nkrumah University of Science and Technology. Also, in Sierra Leone, there are three institutions namely Sierra Leone Agricultural Research Institute (SLARI), Njala University (NU) and the University of Sierra Leone (USL) that are mainly involved in horticultural research. Research and training in horticulture in Togo are done by the School of Agriculture (ESA/UL) and by National Agronomic Research Institute (ITRA). The research conducted is crop-specific. Similarly, several research institutions in Mali including (i) Rural Polytechnic Institute for Training and Applied Research (IPR/IFRA): considered one of the best agricultural engineering schools in the region (ii) Institute of Rural Economy (IER): agricultural research policies; approval and certification of agricultural inputs; and importation, testing and distribution of the latest crop varieties (iii) The DNA (National Directorate of Agriculture) Agricultural Learning Centers (CAA), University of Bamako (FSEG), (iv) Sahel Institute Permanent Interstate Committee for Drought Control in the Sahel (CILSS) CILSS): leads a common regional regulatory framework for pesticides as well as the approval process for new pesticides and (v)

International Crops Research Institute for the Semi-Arid Tropics (ICRIS) (CGIAR network) International research institute actively conducting crop research in Mali and leading a world-class geographic information system (GIS) unit in partnership with IER are among few research institutions that undertake horticulture-related training. However, these public and private research institutions are confronted with challenges such as the (i) lack of or inadequate funding, (ii) lack of conducive research environment and infrastructure including laboratory space, basic laboratory instruments and chemicals, research gardens/stations/growth chambers, greenhouses, internet facility, unreliable electricity supply, (iii) lack of information due to poor access to electronic databases, e-journals, e-books, and lack of mentorship.

Extension-related services in the horticulture sector are mainly undertaken by the public sector in various countries. Private sector participation is relatively low or non-existent. These public extension agents work under the ministry of food and agriculture of the various countries, basically trains small-scale and commercial fruits and vegetable producers in good production practices, pest and disease control, post-harvest management practices (handling, washing, packaging, transportation etc), and food safety standards. However, in Ghana, recently there are been concern about private sector-driven technical support in the fruits and vegetable sector.

REGIONAL AND NATIONAL POLICY ENVIRONMENT

There is no policy for the horticulture sector in West Africa. Issues regarding the horticulture sector in the sub-region are mainly addressed through the ECOWAP/CAADP. On the trade front, African Union SPS Policy Framework lays out a roadmap to maximize the efficiency and effectiveness of SPS systems on the continent to facilitate intra-African agricultural and food trade. The review revealed that national agriculture policies are the main policies guiding the production, processing and export of horticulture products (fruits and vegetables) in member countries. Also, other countries implemented programmes and projects in collaboration with donors to enhance the production, processing and export of horticulture products.

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The U.S. Government's Global Hunger & Food Security Initiative

TECHNICAL REPORT

ANALYSIS OF THE CHALLENGES AND OPPORTUNITIES OF THE HORTICULTURAL VALUE CHAIN OF THE NORTHERN TRIANGLE COUNTRIES

(HONDURAS, GUATEMALA AND EL SALVADOR)

ZAMORANO® USAID FROM THE AMERICAN PEOPLE HORTICULTURE INNOVATION LAB UCDAVIS UNIVERSITY OF CALIFORNIA

The **TECHNICAL REPORT: ANALYSIS OF THE CHALLENGES AND OPPORTUNITIES OF THE HORTICULTURAL VALUE CHAIN OF THE NORTHERN TRIANGLE COUNTRIES** was prepared by the ZAMORANO University with the financial support of UCDavis.

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I. EXECUTIVE OVERVIEW

The University of California, Davis, received funding to lead the new *Horticulture Innovation Lab* program. Within the next five years, the Horticulture Innovation Lab will focus their efforts in four regions, including West Africa (Ghana), East Africa (Kenya), Southeast Asia (Nepal) and Central America (Honduras).

Central American countries have a great potential for horticultural and fruit production. The contribution they make in the production of vegetables supplies the food and nutritional demand. The generation of income through the placement of their products in national and international markets is also well known.

To this end, UC Davis proposed that ZAMORANO University organizes a "Central American Regional Workshop" with decision-makers, management staff and leaders; this would be the first step in building an intervention strategy to involve key institutions in the agricultural sector in the area to work on the enhancement and improvement of the horticultural chain. ZAMORANO also proposed the development of focus groups in horticultural production areas with the participation of members that are involved or influence the horticultural chain in the region.

The application of surveys and interviews is envisioned to broaden the range of opinions and positions regarding the sector's problems and challenges it faces. The information obtained was analyzed to determine the opportunities and levels of involvement of these institutions in the horticultural chain of production, technology, food security, research, youth and gender in Honduras, El Salvador and Guatemala through the months of March to August of 2022.

The *"Regional Workshop to Understand the Context and Establish Challenges and Opportunities for the Horticulture and Fruit Sector in Honduras and Central America"* was held in person at ZAMORANO University from June 15 to 18, 2022. A total of 48 representatives of key institutions and organizations of the horticultural sector in Honduras, El Salvador and Guatemala participated in the workshop. Meanwhile, 8 Focus Groups were developed; six groups in Honduras, with the participation of 110 actors of the chain from the different departments, one in El Salvador with 25 participants and another with actors from Guatemala that for reasons of the pandemic was developed virtually with the participation of 14 institutional representatives.

Through these activities, quantitative and qualitative information was compiled on the constraints, problems, and opportunities, as well as the group agreements found in each component of the vegetable value chain studied, for subsequent analysis and general presentation of the results.
These results are intended to provide a clear path for the actions to be programmed by the Horticultural Innovation Lab through UC Davis in conjunction with key institutions, to develop research proposals to improve production processes, food security, nutrition, use and management of technologies, public policies, natural resources, social inclusion of youth and gender approach in the Central American region.

At the level of opportunities, priority has been given to actions aimed at generating and disseminating knowledge, involving all the actors in the fruit and vegetable chain in an integrated manner. In addition to, a deep reflection on the lack of public policies to promote horticultural production and subsequently a design that includes access to financing and technology.
Guatemala is one of the most competitive countries in terms of vegetable production, which opens the opportunity for other countries such as Honduras and El Salvador to cooperate and join efforts to benefit the region.

2. INTRODUCTION

Fruit and vegetable production is a very important activity for the local and regional economy, from the point of view of consumers and farmers. It is also a key component to increase food security in the countries of the Central American region.

Fruit and vegetable value chains are complex, regardless of the region and type of production. To be efficient, effective, and beneficial, they require integrated work. The various actors in the chain and their actions, such as input suppliers (services and agricultural), producers, processors, distributors, traders, regulators, and end consumers contribute to the desired benefits. All the actors in the fruit and vegetable chain must be involved in order to offer a product with excellent presentation, quality and, above all, safety.

The actors throughout the chain respond to a series of demands, problems, challenges and limitations in terms of regulations and administrative constraints, as well as the availability of inputs, demand, and quality required by consumers. Many of these actors are vulnerable, they have little bargaining power, lack knowledge, training and technical skills, and have difficulty accessing agricultural financial credits.

The analysis study was carried out in the countries of the Northern Triangle of Central America of Central America (Honduras, Guatemala and El Salvador) and focused on identifying problems, requirements and opportunities in the fruit and vegetable chain. This report is focused on the prioritization of the problems and opportunities, in the fruit and vegetable chain, and an appropriate approach to address the needs and overcome the current challenges. It also identifies key research elements required to achieve sustainable development in the fruit and vegetable sector.

Production and trade context of the Northern Triangle of Central America

Honduras
Honduras is a country well-endowed with agricultural land, forests and marine resources. Its territory has an approximate of 11.2 million hectares mostly covered by forested mountains. Arable land is estimated at 1.8 million hectares, and pastureland at over 2.5 million hectares *(World Bank, 2021)*. Honduras is the second country in the region in terms of the ratio of arable land to population (about 0.28 hectares per inhabitant).

Honduras has the potential for significant and continuous growth of its agricultural production; it has a variety of microclimates that allow diversification of production, including, the cultivation of fruits and vegetables that have a very large demand and is located close to the markets of major developed countries. According to the National Investment Council, this strategic location positions Honduras as a major exporter of agricultural products in the world. Likewise, the duty-free access for the entry of fresh fruits and vegetables to different markets due to the FTAs signed with different countries, make the country an ideal place for investment and agribusiness trade.

In January 2021, foreign trade of general merchandise registered a deficit of US$464.3 million; denoting an increase of 1.9% (US$8.6 million) compared to January 2020. The observed result is attributed to the 12.9% drop (US$53.3 million) in the value of exports (particularly coffee, bananas, melons, and watermelons), associated with the contraction in external demand and the negative effects caused by storms Eta and Iota. Meanwhile, imports presented a reduction of 5.2%, mostly explained by lower fuel purchases *(General Merchandise Foreign Trade Report 2021)*.

El Salvador
El Salvador, the smallest country in Central America, has experienced a modest economic growth in recent decades, with annual GDP growth exceeding 3 percent only twice between 2000 and 2020

(World Bank 2022). Even so, the country achieved a significant decrease in poverty and inequality.

In 2021, economic growth rebounded to 10.7 percent, supported by remittance-driven consumption and exports. El Salvador's economy is expected to grow by 2.9 percent in 2022 and 1.9 percent in 2023 *(World Bank 2022)*.

In El Salvador, the main economic activities after oil are agriculture and forestry, mainly because of the people it employs. Another important sector is commerce and tourism. The country produces mainly coffee, sugar cane, basic grains, oilseeds, dairy, poultry, and fish products.

In terms of exports, coffee, sugar, textiles, chemicals, and shrimp are key industries of El Salvador, while raw materials such as fuel, food, electricity and vegetables such as tomato, potato, onion, green chili, carrot, cabbage, banana, orange, banana, lemon, pineapple and papaya are a high range of imports.

Guatemala
Guatemala is an eminently agricultural and forestry country. It is mapped that there are 7.3 million hectares for agricultural use, which is equivalent to 67.7% of the national territory. Of this, 12% is dedicated to the production of annual crops such as corn, beans, rice and vegetables, 14% to sugar cane, coffee, rubber, oil palm and cardamom, 23% to pastures and 51% to forests, scrublands and other non-agricultural uses *(Grupo Hame, 2021)* .

For Guatemala, agricultural production is an important pillar of the economy, contributing 21 percent of GDP, employing more than half of the labor force, and providing two-thirds of exports, mainly coffee, sugar, bananas and beef *(Grupo Hame 2021)*. Guatemala's three main staple foods are corn, beans and rice.

In Guatemala, at least three types of agricultural production are identified: subsistence farming, semi-commercial agriculture and export agriculture *(Guatemalan Climate Change Science System 2019)*.

In 2020, the main exported products were cardamom, bananas, coffee, African palm oil, cane sugar, fruits, legumes and vegetables, which together accounted for 36% of Guatemala's total exports.

Guatemala leads the region in sales

In 2021 the main exporter in Central America was Guatemala with $64.9 million, followed by Honduras with $25.6 million, Costa Rica with $11.1 million, Nicaragua with $4 million, El Salvador with $2 million and Panama with $1 million.

If we break down these exports by country, Guatemala is the leading exporter with 28% of agricultural exports, followed by Costa Rica (24%) and Honduras (16%), together accounting for 68.8% of agricultural exports *(Central American Agricultural Council 2021)*. This denotes and highlights the opportunities that exist throughout the region, such as the generation of jobs, investment, and the opportunities generated by trade agreements, all with the goal of generating sustainable and equitable economic growth for the entire Central American region.

Factors of food insecurity in the Northern Triangle of Central America

High prices of basic commodities and fuels are a trigger for food insecurity in the Northern Triangle of Central America countries (Honduras, Guatemala and El Salvador). Up to 4 million people in this region are expected to suffer borderline levels of acute food insecurity and need emergency food aid according to the Famine Early Warning Systems Network.

Prices of fertilizers, fuels, and high-consumption commodities, including basic grains, beans, oil, and sugar, continue to rise steadily in 2022. This price increase is expected to negatively affect low-income households suffering from food insecure conditions by further restricting purchasing power and leading vulnerable populations to adopt negative coping strategies, such as consuming less and lower quality food, according to *(FEWS NET, 2022)*.

3. OBJECTIVES

3.1. Main Objectives

Establish appropriate parameters on the horticultural context of the countries of the Northern Triangle of Central America of Central America and identify challenges, possible opportunities and needs of the sector. As well as, prioritizing research topics and determining innovation and technology needs through the participation of key stakeholders in the Central American region.

3.1.1. SPECIFIC OBJECTIVES

1. Collect qualitative information on the horticultural and fruit value chain in Honduras, El Salvador and Guatemala, through a regional workshop, to identify challenges and set possible opportunities in the sector.

2. Identify challenges, as well as possible opportunities in the horticultural and fruit value chain of the Northern Triangle of Central America of Central America, through work meetings using the focus group methodology for the collection and analysis of quantitative and qualitative data.

3. Conduct surveys and interviews with key personnel in the horticultural and fruit chain in the region to support data collection to understand the context of this sector in Honduras and Central America.

4. Analyze the quantitative and qualitative information gathered through the regional workshop, focus group meetings and surveys of key personnel in the horticultural and fruit chain in the Northern Triangle of Central America of Central America; to obtain a clear route to identify possible opportunities and lines of research to direct the efforts of direct and indirect actors, as well as national and international ones.

4. METHODOLOGIES FOR INFORMATION COLLECTION

The following procedures were established for the collection and analysis of the information:

- Research with literature and document review
- Develop a regional workshop in ZAMORANO
- Assemble national and regional workshops under the focus group methodology
- Set up field surveys and interviews
- Make internet consultations
- Undergo detailed analysis of the collected data

This type of activity encouraged participants to analyze the main problems, needs, requirements, and challenges, as well as the main opportunities for the sector and those involved possibly in solving the problems. In addition to the opportunity to develop research, training and public policies initiatives to counteract these needs and solve the problems.

4.1. Regional Workshop to Understand the Context and Identify Challenges and Opportunities for the Horticultural and Fruit Value Chain of Honduras and Central America

The development of this regional workshop for the horticultural sector in Honduras, Guatemala and El Salvador was supported by an external consulting team, which used a specific methodology focused on obtaining data through participatory dynamics with workshop participants. The workshop was held at the ZAMORANO University facilities and focused on six dimensions; agronomic management, integrated pest management, post-harvest, storage (cold chain and logistics), value added (processing), and markets and commercialization.

The methodology was designed in two phases, which are shown below:

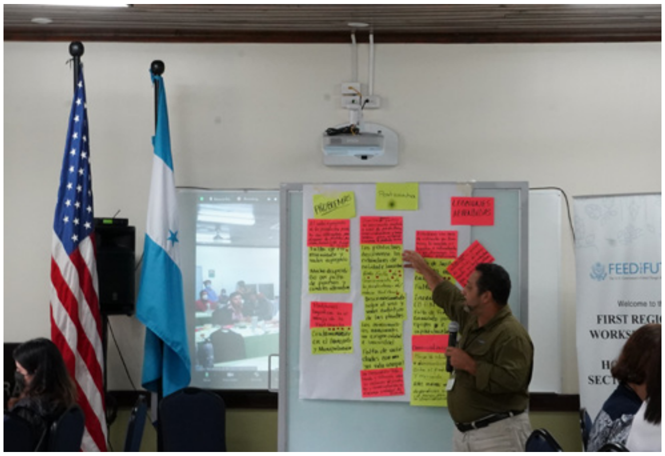

Figure 1. *Development of dynamics within the workshop at the University of ZAMORANO.*

Preliminary Phase

- **Enrollment Process:** ZAMORANO University extended the invitation to 48 decision makers and key role players in the fruit and vegetable chain in the countries of Honduras, El Salvador and Guatemala. Physical and digital tools (such as the Whova platform) were used to collect the attendance of the stakeholders involved in the Regional Workshop *(Appendix 1 - List of attendees)*.

- **Development of Methodological Tools:** The consulting team used a methodology for the collection of information based on three interdependent formats to identify challenges and possible opportunities in the value chain of the fruit and vegetable sector in the region *(Appendix 2 - Methodological tools for the development of the workshop)*.

Figure 2. *Participants from Honduras, Guatemala, El Salvador and the United States together with the coordinating team and technicians from the Regional Innovation Center for Vegetables and Fruits at the University of ZAMORANO.*

The three tools were:

1. **Matrix for the identification of challenges - Brainstorming:** This is the introductory tool where the working groups list the challenges that they considered relevant to be addressed according to their assigned area of work.

2. **Matrix for the prioritization of challenges:** In this tool, the participants listed the challenges found with the support of the first tool and then assigned them a rating on a scale of priority to be addressed.

3. **Tree matrix:** Based on the challenges identified with the highest urgency rating in tool 2, participants were able to identify possible actors, solution proposals and inputs needed to address the identified challenges.

Development Phase

1. **Formation of Working Groups and socialization of instructions:** A study of the profile of the participants in the First Regional Workshop was carried out, and the consultant team proceeded to form groups according to their experience and area of action, then the objective of the workshop and the instructions for the use of the matrices were presented to the participants.

2. **Group work:** The information of the tools was filled in gradually in the time allotted according to the workshop agenda.

3. **Presentation of Results:** At the end of the day's work, each group had a space to present its results, which served to socialize the challenges encountered and proposed solutions so that the other participants could contribute their opinions and generate a time for the appropriation of ideas and concepts.

4.2. Working Meetings through Focus Group Workshops

In Honduras, Guatemala and El Salvador, 8 workshops were held under the focus group methodology. In Honduras, a mapping was carried out, and according to the country's representative productive zones, 6 workshops were held, one in El Salvador and one in Guatemala. The following table shows the distribution:

Table 1. *Distribution of focus groups at the national, regional levels, and dates of fullfilment.*

No	Focus Group	Modality	Place	Date
1	Honduras	On site	Comayagua, Comayagua	March 30th, 2022
2	Honduras	On site	Danlí, El Paraíso	March 31st, 2022
3	Honduras	On site	La Esperanza, Intibucá	July 12th, 2022
4	Honduras	On site	Santa Cruz de Yojoa, Cortes	July 13th, 2022
5	Honduras	On site	Choluteca, Choluteca	July 28th, 2022
6	Honduras	On site	Tegucigalpa, Francisco Morazán	July 29th, 2022
7	El Salvador	On site	San Salvador, El Salvador	July 19th, 2022
8	Guatemala	Online	Guatemala, Guatemala	August 11th, 2022

The people invited to participate were selected according to their sector, their action in the fruit and vegetable value chain, their professional trajectory, and their leadership. All components of the fruit and vegetable value chain were present, from input suppliers of agricultural services, raw materials and professional services, production, post-harvest, processing, transportation, commercialization and distribution. Other participants included international cooperation actors, civil society and government regulators, as well as experts in the areas of gender, climate change, food security, nutrition, research, education and training *(Appendix 3- List of participants)*.

Each workshop was divided in two sessions:

Session 1. Working groups:
They were assigned a matrix for group discussion and debate, in addition to completing a matrix for future actions and involvement in the program *(Appendix 4 - Matrix for identifying problems and opportunities by chain components)*.

The following questions were asked in this session:

1. What are the needs and requirements in each component of the fruit and vegetable value chain?
2. What opportunities are envisaged to address the needs identified in the fruit and vegetable value chain?
3. How could actions be implemented and who should be involved in their implementation and how would they be involved?
4. How can we prepare the fruit and vegetable chain for the challenges that will be faced in the short, medium, and long term?
5. What topics are priorities in research, education, and training?
6. How do you consider the locality is doing in terms of requirements, nutritional demand, and market?

Session 2: Analysis and summary of the day.
A representative from each group reported to the plenary for a general open discussion on the issues identified, main challenges and challenges, as well as the opportunities identified, their conclusions and recommendations.

4.3. Field Surveys - Interviews

A printed survey was prepared and applied to (horticultural producers, academic researchers, government regulators, company managers, traders, distributors, representatives of private enterprise, government, and civil society organizations); as well as several open interviews to obtain a broader perspective and analysis of the fruit and vegetable sector in Central America, with emphasis on Guatemala, Honduras and El Salvador. Fifty-five key actors in the fruit and vegetable chain participated in the surveys *(Appendix 5 - List of participants in the surveys and interviews)*.

The survey included eight sections:

1. Horticultural Production
2. Natural Resources
3. Socioeconomic Context
4. Market
5. Consumption
6. Technology
7. Research-Education-Training
8. Policies in Horticultural Production *(Appendix 6- Survey-field interview).*

It included questions that helped identify the main constraints and problems of the horticultural chain, as well as the main needs for research, education, training, and capacity building.

Figure 3. *Actors of the fruit and vegetable chain during the implementation of surveys.*

5. DEVELOPMENT OF ACTIVITIES

5.1. Geographic Area Covered

The three main activities for information gathering, the regional workshop, focus groups and interview-surveys, involved the participation of key actors and decision-makers in the horticultural and fruit chain in Honduras, El Salvador and Guatemala. The workshop also included the participation of staff representing the agreement between UC Davis, the *Feed the Future Program*, USAID and ZAMORANO University.

The *Regional Workshop to learn about the context of the horticultural and fruit value chain in Honduras, El Salvador and Guatemala* was held at ZAMORANO University in Honduras. The workshop was attended by 48 people, including 39 from Honduras, 3 from Guatemala, 4 from El Salvador and 2 from the United States of America, all from different key sectors in the development and study of the horticultural and fruit value chain.

Figure 4: *Representation of the country of origin of the workshop participants in ZAMORANO.*

Figure 5: *Location of focus groups in the Northern Triangle (Honduras, Guatemala and El Salvador).*

Regarding to the work meetings, under the Focus Group methodology, 8 meetings were held as follows: 6 groups in Honduras in representative departments by productive zones; northwestern zone (Cortés), central western (Intibucá and Comayagua), central eastern (Francisco Morazán and El paraíso) and southern region (Choluteca), 1 in San Salvador, El Salvador and 1 in Guatemala.

5.2. Description of the Participants in the Activities (Workshop, Focus Group and Interviews)

Participants were chosen according to their role in the value chain of the horticultural and fruit sector in the region. Some participants include representatives of public education in the food sector, producers, agricultural exporters, government, private entities, international cooperation agencies, research, supermarkets, NGOs, experts in gender, nutrition, food safety and experts in food safety regulations and standards from the three countries of the Northern Triangle of Central America.

6. RESULTS

6.1. Elements Prioritized at the Regional Workshop

The analysis conducted with key stakeholders in the fruit and vegetable chain revealed a series problems and opportunities, which are summaries below:

Table 2. *Summary and elements prioritized in the regional workshop by dimension of the fruit and vegetable chain*

PRIORITIZED ELEMENTS IN THE REGIONAL WORKSHOP IN EACH DIMENSION OF THE HORTICULTURAL CHAIN			
Dimension	Prioritized problem	Prioritized opportunities	Group agreements
Production systems and integrated pest management (IPM)	**1.** Failure to disclose information.	**1.** Taking advantage of the development of new technologies for biological controls. **2.** Creating alliances for the resolution of problems in the agricultural educational area.	**a.** Developing an effective and equitable outreach program. **b.** Strengthening the education of vulnerable groups, youth, and women. **c.** Updating educational models through new communication technologies. **d.** Expert training for knowledge management.
Natural resources, environment, and socioeconomic context	**1.** Access to water. **2.** Soil degradation. **3.** Unconsolidated producer organizations. **4.** Little access to financing / soft loans. **5.** Lack of regulation on imported products in local competition.	**1.** Implement the use of efficient irrigation technologies. **2.** Better crop yields and increased production areas. **3.** Donor support. **4.** Identify the portfolio of financing projects for the agricultural sector in local and regional private banks. **5.** Reduction of imports through production for self-consumption. **6.** Reduce costs through the implementation of Good Agricultural, Manufacturing and Business Practices to stabilize the prices of products used in the value chain of horticultural production, as part of the strategy to face the global crisis.	**a.** Regulations of areas suitable for cultivation. **b.** Have an environmental and sustainable production adapted to climate change. **c.** Establish an urban development plan and investment o infrastructures for water harvesting. **d.** Soil conservation practices. **e.** Integrated crop management. **f.** Design of financial products adapted to the characteristics of the sector. **g.** Create, review and update public policies regarding imports and exports. **h.** Treaties between countries that can regulate policies regarding imports to give the local market an opportunity.

Dimension	Prioritized problem	Prioritized opportunities	Group agreements
Technologies and produc-tion	**1.** Lack of producer empowerment in relation to infrastructure and shared technology; there is no adoption of this. **2.** Poor infrastructure for value addition (roads, water access and others).	**1.** Development of installed capacities in the producers / return on investment / support of organizations for showcase or model companies. **2.** Within the framework of SICA, create programs to integrate and share technology. **3.** Declaration of emergency oriented to the productive sector.	**a.** Adopt the technologies transmitted through practices in the field / location of the infrastructure in a strategic way. **b.** Training of skills for managing technology. **c.** Design of a financial product to strengthen the infrastructure. **d.** Integrate the academy, government, and productive sector.
Post-harvest and process-ing	**1.** High losses due to food waste. **2.** Low quality and safety of products.	**1.** Interest of international cooperation in strengthening agrifood chains to guarantee Food Security. **2.** Define quality standards to open new markets. **3.** Establish an inter-institutional work agenda for the regulation of food quality.	**a.** Organization and implementation of staggered planting plans that meet quality requirements.
Commercial-ization and distribution	**1.** Lack of cultural identity focused on local consumption. (Local vs/Inter-national, Food Safety, Nutrition-al Advantages). **2.** Lack of orga-nization among producers.	**1.** Determine the characteristics of local demand to respond by expanding the productive sector. **2.** Satisfy the demand for healthy food by promoting greater consumption of local horticultural products. **3.** Improve the quality of life of the population through the consumption of new products rich in vitamins and minerals. **4.** Access to permanent buyers. **5.** Support from international donors. **6.** Improvement in product quality. **7.** Local development.	**a.** Local Consumption Campaigns. **b.** Gastronomic fairs around the promotion of local consumption and food safety. **c.** Create new cultural patterns of local consumption. **d.** Diversification of the basic basket to add local products to it. **e.** Staggered planting. **f.** Promote the organization of producers. **g.** Generation of commercial components.

Dimension	Prioritized problem	Prioritized opportunities	Group agreements
Research, education, and training	**1.** Poor agricultural research. **2.** Lack of knowledge or fear in commercialization in small producers.	**1.** Creation of national and regional research centers. **2.** Establish agricultural research in study centers. **3.** Development of tropicalized genetic materials to increase productivity levels. **4.** Establish the foundations for intelligent agricultural production in the context of developed technologies. **5.** Reactivation of the high-level agricultural extension programs. **6.** Formalization as companies. **7.** Access to value chains, exports, and transformation of products. **8.** Create and support of programs with a gender approach. **9.** Digital transformation and use of new technologies in the horticultural sector.	**a.** Development of prioritized research based on diagnosis by zones and production chains. **b.** Clear public policies in promoting research and budget for implementation. **c.** Coordination with the private company. **d.** Carry out a study and documentation of the best post-harvest practices in vegetables. **e.** Incentives for researchers. **f.** Make alliances with external research centers. **g.** Encourage the participation of young people in research. **h.** Involve producers so that they are participants in the research. **i.** Training programs for negotiation, administration, personal finance, leadership, agribusiness, incoterms, entrepreneurship, among others. **j.** Round of business. **k.** Form cultivation chains to improve local and international commercialization.

6.2. Elements Prioritized in the Focus Groups in Honduras, Guatemala and El Salvador

Through the analysis carried out with the actors of the fruit and vegetable chain in the workshops and meetings, different problems and opportunities were identified, and these are prioritized below:

The complete list of prioritized elements in greater detail for each region of Honduras is presented in *(Appendix 6 - Elements prioritized by focus group in Honduras)*.

Table 3. *Summary and elements prioritized by components of the fruit and vegetable chain in six focus groups in Honduras.*

PRIORITIZED ELEMENTS BY COMPONENTS OF THE HORTICULTURAL VALUE CHAIN IN HONDURAS			
Components of the fruit and vegetable chain			
Dimension	Prioritized problem	Prioritized opportunities	Group agreements
Input Suppliers	**1.** Inadequate registration procedures and import of inputs. **2.** Variability and high costs of raw materials and inputs. **3.** Lack of technical assistance. **4.** Environmental contamination by pesticides and poor handling of containers and packaging . **5.** Inadequate information to customers. **6.** Lack of approved product regulations. **7.** Low product availability.	**1.** Create online program for records. **2.** Search for local alternatives. **3.** Prioritize research topics. **4.** Subsidy program. **5.** Development of technical assistance program for suppliers and producers. **6.** Expand and diversify the supply of products and development of local products. **7.** Training and capacity building in biopesticides and pesticide use. **8.** Establish a management, education and training program for chemical and pesticide waste. **9.** Conduct an agricultural census.	**a.** Broaden the involvement of all the actors in the supply chain. **b.** Strengthen those involved in the fruit and vegetable chain through training and capacity building. **c.** Support an effective communication program. **d.** Support the search for strategic financial partners. **e.** Create youth and women's enterprises in local inputs and promote local products.

Components of the fruit and vegetable chain			
Dimension	Prioritized problem	Prioritized opportunities	Group agreements
Production	**1.** Poor agricultural practices, poor management of resources (soil and water) and climatic conditions. **2.** Lack of access to agricultural credit and financing. **3.** Lack of production technology. **4.** Lack of technical advice and assistance **5.** High production and seed import costs. **6.** Inadequate pest and disease management. **7.** Scarce generational inclusion and land tenure. **8.** Food safety.	**1.** Access to and implementation of environmentally friendly technologies, training, and agricultural practices to mitigate and adapt to climate change. **2.** Reactivation of value chains considering success stories and access to agricultural credit. **3.** Certifications of agricultural production and land legality.	**a.** Organize and implement field school training programs (ECA's), implementation of technologies and research for producers and their families. **b.** Support in the review of credit policies at the central level with the different stakeholders. **c.** Support the identification of entities that have certified material and support the establishment of alliances and agreements with marketers. **d.** Seek business alternatives and youth entrepreneurship. **e.** Involve key stakeholders in research, training, education, and technology transfer processes.
Post-harvest and process-ing	**1.** Waste of products, high rejection of vegetables and lack of added value. **2.** Lack of infrastructure, equipment, and packaging for adequate post-harvesting. **3.** Lack of skilled and available labor. **4.** Lack of post-harvest knowledge. **5.** Residuality of chemical products. **6.** High refrigeration and energy costs.	**1.** To provide added value to products through youth and women's entrepreneurship. **2.** Training in post-harvest issues, value added and technologies. **3.** Traceability and search for financing for technical assistance process.	**a.** Formalize strategic alliances with government agencies, international cooperation agencies, civil society and NGOs and stimulate entrepreneurship among young people and women. **b.** Identify market niches for Commercialization the product with added value.

Components of the fruit and vegetable chain			
Dimension	Prioritized problem	Prioritized opportunities	Group agreements
Comerzial-ization and Distribution	**1.** Lack of equipment and infrastructure to maintain the cold chain. **2.** Lack of understanding of market needs, market windows and price stability. **3.** Road infrastructure in poor condition. **4.** High costs of customs clearance, transportation, land, sea and air customs and fuel costs.	**1.** Implementation of new technologies to maintain the cold chain (mobile cold rooms). **2.** Conduct market studies and make better decisions at the trade level. **3.** Standardize quality standards at local and international level.	**a.** Seek funding for innovation in cold chain maintenance technology. **b.** Establish strategic alliances and linkage of technical training entities for the manufacture of materials for export at the local level. **c.** Maintain updated quality parameters and standards in accordance with the market. **d.** Diversify crops and establish contracts with buyers. **e.** Linking the relevant authorities to improve access roads.
Dimension	Prioritized problem	Prioritized opportunities	Group agreements
Research, training and education	**1.** Lack of education in agricultural practices, pest management, manufacturing, post-harvest, financial and Commercialization. **2.** Lack of funding for agricultural research, Integrated pest management (IPM), technology, nutrition, laboratories for soil and water analysis.	**1.** Creation of a program and technical training for: integrated crop management, technology, good agricultural practices, Integrated pest management (IPM), biological controllers, financial education, production costs, good manufacturing practices and post-harvest handling. **2.** Make a connection between research, practice, and publications. **3.** Establish laboratories at the local level for analysis of water, soil and vegetative material. **4.** Research according to the needs of the basic food basket with a nutritional approach.	**a.** Locate strategic allies to strengthen investigation, analysis, and education.
Dimension	Prioritized problem	Prioritized opportunities	Group agreements
Nutrition	**1.** Lack of laboratories to analyze pesticide residues in vegetables. **2.** Lack of nutritional information and little consumption of what is produced locally. **3.** Over-demand and few production areas.	**1.** Obtaining timely and reliable data for each pillar of Food and Nutrition Security with emphasis on components related to consumption and biological utilization of food. **2.** Advertise horticultural products through awareness, food education, safety and nutrition campaigns.	**a.** Involve specialized actors to implement laboratories at the regional level and government involvement for the implementation of local food safety policies. **b.** Implement family gardens to diversify the diet at the household level.

Dimension	Prioritized problem	Prioritized opportunities	Group agreements
Political, socioeconomic and climate change context	**1.** Lack of opportunities for women, low skilled labor force and deficient government agricultural policies. **2.** Bureaucratic processes for registration, exports and import monopolies. **3.** Water scarcity, deforestation and crop losses due to excessive rainfall and poor management of agricultural waste.	**1.** Involve women and young people in chain activities, mainly in value-added activities. **2.** Produce more environmentally friendly, sustainable products and generate new markets.	**a.** Encourage the creation of training programs for capacity building, search for support programs for gender equity, efficient and sustainable production, and regulation of imports.

Table 4. *Summary and elements prioritized by dimension of the fruit and vegetable chain by focus group in El Salvador, El Salvador*

ELEMENTS PRIORITIZED BY COMPONENTS OF THE FRUIT AND VEGETABLE CHAIN IN EL SALVADOR			
Components of the fruit and vegetable chain			
Dimension	Prioritized problem	Prioritized opportunities	Group agreements
Input Suppliers	**1.** Little offer of alternative products **2.** Shelf life of biological and chemical products. **3.** logistics for imports of agricultural inputs. **4.** Seed availability.	**1.** Strengthening national banking with financial products adapted to producers.	**a.** Search for new technologies, and promotion of new sustainable emerging technologies.
Production	**1.** Limited access to technology. **2.** Misuse of resources. **3.** Poor availability of labour and lack of generational inclusion.	**1.** Technification of production processes and compliance with environmental regulations. **2.** Provision of labor services. **3.** Association between producers. **4.** Empowerment of women in the productive sector.	**a.** Promote the change of project vision to a business-commercial vision.
Post-harvest and processing	**1.** Lack of experience and technology in post-harvest and processing. **2.** Lack of requirement for traceability of products.	**1.** Implementation of registration and certification processes. **2.** Implement export crops and agro-industrial processes.	**a.** Opportunity to generate jobs for the community through local enterprises.
Commercialization and distribution	**1.** Little knowledge of the cold chain. **2.** Geographical location accessible to ports and roads for marketing and distribution.	**1.** Market research and analysis for development processes.	**a.** Search for strategic alloys to define marketing channels for linking to the formal market.

Dimensions	Prioritized Problem	Prioritized Opportunities	Group Agreements
Research, training and education	**1.** Little knowledge of the cold and post-harvest chain.	**1.** Cold chain and post-harvest training processes. **2.** Creation of post-harvest management guides.	**a.** Capacity building and strengthening of new technologies.

Dimensions	Prioritized Problem	Prioritized Opportunities	Group Agreements
Nutrition	**1.** Lack or deficiency of technical knowledge 2. Lack of food insurance laws.	**1.** Organization of products to ensure continuous substitution. **2.** Food sovereignty.	**a.** Involvement of government actors to promote population development and comply with agreements.

Dimensions	Prioritized Problem	Prioritized Opportunities	Group Agreements
Political, socioeconomic and climate change context	**1.** Lack of public policies to regulate imports and phytosanitary controls. **2.** High population migration.	**1.** Diversification of crops, creation of processed products and generation of employment for the population.	**a.** Involve key actors in the chain for regulations and controls.

Table 5. Summary and elements prioritized by dimension of the fruit and vegetable chain by focus groups in Guatemala

ELEMENTS PRIORITIZED BY COMPONENTS OF THE FRUIT AND VEGETABLE CHAIN IN GUATEMALA			
Components of the fruit and vegetable chain			
Dimension	Prioritized problem	Prioritized opportunities	Group agreements
Input Suppliers	**1.** New pesticide molecule alternatives and complex records.	**1.** Updating of records of new molecules and maximum limit allowed in vegetables and fruits.	**a.** Involvement of government entities and actors in the chain for production with quality and safety.
Production	**1.** Lack of productive infrastructure and irrigation technology. **2.** Aspects of incipient plant nutrition. **3.** Land tenure. **4.** Producers' model. **5.** Lack of safety.	**1.** Use of non-renewable resources. **2.** Reduction of pesticide use, reduction of pests in crops and analysis of pesticide residues. **3.** Opportunities for sustainable irrigation technology and water harvesting. **4.** Gender equity in the fields of production5. Mapping of producers and distribution of crops. **5.** Implement geographic information systems (GIS). ***6.*** Preparation of manuals for the safety of fresh agricultural products.	**a.** Search for strategic alloys as educational entities for the analysis of vegetative samples and residues through laboratories, in response to current challenges and reduction of pesticides.
Post-harvest and processing	**1.** Cold chain and quality maintenance. **2.** Fruit and vegetable processing.	**1.** New markets. **2.** Reduction of food waste and Circular Economy. **3.** Added Value.	**a.** Search for strategic alloys for support and new markets.
Commercialization and distribution	**1.** Have the quality requirements for export. **2.** logistics and intermediaries. **3.** Market saturation .	**1.** Improving the economic conditions of farmers.	**a.** Look for new market alternatives and work under a cost structure.

Components of the fruit and vegetable chain			
Dimension	Prioritized problem	Prioritized opportunities	Group agreements
Commercial-ization and distribution	**4.** Packaging.	**2.** Communication and trans-parency between intermediar-ies and data of available prices. **3.** Organization of sowing 4. Decreased use of plastic packaging.	
Dimensions	Prioritized Problem	Prioritized Opportunities	Group Agreements
Research, training and education	**1.** Incipient and transparent research capacity. **2.** Lack of information and professionalization of trainers. **3.** Development of new improved varieties.	**1.** Linking academia and the private sector. **2.** Publications of research and creation of guides for training and education. **3.** Development of a training program for professionals (Training of trainers).	**a.** Search for funds from international cooperation for the development of a specific research center that components producers, agro-exporters and above all that is sustainable over time. **b.** Establish them permanently in response to needs. Getting on track for the “Green Deal”.
Dimensions	Prioritized problem	Prioritized opportunities	Group agreements
Nutrition	**1.** Need for research.	**1.** Conduct a study on production and nutrition education at the household level .	**a.** Search for strategic government alloys for statistical data and search for research centers that have specialized laboratories for nutritional analysis.
Dimensions	Prioritized Problem	Prioritized Opportunities	Group Agreements
Political, so-cioeconomic and climate change con-text	**1.** Low participation of agricultural economists. **2.** Entrepreneurial approach. **3.** Protect intellectual property.	**1.** Establish production costs and crop profitability. **2.** Protection of new and improved varieties.	**a.** Resource management to operate properly.

6.3. Elements Prioritized in Surveys-Interviews

Fifty-five surveys were administered in printed format. Within the group surveyed, in terms of the level of response, most of the respondents represented Honduras (48), followed by El Salvador (4) and Guatemala (3). Of the total number of participants of the survey, 19 were women (34.5%) and 36 were men (65.4%). In addition, according to participation, they were grouped by profession, organization and involvement in the fruit and vegetable chain.

According to the type of sector represented, the highest participation was obtained at the level of: Government with 25.5%, followed by producers' organizations with 20%, NGOs with 16.4%, the private sector with 16.4%, academia with 7.3%, cooperatives, research foundations and international development agencies with 1.8% respectively, and others with 3.8%.

According to participation by components of the chain, 16.36% represents the agricultural input and raw material suppliers link, 45.5% the production link, 23.6% post-harvest and processing, 29.12% Commercialization and distribution, and 5.45% agricultural research and development, among others.

The following are the main limitations expressed by the participants in the survey-interviews:

Table 6. *Main limitations of the fruit and vegetable chain in Honduras*

Main limitations	Averages
Availability of agricultural extension programs	5
Availability of technical advice	5
Agricultural input costs	4
Extended periods of drought	4
Presence of new pests and diseases in production fields	4
Landslides and/or landslides in production fields	4
Distribution of goods and wealth	4
Generational change	4
Youth migration	4
Land tenure	4
Price fluctuation and variation	4
Product with added value	4
Accessible technologies for production (mesh houses, macro tunnel, greenhouses (etc.)	4
Accessible technologies for processing and added value	4
Lack of government programs to support smallholder agriculture	4

Main limitations	Averages
Access to credit for smallholder farmers	5
Availability of agricultural insurance	5
Cost of agricultural insurance	4
Associativity of farmers	4
Access to market information	4

Table 7. Main limitations of the fruit and vegetable chain in Guatemala and El Salvador.

Main limitations	Average
Access to credit for smallholder farmers	3.4
Prices of fruits and vegetables for the consumer	3.4
Lack of government programs to support smallholder agriculture	3.2
Availability of agricultural insurance	3.2
Availability of appropriate technologies for irrigation	3
Extended periods of drought	3
Access to agricultural credit	3
Place of purchase of vegetables	3
Availability of agricultural extension programs	3
Availability of technical advice	3
Accessible technologies for processing and added value	3
Agricultural input costs	2.8
Lack of working capital	2.8
Access to credit	2.8
Accessible technologies for proper storage	2.8
Lack of support programa	2.6
Market requirements	2.6
Market quality policies and parameters	2.6
Increase in pests and diseases in production fields	2.4
Presence of new pests and diseases in production fields	2.4

7. ANALYSIS

7.1. Analysis of the Aspects Prioritized by the Participants in the First Regional Workshop held in ZAMORANO

According to the analysis of the working groups in the workshop, they prioritized the problems in the following 5 elements in the different components of the horticultural chain.

- **Knowledge Management:** such as poor adaptation and appropriation of technologies, little or no technical assistance, little or no training and knowledge transfer, little or no business development, little or no communication of information.
- **Natural Resources, Environment and Socioeconomic Context:** poor access and management of water, soil degradation and poor soil management. Poor access to financing. Little or no action to regulate product imports.
- **Technologies and Production:** limited infrastructure and equipment for value addition, lack of technology adoption.
- **Post-harvest and Processing:** high volumes of harvest waste, low product quality and safety.
- **Product Commercialization and Distribution:** lack of enforcement of regulations, existence of an informal market, little access to high-value markets, low cultural identity in consumption.

In relation to opportunities in the different components of the horticultural chain, the same groups prioritized the following activities;

- Develop a program to generate and disseminate knowledge.
- Develop an education and training program at all levels.
- Establish a program to provide training and technical assistance services.

7.2. Analysis of the Aspects Prioritized by Focus Group Participants

Based on the analysis of the focus groups, the chain actors prioritized the problems in the following elements for the components the horticultural chain.

7.2.1. HORTICULTURAL PRODUCTION

i) Plagues and diseases

a) High handling costs and high volumes of product rejection.
b) Development of high levels of resistance due to misuse of pesticides.
c) Little resistant genetic material
d) Misuse of chemicals increases levels of contamination of water, soil and people.
e) Little knowledge and training in pest management

7.2.2. NATURAL RESOURCES AND CLIMATE CHANGE

i. Water

The availability of water for consumption and irrigation is a problem in the dry months in Honduras, Guatemala, and El Salvador. The dry months are normally from November to March-April. Irrigation technology and equipment are essential to be able to produce and increase productivity. On the other hand, there are viable and feasible alternatives that could be implemented, such as the use of irrigation equipment and systems using solar energy and low-pressure technology. These technologies can help protect the environment.

Water quality is essential, not only for human consumption but also for irrigation in production fields, which is why analysis through certified laboratories is necessary.

ii. Soil

In the production fields, soil weakening is generated day by day. This is caused by bad agricultural practices. Many farmers do not carry out soil analysis before proceeding with fertilization plans, and they continue to burn production plots and deforest to extend their production, which causes accelerated erosion and soil erosion.

iii. Environmental contamination

Bad practices throughout the fruit and vegetable chain generate environmental contamination, due to the indiscriminate and inappropriate use of pesticides in the production fields, as well as the generation of chemical waste, containers, and packaging, which are not biodegradable, and the processing of this waste is expensive and follows a complex process.

iv. Weather

At the regional level, climatic conditions are strongly affected. In many areas, excess rainfall, or droughts (El Niño or La Niña effect) are very prolonged, which has a negative effect on agricultural production and productivity and soil fertility, as well as causing an increase in pests and diseases.

7.2.3. SOCIOECONOMIC CONTEXT

The challenges in the socioeconomic context are quite marked. Today, the *COVID 19* pandemic and the international wars have caused a decrease in imports, which has increased the costs of raw materials, communication, energy, fuel and refrigeration services. Farmers are limited and lacking information to qualify for agricultural credit that would allow them to increase their businesses and thus be able to generate sources of employment in their enterprises. The lack of jobs has increased migration, reduced generational inclusion in the chain and reduced opportunities for both men and women. At the chain level, this has had a strong impact because there is currently a lack of skilled and trained labor.

On the other hand, small farmers are the most prone and vulnerable to climate change events, as are those involved in exports. The cost of agricultural insurance is a major constraint because they are deficient and there is no adequate, timely and timely response to the problems described.

7.2.4. WOMEN IN HORTICULTURE

Women play an important role in agricultural activities, however, they lack the resources to be able to work in them. Women have little power in decision-making, and administrative positions are not evenly represented in farmers' organizations or agricultural cooperatives.

On the other hand, land tenure is a limiting factor in terms of access to agricultural credit and market access. However, women are involved in other areas that have or are more related to industry and value added. On the other hand, according to the Food and Agriculture Organization of the United Nations, women play an important role in household food security and are involved in the production of subsistence crops through the implementation of home gardens.

7.2.5. MARKET

i. Economic Problems

The lack of inventory and high costs of horticultural inputs such as fertilizers, equipment, technologies, chemical and biological inputs, packaging, refrigeration equipment, transportation, storage, and export materials negatively affect the sector, making it look like an unprofitable business. Due to the lack of these resources the product can be lost or sold at uncompetitive prices. This is also affected by production costs exceeding the selling prices of the products, reflecting not a profit margin, but a loss or a liability. There is great variation and fluctuation in the prices of inputs at the country level, which causes farmers near the borders to purchase their agricultural inputs abroad, affecting the local economy.

ii. Access to markets

At the commercialization and distribution level, the actors in the fruit and vegetable chain face many challenges. Poor organization in the production fields at the time of planting leads to an excess of product in the market or over-demand, resulting in poor organization when it comes to the commercialization of the products. On the other hand, there is a lack of understanding of market needs; the supply does not go in hand with the market´s demand. It is important to aspire to reach other targets and explore new market niches, such as school snacks, restaurant chains, and others.
Another major problem is the road infrastructure and access to the sales centers. In order to deliver products on time, they have to leave very early in the morning, additionally, due to political issues, there are often road blockades that cause delays in deliveries, break the cold chain, and cause products to decay reflecting in an economic loss.
In some cases, producers are consistent with their schedules, but in many cases they are not. These structures are sometimes weak because there is a lack of agreements and contracts between producers and the market, and many of the prices are unfair, leading to non-compliance with purchase and sale commitments.

7.2.6. CONSUMPTION

According to data from the *World Health Organization (WHO*), people should consume about five servings of fruits and vegetables per day as part of the guidelines or recommendations for maintaining a healthy diet. In terms of vegetable consumption, the region is below the WHO recommendations in terms of quantity, variety and frequency. communities where vegetables and fruits are produced. Often what happens is that in the communities and places where most vegetables are produced, they are not consumed.

The Central American region has a great diversity of fruits and vegetables. Exploring new products or new recipes can be the key to incorporate vegetables into our diet. It is also important to provide added value to the products. In addition, it is important to analyze that many times there is availability, but little access due to high prices. In the group discussion, the alternative of being able to carry out awareness campaigns for the consumption of vegetables was mentioned. The campaigns should focus on the nutrients they provide, as well as the promotion of access at points of sale.

7.2.7. STRUCTURE AND TECHNOLOGY

Access to structures and technological innovation are key to the functioning of the components in the fruit and vegetable chain. In addition, the horticultural sector needs technologies that improve the quality of its products, are adapted, and minimize environmental impact.

i. Technology for the Production

Agricultural production under protected structure has proven to be effective and is in great demand as it is a great alternative for better management and control of pests and diseases. This helps farmers to increase productivity, produce with quality and safety and above all make a rational use of non-renewable resources.
There is currently a need to opt for this type of technology; however, due to high costs and little or no access to agricultural credit, support is required for the implementation of these technologies in the fields. In addition to this, for it to work it is important to make a correct and adequate transfer of technology, as well as adequate training and training processes on this.

ii. Post-harvest Technology

Adequate handling and preservation of various agricultural products, to maintain their quality and subsequent commercialization or consumption, requires specialized equipment and infrastructure. However, equipment availability and costs are high in the region. On the other hand, it is difficult to maintain the cold chain. As a result, there are large losses and there is a high rejection of vegetables.

There is also little research and innovation in the development of new products and added value. The promotion and development of new products and innovation in new packaging that is biodegradable and thus avoids the use of plastics is considered appropriate, with the intention of maintaining the value of the chain and sustainability.

iii. Transportation and Cold Chain

Agriculture is one of the most important industries in the region. However, the region does not have adequate means of transportation to move crops to the various markets; air, land, and sea freight costs are high and there is no appropriate transportation equipment, which causes the cold chain to be interrupted. At present, there is a shortage of transportation services such as containers used mainly for export.

iv. Labotories

Integrated soil and water management, as the main factors of production and productivity, helps to make the use of resources such as fertilizers and agrochemicals more efficient. At the regional level, the development of laboratories at the local level is considered necessary and opportune.

On the other hand, pesticides are the main product used to handle plagues and disease control. In the region, some pesticides and molecules are still being used despite that they have been forbidden in other countries. That is why the evaluation and analysis of pesticide residues in horticultural products is also essential. There is a lack of laboratories in the region that could perform this type of analysis. It is considered that not only the product for the export market should be tested, but also the product for local consumption.

7.2.8. NUTRITION

Sustainable food, fruit and vegetable production allows the land and water to be resilient and harbor the diversity needed to provide a nutritious and healthy diet. By producing more sustainably, we would be contributing greatly to the reduction of pesticide residues in vegetables and fruits. The lack of product safety is evident. This makes it impossible to open gaps to other markets, since there is also a lack of laboratories in the region that perform this type of analysis. Mitigation strategies are required, and production must be demand-driven. Today, much of what is produced lacks the required nutrients and, in addition, there is often an over-demand.

7.2.9. RESEARCH, EDUCATION, AND TRAINING

The lack of specialized technical advice is a cross-cutting issue in all the components of the fruit and vegetable chain. At the level of input suppliers, the intervention of trained personnel is necessary because in many cases input sellers are not able to advise farmers, which leads to misinformation. Technical assistance and training are key elements; not having assistance intime and form causes the actors to carry out some bad practices during the processes, have problems with plague and disease management, market, post-harvest, processing, and value added, among others.

There are research and education institutions that have all the installed capacity to carry out research, however, sometimes they lack funds to do so and results of research are not published. It is important to mention that a coordination between research entities, government and the private sector should exist to create an institution with the intention of strengthening technology, and knowledge management.

In order to mitigate the lack of research on important topics such as Integrated Pest Management (IPM), nutrition, soil, water, and others, there is an opportunity to create and establish a specific regional research center that would link specific regional research center that links producers, agroexporters and, above all, is sustainable over time and, above all sustainable over time and in accordance with the needs of the sector.

7.2.10. HORTICULTURAL PRODUCTION AND POLICIES

Central America is a region in which the countries have similar characteristics. The horticultural sector plays a very important role in economic and social development as a traditional source of employment, food for the rural and urban population, production, and exports.

According to stakeholders in the chain, many of the processes such as import and export registration in the countries of the region are quite bureaucratic. They consider that there is a huge deficiency in government agricultural policies, a strong monopoly on imports and a lack of compliance with laws, all of which leads to ungovernability.

7.3. Analysis of Surveys and Interviews

For the analysis, to understand the horticultural context, the surveys applied to participants were presented with a set of questions classified in eight prioritized sections based on horticultural production, natural resources, socioeconomic context, market, consumption, technology, research, education, training, and policies in horticultural production. For each of the sections, participants were asked to rate the items according to a scale.

The results coincide with those of the interviews and workshops since technical advisory services are considered cross-cutting in all components of the fruit and vegetable chain. On the other hand, there are also productive constraints, such as the rise and cost of agricultural inputs, an excess of plagues and diseases, and the presence of new pests in the production fields. There are also socioeconomic constraints such as inequality in the distribution of goods and wealth, land tenure, and the lack of involvement of young people in agricultural activities. Women lack representation and many young people do not see agricultural activities as a business, since they lack information, come from homes where subsistence agriculture is practiced and are unaware of the benefits and opportunities that this sector can provide, causing them to look for other options to generate income and make the decision to migrate from the country.

In the production fields, there is a shortage of labor at harvest time, which causes some crops to be lost. On the other hand, many of the farmers do not have access to credit. This reduces the possibilities of diversifying their crop plantations, opting to improve or acquire technologies for new production systems, post-harvest technologies, and processing and thus offer the final consumer a value-added product. There is also wide fluctuation and variation in the prices of horticultural products and producers do not have first-hand information on markets.

Due to climate change, many of the production fields have suffered landslides and extended periods of drought and rainfall, causing crop losses. Many farmers have the initiative to opt for agricultural insurance, but the high costs and low availability of these possibilities are reduced, which is a constraint for the chain. There is also a lack of government support programs for agricultural extension. Participation is considered opportune since farmers need support in the activities of the entire fruit and vegetable chain.

The limitations at the regional level are quite similar. The results obtained in Guatemala and El Salvador are somewhat similar to the constraints in Honduras. Access to credit for small farmers, the lack of support programs from the government and other entities that support farmers, the limited availability of appropriate technologies for production, processing and value added, the increase and presence of new pests and diseases in the production fields because they also face high input costs. There is also limited availability of technical advisory services to support processes throughout the chain. The three countries are also experiencing a lack of availability and high costs of agricultural insurance, which prevents them from insuring their production and protecting it from the effects of climate change. In addition, there is a lack of working capital, which limits farmers' ability to carry out their work, implement new technologies for production, post-harvest, processing, and storage, adapt to market demands, policies and parameters, and qualify for agricultural credit to increase their production fields.

For consumers, one of the limitations to acquiring vegetables and fruits are the places where they can buy them, as well as the prices.

7.4. Research Needs in the Fruit and Vegetable Sector

The survey contained a section on research of the overall needs in the fruit and vegetable sector. As well as plague and crop management and postharvest. Among the main topics for research in the sector we have:

- Genetic improvement and resistant varieties
- In-vitro production
- Water management in horticultural production
- Crop adaptation and management under protected structures
- Soil management and nutrition
- Post-harvest management
- Sociology and rural development
- Agricultural economics
- Business development
- Market access

Specifically for pest and disease management, the most important topic was IPM, followed by the development and use of biological controllers. Most expressed that the use of biological controllers for pest and disease control in production fields should be a priority to have a more sustainable agriculture.

Under the category of integrated crop management, the topics for research were sustainable agriculture, development of plague and disease resistant crops, soil nutrition and development of early warning systems for pest management in crops.
Post-harvest research topics were related to proper handling, education and training, technology, safety, packaging, food waste reduction, pesticide residue analysis in vegetables, and cold chain.

8. GENERAL APPROACHES TO RESULTS

8.1. Approaches at the National Level (Honduras)

The chain approach makes it possible to identify the different actors involved in the process to establish their relationships and functions. It is in this construction process that problems can be mainstreamed and systematized to address them in an established timeline.

The Central Government is of utmost importance for the design of public policies that favor the horticultural and fruit sector, since its duty is to promote and regulate economic activities related to the production, processing, and commercialization of agricultural products, as well as the environment in which they are developed.

Undoubtedly, the lack of public policies to promote horticultural production requires a deep reflection and later a design that includes access to financing and technology. Likewise, the State Modernization Law needs to be revised to improve government services to producers.
Most technical assistance is being provided to producers by non-governmental organizations, but these do not necessarily respond to a comprehensive vision of improving the competitiveness of the horticultural sector.

Although there are four agricultural universities in the country that carry out research, these are not socialized with producers, so productive competitiveness has been stagnant and outdated. Private agricultural companies (national and transnational) carry out and finance their research to improve their production and have access to phylogenetic material that allows them to be competitive in the export market.

Producers are frustrated by the lack of direct support from the State, in addition to the poor management of their crops due to soil impoverishment, lack of renewal of phylogenetic material, phytosanitary problems in their crops, no opportunities to access low-interest loans to finance working capital, the onslaught of extreme conditions resulting from the effects of climate change and, currently, the increase in agricultural inputs as a result of the international crisis.

All these factors considerably reduce the consolidation of adult horticulturists, and in view of these scenarios, the young people called to be their parents' successors do not find motivation to continue their parents' work; on the contrary, they decide to migrate to other countries.
On the other hand, the vegetable processing and packaging industry is very small, first because the product they receive from the producers does meet the quality standards and the volume they deliver is reduced because the grower has many losses in production and post-harvest. Likewise, the industry is incipient in process technology and value addition.

A good part of the production is marketed in markets and supermarkets; however, there are a small number of agricultural exporters that market their products in different countries.

8.2. Approaches at the Regional Level

Central America, being in a biodiversity corridor, has several ecosystems, where each of the countries that comprise, it produces a significant number of vegetables, Guatemala being one of the most competitive countries in the region. This situation opens the opportunity for other countries such as Honduras and El Salvador to establish technical cooperation through existing platforms that could be generated within the region.

The need for technical assistance in all components of the fruit and vegetable chain is an important issue throughout the region, in addition to research processes in integrated pest management, technologies and nutrition. On the other hand, it is essential to be able to carry out nutrition feasibility studies according to the geographical areas where each family is located.

Also, at the chain level, priority should be given to the integration of young people and women, with the aim of generating opportunities through rural enterprises for the vegetable market and generating added value to horticultural products.

On the other hand, at the regional level, the different stakeholders expressed the need for technification at all levels. This opens an excellent opportunities to develop a mapping and diagnosis of the level of technification and equipment available in the region.

9. GENERAL CONCLUSIONS AND RECOMMENDATIONS

a) In order to determine the appropriate parameters for the current situation of the horticultural and fruit chain in the Central American region, it was necessary to gather information through specific methodologies used in the first regional workshop, focus group meetings and interviews with key personnel in the value chain in the countries of Honduras, El Salvador and Guatemala.

b) The analysis of the matrix of results and prioritized actions shows that the most recurrent problems in all components of the chain correspond to knowledge management, financing, public policies and socioeconomic context, natural resources and environment, and use of technology.

c) In the opportunities and group agreements, priority has been given to actions aimed at generating and disseminating knowledge with the participation of the actors involved in training, which are the producers and facilitators, the latter within an institutional system or individually as consultants/providers of training and technical assistance services.

d) Government involvement and the lack of public policies to promote horticultural production require a thorough reflection and later the design of a structure that includes access to financing and technology. In addition, the State Modernization Law needs to be revised to improve government services to producers.

e) In relation to the regional context and the fact that Guatemala is one of the most competitive countries in terms of vegetable production, there is an opportunity for other countries such as Honduras and El Salvador to establish technical cooperation through existing platforms that could be generated in the region.

f) In Honduras, Guatemala, and El Salvador there is a clear need to generate training processes that involve all the actors in the fruit and vegetable chain in an integrated manner.

g) At the regional level, there is a lack of recent data and studies on the nutritional value of vegetables and fruits for the final consumer.

10. SUGGESTIONS AND PROPOSALS FOR NEXT STEPS

a) The continuity of research efforts and compilation of information obtained at the first regional workshop to keep the information up to date, with special emphasis on public policies, climate change, food and nutrition insecurity, and the use of natural resources. Food and nutritional insecurity and the use of natural resources.

b) Develop workshops for the transfer of knowledge and/or disseminate the findings of scientific research developed by the academic institutions involved in the region, with the objective of improving crop productivity levels and increasing economic yields.

c) Implement workshops or educational strategies, and empowerment programs with emphasis on vulnerable groups such as youth, ethnic groups, and women. These implementations are meant to accelerate the potential in terms of product transformation, business, administrative and financial skills, as well as promote business rounds and the formation of crop chains to improve local and international commercialization.

d) Strengthen and enrich the knowledge of chain actors regarding good agricultural practices with emphasis on the protection of non-renewable resources and the promotion of technologies for mitigating and adapting to climate change.

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12. APPENDIX

Appendix 1 – Attendees at the First Regional Workshop to Understand the Context of the Horticultural and Fruit Chain in Honduras

Participants Workshop UCDAVIS -ZAMORANO, from June 15 to 17, 2022

No	Name	Institution	Position	Place of Origin	Contact	Email	Their role in the Horticulture Chain
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Access Databases to read more

Appendix 2 – Methodological tools for the development of the First Regional Workshop

USAID HORTICULTURE INNOVATION LAB UCDAVIS ZAMORANO

First Regional Workshop to Know the Context and Establish Challenges and Opportunities of the Horticultural and Fruit Value Chain of Honduras and Central America

DYNAMICS: TREE DIAGRAM
CHALLENGES
CAUSES
EFFECTS / CONSEQUENCES
SOLUTION PROPOSAL
OPPORTUNITIES
NEEDS OR REQUIREMENTS TO OVERCOME THE CHALLENGE/CHALLENGE
ACTORS THAT CAN CONTRIBUTE TO OVERCOMING THEM
TYPE OF CONTRIBUTION

USAID HORTICULTURE INNOVATION LAB UCDAVIS ZAMORANO

First Regional Workshop to Know the Context and Establish Challenges and Opportunities of the Horticultural and Fruit Value Chain of Honduras and Central America

DYNAMICS: MATRIX FOR PRIORITIZING CHALLENGES AND CHALLENGES

GROUP NAME: ______________________ **DATE:** ______________________

DIMENSION:

CHALLENGES	LEVEL OF PRIORITIZATION TO CONSIDER THE CHALLENGE/CHALLENGE				
	NO PRIORITY	LOW PRIORITY	TO CONSIDER	HIGH PRIORITY	EXTREMELY PRIORITY

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First Regional Workshop to Know the Context and Establish Challenges and Opportunities of the Horticultural and Fruit Value Chain of Honduras and Central America

DYNAMICS: BRAINSTORMING - IDENTIFICATION OF CHALLENGES AND CHALLENGES

GROUP NAME: ______________________ **DATE:** ______________________

DIMENSION	CHALLENGES

Appendix 3 – Attendees at the focus groups for the analysis of the Context of the Horticultural and Fruit Chain in Honduras, Guatemala and El Salvador

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Database of chain actors in focus groups

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Database of Main actors in focus groups

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Appendix 4 – Matrix used by focus group to identify problems, needs, opportunities, challenges and challenges by components of the chain

Chain components	Problems	Needs and requirements	Opportunities	Challenge
Input suppliers				
Production				
Postharvest and processing				
Transport and cold chain				
Marketing and distribution				

Appendix 5 – Participants of the surveys-interviews for the analysis of the Context of the Horticultural and Fruit Chain in Honduras, Guatemala and El Salvador

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Database of respondents for the analysis of the fruit and vegetable chain

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18	Victor Gonzalez	Masculino	Cortés	La Lima	94615657		Agrónomo	Fundación	Investigación y Desarrollo
19	Miguel Flores	Masculino	Intibuca	Jesús de Otoro	31650652	Miguel.Flores@crs.org	Ingeniero Civil, Maestria en Desarrollo Rural y Producción	ONG	Proveedores de Insumos, Producción
20	Victor Barahona	Masculino	Comayagua	Siguatepeque	33919678	vbarahona@cohorsil.hn	Productor	Cooperativa	Proveedor de insumos, producción, comercialización y distribución
21	Stanly Perdomo	Masculino	San Salvador	San Salvador	503 7140 1555	stanly.perdomo@mag.gob.sv	Administrador de empresas	Gobierno	Producción, Postcosecha y Procesamiento
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24	Zaira Colindres	Femenino	Francisco Morazán	Tegucigalpa	504 3391 0595	zaira.colindres@rikolto.org	Ingeniero Agónomo	ONG	Producción, Postcosecha y procesamiento, Comercialización y Distribución
25	Roger Motoya	Masculino	Francisco Morazán	Tegucigalpa	31482215	gerenciaconagroh@gmail.com	Ingeniero Agónomo	Organización de productores	Producción, Comercialización y Distribución
26	Maria Bucaro	Femenino	Guatemala	Guatemala	502 4016 9756	mbucaro@canterpast.org	Ingeniería en Ciencia de Aliment	ONG	Producción, Postcosecha y procesamiento, Comercialización y Distribución
27	José Rodas	Masculino	Comayagua	Comayagua	94593105	jrodas@deglobal.org	Ingeniero Agónomo	ONG	Proveedor de insumos, Producción, comercialización y Distribución

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Appendix 6 – Field survey-interview for the analysis of the horticultural and fruit and vegetable context

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SURVEY

ANALYSIS OF THE CENTRAL AMERICAN FRUIT AND VEGETABLE CONTEXT

Objective: To characterize the current situation of the fruit and vegetable sector in Central America and prioritize the opportunities, needs, requirements, challenges existing in the sector; in order to establish a participatory manner, models, approaches and appropriate solution strategies in accordance with local contexts.

BASIC INFORMATION OF THE RESPONDENT

Full name	
Gender	
Department	
City and/or community	
Contact (email, landline or cell phone)	
Profession	
Name of the organization/company/entity it represents	
Type or sector to which the entity it represents belongs (enclose in a circle)	a. NGO b. Foundation c. Government d. Academy e. Producer organization f. Consultant g. International Development Agency h. Independent i. Other, please specify: ___
Participation in the chain	j. Suppliers of inputs or raw materials k. Production l. Post-harvest and/or Processing m. Transport and/or cold chain n. Marketing and distribution o. Other___________________

II. Characterization of the horticultural sector

Instructions: Below you will find a series of questions with multiple answer options, please consider your geographical area of influence and use the following rating scale and assign a value at your discretion. In some cases, several options may receive the same rating.

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Qualification

Value	Description
1	It is not limiting
2	Little limiting
3	Moderately limiting
4	Very limiting
5	Extremely limiting
6	I do not know

1. HORTICULTURE – BIOPHYSICS

1.1. Rate the following limitations related to fruit and vegetable production, based on your experience or knowledge.

Limiting	Qualification
a. Agricultural input costs	
b. Lack of access to pest-resistant varieties and diseases	
c. Availability of appropriate technologies for irrigation	
d. Availability of appropriate and environmentally friendly agronomic technologies	
e. Availability of products for phytosanitary control	
f. Technical and managerial capacity of farmers	
g. Technical assistance and advice offered by experts	
h. Availability of certified and treated seeds	
i. Other, specify	

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2. NATURAL RESOURCES

2.1. Rate according to the scale, the limitations related to climate change in fruit and vegetable production in your geographical area of influence.

Limiting	Qualification
a. Increased and excessive rainfall	
b. Extended periods of drought	
c. Flooding in production fields	
d. Cloudiness	
e. Low temperatures	
f. High temperatures	
g. Soil compaction	
h. Soil erosion	
i. Increase in pests and diseases in production fields	
j. Presence of new pests and diseases in production fields	
k. Landslides and/or landslides in production fields	
l. Other, specify	

3. SOCIO-ECONOMIC CONTEXT

3.1. Rate socio-economic constraints for production/processing/value added in the fruit and vegetable sector

Limiting	Qualification
a. Distribution of goods and wealth	
b. Access to education	
c. Lack of support programmes	
d. Market access	
e. Access to agricultural credit	
f. Lack of working capital	
g. Access to agricultural insurance	
h. Generational change	

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i. Gender equity	
j. Youth migration	
k. Land tenure	
l. Other, specify	

4. MARKET

4.1. Rate the following limitations related to the market and marketing of fruit and vegetable products:

Limiting	Qualification
a. Access to credit	
b. Price fluctuation and variation	
c. Demand for fruit and vegetable products	
d. Offer of fruit and vegetable products	
e. Access to export markets	
f. Market requirements	
g. Market quality policies and parameters	
h. Access to informal markets	
i. Access to formal markets	
j. Formal market payment policies	
k. Payment time and periods	
l. Access to market and square information	
m. Access to pricing information	
n. Product Superabundance	
o. ñ. Other, specify	

4.2. **If the entity you represent is engaged in marketing and/or distribution, please answer the following question:**

Mark with an x the market channels you use to sell your fruit and vegetable product.

Canals	Qualification
a. Sales to the intermediary directly, because it treats me fairly	

b. Sales to the intermediary directly, because I have no other marketing channel	
c. All the fruit and vegetable product is put together and sold to the one who offers to buy	
d. Farmer's Fairs	
e. Wholesale market	
f. Contract with recognized supermarket chains	
g. I sell to other farmers who have contacts with marketers	
h. Grocery stores and convenience stores	
i. Other, specify	

4.3. Marking with an X the mechanisms you consider would result in a fairer and more stable price for farmers in the *informal market*.

a. Establish staggered plantings to avoid overabundance of producto__
b. Establish plantings of products according to geographical areas ___
c. Organize into consortia, cooperatives or farmers' associations ____
d. Establish contracts with wholesale market sellers _____
e. Other, specify
____
____

5. CONSUMPTION

5.1. Rate the following limitations related to the consumption of fruit and vegetable products, based on your experience or knowledge.

Limiting	Qualification
a. Demand for nutritious product	
b. Product with added value	
c. Place of purchase of fruits	
d. Place of purchase of vegetables	
e. Prices	
f. Time required for food preparation	
g. Other, specify	

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6. STRUCTURES AND TECHNOLOGY

6.1. Rate the following technology-related limitations in the fruit and vegetable chain:

Limiting	Qualification
a. Accessible technologies for production under protected structures (mesh houses, macrotunnel, greenhouses (etc.)	
b. Accessible technologies for post-harvest	
c. Accessible technologies for proper storage	
d. Accessible technologies for processing and added value	
e. Production supplies	
f. Technology suitable for transport and cold chain	
g. Other, specify	

7. RESEARCH, EDUCATION AND TRAINING

7.1. Rate the following limitations related to education, research and training:

Limiting	Qualification
a. Operational capacity of farmers	
b. Availability of training programs	
c. Availability of training programs	
d. Availability of agricultural extension programs	
e. Availability of technical advice	
f. Other, specify	

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7.2. Mark with an X the *research needs* in the fruit and vegetable sector:

a. Genetic improvement (resistant varieties) ______
b. Invitro production- Biotechnology ______
c. Integrated crop management ______
d. Water management in hortícola______ production
e. Adaptation and management of crops under protected structures ______
f. Integrated pest and enfermedades______
g. Optimization of production systems ______
h. Soil management and nutrition ______
i. Post-harvest management ______
j. Sociology and rural development ______
k. Agricultural economy ______
l. Business Development/Market Access ______
m. Other (specify): ____

7.3. In his opinion and experience, the research priorities in Integrated Pest Management (IPM) and Diseases in fruit and vegetable crops should be in:

Specify:

7.4. In your opinion and experience, research on Integrated Crop Production and Management (MIC) issues should include:

Specify:

7.5. In your opinion and experience, in the area of post-harvest research, the priority topics should be:

Specify:

8. HORTICULTURAL POLICY AND PRODUCTION

8.1. Rate the following limitations related to political factors and fruit and vegetable production, based on your experience or knowledge.

Limiting	Qualification
a. Lack of government programs to support smallholder agriculture	
b. Access to credit for smallholder farmers	
c. Availability of agricultural insurance	
d. Cost of agricultural insurance	
e. Associativity of farmers	
f. Confidence in the fruit and vegetable value chain	
g. Access to market information	
h. Availability of land suitable for agriculture	

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a. Security of land tenure (invasions, expropriations)	
b. Other, specify	

8.2. Mark with an X the options you consider necessary. To improve business relations between farmers and fruit and vegetable marketers, you believe that the *Government* could:

a. Implement policies to support the agricultural sector. ______
b. Establish stricter price control laws. ______
c. Establish more collection centers. ______
d. Establish a business center that allows farmers and marketers to meet. ______
e. Provide agribusiness training to farmers and marketers. ______
f. Create places for the marketing of horticultural products such as fairs ______
g. Other (specify) ____

8.3. Mark with an X the options you consider appropriate. You believe that *non-governmental organizations* (NGOs) could support as follows:

a. Agribusiness training services to various segments of the value chain ______
b. Provide market intelligence services to farmers ______
c. Offer marketing services to farmers ______
d. Promote spaces between farmers and marketers through fairs, business roundtables, etc. ______
e. Create interinstitucionales______ spaces
f. Other (specify) ____

Appendix 7 – Problems and opportunities prioritized by focus group in Honduras

Table 1. Summary and elements prioritized by components of the fruit and vegetable chain in the focus group in Comayagua, Comayagua, Honduras.

ELEMENTS PRIORITIZED BY COMPONENTS OF THE FRUIT AND VEGETABLE CHAIN COMAYAGUA, COMAYAGUA			
Components of the Fruit and Vegetable Chain			
Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Input Suppliers	**1.** Bureaucratic procedures for registration and import of inputs. **2.** High raw material costs. **3.** Lack of technical assistance.	**1.** Create online program for records. **2.** Search for local alternatives. **3.** Lines of research at the regional level . **4.** Rregulation of subsidies. **5.** Creation of a technical assistance programme and research programme.	**a.** Greater involvement of actors. **b.** Decentralization of procedures. **c.** Facilitate registration processes. **d.** Strengthen support programs for SMEs and rational agriculture. **e.** Create program in BPA´s.
Production	**1.** Poor agricultural practices and mismanagement of resources. **2.** Inappropriate use of agricultural inputs. **3.** Lack of access to agricultural credit. **4.** Lack of technology for production.	**1.** Access to irrigation systems and creation of reservoirs or wells in a sustainable manner. **2.** Characterization of soils and water sources in the region. **3.** Promote crop rotation, soil analysis, use of green manures, use of fungi and bacteria. **4.** Training processes for the proper use of agricultural inputs. **5.** Reactivation of value chains considering Success Stories. **6.** Implementation and transfer of technology.	**a.** Organization and implementation of Field Schools (ECA's) for producers and their families. In addition to the generation of information at the regional level. **b.** Encourage the creation of certification programs for Agrochemical applicators. **c.** Review of credit policies at the central level with the different actors. **d.** Create new production opportunities involving the entire chain.

Components of the Fruit and Vegetable Chain			
Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Post-harvest and processing	**1.** Waste of products and high rejection of vegetables.	**1.** Provide added value to discard and rejection products. **2.** Entrepreneurship at the level of young people and women of the locality.	**a.** Stimulate entrepreneurship at the local level. In addition to resource management at the level of international cooperation for post-harvest projects.
Comerzialization and Distribution	**1.** Maintain the cold chain. **2.** Lack of organization in marketing. **3.** Lack of inputs and materials for export.	**1.** Implementation of Mobile Cold Rooms. **2.** Improve prices, better windows for marketing and better decisions at the union level. **3.** Local pallet manufacturing and exploration of new materials.	**a.** Search for funds for innovation technology in cold rooms. **b.** Encourage the creation of market intelligence offices. **c.** Establish strategic alloys and link technical training entities for manufacturing.
Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Research, training and education	**1.** Poor Agricultural and Manufacturing Practices .	**1.** Creation of a technical training program for specialists in post-harvest management.	**a.** Strengthening of educational institutions at the local level.
Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Nutrition	**1.** Lack of laboratories for the analysis of pesticide residues in vegetables.	**1.** Safety and certification processes.	**a.** Involve specialized actors to implement laboratories at the regional level.
Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Political, socio-economic and climate change context	**1.** Lack of skilled and skilled labor.	**1.** Job creation through production, post-harvest and processing.	**a.** Encourage the creation of training programs for the provision of skills.

Table 2. Summary and elements prioritized by compnents of the fruit and vegetable chain in the focus group in La Esperanza, Intibucá, Honduras.

ELEMENTS PRIORITIZED BY COMPONENTS OF THE FRUIT AND VEGETABLE CHAIN LA ESPERANZA, INTIBUCÁ			
Components of the Fruit and Vegetable Chain			
Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Input Suppliers	1.Input costs. 2. Environmental pollution from the use of pesticides. 3. Poor management of chemical waste, packaging.	1. Expand and diversify the product offering. 2. Training in biological controllers, organic products and biopesticides. 3. Promote at the level of all producers the use of biological controllers. 4. Formalize a program for the management of chemical and pesticide products and wastes.	a. Keep all members of the chain informed and trained. b. Develop demonstration plots and model farms on management, pest control, Good Agricultural Practices, biological controllers and organic plots. c. Look for alternatives for incentive program.
Production	1. Lack of advice and technical assistance. 2. Lack of technology transfer. 3. High costs of production and import of seeds.	1. Create a program of assistance and technical advice for the fruit and vegetable chain. 2. Training and knowledge in new technologies. 3. Diversify crops and rescue of native and native seeds.	a. Involve all actors. b. Create a platform for technology access. c. Improve and establish agreements with marketers.
Post-Harvest and Process-ing	1. Lack of infrastructure for an adequate post-harvest. 2. Lack of specialized and available labor.	1. Innovate in new technologies. 2. Training in post-harvest and value-added issues.	a. Search for sources of investment for technological options. b. Formalize strategic alliances with government, civil and NGO agencies.

Components of the Fruit and Vegetable Chain			
Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Commercialization and distribution	**1.** Lack of understanding of market needs. **2.** Weak organizational structures.	**1.** Standardize quality parameters. **2.** Market training. **3.** Organization of the production chain.	**a.** Update on parameters and product presentation in optimal conditions. **b.** Diversify crops, improve and establish contracts with buyers.
Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Research, training and education	**1.** Lack of nutrition research. **2.** Lack of financial and market education.	**1.** Research according to the needs of the basic food basket with a nutritional approach. **2.** Investment plans. **3.** Evaluation of production costs. **4.** Mandatory training programs to access markets.	**a.** Dissemination of technical guidelines for food education. **b.** Create sustainable business and investment models.
Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Nutrition	**1.** Little consumption of what is produced. **2.** Pesticide residues in vegetables and fruits.	**1.** Awareness campaigns to motivate consumption through nutrition education. **2.** Perform analysis of horticultural products to determine residuality.	**a.** Implementation of family gardens for the diversification of the family diet. **b.** Improve the quality and safety of horticultural products.
Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Political, socio-economic and climate change context	**1.** Lack of opportunities for women. **2.** Deficiency in agricultural government policies.	**1.** Involvement of women in activities of the chain mainly in added value. **2.** Impact by the government on aspects of imports.	**a.** Search for support and gender equity programs. **b.** Promote efficient agricultural programs and policies.

Table 3. Summary and elements prioritized by components of the fruit and vegetable chain in the focus group in Tegucigalpa, Francisco Morazán, Honduras.

ELEMENTS PRIORITIZED BY COMPONENTS OF THE FRUIT AND VEGETABLE CHAIN TEGUCIGALPA, FRANCISCO MORAZÁN			
Components of the Fruit and Vegetable Chain			
Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Input Suppliers	**1.** Price fluctuations of agricultural inputs. **2.** Institutional weakening in technology transfer and advice.	**1.** Development of alternative products. **2.** Application of subsidies. **3.** Production management plan. **4.** Investment plans by farmers. **5.** Technical advice under controls and protocols. **6.** Chain-wide technology transfer.	**a.** Search for strategic alloys for policies and regulations in accordance with consumer law. **b.** Associated producers by category. **c.** Government involvement in the creation of a program for specialized technical assistance.
Production	**1.** Resistance and new pests. **2.** Soil erosion and weakening. **3.** Low generational inclusion.	**1.** Implementation and use of environmentally friendly technology. **2.** Creation of organic communities hand in hand with food education. **3.** Implementation of practices for proper soil management. **4.** Perform soil analysis according to production items. **5.** Involvement of young people in agricultural activities from the business point of view. **6.** Job creation at the rural sector level.	**a.** Implementation of new technologies to make productivity more efficient. **b.** Search for business alternatives and youth enterprises.

Components of the Fruit and Vegetable Chain			
Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Post-Harvest and Processing	**1.** Low availability of equipment and machinery for post-harvest and processing. **2.** High equipment and machinery costs. **3.** Lack of proper packaging.	**1.** New technologies adapted to climate change.	**a.** Identify market niches for the commercialization of the product with added value and management of funds for an adequate post-harvest.
Commercialization and distribution	**1.** Poor road infrastructure. **2.** Improper transport- Cold chain. **3.** Poor infrastructure of formal and informal markets.	**1.** Knowledge of packaging and handling during transport. **2.** New markets; Schools, Hospitals and Supply Centers.	**a.** Link the government to improve access roads and manage funds for technology suitable for the old chain.
Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Research, training and education	**1.** Lack of nutrition research. **2.** Lack of financial and market education.	**1.** Research according to the needs of the basic food basket with a nutritional approach. **2.** Investment plans. **3.** Evaluation of production costs. **4.** Mandatory training programs to access markets.	**a.**Dissemination of technical guidelines for food education. **b.** Create sustainable business and investment models.
Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Nutrition	**1.** Lack of mitigation strategies.	**1.** Obtaining timely and reliable data for each pillar of Nutritional Food Security with emphasis on components related to the consumption and biological use of food. **2.** Publicize horticultural products through awareness campaigns and large-scale food and nutrition education.	**a.** Involve key actors for research in a disaggregated manner and based on reliable results perform a correct and adequate intervention and follow-up.

Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Political, socio-economic and climate change context	**1.** Import monopoly.	**1.** New policies and regulations to favour producers, such as trade corridors.	**a.** Search for strategic alloys for new policies and regulation of imports.

Table 4. Summary and prioritized elements by components of the fruit and vegetable chain in the focus group in Danlí, El Paraíso, Honduras.

ELEMENTS PRIORITIZED BY COMPONENTS OF THE HORTICULTURAL CHAIN DANLÍ, EL PARAÍSO			
Components of the Fruit and Vegetable Chain			
Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Input Suppliers	1. Misinformation on the part of the supplier towards customers. 2. Lack of quality regulations towards inputs.	1. Education and training on the appropriate use of agricultural inputs specifically pesticides. 2. Conduct of the Agricultural Census.	a. Search for strategic funding allies. b. Incorporation by the government for law enforcement and regulation.
Production	1. Pests and diseases. 2. Lack of funding.	1. Specialized technical advice. 2. Organize and coordinate plantings. 3. Upgrade production systems. 4. Agricultural loans at low interest rates. 5. Certifications of agricultural production.	a. Need for certification in local and international production.
Post-harvest and process-ing	1. Lack of added value.	1. Increased employment at the local level.	a. Involve key stakeholders for the search and management of funds for the implementation of processing plants by vegetable category.
Commercial-ization and distribution	1. Lack of new market windows. 2. Lack of price stability in the market.	1. Contribute to food security. 2. Certifications in production farms. 3. Reduce intermediaries.	a. Conduct emerging market research and market research. b. Involvement of the government and local private entities for certification processes.

Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Research, training and education	**1.** Little research on pests and diseases. **2.** Little training in new agricultural production technologies.	**1.** Training in pest and disease management by crop category. **2.** Technology transfer and capacity building.	**a.** Involvement of the academy training and research entities.

Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Nutrition	**1.** Lack of product safety .	**1**. Provide security and safety in the market.	**a.** Government involvement in the implementation of local safety policies.

Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Political, socio-economic and climate change context	**1.** Mismanagement of agricultural waste. **2**. Lack of manpower.	**1.** Formalize a program for the collection of waste. **2.** Inclusion and gender equity in chain activities.	**a.** Involvement of government entities for the process. **b.** Seek the generation of jobs in the productive sector to avoid migration.

Table 5. Summary and prioritized elements by components of the fruit and vegetable chain in the focus group in Santa Cruz de Yojoa, Cortés, Honduras.

ELEMENTS PRIORITIZED BY COMPONENTS OF THE HORTICULTURAL CHAIN SANTA CRUZ DE YOJOA, CORTES			
Components of the Fruit and Vegetable Chain			
Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Input Suppliers	**1.** Input cost elevator.	**1.** Search for alternatives for production such as botanicals and biological controllers.	**a.** Implementation of organic farming.
Production	**1.** Lack of adapted and accessible genetic material. **2.** Environmental conditions.	**1.** Alternative Agriculture and application of mitigation practices.	**a.** Implementation of new technologies, such as precision equipment.
Post-harvest and process-ing	**1.** Lack of post-harvest knowledge. **2.** Migration.	**1.** Seeking funding for technical assistance processes. **2.** Increase the processing of raw materials.	**a.** Make product deliveries while maintaining quality. **b.** Job creation for young people and women.
Commercial-ization and distribution	**1.** High fuel and energy costs. **2.** No cold chain. **3.** Lack of knowledge of the claim.	**1.** Search for alternatives for storage - cold rooms. **2.** Do market research.	**a.** Establish contracts to ensure fair prices for farmers under quality standards.

Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Research, training and education	**1.** Lack of post-harvest knowledge. **2.** Lack of marketing.	**1.** Management training and good manufacturing practices. **2.** Conducting market research.	**a.** Reach new markets with quality standards and export options.
Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Nutricion	**1.** Deamnd overclaim.	**1.** Avoid intermediation.	**a.** Produce with the highest standards of quality, safety and nutrition.
Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Political, so-cio-economic and climate change con-text	**1.** Deforestation. **2.** Water resource shortages. **3.** Excess rainfall. **4.** Unfair selling prices.	**1.** Produce more environmentally friendly. **2.** New markets for marketing.	**a.** Generating Sustainable Agriculture. **b.** Government intervention for price regulation.

Table 6. Summary and prioritized elements by components of the fruit and vegetable chain in the focus group in Choluteca, Choluteca, Honduras.

ELEMENTS PRIORITIZED BY COMPONENTS OF THE HORTICULTURAL CHAIN CHOLUTECA, CHOLUTECA			
Components of the Fruit and Vegetable Chain			
Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Input Suppliers	**1.** Low product availability. **2.** Untrained vendors.	**1.** Development of new products at the local level. **2.** Training for agricultural personnel .	**a.** Creation of youth and women's enterprises in local inputs and promote local product . **b.** Strengthen the technical staff of agro-services.
Production	**1.** Food safety. **2.** Poor Planting Planning. **3.** Land tenure. **4.** Inadequate pest management and control. **5.** Citizen Insecurity.	**1.** Technical assistance for producers. **2.** Make use of pesticide application registration. **3.** Update statistical data (Agricultural Census). **4.** Support for land legalization. **5**. Training and technology for good control and management.	**a.**Involvement of government entities to perform traceability to production batches. **b.** Bring together actors (government, academia, private enterprise willing to act to improve production conditions).
Post-harvest and processing	**1.** Residuality of chemicals. **2.** High cooling and energy costs. **3.** Lack of added value.	**1.** Traceability and records of production batches. **2**. Create spaces for consultation. **3.** Knowledge transfer.	**a.** Involvement of the government and its main actors. **b.** Strengthening of technical capacities. Management for equipment acquisition.

Components of the Fruit and Vegetable Chain			
Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Commercial-ization and distribution	1. High costs of customs procedures. 2. Limited internet access and communication. 3. Shortage of transport services. 4. Lack of agreements and fulfillment of contracts.	1. Spaces for consultation between the government, transport leaders and producers. 2. Immediate market access.	a. Supporting international cooperation through multi-stakeholder platforms.
Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Research, training and education	1. Pest and disease management problems. Poor handling of stubble.	1. Training through demonstration plots. 2. IPM Training. 3. Research to solve new problems and low use of inputs.	a. Search for strategic alloys for learning new methods, techniques and technologies. Knowledge transfer.
Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Nutrition	1. Little area for existing demand.	1. Produce according to demand.	a. It is considered that you can enter a food crisis.
Dimensions	Prioritized problems	Prioritized opportunities	Group Agreements
Political, so-cio-economic and climate change con-text	1. Ungovernability. 2. Failure to comply with laws on stubble destruction and agricultural bans. 3. Bureaucratic processes for registrations and exports.	1. State policies for road improvement. 2. Find resources to enforce bans. 3. Create exclusivity windows for exports.	a. Involvement of the state and competent actors.

Project Report

Feed the Future Innovation Lab for Horticulture in South Asia

Submitted to

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FORWARD Nepal

Bharatpur, Chitwan, Nepal

Abbreviations/Acronyms

Abbreviations/Acronyms	Definition
a.i.	Active ingredient
ADI	Acceptable Daily Intake
AFU	Agriculture and Forestry University
AGDP	Agricultural Gross Domestic Product
AIS	Agriculture Innovation System
AKC	Agriculture Knowledge Center
app	application
BARI	Bangladesh Agriculture Research Institute
BAU	Bangladesh Agricultural University
BMPs	Best Management Practices
CBSP	Community Based Seed Production
CEAPRED	Center for Environmental and Agricultural Policy Research, Extension and Development
CO2	Carbon Dioxide
DEI	Diversity, Equity and Inclusion
DNA	Deoxyribo Nucl eic acid
DoA	Department of Agriculture
DOREX	Directorate of Research and Extension
etc	et cetera
F1	First Filial
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
FAVF	Faculty of Animal Science, Veterinary Science, and Fisheries
FGD	Focus Group Discussion
FoA	Faculty of Agriculture
FoF	Faculty of Forestry

FORWARD Nepal	Forum for Rural Welfare and Agricultural Reform for Development
FtF	Feed the Future
FYM	Farm Yard Manure
GAFC	Gandaki Agriculture Farmers Cooperatives
GAP	Good Agricultural Practices
GDP	Gross Domestic Product
GESI	Gender Equality Social Inclusion
GHG	Greenh ouse Gases
GHI	Global Hunger Index
GI	Galvanized Iron
gm	gram
GM	Genetically Modified
GU	Gandaki University
ha	Hectare
HH	Household
IAAS	Institute of Agriculture and Animal Science
ICAR	Indian Council of Agricultural Research
ICT	Information and Communications Technology
IFVs	Indigenous Fruits and Vegetables
INGOs	International Non-Governmental Organization
IPM	Integrated Pest management
IPNM	Integrated Plant Nutrient Management
KII	Key Informant Interview
KIS	Key Informant Survey
KISAN	Knowledge-Based Integrated Sustainable Agriculture in Nepal
KOICA	Korea International Cooperation Agency
KU	Kathmandu University
LI-BIRD	Local Initiatives for Biodiversity, Research and Development
Ltd.	Limited

masl	Meters above sea level
MIDH	Mission for Integrated Development of Horticulture
MOAD	Ministry of Agriculture Development
MoALD	Ministry of Agriculture and Livestock Development
MRL	M aximum R esidue L vel
MT	Metric tons
NARC	Nepal Agricultural Research Council
NGO	Non-Governmental Organization
NPVSDC	National Center for Potato, Vegetable and Spice Crops
NSC	National Seed Company Limited
NTFPs	Non-Timber Forest Products
OA	Organic Agriculture
OP	Open Pollinated
PCR	polymerase chain reaction
PEN	Pest-Exclusion Net
Ph.D	Doctor of Philosophy
PMAMP	Prime Minister Agriculture Modernization Project
Pvt	Private
RAPD	Randomly amplified polymorphi DNA
SAARC	South Asian Association for Regional Cooperation
SAC	SAARC Agriculture Centre
SAIC	SAARC Agriculture Information Centre
SEAN	Seed Entrepreneur's Association of Nepal
SPS	Sanitary and PhytoSanitary
SQCC	Seed Quality Control Centre
SSRs	Simple Sequence Markers
TU	Tribhuvan University
UN	United Nations
UNDP	United Nation Development Programme
UNICEF	United Nations Children's Education Fund

US	United States
USAID	United States Agency for International Development
USD	United States Dollar
USDA	The United States Department of Agriculture
VC	Vice-Chancellor
VCDP	Value Chain Development Program
ZOI	Zone of Influence

Executive Summary

South Asia comprises eight countries with a population equivalent to 24.89% of the total world population; a disproportionate 44% of the global poor reside in the region. Agriculture is still the backbone of the South Asian economies and horticulture sub sector esp. fruit and vegetable sector is key in South Asia considering the economical, nutritional, and cultural significance. Further, countries in South Asia are grappling with rising commodity prices, supply bottlenecks, and vulnerabilities in financial sectors. On the other hand, the diverse agro-climatic conditions and rich diversity in horticultural crops and genetic resources enable this region to produce a wide range of horticultural crops round the year. A/c to FAOSTAT (2022), the area under fruit and vegetable in south Asia is 10,452,079 and11,277,610 ha respectively with productivity of 13.98 and 15.41 mt/ ha. Huge efforts is needed to minimize the gap between the demand and supply of quality fruit and vegetable in South Asia especially in Nepal and Bangladesh to enhance the per capita fruit and vegetable consumption in these countries. Various issues including the policy intervention, generation and adoption of production and post-harvest technology are vital for the sustainable growth of fruit and vegetable sector. To identify the priorities in the South Asia regional level, a three-day (12-14 September, 2022) regional horticulture workshop was organized in Kathmandu, Nepal in which local and regional leaders in academia, private sector, and NGOs working in Nepal and Bangladesh were gathered and thematic papers were presented in 18 priority areas followed by group discussion. Prior to this workshop, short studies including survey, focus group discussion, key informant interviews, etc. were also carried out to get the primary data in this regard. Based on the regional workshop and the direct field studies, the possible research areas in the fruit and vegetable sectors have been identified that includes the development of quality seed/ seedling/ sapling in different crops, enhancement of productivity through the adoption of high yielding variety, agronomic practices, management of serious insect pest and diseases. The development of package of practices for the emerging protected cultivation of fruit and vegetables and promotion of major indigenous fruits and vegetables of this region are also equally important areas. In addition, the development of proper post-harvest handling practices for the commercially produced fruits and vegetables and processing technology are urgently needed in this region.

1. Background

Agriculture is one of the major sectors of Nepalese economy (NPC, 2020) contributing 27% of the GDP of the country, providing employment to 65% of the country's population (MoALD, 2021) of which vegetables and fruit of the horticulture sector solely contribute 18%. Nepal's constitution (Article 36, p.17) exclusively provisioned the right to food and food sovereignty. Agriculture Development Strategy (2015-35) prioritized horticultural crops for import substitution and trade surplus. Commercialization of high value and low volume crops farming in the country is getting momentum at present (ADS, 2015). Article 51 (p.26) of the constitution-country's policies which should have major provisions- such as land consolidation, increasing production and productivity, commercialization, industrialization, diversification and modernization of the agriculture sector. The constitution has delineated constitutional rights to have governments' policies for easy availability of agro-inputs, reasonable pricing of agro-produce and access to markets for the farmers. Three tiers of the governments should have policies to increase investment to the agriculture sector for sustainable production, supply, storage, security and smooth distribution of agricultural produce (Constitution of Nepal, 2015, p.23). Agriculture is the top political and economic agenda of the country. Nepal has highly prioritized horticulture sub-sector (mostly season/off season vegetables and fruits) in almost all of the government plan and policies including APP (1995-2015), ADS (2015-2035) and other periodic and annual plans. Demand of fresh vegetables is ever increasing with continued population growth, rapid urbanization, economic progress, increased spending power from income growth and migrant remittance. For example, per-capita vegetable consumption has increased to 114 kg per year from 60 kg over the last two decades (Ukaid, 2020). Federal government (NPC, 2020; NPC, 2018-2022), Province Government and Local Governments has been prioritizing the horticulture sector (mostly vegetable enterprising) as a strategy to retain youth and engage returnee migrants in the agriculture sector.

Fruits and vegetables represent an important opportunity to enhance food and nutrition security as well as increase income for smallholder farmers as horticultural crops generate high economic returns per unit of land and offer off-farm entrepreneurial opportunities - creating more holistic and inclusive food systems. The gap between the demand and supply of quality fruits and vegetables has widened over the years with its negative consequent effects on food security, nutrition and trade imbalance. In addition, the studies suggest that marginalized social groups including women and youth are the key actors in the production and marketing of fruits and vegetables. The high value of horticultural commodities along with consequent higher returns make investment in this sector a step toward socio-economic transformation of farming communities. Moreover, horticulture has a unique role in ensuring access to and availability of diverse, nutritious food. The South Asia region has enormous opportunities to grow tropical, subtropical and sub-temperate horticultural crops of commercial importance. South Asian countries are trying hard to improve the income, nutritional, financial and food security of millions of poor people through this sector (Thapa & Dhimal, 2017). Within agriculture, horticulture offers unique benefits in generating inclusive and sustainable agriculture-led economic growth. Horticulture production and marketing especially the free market is often the domain of women, the entire value chain employs a greater number of people compared to many other industries, fruit and vegetables are high-value commodities that support economic growth, and increased accessibility of horticultural crops has nutritional benefits for communities.

The Global Hunger Index 2022 demands an immediate attention of South Asia region to focus our programs towards the development of the fruits and vegetables sector in South Asia. The access to fruit and vegetables is generally limited by country wealth, production and trade, while individual access is limited by social norms and individual demographics. Multiple models of global scenarios of fruit and vegetable production and dietary requirements of fruits and vegetables reveal significant gaps. It is critical to develop and strengthen horticulture value chains that provide equitable access to safe and affordable fruits and vegetables. Horticulture can also make a direct contribution to the sustainability of agriculture by adding biodiversity and enabling the production of nutritious, high-value foods on even small plots of existing agricultural land.

With a majority of growers in Nepal, being smallholders producing primarily rice, wheat, and corn, integration of high-value horticulture crops would generate additional income, employment opportunities, and increased access to nutritious vegetables and fruit in their communities. Research and development projects primarily focus in the agronomical sector with significant results in certain aspects in South Asia particularly in Bangladesh and Nepal. The Horticulture Innovation Lab is planning to assist to tailor similar activities in South Asia with particular focus in Nepal. USAID/Nepal has also elevated high-value vegetables as a top priority for investment owing to the increased accessibility of nutritious foods, leading to better health outcomes for individuals, especially for women and children, and consequent increased resilience through individual well-being. Nepal is facing a severe challenge of reintegrating young Nepali men who have been forced to return to Nepal due to COVID-19. Coupled with this is a loss of national income from remittances.

Gender Equality and Inclusive Participation: Women play significant roles in horticulture value chains. However, women frequently do not have equity in the household to determine how income from crops should be spent or how household or farm labor could be more equally divided. Gender equality, equity, and participation will be addressed in our projects through the design of gender-friendly innovations, in particular reducing drudgery in the horticulture sector. The use of pest-exclusion net (PEN), improved irrigation technologies and no-till/minimum till agriculture are few examples directed to shift power-dynamics within households and the greater community. The leverage of regional and in-country networks connect women to horticulture value chains and markets.

Youth Opportunities: In-country experts in youth from Bangladesh and Nepal have participated in the Regional Horticulture Workshop along with the Consortium –related mechanisms to increase youth engagement. Further, the focus should be shifted towards horticultural entrepreneurship through access to finance and private sector for job creation. Due to the high-value of the commodities, opportunities for technology application, potential for entrepreneurial opportunities throughout the value chain and short crop cycles as well as capacity to grow in small spaces in case of vegetables; horticulture can be a major driver for youth opportunities within the agricultural sector.

Nutrition and Food Safety: Considering the nutritional importance of vegetables and fruits, increasing access to horticulture crops is critical to reduce the hidden hunger prevalent in South Asia region. Research on production practices to increase yields as well as reduce the postharvest loss helps to increase the availability of nutritious fruits and vegetables. Enhanced engagement of women in decision-making is directly related to improvements in nutrition through household consumption of horticultural crops. In this context, food safety is a vital issue for horticulture crops as they can also be consumed raw. Incorporation of research related to processing and preservation of fruits and vegetables along with training for stakeholders in food safety practices can be the other area the Horticulture Innovation Lab need to address in South Asia.

2. Project Management

2.1 USAID

USAID (www.usaid.gov) leads to international development and humanitarian efforts to save lives, reduce poverty, strengthen democratic governance and help progress of people beyond assistance. In Nepal, there are several completed and ongoing agricultural projects funded by USAID. Whether by preventing the next global epidemic, responding to a devastating earthquake, or helping a farmer access tools to grow her business, programs of USAID transform families, communities, and countries, so they can thrive and prosper.

Led by USAID, Feed the Future (FtF) initiative brings partners together to address the root causes of hunger and poverty by boosting agriculture-led growth, resilience and nutrition in countries with great need and opportunity for improvement. FtF and its partners work throughout the food system to help countries overcome agriculture and nutrition challenges with entrepreneurship, partnership and innovation.

Feed the Future helps partner countries accomplish the following:

- Improve agricultural production and markets and create new opportunities.
- Strengthen the resilience of communities to shocks.
- Reduce hunger and improve nutrition, especially among mothers and children.
- Increase the exchange of ideas, technologies and products that benefit citizens at home and communities abroad.

2.2 Horticulture Innovation Lab

Horticulture Innovation Lab (www.horticulture.ucdavis.edu) is funded by the US Agency for International Development and led by a team at the University of California, Davis, as part of the US government's Feed the Future initiative. The Horticulture Innovation Lab's global research network advances fruit and vegetable innovations, empowering smallholder farmers to earn more income while better nourishing their communities. Improving livelihoods through higher profits and diversified, nutrient-rich diets is a primary goal for the Horticulture Innovation Lab's research efforts around the world. The program's work is guided by ensuring gender equality, improving information access, targeting innovative technologies and increasing research capacity. Individual projects are led by US university researchers with collaborating partners in developing countries. Through partnerships and collaborative research, the program also aims to build the capacity of researchers, institutions and farmers to advance horticultural science.

2.3 The University of California, Davis (UC Davis)

UC Davis (www.ucdavis.edu) is a public land-grant research university founded in 1908 to serve the state of California. Founded as a primarily agricultural campus, the university has expanded over the past century to include graduate and professional programs in medicine, law, veterinary medicine, education, nursing, and business management, in addition to 90 research programs offered by UC Davis Graduate Studies. UC Davis also offers certificates and courses, including online classes, for adults and non-traditional learners through its Division of Continuing and Professional Education. UC Davis Office of Research aims to maintain excellence in research, innovation and discovery.

2.4 FORWARD Nepal

FORWARD Nepal (www.forwardnepal.org) is a non-profit, service-oriented non-governmental organization established in 1997 to help disadvantaged groups and the rural poor. It is registered at the District Administration Office, Chitwan, and affiliated to the Social Welfare Council, Nepal. The organization aims at reducing poverty of rural communities through integrated and sustainable development interventions. FORWARD's program activities are focused on improving food security, household incomes and resource conservation that contribute to sustainable rural livelihoods. It adopts a multi-stakeholder approach in partnership with government, non-government organizations and private sectors at national, regional and local levels to design and implement projects focused on social mobilization, agriculture, livestock, aquaculture, farm forestry, biodiversity conservation, value chain and market development. The organization has its head office in Chitwan district of Nepal while project offices are located in various working districts. Over 25 years, FORWARD has successfully implemented 111 projects in 61 districts involving a total of 0.6 million households representing the poor, women, Dalits, Janajati, and children. FORWARD embraces multi-pronged strategy integrating key interventions both in horizontal and vertical dimensions that enhance sustainable livelihoods and ensure positive socio-economic impacts on the communities. FORWARD Nepal implements programmes in the following thematic areas:

I. Food and Nutrition Security (Field crops and horticulture, local seed supply system, high value commodities, farm forestry and Non-Timber Forest Products (NTFPs), productive infrastructure)

II. Business Promotion and Market Development (Enterprise development, value chain development, market promotion and networking)

III. Adaptive Research and Development (Participatory innovation, technology development and verification, development studies and technology dissemination)

IV. Natural Resource Management (Biodiversity conservation, promotion and optimum utilization, promotion of renewable energy, nutrient use efficiency and recycling, best management practices - BMPs)
V. Climate Change and Disaster Risk Management (Awareness raising and capacity building, climate smart agriculture, disaster preparedness, emergency response, rehabilitation and recovery)
VI. Cross cutting themes (Gender and social inclusion including disability, participatory planning, monitoring and evaluation, rights-based approaches to development.

2.5 Agriculture and Forestry University (AFU)

The Agriculture and Forestry University (www.afu.edu.np) established in Rampur, Chitwan, in 2010, is the first technical university in Nepal. This university aims at producing highly skilled human resources required to work on quality research and development in agriculture. AFU includes complete integration of education, research and extension services. There are three faculties namely Faculty of Agriculture (FoA), Faculty of Forestry (FoF), and Faculty of Animal Science, Veterinary Science, and Fisheries (FAVF). Building capable manpower is the primary mission of the University. Undergraduate, Postgraduate and Ph.D. programs in several departments of Agriculture and Forestry are major programs for capacity building in the agriculture sector. Research and extension, besides teaching are also mandatory functions at AFU as envisaged in its Act. Research works on different aspects of agriculture such as increasing production and productivity of agricultural commodities, post-harvest technology, biodiversity conservation, and local innovation adopting participatory approaches to enhance sustainable livelihood systems of farming communities are conducted on central, constituent and affiliated colleges of AFU. Furthermore, the extension programs are operated and considered a valuable component of the University system to solve current problems in agriculture, including livestock and forestry, by linking its activities to the government's extension line agencies and research bodies.

2.6 Ministry of Agriculture and Livestock Development (MoALD)

MoALD (www.moald.gov.np) is a public institution and largest organization of Nepal that bears the overall responsibility of growth and development of the agriculture and livestock sector. Department of Agriculture (DoA) is working within MoALD to diversify agriculture and transform it into commercialization, ensure food security and contribute to poverty alleviation.
The objectives of DoA are:

- ❖ To increase in production and productivity to meet the growing internal and external demand for agricultural products.
- ❖ To increase the production and productivity of raw materials needed by agriculture-based industries.
- ❖ To contribute to reducing poverty by conducting productive and employment programs for small, marginal and women farmers.
- ❖ To maintain a balance between agricultural development and environmental protection, and conducting sustainable agricultural development programs.

Some institutions/projects working within MOALD were collaborated as:

Seed Quality Control Centre (SQCC)

SQCC (www.sqcc.gov.np) is a public institution working under MoALD to ensure the availability of quality seeds to the common farmers by implementing the seed quality control system throughout the country of Nepal.

Value Chain Development Program (VCDP)

VCDP(www.undp.org/nepal/projects/vcdp) is an ongoing project since 2018, that aims to increase incomes of smallholder farmers with a focus on farmers' enhanced access to agricultural technologies, minimized postharvest losses, and improved market linkages in fruits and vegetables.

Prime Minister Agriculture Modernization Project (PMAMP)

PMAMP (www.pmamp.gov.np) is an ongoing project that aims towards shifting the agriculture-subsistence based economies to agro-based industries, and development of modern, commercial, sustainable, and self-sufficient agricultural sectors. It envisions the establishment of commercial production areas as 15000 pockets, 1500 blocks, 300 zones and 21 superzones by the end of ten years.

The Rural Enterprise and Economic Development (REED)

REED (www.reed.moald.gov.np) project of MoALD aims to stimulate the development of rural enterprises by strengthening market linkages among smallholder producers and players in the agricultural commodity value chain; and by strengthening the enabling environment for the development of enterprises.

2.7 Nepal Agricultural Research Council (NARC)

NARC (www.narc.gov.np) was established in 1991 as an autonomous organization under "Nepal Agricultural Research Council Act - 1991" to conduct agricultural research in the country to uplift the economic level of the people. NARC is the principal organization for conducting agricultural research in Nepal and it targets to conduct qualitative studies and research on different aspects of agriculture, identify the existing problems in agriculture and find out the solution and assist the government in formulation of agricultural policies and strategies.

Functions and Responsibilities of NARC are:

- Conduct qualitative agricultural research required for national agricultural policies,
- Prioritize studies and researches to be conducted,
- Provide research and consultancy services to the clients,
- Coordinate, monitor and evaluate the agricultural research activities in Nepal,
- Document the research activities.

2.8 Bangladesh Agricultural University (BAU)

BAU (www.bau.edu.bd) is the premier seat of higher agricultural education and research in Bangladesh. Its scholastic activities having direct bearing on terrestrial and aquatic productivity. In addition to academic and training activities, BAU also conducts programs related to research, extension and extra-curricular activities. 262 Research projects and 40 extension projects are currently on-going. The vision of BAU is to serve as an integrated institution with functional relationships with relevant government organizations, non-government organizations, and private sector firms in Bangladesh and to contribute meaningfully to agricultural development of Bangladesh.

The working missions of the University are:

- To provide higher learning in all branches of agricultural sciences as a profession-based education;
- To conduct basic and applied research in various aspects of agricultural problems faced by farmers, change-agents and agro-industrialists with a view to recommending possible measures for solving them;
- To organize and supervise extension and related nation-building activities at different levels and in different forms;

- To provide training for personnel of different government and non-government organizations and also for farmers and farm-leaders on various aspects of agriculture and rural development; and
- To provide facilities for bilateral and multilateral cooperation and collaboration with institutes or organizations within and outside Bangladesh.

2.9 Bangladesh Agricultural Research Institute (BARI)

BARI (www.bari.gov.bd) is an autonomous organization under the Ministry of Agriculture, Bangladesh , in 1908, that conducts research on all crops in Bangladesh except rice, jute, sugarcane and tea. It is the largest multi-crop research institute for a wide variety of crops including cereals, tubers, pulses, oilseeds, vegetables, fruits, spices, flowers, etc. Besides variety development, this institute carries out research on areas as soil and crop management, disease and insect management, water management and irrigation, development of farm machinery, improvement of cropping and farming system management, post-harvest handling and processing, and socio-economic studies related to production, processing, marketing and consumption. The institute functions with four of its major wings, such as Research Wing, Support Service Wing, Training and Communication Wing and Planning and Evaluation wing.

2.10 Other collaborators

2.10.1 SAARC Agriculture Center

SAC (www.sac.gov.bd) renamed in 2007, is the first regional Centre established by the SAARC. The Centre started functioning in 1988 with a mandate for information management, primarily in the field of agriculture and allied discipline. With the passage of time, the Centre braced up broader challenges to make regional cooperation more responsive to the needs of the stakeholders and farming communities as South Asia heads for a new order of agricultural transformation. The SAARC Agriculture Centre thus has been given an enhanced mandate for agricultural research and development, policy planning, and knowledge management.

2.10.2 Institute of Agriculture and Animal Science (IAAS)/TU

IAAS (www.iaas.edu.np) is an autonomous academic center of Tribhuvan University (TU) for imparting education in three disciplines: Agriculture, Animal sciences and Veterinary Sciences. Promoting agricultural science and train manpower for agricultural development focusing on teaching, research and extension is the mission of the organization. IAAS has been making continuous efforts to solve the challenges in agricultural education in Nepal since its beginning. In the course of time, programs are being modified or up-graded to adapt the role in addressing the persistent needs and priorities of agricultural sector in Nepal.

2.10.3 Private sector/Social organizations

Seed Entrepreneurs' Association of Nepal (SEAN)

SEAN (www.nepalseedassociation.org.np) is a non-profit non-governmental organization, established by a group of seed producers, importers/exporters, distributors and experts in the field of seed sub-sector. It involves all relevant seed sub-sector actors including national and international companies to join hands in the sustainable supply of high quality seed of different crops at an affordable price to farmers for increasing yield.

Local Initiatives for Biodiversity, Research and Development (LI-BIRD)

LI-BIRD (www.libird.org) is a non-profit making, non-governmental organization established in 1995 to capitalize on local resources, innovations, and institutions for sustainable management of natural resources for improving livelihoods of smallholder farmers.

Collaboration with proprietor or participants from horticultural entrepreneurs from different private farms such as:

- R and D Innovative Solutions
- Smriti Pragyan Krishi Kendra, Lalitpur
- Himalaya Organic Garden
- Nepal Agrovine Private Limited
- Samriddhi agri-farm
- Prasiddhi Agro Enterprises

3. Project Approach

The study was accomplished in three phases as desk study, collection of information from the fields (study areas in Nepal and Bangladesh as shown in Figure 1 and 2), and conduction of a regional workshop in Kathmandu. The collected data was processed and analyzed, and the study findings were presented in the report. Descriptive statistics (frequency, percentage, average, etc.) and index ranking were mainly used to analyze the data and present the findings.

3.1. Desk Review

The desk study is mainly concerned with reviewing the existing studies and publications on the horticulture sector in South Asia, particularly in Nepal and Bangladesh. The findings of the desk study and recent studies on different topics of fruits and vegetables sub-sectors were presented by different experts in the regional workshop (Annex 8). Each presentation in the workshop was followed by the discussion, and this report includes the knowledge and learning, as well as suggestions from the workshop participants (experts).

3.2. Collection of the Primary Data

The study considered both qualitative and quantitative data collected through a consortium of different social research tools as household survey, focus group discussions (FGDs), key informant interviews (KIIs), and field observations. Six enumerators, the assistant professors of AFU's constituent colleges, were trained and deployed to conduct the surveys, focus group discussions, and interviews with key informants in the study districts of Nepal. Similarly, in Bangladesh, SAARC Agriculture Center, Professor from Bangladesh Agricultural University (BAU) and Senior Scientist from Bangladesh Agricultural Research Institute (BARI) were engaged for the research task including the field study (focus group discussion, key informant interview and household surveys). Project Manager, technical team lead and other experts were involved in field data collection, compilation and ensured the data quality and consistency.

Focus group discussions (FGDs) with representatives of heterogeneous groups of the farmer associations in a mixed gender group were conducted to get their understanding of challenges and opportunities of the selected sub-sector (fruit/vegetable). The FGD participants were identified based on suggestions from the farmer-based institutions (i.e., cooperatives, farmer groups, and lead farmers), local governments, and local level government organizations working for the research and development of the horticulture sector. A total of twenty-nine FGDs (17 in Nepal and 12 in Bangladesh) were conducted for obtaining both qualitative and observational data. The FGD participants also suggested the appropriate farm-households and the input/output traders for survey related to the specific sub-sector (fruit/vegetable).

A household survey schedule was used to collect the information from the farm households. The farm household survey was undertaken to obtain the socio-economic data of communities (farm households) especially demographic information, status of priority crop's area and productivity, and existing challenges and opportunities in the selected sub-sector (fruit/vegetable). The sampling units (farmers), 62 in Nepal and 25 in Bangladesh, for the household survey were identified during the focus group discussion (Table 1).

The Key Informant Interview (KII) was conducted to obtain the sub-sector/topic-specific information from different experts, including policy makers, researchers, academicians, technicians, and private sector (entrepreneurs/producers, traders). The KIIs were focused in obtaining the information on government policies, plans and programs in the fruit and vegetable sub-sectors, challenges and opportunities in the production, marketing and value addition of fruits and vegetables, as well as challenges and opportunities in the trade of agricultural inputs and farm produce.

Table 1: Data collection tools

Data collection tool		Number		Focus area
		Nepal	Bangladesh	
Household survey		62	25	Perceptions and participation of farm households in the production and marketing of fruits and vegetables
Focus Group Discussion (FGD)		17	12	Vegetables (fresh vegetables, riverbed farming, potato), Fruits (banana, citrus, avocado, kiwi, apple, mango)
Key Informant Survey (KIS)	Experts/ Scientists and farmers	10	10	Government policies, plans, and programs; Technical aspects in the production and marketing of fruits and vegetables
	Output traders	19		Challenges and opportunities in the marketing and value addition of fruits and vegetables
	Input suppliers	7		Challenges and opportunities in trade of necessary inputs

Table 2: Commodity-wise household survey and focus group discussion (FGD) in Nepal

District	Number of Farm HHs (survey)	FGD	
		Number	Crop focus
Chitwan	10	3	Banana, vegetables, input suppliers
Dhankuta	10	2	Citrus, avocado
Dolakha	5	1	Kiwi
Jumla	-	1	Apple
Kailali	10	1	Vegetables
Kaski	-	2	Vegetables
Kathmandu	-	2	Nepal Horticulture Society, Plant Protection Society
Kavreplanchok	-	1	Potato
Mahottari	5	-	
Saptari	5	2	Riverbed farming, mango
Surkhet	17	2	Vegetables, input suppliers
Total	62	17	

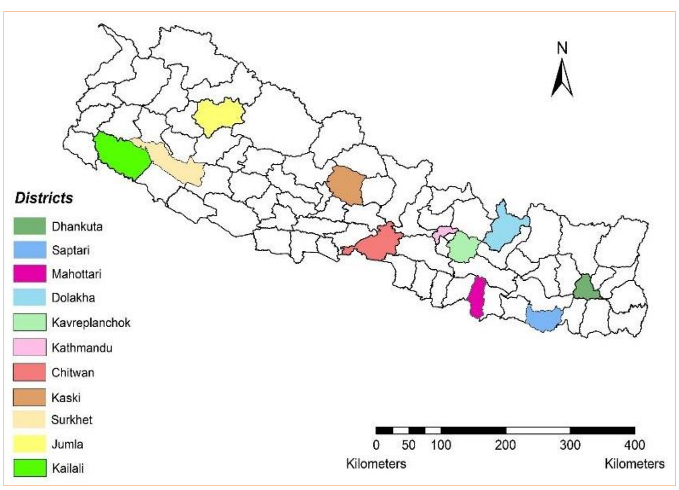


Figure 1. Study districts in Nepal

(Chitwan, Dhankuta, Dolakha, Jumla, Kailali, Kaski, Kathmandu, Kavreplanchok, Mahottari, Saptari, Surkhet)

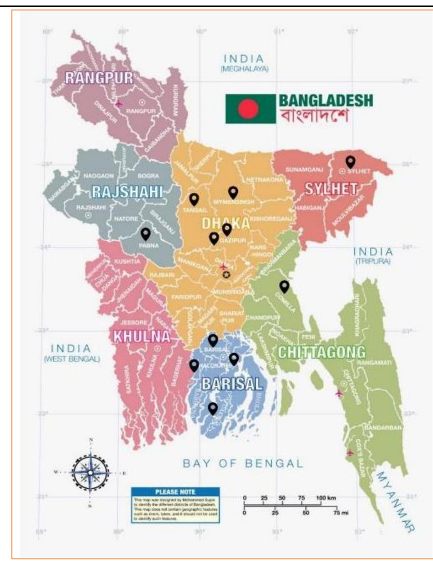


Figure 2. Study districts in Bangladesh (Narsingdi, Comilla, Ulokhola Gazipur, Pabna, Sylhet, Tangail, Barisal, Pirojpur, Patuakhali, Jhalokati, Mymensingh)

3.3. Regional Workshop

Horticulture Innovation Lab conducted one regional workshop from 12-14 September 2022 in Kathmandu, Nepal and some short studies (including survey, focus group discussion, key informant interviews, etc.) to identify and prioritize real challenges and potential opportunities of horticulture sector in the South Asia region. The workshop aimed at including local and regional leaders in academia, private sector, and NGOs in Nepal and Bangladesh. This will help develop a comprehensive report consisting of an assessment of the horticulture sector in the region, which could be addressed through research or capacity building activities in the near future. This approach encourages local engagement and ownership, influencing the overarching sustainability of this work to continue beyond the Horticulture Innovation Lab's involvement to contribute to both more inclusive economic growth and a more resilient system led by regional experts.

The workshop had identified the following 12 themes for successful identification and progressment of the project initiatives for an inclusive horticulture sector development in South Asia:

- Quality Input System
- Quality seed, Sapling and Varieties
- Technology Transfer Mechanism
- Production system
    - Conventional
    - Urban and Peri-urban –Protected horticulture
- Marketing opportunities and challenges
    - Domestic consumer focused
    - Export potential commodities
- Post-harvest
    - Existing issues
    - Cold chain Maintenance
- Food quality, Nutritional value, Product diversification including Processing
- Policy reform
- R and D in new technology in Horticulture sector
- Mechanization in Agriculture
- Socio-economic factor
- Inclusive Market system Development : Youth, GESI, DAG

Based on these themes, the working group was formed to contribute in the respective area of expertise who in turn identified the different topics of the presentation and the explored respective presenter in the area from government, research and academic as well as social and private sector for the south Asian regional horticulture workshop. The presentation were focused on the current status, opportunities and ways forward for the sustainable growth of the fruits and vegetable sector in South Asia with perspectives from food and nutrition security, Insect, pest and disease management, farm mechanization, biotechnological improvements, vegetable seed production, marketing and value chain, post-harvest management, extension, indigenous fruits promotion, organic horticulture in South Asia. Besides these, the cross cutting themes of Gender Equality and Social Inclusion (GESI) and Youth Entrepreneurship, Climate Change, Pollination and Food Safety and quality were also presented in the workshop after which a through discussion among diverse group of participants was allowed for getting inputs, suggestions and feedback that was recorded by a Rapporteur which was compiled and reported to the project manager and moderated by the session chair for each dedicated session of 3 presentations as detailed in the Annex 8. The Professors from universities in Bangladesh, Nepal and USA, research scientists, government officials, development workers and young entrepreneurs presented the sessions. The workshop was conducted in a hybrid mode enabling virtual participation together with physical presence. It had the presence of 89 physical participants (63M and 26F) and 51(36M and 15F) virtual participants (Annex 2). The workshop had the gracious presence of Vice Chancellor of AFU as Chair person of the opening ceremony and the Vice Chancellor of Gandaki University as the Chief Guest. There was presence of Chartered Vice Chancellor of AFU, Chartered Registrar from AFU, Dean from AFU and TU, USAID, MoALD, NARC, PMAMP, VCDP, Bangladesh Agricultural University (BAU), Bangladesh Agriculture Research Institute (BARI) and SAARC Agriculture Center.

a. Consultation Meetings with Key Stakeholders

The project team had rigorous meetings with the designated officials such as Vice Chancellor, Registrar and Dean of Agriculture and Forestry University for the briefing of the project and requesting for their coordination and support in smooth functioning of the workshop. We also had a meeting with the Secretary of MOALD, Director General of DoA, Executive Director of NARC and Chief of different programs and relevant societies (Nepal Horticulture Society, Plant Protection Society Nepal) and individual experts for buying in their cooperation and coordination together with ensuring the expert views in the research. Details in Annex 1.

4. Project outputs and outcomes

4.1. Challenges and Opportunities of Vegetable Sub-sector

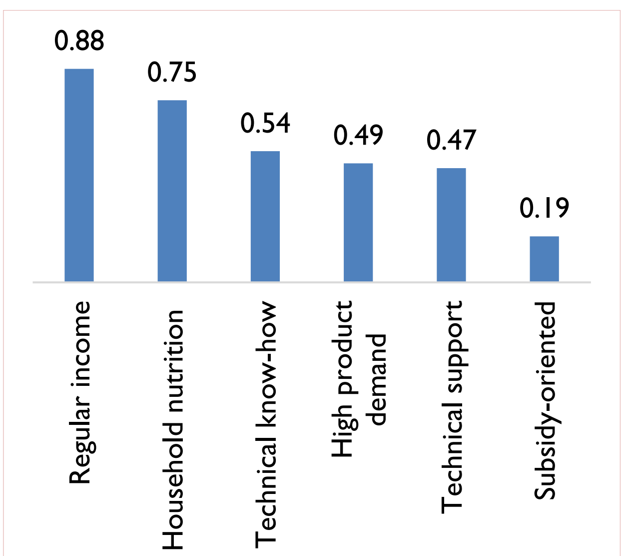
Vegetables are rich sources of vitamins like vitamin A, vitamin B, vitamin C, riboflavin, thiamin, niacin, and minerals such as calcium and iron that also supply different dietary fibers, which are essential for digestion, maintaining good health, and curing nutritional disorders (Terry, 2011). Increment in the volume of vegetable production over 3-4 years implies a shifting trend to vegetable farming from cereal crop cultivation due to higher and quicker economic returns (Gurung et al., 2016). Vegetable production is the major subsector of agriculture that provides employment to large number of people and contributes about 11.92% to AGDP (MOALD, 2021).

Even though vegetable farming is a good source of income, farmers have faced several challenges in vegetable production (Gurung et al., 2016). Climate change is one of the major factors affecting the productivity of vegetable production as it has altered the cropping pattern, biology of insects, pest and disease occurrence, and host-pathogen interaction, which is becoming a major setback to vegetable cultivation (Abewoy, 2017). Incidence of pest and diseases has caused the haphazard use of pesticides and fungicides in Nepal. Pesticides used have been found above the allowable limit (The Kathmandu Post, 2022). We currently have more than 35 open pollinated varieties of commercially and semi-commercially grown vegetable crops being recommended and released as well as around 300 hybrid varieties being registered in the National Seed Board of Nepal, yet we have not been able to harness the enormous hidden potential to even a minimum satisfactory level. Except for a few F1 hybrid varieties such as Srijana variety of tomato crop, most of the hybrid varieties are being imported (NPVSDC, 2018). Further, inadequate research on commercial vegetable production has hindered the growth and development of the vegetable sector although some initiatives have been conducted at the National Level (Ghimire et al., 2018).

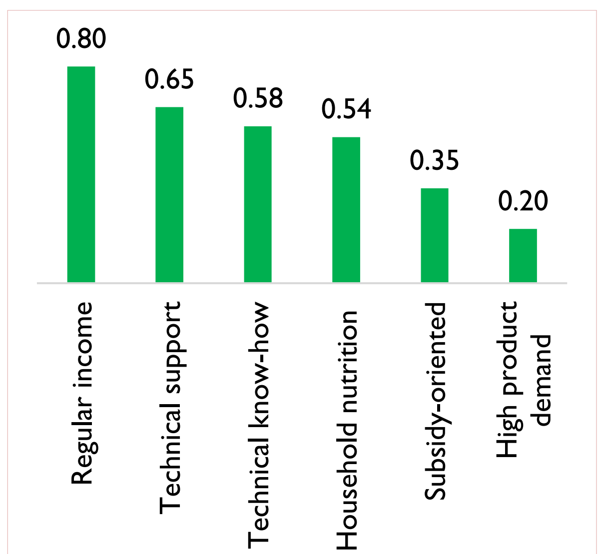
Along with challenges, there are several opportunities in the vegetable sector in South Asia. Diversified agro-ecological zones, distinct seasons, variation in the weather and climate within a year favors the production of vegetables in Nepal to a large extent. Climate and soils of Bangladesh are ideal for vegetable cultivation, allowing more than 60 different varieties of vegetables, both indigenous and exotic, to be grown in the country's various agro-climatic zones. The hilly area of Nepal has microclimatic diversity to produce several kinds of vegetable seeds (Timsina & Shivakoti, 2018). Also, commercial vegetable farming is in increasing trend in Nepal (Shrestha et al., 2018). Moreover, vegetable farming allows small land holding farmers to generate cash in a short period of time and can help to raise their living standard (Gurung et a.

, 2016). Vegetable farming due to its higher price value at farm-gate and productivity stand as an important sector in agribusiness (Mariyono, 2017). Nowadays, youth after returning from foreign employment are highly inclined toward vegetables. Higher import than that of export reflect the scope of vegetable farming in Nepal. Also, the per capita consumption of vegetable has increased to 105 kg from 60 kg over last two decades due to increase in awareness among consumers and rise in production area in Nepal. Farmer are becoming more specialized in production of particular type of vegetable.

The figures below show the household preference of fruit and vegetable enterprises in Nepal and Bangladesh. In Nepal, the farmers prefer the fruit enterprises mainly for the regular income followed by household nutrition and technical knowledge whereas the subsidy grant has least influence in the farmer decision to take the fruit enterprises. In the vegetable sector, farmers select the vegetable enterprises primarily for the regular income followed by technical support and technical knowledge whereas product demand has the least impact in the farmer's decision. In Bangladesh, it is observed that farmers mainly choose the fruit enterprises for the household nutrition whereas subsidy has a minor impact in the decision making for fruit enterprises. Likewise, in the vegetable sector, farmers choose vegetable enterprises primarily for regular income whereas most of the farmers don't choose the vegetable enterprise because of lacking the technical knowledge.

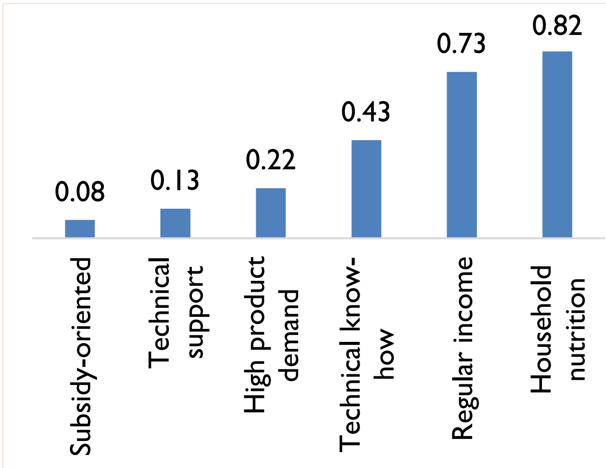


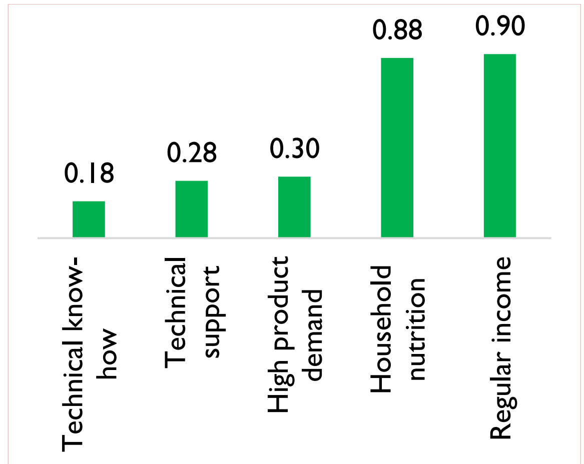
Index value of preferences for fruits (n=27)



Index value of preferences for vegetables (n=52)

Figure 3: Household preference for fruit and vegetable enterprises in Nepal





Index value of preferences for fruits (n=21)

Index value of preferences for vegetables (n=15)

Figure 4: Household preference for fruit and vegetable enterprises in Bangladesh

Table 3: Existing and potential vegetables in Nepal

Agro-ecological region	Major vegetables (existing - large scale)	Potential vegetables (commercialization)
Terai	Tomato, cucurbits, okra, sweet pepper, chilly, cow pea, French bean, potato, cauliflower, broccoli, broad leaf mustard, radish, carrot	Akbare chilly, , amaranthus, black tomato, celery, beet root, Lettuce
Mid-hill	Cauliflower, cabbage, broccoli, broad leaf mustard, radish, potato, cucurbits, carrot	Asparagus, chayote, beet root
High-hill/ Mountain	Carrot, radish, broad leaf mustard	Pea, local potato

Challenges in vegetables

- High involvement of middleman in the trading of vegetables
- Irrigation management problem
- Limited storage facility
- High competition with vegetables imported from India
- Climate change and disasters

Opportunities in vegetables

- Government and projects' support: regular programs and projects (i.e., PMAMP, AKC, I/NGOs)
- High price of off-season vegetables
- Export potential of new species and high-value vegetables
- Production of diversified vegetables in different agro-ecological regions

4.2. Challenges and Opportunities of Fruit Sub-sector

Approximately 60% of South Asians are engaged in agriculture. Fruits are a highly nutritious food mainly consisting of vitamins and minerals that have an important role in the national security of people (Chay et al., 2019). In South Asia, the gross fruit production has increased by 65% from 1990-2020. However, South Asia's Global Hunger Index (GHI) score in 2019 was 29.3, the highest in the world that is mainly associated with a low intake of fruits and vegetables.

There are many challenges faced by the fruit farmers of Nepal and Bangladesh. The agricultural system in South Asian countries is dominated by smallholder farmers, hindering the mechanization of the fruit and vegetable sectors. The average size of land holding is about 0.8 ha in Nepal and 0.5 ha in Bangladesh. Farmers have limited access to pre and post-harvest technologies. Lack of quality input supply and poor orchard management are one of the major factors reducing productivity. Trees having dead and dried twigs, and crowded conditions lead to poor light exposure producing reduced size and poor quality fruits (Tucker, Wheaton, & Muraro, 1994). Poor knowledge of the harvesting stage, post-harvest handling techniques, lack of storage facilities and other proper post-harvest handling technologies have caused heavy post-harvest losses in fruit such as banana , mango, litchi, citrus etc. Most farmers use a traditional bamboo basket and jute or plastic sacks which induce physical damage due to bruising and compaction of fruits (Acharya & Shrestha, 2021). Poor post-harvest handlings of apples are causing mechanically damaged and bruised fruits, reducing the quality and shelf life of the fruits (Subedi et al., 2016). Over and above, climate change and the higher incidence of diseases and pests (Citrus psylla, fruit fly, banana wilt, guava scab, etc.) are hampering the production of fruit. During the flowering and fruiting season, a long drought period and strong hailstorm cause the citrus bloom and fruit to drop (Paudyal et al., 2016). The increase in number, occurrence and intensity of pests and diseases in fruit has led to the haphazard use of pesticides and fungicides that is affecting the sustainability of fruit production as well as human health. Pesticide residue and fruit fly infestation hindered the export of mango in the foreign market (Saripalle, 2019). There is a need to consider the pollination problem in some fruit such as apple, citrus, dragon fruit. High transaction costs and lack of transparency in price fixation have disheartened the farmer involved in mango farming (Saripalle, 2019). Further, due to the prevalence of cheaper imported mango from India, the Nepalese market is not getting the proper price and market (Shrestha et al., 2020). Most of the important fruit of the world can be grown in Nepal with comparative advantages for producing temperate to tropical fruit and value chain development for apple, mango, litchi, banana, avocado, citrus for import substitution; and mandarin, kiwi, plum, berries, and nuts for export promotion; and production of avocado, persimmon , pear, kiwi and different nut fruits for fulfilling the demand of tourism sector.

Along with challenges, there are many opportunities in the fruit sector of South Asia . Fruit being a nutritious food is gaining popularity in the national as well as international market. The import of fruit in Nepal, as well as South Asia, is higher than that of export which shows the higher demand for fruit (FAOSTAT, 2022). The South Asia region has suitable topographic, climatic, and natural resources to grow tropical, sub-tropical, and temperate fruit crops (Faqeerzada et al., 2018) that have made the year-round production of fruit possible. Due to insufficient production, demand and the fluctuation in price of the fruits are very high. The forty percentage of agricultural land in the hill agro-ecological zone can be utilized for fruit cultivation. Further, the cultivation of fruit crops includes production, processing, marketing, and value addition that require manpower, thus aiding in creating employment opportunities for the youth (Thapa & Dhimal, 2017). With the installation of processing industries and cold storage, the farmers will also be inspired to cultivate more fruits. In addition, the government is providing subsidies to encourage the farmers to be involved in fruit farming. The government has declared 2018 as Fruit Year, and 2017/18 as fruit Decade to promote fruit export in Nepal (NHPC, 2017). Further, the benefit-cost ratio ranges from 1-5, and Kiwi has a higher B/C ratio followed by banana and papaya (Bhandari & Aryal, 2015).

Table 4: Existing and potential fruits in Nepal

Agro-ecological region	Major fruits (existing - large scale)	Potential fruits (commercialization)
Terai	Banana, mango, litchi, pineapple, guava, jackfruit, citrus (lime), papaya	Pomegranate,Dragon fruit, strawberries, lime (Sun Kagati)blue berries, , avocado
Mid-hill	Citrus (mandarin, sweet orange, lime/lemon), litchi	Cherry, avocado, kiwi, blueberries
High-hill/ Mountain	Apple, walnut, apricot	Olive, black walnut

Challenges in fruits

- Increasing imports of fruits and high price competition
- Unavailability of production inputs in time specifically the quality saplings
- High post harvest losses coupled with limited packaging and storage facilities
- High business risk, i.e., yield variability, price variability
- Limited knowledge on value addition, farm planning and management

Opportunities in fruits

- High density planting of fruits e.g. apple, Citrus, mango, banana, guava
- Production of diversified fruits in various agro-ecological regions
- Growing national markets and increasing access to export markets
- Increasing demand for fruits for human nutrition and health

4.3. Policies and Programs for Horticulture Sector Development

South Asian countries have developed a series of policies and programs for the overall agriculture sector over the years. Several programs and projects targeted particularly to the horticulture sector are also developed. Project on Horticulture Value Chain Development 2019-2024 in Afghanistan, National Plan of Action for Nutrition 2016-2025 stressing on increasing vegetable and fruit production at national levels in Bangladesh, 12th five year plan 2018-2023 targeting to increase vegetable production towards 100% self-sufficiency in Bhutan, National Agricultural Policy for Food and Export Agricultural Crops and Floriculture 2007 in Sri Lanka, National Food Security Policy 2017 in Pakistan introducing high value fruit crops like Olive, Pistachio, and Almond. Similarly, development of modern seed industry to produce hybrid vegetable seeds and disease-free planting materials of fruits; Mission for Integrated Development of Horticulture (MIDH) to develop important post entry quarantine facilities for temperate fruits (apple, walnut, and almond) at ICAR in India, FAO's Maldives Country Programing Framework 2013-2017 promoting home gardening of fruit and vegetables to improve the nutritional status of communities are some of the efforts made by governments of South Asia for the promotion of horticulture sector.

In Nepal, National Agriculture Policy 2061 was one of the primary policies related to agriculture in Nepal. It focuses on many areas such as research, production, and market and technology adoption. The policy recommends establishment of research and development systems such as production, collection, grading, storage, processing and packaging of fruits and vegetables, and feasibility study and comparative advantage identification of horticultural species. National seed sector policy 2056 promotes use of advanced technology like tissue culture, biotechnology in disease free planting materials production. Agribusiness promotion policy 2063 primarily focuses on production, market, insurance and loan, technology adaptation and mechanization, and post-harvest management and processing of horticultural crops. In addition to that, the Agriculture Perspective Plan (1995-2015) gave priority to certain key inputs (i.e. irrigation, fertilizer, technology, roads and power, and financial credit for agriculture). Agriculture Mechanization Promotion Policy 2072 is an important policy which focuses on identification of best machinery, tool's research and development and promotion of appropriate equipment and technologies for agriculture operations including production, processing, storage, and marketing of agriculture. National Food Safety Policy 2075 helps to promote farmers in producing safe and quality products through Good Agricultural Practices (GAP). Agriculture Development Strategy (2015-2035) considers the agricultural sector in its complexity, and encompasses not only the production sectors (crops, livestock, fisheries, forestry) but also the processing sector, trade and other services (storage, transportation and logistics, finance, marketing, research, extension) and strengthens the functional linkage between research, e xtension and e ducation and intends towards higher productivity, profitable commercialization, increase competitiveness.

Challenges related to policy in South Asia are mainly associated with their implementation. The target of programs and projects are not met, many programs are discontinued without being successful. Policies related to trade and tariffs for promotion of domestic products, strict laws for SPS and plant quarantine measures, determination of floor price by the government for horticultural commodities to support producers are still major issues related to horticulture in Nepal.

4.4. Gender Equality and Social Inclusion (GESI) in Horticulture Sector

Nepal has high potentials of investing in processing industries and adding value of the fruits and vegetables being produced in Nepal which adds opportunity for youth employment. Women are actively involved in production, processing and trade of vegetables and fruit in Nepal (Saavedra & Shrestha, 2021). It is estimated that over 3.2 million households are cultivating vegetables, of which 17% are headed by women (UKaid, 2020). Horticulture sector (season and off- season vegetables are one of the major sub sectors providing employment and income to women farmers in Nepal. Youth (men and women) farmers are engaged in production and trading of fruit and vegetables.

Significance of horticulture sector- GESI and smallholder farmers

Significance	Area of significance	Growth potential
Employment creation	Seasonal employment creation- production, processing, trading	Higher due to increasing collective farming and marketing, government focus e.g. co-investment support, technologies
Income	Fruit and vegetables are one of the major sources of on farm income of smallholder farmers and specially women	Ever increasing demand
Inclusion	Collective farming/marketing	Increasing market governance, information exchange among value chain actors
Investment	Even small holder and low investment can establish enterprise-e.g. vegetables	Co-investment policies, private sector involvement e.g. market services, insurance

Women and smallholder farmers

Ever increasing youth (men and women) migration in search of employment opportunities (e.g. Golf countries, Malaysia , India- seasonal) are the issues of women and smallholder farmers besides co-investment policies**,** unstable subsidy policies, cumbersome procedures to small farmers etc. Only about 21% of women have land ownership, when their counterpart is abroad, they cannot even get a loan from the bank due to lack of land certificate. Unavailability of women friendly technologies- for example most of the equipment such as tiller, harvester, fruit clipper available in the market are reported difficult to be operated by women. Uncertainty and higher risk due to increasing adverse effects of climate change, limited engagement particularly in market negotiation – and absence of women friendly infrastructures (e.g. sitting, toiletries, breast feeding chambres) in custom yard, collection centers, market centers etc. are some of the other challenges. Besides, lack of concrete policies- incentives and support to women led enterprises (APP, even ADS and recently formulated guidelines and procedures) is reported as obstacle, though ADS has a policy to increase land ownership of women.

Youth entrepreneurship in commercial farming of horticultural commodities

Large numbers of deprived young people in the world are living in the rural areas whose fragile economies give them few opportunities for decent jobs and their numbers are increasing. As young people are poised to enter into the labor market, it needs serious attention to engage them in sustainable enterprises and viable economic opportunities. For rural youth in particular, new business creation in the agriculture sector focusing on commercial vegetables and fruit processing can present an important and viable opportunity to earn a decent living. Agricultural value chain can give rural youth the chance to engage in productive work. An often-overlooked area of opportunity is the 'green economy' (organic agriculture, fruit and vegetable processing), which has the potential to become a growth sector for rural youth. Foreign migrant returnees, mostly Israel and Korea returnees have invested in farm business including fruit processing. This shows scope of youth employment in the horticulture sector.

Nepal is a small land-locked country with diverse agro-ecologies, where agriculture is a key source of economic growth, poverty reduction, and environmental sustainability in (Gauchan & Shrestha, 2017). With the passage of time, contribution of agriculture in GDP seems decreasing and youths' involvement towards agricultural entrepreneurship has been increasing in Nepal. Agro-entrepreneurship is rising due to technological innovation and transformation in the production process that will provide higher output aiding in income generation (Devkota, 2020). Many horticultural crops are high-value crops, which can increase the earning potential for youth and smallholder farmers. Horticulture crops can be grown on small plots of land, allowing youth easier access to get involved and manage production. Approximately 3.5 million Nepalese (14% of total population) are working abroad; primarily in Malaysia, the six countries of the Gulf Co-operation Council (GCC), and India. As youth represent the most active segment of the population with dynamism, strength, adventure and ambition and can play an important role for transforming Nepali agriculture. Entrepreneurship can be a powerful tool to help fight youth unemployment and youth entrepreneurship offers innovative solutions for economic growth among young people.

The horticulture sector is not considered as a business, rather continuing as subsistence farming for long. outh involvement in horticulture is limited by number of reasons such as inadequate knowledge on production, processing and marketing; lack of access to land and credit; and lack of passion and training among youth. Horticultural crops require high investment to start, are perishable thus require fine postharvest activities, access to market, and quality agricultural inputs. Since youths are not willing to take risks due to unfavorable policies for horticultural enterprise, there should be engagement of youth in policy dialogue.

Challenges in youth entrepreneurship

Horticulture can contribute positively to economic growth of women, youth and disadvantaged groups. There is high scope of involvement of socially and economically backward groups in horticulture if government's/development partner's resource and leverage fund is utilized to start and strengthen agriculture/ horticulture enterprises targeted for youth. There are educated, skilled and experienced youth who have been forced to leave the country, they can be brought back and integrated to horticultural entrepreneurship if proper working environment is provided. Establishment of processing and packaging industries (preparation of secondary products), cold storage for preservation of fruits and vegetables during peak season and supply high value fruit and vegetables to national and international market during lean season are the scope for promotion of horticultural enterprise.

Required Policy and plans for vegetable production

Increase access to productive resources- land ownership (also focused by ADS), loan facility, priority for inputs provisions (seeds, fertilizer). Concrete policy provisions are missing in most of the guidelines developed by MoALD and local governments- e.g. for establishing horticultural enterprise such as orchards , nurseries, vegetable farming- how women farmers will get prioritized and additional support in case of women farmers?

Technology research policies and priorities particularly for women are missing in the NARC research system. Agriculture service delivery- Local governments need to have specific policies and resources to recruit more women extension workers and Local Agriculture Resource persons to provide agricultural services. The current technology demonstration and promotion is led by men farmers mostly, government institutions, projects like PMAMP need to promote women farmers for technology demonstration and leadership capacity for dissemination.

The current subsidy policy does not favor women led enterprising- subsidy policy needs to be women sensitive. Financial resource allocation priority at local government in the horticultural sector is less (only 2-5% on an average) as compared to other sectors (such as road, electricity) which need to be increased significantly. Horticultural enterprising (e.g. fruit) is long term investment where farmers need continued support and coordinated efforts between three tiers of the government in terms of technology development, capacity development, specialized services and co-investment support.

The best GESI policies for youth enterprise in horticulture

- Constitutions of Nepal and GESI Policy has covered almost everything to make Equitable society
- The UN Women's Strategic Plan 2022-25 can be a good reference for women empowerment

Way Forward

- Strengthen post-harvest storage house
- Develop processing industry eg. jam, jelly, brandy, gundruk, masaura etc.
- Strengthen hi-tech technology in the post harvest handling and processing sector
- Introduce improved kitchen garden for ensuring household nutrition
- Youth should trend on modern ways of agriculture and agribusiness immediately after high school education
- Awareness campaign on promotion of highly nutritious, but neglected vegetable and fruit species

Gender inclusion in the farming activities is crucial for the socio-economic transformation of farming communities, particularly of smallholder farmers. The study shows that involvement of women and participatory decision-making are crucial in the field-level activities - production of fruits and vegetables, whereas men are mostly involved in the marketing activities, i.e., buying of inputs and selling of the produce (Table5 and 6).

In Nepal, although most of the decisions are made mutually in most cases, the decisions related to the market are dominated by male (Table 5). Involvement and taking decisions related to vegetable production have more female participation while the same for fruits is led by male. Access and control over farm resources are mostly participatory with more dominance of male. In Bangladesh, all decisions are dominated by male including the selection of varieties, Agri-inputs, and buyers, for both vegetables and fruits, while involvement in production is more for female farmers.

Table 5: Gender roles in household decision-making (Nepal)

Decision category	Gender participation (% Response)		
	Male	Female	Participatory
Selection of vegetable types	11.5	17.3	71.2
Selection of fruit types	36.3	6.1	57.6
Involvement in vegetable production	7.8	25.5	66.7
Involvement in fruit production	6.5	6.4	87.1
Access to and control over farm resources	35.5	17.7	46.8
Acquiring/purchasing the required agro-inputs	75.8	4.8	19.4
Market decision on selling vegetables	33.9	10.7	55.4
Selection of the buyers for vegetables trade	13.7	13.7	72.6
Market decision on selling fruits	55.2	20.7	24.1
Selection of the buyers for fruits trade	53.3	6.7	40.0
Determination of the price of produce (fruit/vegetables)	11.3	8.1	80.6

Table 6: Gender roles in household decision-making (Bangladesh)

Decision category	Gender participation (% Response)		
	Male	Female	Participatory
Selection of vegetable types	47.83	21.74	30.43
Selection of fruit types	47.83	21.74	30.43
Involvement in vegetable production	-	26.09	73.91
Involvement in fruit production	-	30.43	69.57
Access to and control over farm resources	69.57	8.70	21.74
Acquiring/purchasing the required agro-inputs	78.26	-	21.74
Market decision on selling vegetables	60.87	8.70	30.43
Selection of the buyers for vegetables trade	100.00	-	-
Market decision on selling fruits	65.22	8.70	26.09
Selection of the buyers for fruits trade	100.00	-	-
Determination of the price of produce (fruit/vegetables)	69.57	-	30.43

4.5. Marketing and Value Chain of Fruits and Vegetables

Table 7: Marketing and value addition in fruits and vegetables in Nepal

Fruit/ Vegetable	Existing value addition	Required interventions for promotion
Guava, peach, apple, orange, mango	Jam, jelly, marmalades	Storage facility, packaging, labeling
Tomato	Tomato ketchup, pickles	Storage facility, technical trainings
Mango, lemon	Pickles	Storage facility, technical trainings
Chilly, cucumber	Pickles	Storage facility, labeling, market promotion
Potato	Finger chips	Drying, packaging, labeling, storage

4.6. Challenges and Opportunities of Indigenous Fruits and Vegetables

The majority of native fruits and vegetables in South Asia are undervalued, underutilized and understudied. South Asian countries have more than 100 unique fruits and vegetables that can be marketed globally (SAIC, 2003; Durst & Bayasgalanbat 2014; Gautam & Gotame, 2020). Nevertheless, unfortunately, country-wise data on indigenous fruits and vegetables is not available. In Nepal, indigenous species of vegetables like asparagus, colocasia, yam, drumstick, fiddlehead fern, chayote, potato, bean, leafy vegetables, and gourds are of high value, nutritious, and have a huge potential to contribute in national economy in the future. Similarly, indigenous species of fruits including apricot, amala, grapefruit, persimmon, mulberry, raspberry, fig, sapota, plum, citron, walnut, chestnut, banana, apple, pear, guava, mandarin, and many more not only have economic potential but also are highly valuable as genetic resources and thus need to be protected. However, studies show that recent generations have slowly but surely excluded native foods from their diets (Li & Siddique, 2018).

South Asian literatures are hugely dominated by major commercially exploited fruits and vegetables species. Lack of research on indigenous fruits and vegetables, shortage of seed and other propagating material, decline in consumption of indigenous crops, shortage of appropriate processing technologies, extinction of the species especially due to little effort to protect and conserve these plants are some of the major challenges related to indigenous fruits and vegetables. In addition to that, lack of market access, production risks associated with it, and lack of knowledge are challenges associated with cultivation of these species. Higher market demand of commercial fruits and vegetables from consumers over indigenous ones for their aesthetics, color, keeping quality, firmness and texture disregarding their nutritional contribution to diets (Keatinge et al., 2015) is major limitation on consumers' side .

Studies show that increasing dietary diversity and the intake of vegetables and fruits is a key strategy to address the problem of hunger and malnutrition, particularly to poor people (Hughes & Keatinge, 2013; Bokelmann et al., 2022). Indigenous fruits and vegetables are comparatively hardy, have typical pest and insect resistance genes, adapted to marginal soil and climatic conditions, and often can be grown in less inputs (De la Pena et al., 2011; Hughes & Ebert, 2013), thus they can play an important role in use of landraces in research and breeding (Joshi et al., 2019). Indigenous fruits and vegetables have potential to be cultivated even in the rural and marginal lands of Nepal where farmers are deprived of agricultural inputs like fertilizers, pesticides, improved varieties, grafting technologies, irrigation facilities, etc., intensive agriculture, using hybrid and modern crop varieties. Moreover, they generally have shorter production cycles, compared to cultivated crops (Keatinge et al., 2015), which is an extra advantage of traditional fruits and vegetables. Although the commercial market has always been dominated by a handful species of fruits and vegetables, recent trends show the increasing demand of indigenous crops from consumers as well. Vegetables like fiddlehead fern, young bamboo shoot, yam, etc. have created a market for themselves due to their unique taste and flavor. Survey done in eastern Chitwan revealed that the majority of respondents believed an increasing trend of consumption in indigenous and underutilized crops (Timilsina et al., 2022).

To promote Indigenous fruits and vegetables at farmers level, identification, research and proper documentation of indigenous fruits and vegetables is required to be done. Similarly, exploring medicinal, religious, industrial and nutritional values along with different food recipes of indigenous crops are important to expand their cultivation areas, to increase the number of consumers, to encourage researchers and policy makers to consider native crops as priority. In addition, promoting Indigenous fruits and vegetables for export, and processing and value addition of the products to make the industry larger and more profitable. Moreover, to utilize our landraces in breeding programs, initiation should be taken by research institutions and plant breeders. And awareness programs for consumers regarding the health benefits of indigenous varieties.

4.7. Challenges and Opportunities of Vegetable Seed Production and Fruits Saplings

Seed and saplings are the fundamental and most important inputs in fruits and vegetables that determine crop yield and efficiency of other input. In Nepal, variety development, maintenance and breeder seed production and supply are mainly carried out by public research institutions such as NARC. Foundation seed is produced and multiplied by both government (NARC, DOA) and private sector including cooperatives/CBSP groups in close supervision of NARC research centers and few NGOs (LI-BIRD, FORWARD and CEAPRED).

There are many challenges on seed and sapling production in Nepal. Farmers are not getting seeds and saplings at the right quantity and time leading to lower production. Seed and saplings are high-value and low-volume products. Also, there is limited trained human resource in the government and private sector, no vegetable breeders with the private sector. Also, seed production is being done in a very limited area. The only large vegetable seed production pockets that exist in Nepal are in Rapti area (especially Rukum) and central hills around Kavre and Dolakha. There is a lack of a licensing system of national variety. Currently, there are more than 35 open-pollinated varieties of commercially and semi-commercially grown vegetable crops being recommended and released as well as around 300 hybrid varieties being registered in the National Seed Board of Nepal, yet we have not been able to harness the enormous hidden potential to even a minimum satisfactory level. Except for a few F1 hybrid varieties such as Srijana of tomato crop, most of the hybrid varieties are being imported (NPVSDC, 2018). Saplings produced are not of good quality or are produced by those who don't have proper guidance regarding healthy seedling and sapling, and also the open border has raised the risk. Farmers are using the same apple varieties since the 1970s and 1980s (Gandaki Agriculture Farmers Cooperatives Ltd., 2020).

However, there are several challenges, there are also opportunities in seed and sapling production of fruits and vegetables. The expansion in acreage under vegetable cultivation and fruit has increased the seed and sapling requirement. The hilly areas of Nepal have microclimatic diversity to produce several kinds of vegetable seeds (Timsina & Shivakoti, 2018). Altogether 200 local species are consumed as vegetables which could be conserved and in the breeding program. Moreover, the vegetable seed enterprise is considered as the high potential sub-sector for the economic growth of rural farmers in Nepal (Pun & Poudyal, 2018). The market and demand for vegetable seed is high in this region. Also, the government of Nepal has been prioritizing seed sector development through its programs and policies to increase farmers' access to quality seeds of their choice. Apart from this, the government is also providing subsidies for saplings. South Asia has Coordination and participatory approaches among stakeholders in seed value chain activities which is also one of the opportunities in seed and sapling production. The concerned stakeholders and policymakers need to focus on enhancing market linkage and farmers' technical know-how to promote vegetable seed production. Based on the description of the above challenges and opportunities, following topic are the possible research areas in vegetable seed production:

- Focus research on varietal development of hybrids seeds
- Location specific seed production of vegetable crops
- Promotion of seed production to locally adopted indigenous varieties
- Seed certification and quality seed production

Large number of farmers produce the seedlings and saplings in their own farm or get it from the private nursery. Whereas, a lesser number of farmers get the seedlings and saplings from the Agriculture Knowledge Center (Figure 5)

Input management

Farmers mainly concern themselves with the management of the agricultural inputs. They receive the required inputs (i.e., seeds, seedlings/saplings, fertilizers, etc.) from many sources (Figure). The major source of seedlings and saplings to farmers are own production (36.17%), followed by private nursery (34.04%), development projects (10.64%), local governments (8.51%), neighbors (6.38%), and Agriculture Knowledge Center (4.26%). The major sources of seeds to farmers are agro-vets (67%) followed by own production (18%), and cooperatives (13). The major sources of chemical fertilizers are agro-vets (54%) and cooperatives (46%). And, the major sources of farm-yard manure (FYM) include own production (76%), neighbor-farmers (12%), and entrepreneurs (12%). About 8% respondent farmers used to test the soils prior to the application of fertilizers in the field.

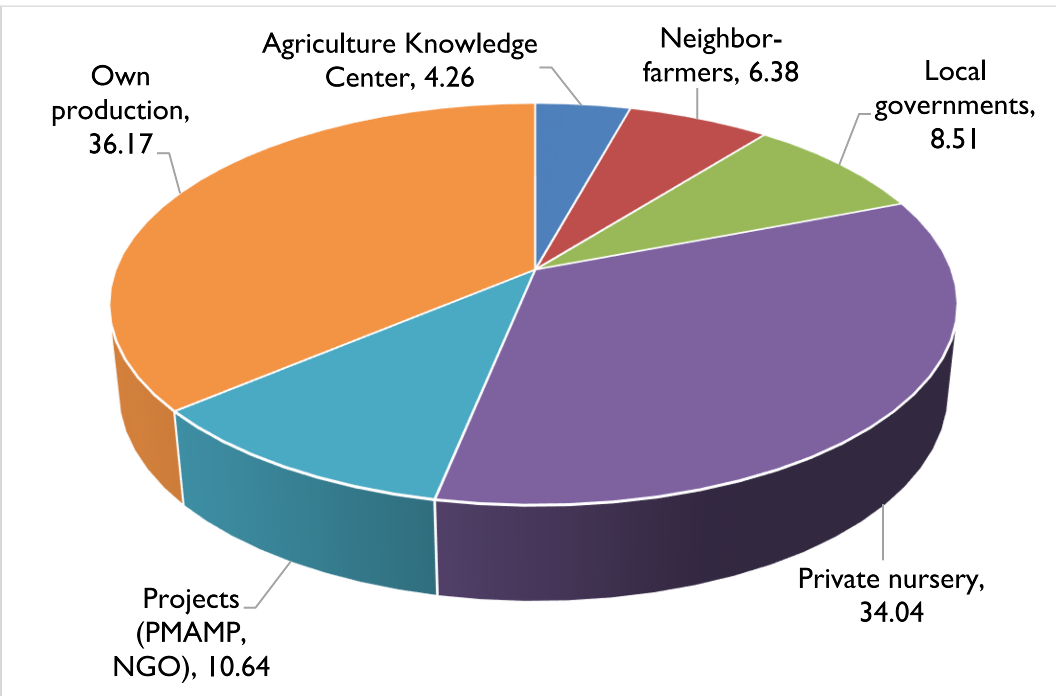


Figure. 5: Source of seedlings and saplings in Nepal (% HH response)

Table 8: Source of seeds and fertilizers in Nepal

Input type	Source	Response (%)
Seeds	Agro-vets	67
	Own production	18
	Cooperatives	13
	Other	2
Chemical fertilizers	Agro-vets	54
	Cooperatives	46
Farm-yard manure (FYM)	Own production	76
	Neighbor	12
	Entrepreneur	12

Farmers face a great challenge in management of chemical fertilizers, particularly due to unavailability of chemical fertilizers in time and required quantity.

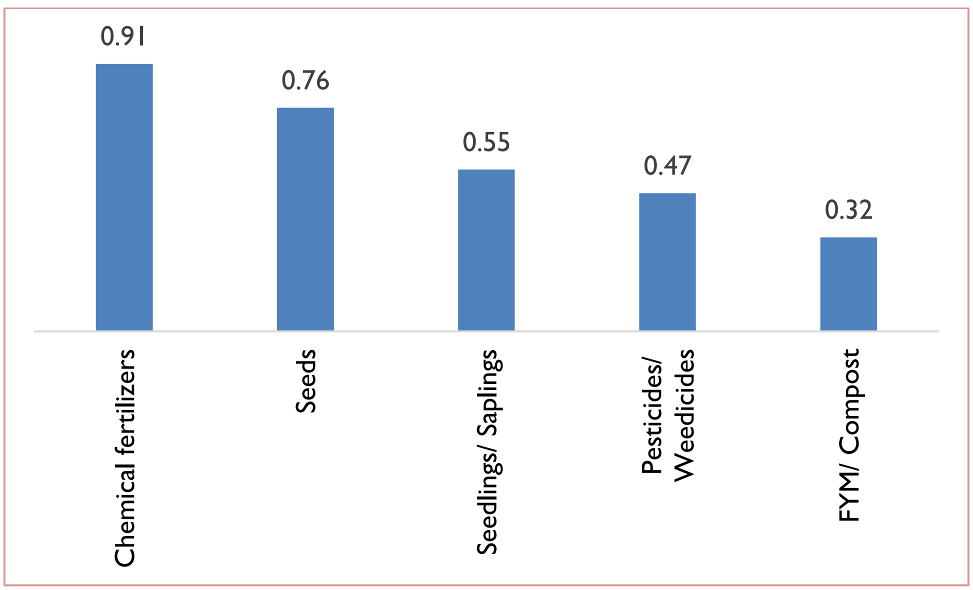


Figure. 6: Problem areas for the input management in Nepal (Index value; n=61)

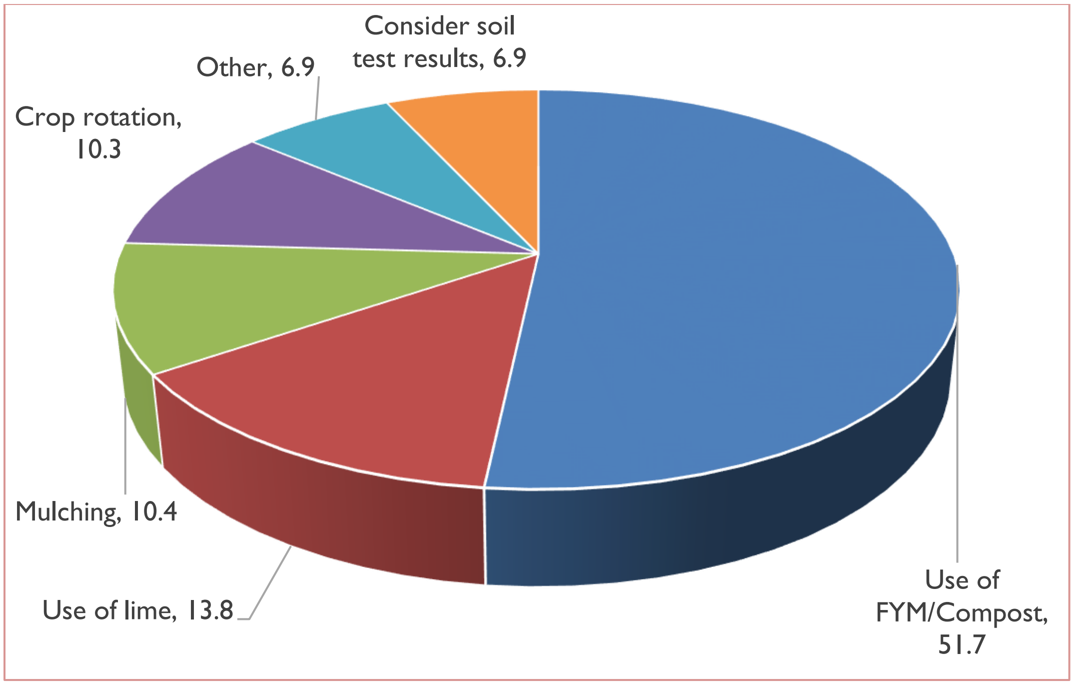


Figure. 7: Different practices adopted by farmers for soil nutrient management (% HH response)

In Nepal, major soil nutrient management practices adopted by the farmers themselves (Figure 7). The research reveals that the major problem is the timely availability of chemical fertilizer followed by quality seeds and sapling management whereas relatively few farmers are facing problems in the management of FYM/compost. Majority of farmers have been using FYM/Compost for soil nutrient management as they are easily available in the locality. Minority of farmers are found to practice the soil test practices.

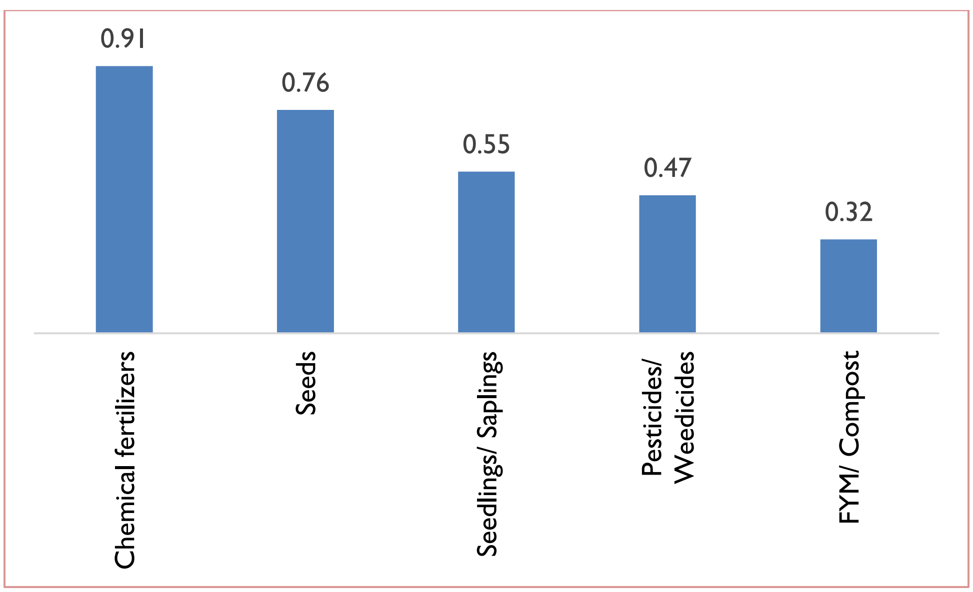


Figure 8: Problem areas for the input management in Nepal (Index value; n=61)

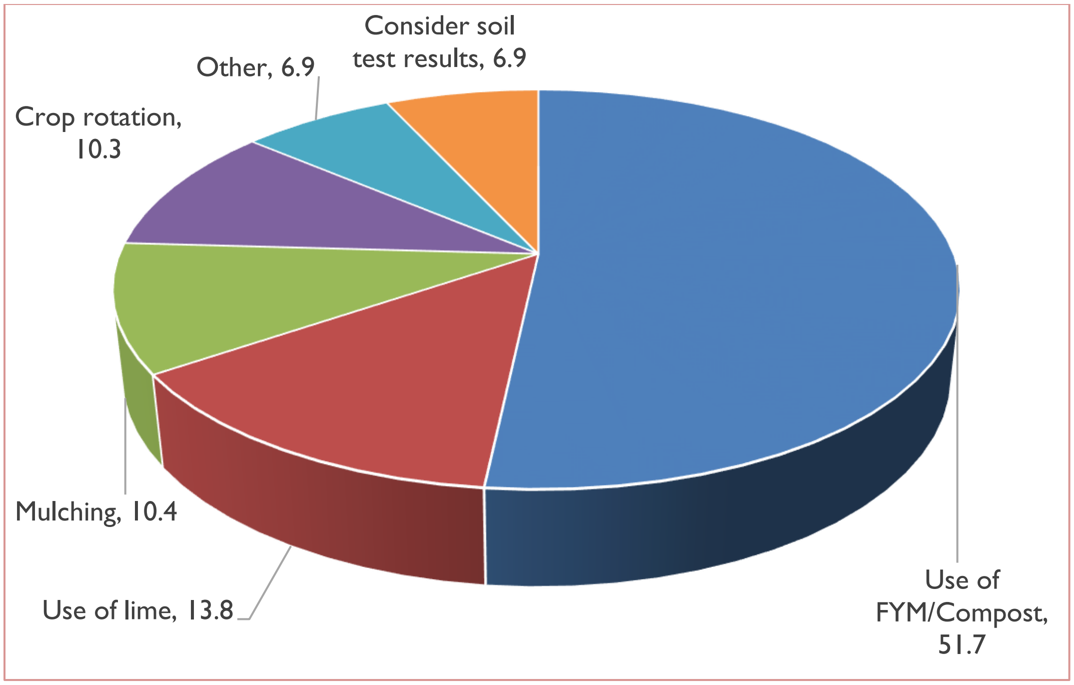


Figure 9: Different practices adopted by farmers for soil nutrient management (% HH response)

Table 9: Potential vegetables for seed production in Nepal

Vegetable	Variety/ Cultivar	Specific location for seed production (districts)
Broad leaf mustard	Marpha Broad Leaf, Khumal Broad Lead	Rolpa, Rukum, Parbat, Baglung, Dhankuta
Potato	MS-42, Cardinal, Kufri Sindhuli, Janak Dev, Khumal Rato	Kavreplanchowk, Nuwakot, Makwanpur, Sindhuli
Beans	Chaumase	Doti, Dadeldhura
Cowpea	Malepatan, Aakash, Prakash	Kaski, Chitwan
Radish	Minu Early, 40-Days	Rolpa, Rukum
Onion	Red Creole	Rolpa, Rukum
Cauliflower	Kathmandu Local, Dolpa Snowball	Dadeldhura, Dolpa, Rukum
Cucumber	Bhaktapur Local	Parbat, Baglung, Dhankuta
Carrot	New Kuroda	Dolpa
Pea	Sikkim Local	Makwanpur
Tomato	Srijana, Samjhana, Jharana	Chitwan, Kaski

4.8. Climate Change Impacts and Adaptation in Fruits and Vegetables

Climate change is impacting both direct and indirect prospects in agriculture. The direct impacts include the effect of modification of physical characteristics such as temperature levels and rainfall distribution on agriculture and indirect impacts include changes in pollination, pest, disease, vector and invasive species (Gitz et al., 2016). Due to climate change, the availability of water is expected to decline whereas water use in the agriculture sector is predicted to increase by 19% in 2050 (UN-Water, 2013). In South Asia, the annual average maximum temperature is predicted to increase by 1.4-1.8°C in 2030 and 2.1-2.6°C in 2050 leading to an increment in the heat-stressed area in the region by 12% in 2030 and 21% in 2050 (Tesfaye et al., 2017). And, South Asia could lose about 1.8% of its annual gross domestic product by 2030 and 8.8% by 2050 (Ahmed & Suphachalasai, 2014). The extreme climates prevailing at different time intervals in the crop cycle decrease productivity (Beillouin et al., 2020). An increase in carbon dioxide gas has caused the reduction of elements such as iron, zinc, manganese, and sulfur in potatoes (Malla, 2009) as well as increase in vitamin C in citrus by approximately 5% (Kimball and Mitchell, 1981 as cited in Atreya & Kaphle, 2020). Climate change causes the shifting in climatic zones, disease pest outbreaks, drought, landslides, flood erosion, etc. (Shrestha & Bhurer, 2014). Previously citrus psylla was only found below 1000 masl, but now they can survive in mid hill up to 1500 masl (Atreya & Kaphle, 2020). During the flowering and fruiting season, a long drought period and strong hailstorms cause the bloom and fruit to drop (Paudyal et al., 2016). The higher temperature in papaya has led to flower drop in female and hermaphrodite, sex changes in hermaphrodite and male plants, and promoted sterility (Bakshi, 2015). Due to the lack of rainfall in Solukhumbu, there was a heavy loss in potato production; about 90% of potatoes were destroyed as the people of this district depend on rainfall for irrigation (Taylor, 2021).

One of the important factors causing biodiversity loss over the next 100 years will be climate change which brings the change in species distribution, phenology, and ecological interaction, affecting the pollination of fruits and vegetables as many crops of fruit and vegetable are pollinated by the insects (Bhandari & Thapa, 2018). Climate change has caused an increase in insects and pests in vegetable production due to which the farmers are using pesticides in vegetables haphazardly. Cauliflower grown in Dhading showed pesticide levels of the organophosphate family that were more than 45% above the allowable limit (The Kathmandu Post, 2022). The wind has become one of the major threats to banana growers (Joshi et al., 2020). Climate change has affected apple production hampering the yield and quality (size, color, and taste) of apples as well as pollination (Partap & Partap, 2002). Due to climate change, there is less snowing in Manang which might be the reason behind the losing reddish hue and taste of apples, and also flowers are blooming before normal dates (Rai, 2017). Early flowering has been observed in olive, apple, and pear, and flower size and pedicel lengths in cherry were also found reduced as a result of less chilling (Rai et al., 2015). Looking at the global scenario with respect to climate change, sustainability of current dietary patterns will be a huge challenge. In this context, horticultural crops are considered as more climate-smart crops that contribute less to climate change than nutritious animal-based foods, and can have positive impacts by absorbing CO2, particularly fruit trees. However, the post-harvest food loss within the range of 35-55% is a serious issue. Furthermore, horticulture is often associated with adoption of agro-chemicals, which may pose risks as the scale of horticultural production intensifies. Excessive and improper use of chemical pesticides in vegetables has adverse impacts on the environment. We recognize many of the challenges that limit further development of the horticulture sector, including climate change (changing temperatures, erratic rainfall, intense winds and heavy rains), poor access to quality inputs (including quality seed, adapted varieties and quality planting materials), pests and diseases, land ownership, access to credit, access to viable markets, lack of cold storage, cold transport and reliable transportation, and lack of information and required skills. The susceptibility of horticultural crops to climate change is substantial. Higher temperatures impact the ability to successfully grow particular crops and varieties, and can exacerbate disease and insect damage because plants are weaker and pests are better adapted. Erratic rainfall and more intense storms (wind, heavy rain, floods) result in crop damage or complete loss, as well as the inability to plant at the proper time for the season or market needs.

Opportunities and Adaptation Strategies against Climate Change

The tools for assessment of the impacts of climate change on agriculture are now available (Gitz et al., 2016). The increase in temperature causes the early maturity of crops resulting in the harvest of crops more than once a year. (Malla, 2009). Chili, Tomato, and Cucumber are now grown in Mustang district due to the change in the climate (Malla, 2009). Due to the temperature rise, apples with good taste and size can be grown at higher altitudes (Lohani, 2007). In Nepal, farmers are shifting from cultivating highly water-consuming crops such as rice to high value crops such as fruits and vegetables (Poude et al., 2017).

Effective adaptation techniques such as cultivation in a greenhouse, variety selection, mulching techniques, and planting time modification are being applied by the farmer (Subedi, 2022). Extreme climatic events increase the process of soil erosion (Bhattacharyya et al., 2015). Tree planting, and hedge row planting in a semi-arid region, while cover crops, and counter plowing in humid and coastal regions are practiced to reduce soil erosion (Aryal et al., 2020). Alternative use of water is another approach for adoption to water stress. Water harvesting has been practiced long ago in India (Satapathy, 2011) and also in rural Bangladesh by approximately 35% of the coastal area households (Ferdausi, 2000) which helps to reduce the surface runoff and maintain the groundwater table as well.

Strategies to reduce these risks include the use of protected culture (screen houses, glasshouses) to protect from heavy winds and insects, implementation of IPM strategies, deployment of improved horticultural crop genetics that have wide environmental tolerance, conservation agriculture and micro-irrigation to increase the efficiency of water use and reduce the risk from erratic rainfall, waste-water and rainwater harvesting, and use of solar-powered irrigation pumps.

4.9. Integrated Pest Management (IPM) on Fruits and Vegetables

Fruit and vegetable production are influenced by various biotic and abiotic factors, insect pests and diseases are one of them (Dinham, 2003; Schreinemachers et al., 2018). Fruit-fly, Panama wilt, Bight, Citrus psylla, Anthracnose, Aphid, Citrus decline, Banana Bunchy top, Powdery Mildew etc. are the major insect pests and diseases seen in fruit and vegetable production. IPM, one of the management approaches, is the integration of cultural, physical, mechanical, biological, and legislative which are more economical and safe to human beings and the environment, and giving the least emphasis to the chemical pesticide (Tiwari et al., 2019).

There are many challenges prevailing in the integrated pest management practice on fruit and vegetable. Climate change has severely affected our agriculture system in general and insect pest and diseases in particular, leading to the appearance of new pests and diseases. Pesticide resistance, pest outbreak, pest resurgence, pollinators declining etc. are the current challenges faced in the fruits and vegetables due to the haphazard use of pesticides and fungicides. In SAARC countries, India uses maximum pesticides followed by Bangladesh, Pakistan, Sri Lanka, Nepal, Maldives, and Bhutan (FAOSTAT, 2020). The average pesticide used in Nepal is 396 a.i. g/ha (FAOSTAT, 2020). In tomato grown in Kavre, the pesticide residue has been recorded above Acceptable Daily Intake (ADI) and maximum residue level (MRL) (Aryal, 2014). The pesticides residue in fruits in Nepal is recorded to be 0.029187 kg a.i. /ha (Adhikari, 2017). The wide application of chemical pesticide had caused rejection of Nepalese product from the European Union (The Himalayan Times, 2007). Moreover, banned pesticides were commonly used for many years in South Asia and resulted in many consequences in agriculture (Rani et al., 2021). The farmers from Dhankuta were using banned pesticides such as monocrotophos, phorate, and quinalphos (The Himalayan Times, 2018) . The farmer's reluctance to adapt the pest management practices such as cultural, mechanical, use of botanical pesticides and other bio-pesticides, and other safe pest management practices is due to their low effectiveness as compared to chemical pesticides and their slow acting nature. Even if farmers are motivated to use sustainable agriculture practices such as integrated pest management, the IPM tools are not easily accessible to farmers. Also, there is a lack of pesticide residue analysis laboratory facilities in Nepal. Further, the premium price of pesticide-free products is not different from the products of conventional farming. Similarly, the current government rules and regulations are not enough and the implementation part and monitoring are very weak. Lack of sufficient technical manpower, market guarantee, IPM tool, and government subsidy on IPM practices, awareness and training regarding IPM, and pesticide residue analysis facility, and ignorance of the researcher on IPM, etc. are the current challenges for the development of pest and disease management strategy in fruits and vegetables.

However, there are several opportunities for the development of IPM in fruit and vegetable. Integrated pest management (IPM) approaches have emerged in many countries for insect pest and disease management (Deping et al., 2019). The majority of farmers are aligned toward sustainable pest management practices as consumers are more cautious, and are ready to pay a premium price for pesticide-free products. Trichoderma is commonly used for the management of damping off or other soil fungi, *Metarhizium* is used for soil pest management, and neem-based pesticides such as Margosom are used for sucking or other biting pest management. In addition, bio-pesticide companies are increasing. Furthermore, the government is giving priority to safe food production by developing plans and policies for environmentally friendly and sustainable vegetable production.

There is a need to carry out details surveys and surveillance of insect pests and diseases in major vegetables and fruits in various agro-ecological zones of Nepal and Bangladesh. The threshold level of each insect pest and disease should be identified. Awareness and training on various aspects of integrated insect pest and disease management are of utmost importance. Further, the government should provide a subsidy to the IPM tools and materials for the farmers, pesticide residue analysis facility for the farm products, and set premium prices for the IPM or organic products or safe products.

IPM practices

- Pheromone trap and sticky trapping
- Cultural practices and use of bio-pesticides
- Hand picking of insects

Challenges in promotion of IPM

- Limited technical know-how
- Labor intensive
- Less efficacy
- Discourage off-season and commercial vegetable production

Suggestions for promotion of IPM techniques

- Awareness to growers on the negative effects of chemical pesticides on human health and environment
- Trainings to farmers about the use of IPM practices
- Awareness to input suppliers on the importance of IPM

4.10. Pollination in Horticultural Crops

Pollinators ensure 75% of crops yields, including many economically and nutritionally important fruits, vegetables, and seeds (Klein et al. 2007). Various studies have valued insect pollination as an ecosystem service for agriculture production at both global, regional and national levels. Smallholder farmers in the developing world are disproportionately reliant on insect-pollinated crops for their livelihoods and key dietary micronutrients such as vitamin A and folate . However, they often lack the flexibility to change their farming practices or diets and are therefore highly vulnerable to the loss of pollination services. Pollinator declines have been reported in many parts of the world, including our project country of Nepal where agricultural intensification, habitat loss and climate change pose a rapidly increasing threat to pollinators .

Numerous fruit crops depend upon insect pollinator to help insure pollination (i.e. apples, blueberries, blackberries, cherries, cranberries, raspberries, strawberries). Appropriate pollination boosts fruit size at harvest, speeds up maturity and results in a more symmetrical fruit form. Although inappropriate pollination will result in deformed fruits with smaller seeds thus lowering the market value of the product). The vulnerability ratio (the ratio of the economic value of insect pollination divided by the total crop production value) varied considerably among crop categories with a maximum of 39% for stimulants (coffee and cocoa are insect-pollinated), 31% for nuts and 23% for fruits. Pollinator declines negatively impact people's livelihoods and health, as crop yields decrease, and key micronutrients found in pollinator-dependent crops are lost from their diet.

4.11. Contemporary Issues of Horticulture Extension

To meet the overall challenges in the horticultural sector, agricultural extension and advisory services in South Asia have followed an evolutionary process of experimentation with the components of several recognized extension approaches. The key characteristics of extension include governance structures, capacity, management, and advisory methods (Joshi & Babu, 2019). There are several forms of extension service delivery systems in South Asia.

Public agricultural extension system is the dominant extension system in South-Asia. The extension system is decentralized with varying degrees of decentralization of power, resource and control. India has the highest number of agriculture extension staffs (90000) followed by Bangladesh (14035), and Pakistan (9749). Private sector extension also plays significant role in the transfer of new information such as variety, breed, agricultural practices and mechanization. The private sector agricultural extension services are being provided by the NGOs, private companies, and individual consultants. Increased involvement of private sector is continuously replacing the dominance of public extension system in South Asia.

Rising population pressures, growing and changing demand for fruit and vegetables products, increasing resource scarcity, intensifying climate change, and rising production uncertainties are some challenges noted in South Asian context (Davis et al., 2018). In addition to that public extension workers are accused to have less contact with farmers and more involved in administrative work such as subsidy provisioning rather than technical support to the farmers. Reaching youth and women is also one of the major challenges of extension systems in South Asian countries. Some other challenges are offering new technology available in market and services, ensuring the quality of services, and strengthening collaboration and synergy among extension service providers (Sulaiman & Davis, 2012). Fast changing technologies demand for effective extension and many new sectors in horticulture such as post-harvest technologies, food processing and food safety, plastic house, green house, emerging crops, urban and roof-top farming are still new to farmers, where horticulture extension has a great scope.

To increase the efficiency of the agricultural extension system, it is necessary to shift its narrow, top-down approach to a wider, bottom-up system with greater beneficiary participation and also to strengthen the institutional base needed to sustain the new system. A large number and variety of reforms have already been put in place worldwide. Developing countries of South Asia can learn from the successful experiences of different extension approaches like cost-sharing approach, privatization of extension services, and pluralistic approach of extension delivery services.

4.12. Post-harvest Management of Fruits and Vegetables

Postharvest technology implies the protection, processing, packaging, distribution, marketing, and utilization of a product after harvest to meet the food and nutritional requirements of the population (Faqeerzada et al., 2018). Post-harvest management is one of the critical issues in fruit and vegetable production. About 20-44% of postharvest losses are due to a lack of pre and postharvest technologies primarily because of improper handling, transportation, packaging, and storage facilities. Primarily, farmers do not have proper knowledge ~~r~~ on the harvesting stage of the horticultural commodities and post-harvest handling techniques. Apple farmers are facing the bruising of apples as the main problem due to a lack of appropriate tools for harvesting and packaging (Shahi, 2005). Infrastructure for grading and packaging facilities , cold chain management, storage, and transportation is lacking in the country. The apple produced in Nepal has a poor physical appearance with no grading facilities (Atreya & Kafle, 2018). The present packaging system still depends on the traditional forms of packages such as bamboo baskets (Doko) and gunny sacks. In banana, the post-harvest loss is found to be about 10-15%. Poor post-harvest handling such as no cleaning and packaging is observed in banana farming (Joshi et al., 2020). Most produce is transported in non-refrigerated trucks and very little information is available on the actual loss of produce during transportation. In Jumla, the only way to transport apples is through the airway which makes the price of apples higher than that of the imported apple (Partap & Partap, 2002). There are only 35 cold storages in the country with an average capacity of 3,000 mt each. Also, the available cold storage is not accessible to the farmer due to its high cost for storage. Processing is done very rarely while only imported canned and soup powders are mostly available in supermarkets. Incidences of insects and diseases are also another major problem seen in post-harvest management. Anthracnose disease (*Colletotrichum gloeosporioides)* is the most critical disease that causes damage at the vegetative stage, fruiting stage, and storage condition (Ministry of Agriculture, 2015).

Beside the above challenges, there are opportunities as well. Complex and fragmented marketing systems reflect the need of post-harvest technology. Low-cost technologies through precise research efforts has the potential to prevent huge losses and help to meet the ever-increasing demand for food in South Asian Countries. Low cost evaporative cool chambers are developed at various research institutions like zero energy cool chamber. Different types of driers developed at various research institutes include: solar cabinet dryer for vegetables, waste fired dry er, and cardamom dryer. The Government of Nepal is also giving the priority on post-harvest management while 25% governmental subsidy has popularized for the plastic crates. Some commercial farmers in the region are slowly adopting recent technologies for reducing postharvest losses and production costs using harvest machinery and improved packaging. Intensive emphasis is required to develop the advanced postharvest technologies for improving global food security. Temperature management during transportation of fresh fruits and vegetables over long distances is critical.

Produce waste must be reduced to avoid wasting the natural resources that were used to produce the crop, including land, water, and energy, as well as its impact on GHG emissions. Our strategy to reduce produce loss and waste after harvest will be to connect agribusinesses to a range of buyers using a Participatory Market Chain Assessment, and empower these businesses to adopt improved postharvest practices, including better packaging, cooling, sorting, grading, and transportation systems. Businesses with access to markets are incentivized to invest in improved practices. In each region we will work in, we will assess key horticulture value chains to determine successful and promising agribusinesses to work with, and understand their challenges and opportunities. The capacity of these businesses to successfully handle and market horticultural crops will be enhanced through project activities to reduce loss and waste.

Table 10: Post-harvest handling operations practiced in fruits

Fruit	Existing post-harvest handling practices	Additional post-harvest handling practices for promotion
Mango	Sorting, grading, cleaning	De-sapping, packaging, labeling
Banana	Sorting, grading,	Packaging, cleaning and labeling
Kiwi	Sorting, grading, cleaning	Proper packaging and labeling
Citrus	Grading, cleaning	Waxing,, packaging, labeling
Apple	Sorting and grading	Packaging,, waxing, packaging, labeling
Dragon fruit	Sorting and grading	Grading, cleaning, trimming, packaging, labeling

Table 11: Post-harvest handling operations practiced in vegetables

Vegetable	Existing post-harvest handling practices	Required post-harvest handling
Potato	Grading, cleaning, packaging	Curing, labeling
Cauliflower	Sorting, trimming	Packaging
Leafy vegetables	Sorting, cleaning	Trimming, packaging
Tomato	Grading, cleaning, packaging	Proper packaging, labeling
Chilly/Sweet Pepper	Grading, cleaning, packaging	Proper packaging, labeling
Cucumber	Grading, cleaning, packaging	Proper packaging, labeling
Cowpea	Cleaning, packaging	Proper packaging, labeling
Bitter gourd	Grading, cleaning	Packaging , labeling

Challenges and opportunities in post-harvest handling and value addition

Challenges

- Transportation without proper packaging, trimming, cleaning, curing, grading
- Inadequate transportation means for reducing post-harvest losses
- Absence of individual packaging during transportation
- Lack of pack-house facility for postharvest handling operations
- Limited cold storage facilities nearby farms

Opportunities

- Value addition of the horticultural commodities
- Export potential of high-value commodities
- Availability of products in the off-season
- Employment creation in post-harvest handling and value addition
- Government subsidies for the promotion of postharvest handling operations

4.13. Challenges and Opportunities of Organic Horticulture

In the present context, South Asian countries are still struggling to meet the food demands of a growing population. This has resulted in intensive use of chemical fertilizers and pesticides to control insects, weeds and diseases and maintain crop yield (Schreinemachers et al., 2017; Wang et al., 2017). In view of growing awareness of health and environment issues, organic farming mainly in vegetables is gaining momentum across the world. Studies also suggest a growing trend among urban consumers to have higher willingness to pay for organic products from places where they could get an assurance about the quality of the products (Aryal et al., 2009; Bhatta et al., 2009). To catch the demand of consumers, organic cultivation has been started in parts of South Asian countries. Bhutan has been declared an organic nation by 2022, Sikkim and few other places in India have been pesticide free. In Nepal, Jumla is declared an organic district in 2009 and Karnali province is declared an organic province in 2019, and several places in South Asia are by default organic due to lack of access to chemical pesticides. At present, some organic products such as coffee, tea, honey, large cardamom, ginger etc. are exported to the international market from Nepal. In global context, despite the higher cost, the demand for organically grown foods has been increasing. Local farmers knowingly or unknowingly practice organic agriculture and have invented various organic techniques but are not acknowledged for their contribution. Nepalese organic products reach the standard for the Nepalese market but competing with the international market is too difficult for them. Furthermore, because of the complicated and expensive certification process, marketing organic products in the international market is still a huge limitation. Due to the lack of accredited laboratory facilities , several cases of return of the certified organic products (honey) had been seen in the recent past as well. Poor Research and Extension System in organic cultivation, lack of alternative technologies and inputs, lack of human resources are major challenges in Organic Agriculture. There are limited and scattered researches on organic farming, which are not properly documented and thus repeated on the limited issues.

Great possibility of organic farming exists because many places are still organic in nature and yet to be not reached by modern technologies and chemical fertilizers. Also, there is increasing awareness among consumers about risks of pesticide residues thus increasing the demand for organic fruits and vegetables in domestic as well as global markets . To promote Organic Agriculture in South Asia, production pockets and commodities can be categorized as red, yellow and green zones. Integrating Organic Agriculture in the education system from school to university course can support in increasing human resources and Organic Agriculture entrepreneurship.

Vegetables mainly produced organically

- Chilly, radish, beet root, carrot, cabbage, broccoli, sponge gourd, bitter gourd, bottle gourd, leafy vegetables, ginger, garlic, onion

Challenges in organic production

- Quality and FYM/Compost management for plant nutrient management
- Less price premium for organic products
- Difficulty in the management of disease and pests
- Problems for certification system of organic products for effective implementation of organic certification system

Opportunities for organic production

- High price premium if certification works properly
- Potentiality for export of the horticultural products
- Focus of the government and projects in the specific areas
- Health benefits and eco-friendly

4.14. Challenges and Opportunities in the Promotion of Protected Horticulture

South Asia has varying agro-ecological conditions ranging from tropical to temperate that allow the successful cultivation of different crops and cultivars of fruits and vegetables (Shahi, 2016). Climate change harms open-field farming in this region. Protected cultivation could be an alternative to open field cultivation because the effect of climate can be minimized as the environment is controlled. Protected cultivation is a process of growing crops where temperature, humidity, light and other such factors can be regulated partially or fully as per the requirement of the crop. The inputs such as fertilizers, pesticides, and water are utilized more efficiently and improve productivity with better quality, which ensures higher returns to the farmers. There are various forms of protected cultivation practices in South Asia, which provide a better growing environment than the open field to increase the quantity, quality, and off-season production of vegetables, fruits, and ornamentals. Greenhouse, naturally ventilated poly-house, net house, shade net-house, plastic tunnel, mulching, and drip irrigation are commonly used protected practices in this region. These practices can be used independently or in combination to provide a favorable growing environment to save plants from harsh climates and extend the duration of cultivation or off-season crop production.

In Nepal, Protected horticulture was started by Lumle Agriculture Research Centre for research proposed around the 1990s, whereas commercialization was started in 2000s with hotbed and low plastic tunnels (Atreya et al., 2019). In the last two and half decades, the area under protected cultivation in South Asia has increased exponentially. During the last five years, naturally ventilated permanent structures have increased by 10-20% annually due to subsidy provisions. Now GI tunnels, net-houses, naturally ventilated plastic houses, and hi-tech and semi hi-tech greenhouses are adopted. However, a low-tech bamboo plastic tunnel is popular among small and medium farmers due to its higher B:C ratio. Protected cultivation enhances the productivity and quality of horticultural crops by managing the biotic and abiotic stresses.

Technology-based production practices are critical for agricultural growth and sustainable development in low-income countries like Nepal. In the last few years, commercial cultivation of fruit, vegetables in high-tech tunnel houses has been increasingly promoted as tools to enhance smallholder farmers' livelihood and tackle climate adversaries (KC et al., 2021).

a) Challenges for the promotion of protected Horticulture

- Environmental Challenges: Highly erratic weather conditions demand higher care and better management of crops, which increases the cost of production. The occurrence of pest and diseases sometimes exceed inside the protected structure because of favorable climatic conditions such as high moisture and high temperature. Low crop rotation is due to lower crop choice for protected farming, which leads to higher risk of crop pests, especially soil-borne diseases and nematode. Moreover, post-maintenance and cleaning service are weak, and the roof is covered with algae that reduce sunlight inside the structure resulting in lower crop yield and quality. Damage to protected structures due to the heavy storm is also seen in many parts of the region.
- Technical challenges: Production of crops under a protected structure is knowledge and skill intensive. However, extension workers, agriculture technicians' structure designers and structure installers, and farmers lack scientific knowledge of protected cultivation. Farmers find it difficult to get technical guidance and relevant information on crop production under protected structures in their local language. No specific breeding work has been done to develop suitable varieties for protected cultivation, even in popular vegetables e.g. tomato, sweet pepper, eggplant, and cucumber. Available varieties also show poor performance due to a lack of pollinators.
- Economic challenges: Protected cultivation is beyond the reach of small and medium farmers because it is required a high initial cost to establish a protected structure. The high cost and unavailability of planting material, water-soluble fertilizers, and plant protection chemicals is one of the major challenges of protected cultivation. The loan procedure is complex and loan is not timely available from financial institutions to the farmers. Farmers have to pay a high import tax for plastic, net, and GI pipe that are used in the protected structure.
- Policy-related challenges: There is a lack of site-specific designs for protected structures; therefore the same design is used in all climatic zones. Only a 50% subsidy is available from most of the Government programs, which is not suitable for small farmers. The subsidy policy is focused only on the structure without technical help, and repair and maintenance of the structure. Farmers have faced the problems of insurance schemes for both structure and crops. Although the Government has come up with several policies/plans/programs and directives, however, the above-mentioned points are not included well in the policy, implementation, and monitoring arrangement. Moreover, water-soluble fertilizer is the most effective way to feed crops via drip irrigation system but there

is no provision for importing total water-soluble fertilizers. Therefore, farmers are using illegally imported fertilizers and other growth promoters and pay higher prices despite the quality.

- Human resource-related challenges: Only very few protected horticulture experts, researchers, and technicians are available and they are beyond the reach of small and medium farmers. Trained/skilled laborers are not easily available, if available they are expensive, therefore farmers are unable to get them. There are not sufficient skilled workers available in the market. Most of the labor forces are going for foreign employment, therefore non-skilled labors are scarce during peak seasons. This is hindering the speed of development of protected cultivation.
- Marketing challenges: Limited market, consumers unaware about quality, porous border, lack of production planning and market information, weak post-harvest handling, lack of competitiveness (small-scale low production, traditional technology).

b. Opportunities for the promotion of protected Horticulture

- High income: The crop productivity increased up to 5 to 8 times in the protected cultivation due to the increased harvesting length of the crops. Plants can be grown anywhere in any season, which insure more fresh vegetables are available year-round. Off-season or early production can be obtained from protected cultivation, which gives higher income to the farmers. Reduces labor need due to less inter-cultural operation and easy management.
- Healthier products: Pesticide use reduces up to 90% to protect the crop from pests, which results in low pesticide residue in the products. Uniform and better quality of a product can be obtained due to better growing environment.
- Efficient use of inputs: In protected cultivation, fertilizer use efficiency increases by 30%, and water requirement is reduced up to 50%.
- More young and educated growers are getting involved in protected cultivation.

c) Way forward for the promotion of protected Horticulture

Need for a separate protected horticulture development unit. Need for research to develop suitable varieties for protected structure or register high yielding imported varieties in a fast track. Need for research and development in fertigation formulation and subsidy in water-soluble fertilizer. Needs a strong monitoring and evaluation mechanism for quality control of materials. Reduce tax on materials used in protected horticulture with the recommendation of related authorities. Focus on skilled human resources development under research, education, and extension for technology generation and dissemination. Revision of the course curriculum of agricultural institutions to meet the current demand for knowledge. Development of a learning center on protected cultivation for technology development, demonstration training, and extension. The loan procedure should be easy, where zero-interest loans should be provided to small and medium farmers and soft loans for big farmers. The subsidy scheme should be based on output and it needs to increase up to 90%, especially for small farmers. The repair and maintenance of the structure should be included in the policy before construction. A detailed economic analysis is recommended for protected cultivation in different types of structures. Insurance schemes for structure and crops should be easy and farmers-friendly. Technical support should be included in subsidy programs because structures demand technologies in all dimensions, thus research and training should be on varietal screening, agronomic practices, nursery raising, fertigation formulation, and repairs and maintenance of the structures. The researchers should focus their studies on the development of low-cost designs and equipment for protected technology, the development, and multiplication of quality planting materials, and low-cost post-harvest operations to reduce losses, which are the research priorities to be addressed by research institutes. Moreover, research and development initiatives should aim to reduce the cost of installation of protected structures and the cost of cultivation. The success of the adoption of protected technology also depends on how well the farmers integrate this technology on their farms to suit their socio-economic and agro-ecological conditions. Favorable policy measures such as expanding the scope and amount of subsidy, provision of quality planting material and inputs at affordable prices, investment in infrastructure and pricing policy would enhance the profitability and sustainability along with increasing the adoption of protected cultivation.

Practices in protected Horticulture: Plastic house, net house, plastic tunnel

Crops/varieties suitable/preferred: Tomato, chilly, sweet pepper

Challenges in adoption of the practice

- High investment cost
- Inadequate know-how of specific crops for protected practice

Opportunities for the promotion of the practice

- Higher crop productivity
- Possible for off-season production
- External support to farmers for the adoption of practice

4.15. Challenges and Opportunities of ICT in Horticulture Sector Development

ICT is an umbrella term used to denote the communication and information technologies such as newspaper, radio, television, cell phone, computers, satellite technology; internet (email, messaging, video conferencing and Facebook and other social media apps). ICTs provide access to standard information and are applied for processing, exchanging and managing data, information and knowledge across wider audience in a very short span of time.

In the present scenario where the ratio of extension workers to farmers is extremely low and poor extension advisory services are accused for slow development of the agriculture system in Nepal and other South Asian countries, ICTs widen the reach of local communities including women and youth, and provide newer business opportunities thereby enhancing the livelihoods. It is also used in providing actionable information on disaster prevention in real-time. ICTs bridge the gap between researchers, extension agents and farmers. They can be used in fast and accurate information management, farm management and database management. They have the potential to be used in market information and management, post-harvest tracking, and demand and supply tracking for promotion of agribusiness and its marketing. In addition, they also help to increase access to financial services for local communities, helping to secure savings, find affordable insurance and tools to better manage the risk.

Despite huge potential to be used in agricultural improvement, ICTs are still not in practice in horticulture extension in Nepal, due to the high initial cost, and lack of access and skills. Also, relevance in content and use of local language are barriers for adoption of ICT based agro-advisory services (Munyua, 2007). Moreover, absent farm records, low farmer literacy, software malfunction, and insufficient technical support are some challenges faced in using the technology (Tata & McNamara, 2018). Other challenges associated with ICTs also include the requirement of smart mobile, computer or television, internet for which rural farmers, women and elderly do not have access to these technologies in Nepal. In addition, inadequate human resources and lack of skills and training provided about ICT to agriculture extension officers also pose some difficulties for the application of these technologies. Therefore, for the updated, scientific and commercial horticulture, establishment and proper maintenance of agriculture information centers in each local level, skill development training to staff and awareness about ICTs to farmers, and promotion of e-agriculture by government can be probable steps.

4.16. Challenges and Opportunities of Biotechnological Improvement in Horticulture

Biotechnology is a rapidly growing field that proffers both Innovation and technology. In South Asia, three sectors of biotechnology are focused on horticulture viz. micro-propagation, molecular markers and genetic engineering. Among them, micro-propagation is the one that is extensively adopted in Nepal. National potato research program is focused on micro-propagation of potato, National citrus research program on citrus, National Biotechnology research division of NARC on sugarcane, Agriculture Research Station, Dhankuta for cardamom. Tribhuvan University, Kathmandu University, and AFU are the major institutions conducting tissue culture in Nepal. In Bangladesh, much advanced technologies are being used at research level and farmers level as well. BARI, some NGOs, and research organizations are carrying out several programs related to biotechnology. Molecular markers have been used for the diversity analysis of several crops such as wheat (Khadka et al, 2020), rice (Sharma et al., 2003), maize (Gurung et al., 2011). Mainly simple sequence markers (SSRs) and randomly amplified polymorphic DNA (RAPD) markers have been used in Nepal. However, research on genetic engineering or recombinant DNA technology is not started in Nepal. GMOs are still in debate yet Nepal is conditionally allowed to import GM soybean, corn and canola for animal feed purposes only on (Plant Quarantine and Pesticide Management Centre, 2021).

Major challenges related to biotechnology in South Asia are lack of funding for research, poor infrastructure for laboratories, expensive reagents and equipment, lack of maintenance of those equipment, etc. Government policies are not stable for GM, and lack of attention from the public sector is seen for biotechnological improvements of horticultural crops.

Biotechnological advancements have huge potential to increase the productivity of horticultural crops in South Asia. Management of insect pests and diseases with the highest injury level can be possible by genetic engineering in the most effective way. Using efficient and cost-effective micro-propagation technologies such as using somatic embryogenesis, using bioreactors, using liquid medium culture can be a huge progress in the production of commercial fruits and vegetables. DNA barcoding for indigenous varieties, development of climate resilient varieties, development of quality rootstocks for vegetative propagation etc. are the crucial trail to improved horticulture in South Asia.

4.17. Challenges and Opportunities of Farm Mechanization in Horticulture Sector

Farm mechanization is the application of engineering principles and technology in agricultural production, storage, and processing on the farm. Among the South Asian countries, the level of farm mechanization is the highest in India when compared because of machinery used in multiple farm operations and farm machinery production in the country. In Bangladesh, farm machinery is mostly used for land preparation (80%) and threshing (>80%), while other farm operations such as planting and harvesting are usually performed manually. The Southeast Asian agriculture equipment market by revenue is expected to reach approximately USD 13 billion by 2028.

However, there are many challenges in farm mechanization in the horticulture sector in the South Asia region. Most of the South Asian farmers are not economically sound to afford the cost of tractors and farm implements leading to subsistence farming. Even if they use such mechanization tools, the facilities or machinery for fabricating and repairing farm implements are grossly insufficient. The primary challenge in the adaptation of farm mechanization are fragmented land and varying topography that hinders the use of mechanization on a large scale. In addition, the topography of most countries' landscapes is too rough and unconducive for farm mechanization. Further, the soil types are extremely varied and the similar types cannot be used in all soil types. Another major problem is the unavailable technical manpower to operate or service the implements and machines. New farm mechanization tools are imported in Nepal but there is no proper knowledge among farmers about the scientific way of their use. And, even there is lack of proper training and policy to promote agri-machineries manufacturer

Along with challenges, there are opportunities in the farm mechanization of the fruit and vegetable sector. The farm mechanization improved labor and agricultural productivity, reduced the cost of production, increased commercialization of agriculture, enhanced climate change mitigation through reduced greenhouse gas emissions from agriculture, etc. The increment in the shortage of farm labor and rise in wages of labor has caused the crucial need for augmentation in farm mechanization in developing countries. The pandemic has triggered labor shortage issues in countries such as Malaysia, Vietnam, and Thailand engendering the need for farm mechanization in the sorting and grading of horticultural crops. The labor shortage issues push demand for digitalization and automation in agriculture equipment. The demand for auto steering, and artificial intelligence is increasing in agriculture equipment such as sprayers and farm tractors. Drones-based disease surveillance using image processing and aerial precision plant protection measures in orchards. Furthermore, the government is also prioritizing the area of farm mechanization by providing subsidies for the farm mechanization tools such as tractors, power tillers, sprayers, transplanters, tractors, etc. which is encouraging farmers to adopt mechanization in the horticulture sector.

Considering a small farm size, fragmented land holdings, and difficult terrain of hills and mountains, the promotion of small-scale machinery is most suited for this region. In order to promote farm mechanization, there is a need to develop and strengthen institutional and human resource development in farm mechanization at all levels (national, sub-national & local level) and ecological and development regions. The government needs to make provisions for appropriate policies and regulations on mechanization, preferential treatment on capital machinery importation and multiple value-added taxes on imported raw materials. Tax and subsidy rationalization is needed to promote use of farm machinery without distorting the market and making it compatible with private traders' incentives.

Problems of farmers in the adoption of improved technologies

- Less technical know-how and skills for adoption
- Limited investment capacity (capital shortage)
- Limited access to adequate extension services and technical support
- Low infrastructure facility
- Unavailability of required inputs in time
- Felt high risk in the technology adoption
- Insufficient location-specific technology testing and validation
- High cost of machinery and operations

4.18. Priority Research Areas in Fruit Sub-sector in South Asia

Based on the above challenges and opportunities, following topics are the possible research areas in fruits:

- Productivity increase through
    - Varietal testing and validation (i.e., varieties of avocado and kiwi)
    - High density planting in apple, citrus, mango, banana, guava.
    - Management of serious disease and pests (i.e., citrus decline, Fruit fly, Citrus wilt, panama wilt and weevil of banana)
    - Management against physiological disorder including fruit drop, alternate bearing and malformation in mango
    - Nutrition and pollination management in fruit orchard

- Domestication and commercialization of indgenous fruit species
- Suitable post-harvest technologies and handling operations associated costs and benefits
- Extension based farm management and marketing advisory

4.19. Priority Research Areas in Vegetables Sub-sector in South Asia

- Production and promotion of indigenous vegetables (Akabare chilly, Asparagus, Chenopodium and beet root)
- Identification of short duration high yielding varieties of garlic and onion
- Seed multiplication and promotion of cauliflower (Kathmandu Local and Amazing)
- Post-harvest technology and handling operations of (Garlic, onion, potato, tomato, chilly)
- Integrated plant nutrient management (IPNM) in tomato, chilly, sweet pepper, cauliflower and cucumber
- IPM and disease management in toamto, chilly, sweet pepper, brinjal and cucurbits
- Protected horticultural technologies in tomato, sweet pepper, chilly, F1 cucurbits
- Grafting of vegetables (i.e., tomatoes)

5. Conclusion and Way Forward

The field study, including the workshop, has identified many areas that are crucial for the development of the horticulture sector focused on fruits and vegetables in South Asia with a special emphasis on Bangladesh and Nepal. Based on the above challenges and seeking opportunities in the fruits and vegetable sub-sectors, following topic are the possible research areas in South Asia:

- High density planting in apple, walnut, mango, avocado, kiwi etc: The practice of planting maximum number of plants per unit area from grafted saplings to get maximum yield per unit area without impairing the soil fertility is called high density planting. It fruits early and makes the orchard easy to manage. In HDP, the dwarf varieties of saplings are planted at close distances, which are pruned at regular intervals during the early stages of development to keep the size dwarf and the canopy small. It allows better air circulation, sunlight penetration, easier pruning and pesticide management which results in higher productivity at a lower cost.
- Post-harvest management in fruits and vegetables: Post-harvest loss in fruits and vegetables has been pronounced to be significant in both fruits and vegetables. Hence, research in the following specific areas are essential for the optimization and utilization of the harvest:
    - Cold chain technology for reducing the wastage and quality loss of fruits and vegetables
    - Handling techniques for minimizing the wastage and quality loss of fruits and vegetables
    - Improve knowledge on maturity indices, harvesting, grading, packaging, waxing, transportation and chemical treatment for extending the shelf-life of fruits and vegetables
    - Storage and loss assessment for reducing the microbial loads and extending shelf-life of fruits and vegetables
    - Pre-harvest hormone application for the extending shelf life of the fruits and vegetables.
- Disease, pest and physiological disorder management in major fruits:
    - Citrus decline in citrus
    - Fruitfly in major fruits
    - Alternate bearing in mango

- Soil tests and integrated plant nutrient management (IPNM)
- Disease and pest management in vegetable crops
- Quality hybrid and OP variety development, testing and validation
- Development of climate resilience variety using biotechnological approach

- Development of biotic and abiotic stress tolerant varieties
- Processing of vegetables and value additions
- Promotion of protected horticultural technologies for year-round high value vegetables
- Grafting in vegetable crops (i.e., tomatoes)
- Promotion and marketing of major indigenous vegetables
- Postharvest technology and storage of vegetable crops
- Safe and organic vegetable production technology
- Model-based quality vegetable production: Hydroponics and rooftop gardening, home gardening etc.

Based on the above challenges in the fruit sub-sectors, following topic are the possible research areas in South Asia:

- High density planting in apple, walnut, mango, citrus, kiwi
- Disease and pest management in fruits
- Varietal testing and validation of fruits
- Postharvest management and storage of fruits
- Fruits processing and value addition in fruits
- Alternate bearing and malformation of mango
- Plant propagation and production of planting materials
- Certification of quality planting materials
- Use of good agricultural practices (GAP) for fruit production
- Strengthening high planting density on promising exotic fruits like apple, pomegranate, mango and orange
- Promotion marketing of underutilized indigenous fruits
- Strengthening research on variety development through traditional and speed breeding approaches
- Development of climate resilience variety using biotechnological approach

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7. Appendices

Annex 1: List of stakeholders consulted

SN	Name of official	Position and Organization
1	Prof. Dr. Punya Prasad Regmi	Vice Chancellor, AFU
2	Prof. Dr. Sharada Thapaliya	Registrar, AFU
3	Prof. Jay Prakash Dutta	Dean, Agriculture and Forestry University (AFU)
4	Dr. Govinda Prasad Sharma	Secretary, Ministry of Agriculture and Livestock Development (MOALD)
5	Dr. Rewati Raman Poudel	Director General, Department of Agriculture,
6	Dr. Hasta Bahadur Bista	Chief, Meeting with Prime Minister Agriculture Modernization Project (PMAMP), Fruits zone, super zone
7	Dr Surendra Kumar Shrestha	Horticulture Research Division, Chief – Nepal Agriculture Research Council (NARC), Khumaltar
8	Mr. Dr. Rajendra Koirala	Chief, National Center for Potato, Vegetable and Spice crop Development
9	Mr. Basudev Kaphle	Chief, National Centre for Fruits development
10	Dr Deepak Bhandari	Executive Director, NARC, Khumaltar
11	Dr. Chandra Risal	Program Chief, Rural enterprise and economic development (REED) project
12	Mr. Purusottam Khatiwada	Horticulture Expert, Value Chain Development of Fruits and Vegetables Project (VCDP)
13	Mr. Gopal Prasad Shrestha	Chairman, Nepal Horticulture Society
14	Dr. Dilli Ram Sharma	Chief, Plant Protection Society

15	Dr Rajendra Mishra	Joint Secretary, MoALD
16	Prof. Bhargav Dhital	Meeting with Dean-Agriculture of Tribhuvan University

Annex 2: Regional Horticulture Workshop Participants (In person and Virtual)

SN	Name	Gender	Participation	Designation, Organization
1	Prof. Dr. Punya Prasad Regmi	M	Chief Guest	Vice Chancellor, AFU
2	Dr. Hom Nath Giri	M	Presenter/Working Team	Assistant Professor, Head of Department (Horticulture), AFU
3	Dr. Sundar Tiwari	M	Presenter	Assistant Professor, Department of Entomology, AFU
4	Dr. Ujjal Tiwari	M	Presenter/Working Team	Assistant Professor, Department of Agricultural Economics & Agribusiness Management, AFU
5	Mr. Bishal Shrestha	M	Working Team	Assistant Professor, Department of Horticulture, AFU
6	Mr. Ram Hari Timilsina	M	Presenter/Working Team	Assistant Professor, Agricultural Extension and Rural Sociology, AFU
7	Mr. Umanath Sharma	M	Presenter	Assistant Professor, Center of Biotechnology, AFU
8	Ms. Anju Adhikari	F	Surveyor, Rapporteur	Assistant Professor, Department of Horticulture, AFU
9	Prof. Dr. Durga Devkota	F	Presenter/Working Team	Professor, Department for Rural Sociology and Development Studies, AFU
10	Prof. Dr. Kalyani Mishra Tripathi	F	Presenter/Special Guest	Chairman, AFU Service Commision
11	Prof. Jay Prakash Dutta	M	Special Guest	Dean, AFU
12	Dr. Shanker Raj Barsila	M	Presenter/Working Team	Assistant Professor, Animal Nutrition and Fodder Production, AFU

SN	Name	Gender	Participation	Designation, Organization
13	Dr. Surya Kant Ghimire	M	Special Guest	Chartered Registrar, AFU
14	Prof. Dr. Arjun Kumar Shrestha	M	Technical Lead/Presenter	Director, DOREX and Technical Lead of Horticulture Innovation Lab project in Nepal, AFU
15	Dr. Kalika Prasad Upadhyay	M	Participant	Sr. Scientist, Agriculture Research Station, Lumle
16	Dr. Krishna Paudel	M	Participant	Scientist, Agriculture Research Station, Pakhribas
17	Ms. Morzina Begim	F	Participant	Input Supplier, Bangladesh Agricultural Research Institute (BARI)
18	Dr. Ferdouse Islam	F	Presenter	Representative, Bangladesh Agricultural Research Institute (BARI)
19	Prof. Dr. Tamanna Haque	F	Working Team	Professor, Bangladesh Agricultural University (BAU)
20	Prof Dr. MD Rezaul Karim	M	Presenter/Working Team	Professor, Bangladesh Agricultural University (BAU)
21	Ms. Mst Nurunnaher Begum	F	Participant	Farmer Representative, Bangladesh
22	Mr. Arjun Silwal	M	Participant	Board representative committee member, Fruits and Vegetable Traders Association
23	Prof. Dr. Naba Raj Devkota	M	Special Guest	Vice Chancellor, Gandaki University
24	Ms. Rekha Shrestha	F	Reporter	Reporter, Halo Khabar
25	Dr. Hari Krishna Panta	M	Participant	Associate Professor, Agricultural Economics, IAAS, TU
26	Dr. Puspa Raj Paudel	M	Participant	Assistant Professor, Department of Horticulture, IAAS, TU
27	Mr. Laxman Dangol	M	Media	Cameraman, Image TV
28	Dr. Umesh Acharya	M	Participant	Sr. Scientist, National Citrus Research Program

SN	Name	Gender	Participation	Designation, Organization
29	Dr. Narayan Khanal	M	Presenter	Agriculture Economist, International Maize and Wheat Improvement Center
30	Mr. Manoj Dhital	M	Participant	Deputy Director, Kalimati Fruits and Vegetable Market Development Board
31	Dr. Santosh Shrestha	M	Participant	Sr. Program Manager, LIBIRD
32	Ms. Pramila Wagle	F	Working Team	Horticulture Officer, MoALD (DOA)
33	Dr. Shanta Karki	F	Presenter	DDG, MoALD (DOA)
34	Ms. Riti Singh	F	Participant	Sr. Horticulture Development Officer, MoALD (DOA)
35	Dr. Ranjana Rawal	F	Working Team/MC	Scientist, NARC
36	Dr. Bal Krishna Joshi	M	Presenter	Chief, NARC
37	Dr. Giridhari Subedi	M	Participant	Head, NPRP, NARC
38	Mr. Bashu Dev Kafle	M	Special Guest	Chief, National Center for Potato, Vegetable and Spice Crops Development
39	Mr. Rajendra Prasad Koirala	M	Special Guest	Chief, National Centre for Fruit Development
40	Ms. Rita Bastakoti	F	Participant	General secretary, Nepal Farmers Group Federation
41	Mr. Gopal Prasad Shrestha	M	Participant	Chairperson, Nepal Horticulture Society
42	Mr. Sanjay Dhimal	M	Participant	Executive Committee Member, Nepal Horticulture Society
43	Mr. Ram Bahadur KC	M	Participant	Vice-President, Nepal Horticulture Society
44	Mr. Hasta Bahadur Bista	M	Special Guest	Chief, PMAMP
45	Mr. Hikmat Kumar Shrestha	M	Participant	Sr. Agriculture Development Officer - PMAMP, Khumaltar
46	Mr. Madhav Lamsal	M	Participant	Sr. Agriculture Development Officer, PMAMP Citrus Zone, Syangja

SN	Name	Gender	Participation	Designation, Organization
47	Mr. Dhan Bahadur Thapa	M	Participant	Sr. Agriculture Development Officer, PMAMP, Vegetable Zone, Chitwan
48	Mr. Nitesh K. Poudel	M	Participant	Tech-Head, R & D innovative Solutions
49	Dr. Ganga Dutta Acharya	M	Working Team	Sr. Program Specialist, SAARC Agriculture Center
50	Dr. Nasreen Sultana	F	Presenter/Working Team	Sr. Program Specialist (Horticulture), SAARC Agriculture Center
51	Mr. Basanta Marahatta	M	Participant	President, Seed Entrepreneurs Association of Nepal (SEAN)
52	Mr. Benu Prasad Prasai	M	Special Guest	Chief, Seed Quality Control Centre
53	Dr. Prakash Acharya	M	Participant	Sr. Cooperative Development Officer, Seed Quality Control Centre
54	Ms. Shriesty Chaudhary	F	Participant	Intern, USAID
55	Mr. Purusottam Khatiwada	M	Participant	Horticulture Specialist, Value Chain Development Program
56	Ms. Bimala Sharma Acharya	F	Participant	Proprieter, Himalaya Organic Garden
57	Mr. Attanu Bhattacharjee	M	Participant	Youth Entrepreneur, Bangladesh
58	Dr. Bhaneshwar Pokhrel	M	Presenter	Youth Entrepreneur, Samriddi Agri-farm
59	Mr. MD Ismail Khan	F	Participant	Youth Entrepreneur, Bangladesh
60	Mr. Shashan Devkota	M	Participant	Youth Entrepreneur, Nepal Agrovines Pvt. Ltd
61	Mr. Anjesh Shrestha	M	Participant	Youth Entrepreneur, Lele, Lalitpur
62	Dr. Kedar Devkota	M	Presenter	Assistant Professor, Agricultural Economics and Agribusiness Management
63	Mr. Rajendra Gautam	M	Participant	MD, Samriddhi Agro Farm
64	Mr. Dinesh Prasad Sapkota	M	Participant	Farm Manager, VCDC
65	Prof. Dr. Bim Prasad Shrestha	M	Presenter	Professor, Department of Mechanical Engineering, KU

SN	Name	Gender	Participation	Designation, Organization
66	Prof. Dr. Arvind Srivastava	M	Special Guest	Professor and Academic Dean, AFU
67	Mr. Bhola Shrestha	M	Presenter	Organic Agriculture Inspector, OCN
68	Swastika Shrestha	F	Presenter	Student, AFU
69	Jason Seuc	M	Special Guest	EG Director, USAID
70	Pujan Bashyal	M	Participant/IT Support	IT Officer, AFU
71	Matina Vaidya Joshi	F	Presenter	Director General, Department of Food Technology and Quality Control
72	Dr. Elizabeth Mitcham	F	Presenter/Special Guest	Director, UC-Davis
73	Dr. Jenelle Beth Larson	F	Special Guest	Associate Professor, Agri economics, Penstate Unversity
74	Dr. Nanda Prakash Joshi	M	Special Guest	Professor, Michigan State University
75	Dr. William Vance Baird	M	Special Guest	Chairperson and Professor, Department of Horticulture, Michigan State University
76	Gi Un Kim	F	Special Guest	Technical Specialist, UNDP
77	Rajendra Mishra	M	Special Guest	Joint Secretary, MoALD
78	Lal Bahadur Chhetri	M	Participant	Assistant Professor, Department of Horticulture, AFU
79	Alexis Ellicot	F	Special Guest	Chief of Party (COP), WI, KISAN II
80	Sujan Piya	M	Special Guest	Program Director, USAID
81	Netra Pratap Sen	M	Organizer	Executive Director, FORWARD Nepal
82	Ram Krishna Neupane	M	Organizer	Program Director, FORWARD Nepal
83	Ram Dayal Tharu	M	Organizer	Admin and Finance Officer, FORWARD Nepal
84	Krishna Prasad Sapkota	M	Organizer	Project Manager, FORWARD Nepal
85	Pramod Gautam	M	Organizer	Project Manager, FORWARD Nepal

SN	Name	Gender	Participation	Designation, Organization
86	Srijana Neupane	F	Organizer	Technical Research Officer, FORWARD Nepal
87	Manisha Shrestha	F	Organizer	Technical Research Officer, FORWARD Nepal
88	Madhav Lamsal	M	Participant	Chief, PMAMP PIU Syangja
89	Smrittee Kala Panta	F	Participant	Youth Entrepreneur
	Virtual Participants			
1	Surendra Shrestha	M	Participant	Senior Scientist, NARC
2	Anjana Sharma	F	Participant	PhD Fellow, Australia and Ex-staff FORWARD Nepal
3	Ferdous Chowdhury	M	Participant	Senior Scientific Officer, BARI Bangladesh
4	Archie Jarman	M	Participant	Operation Manager, Feed the Future Innovation Lab for Horticulture
5	Durga Mani Gautam	M	Participant	Professor, Horticulture, AFU
6	Kaushila Bista	F	Participant	Student, AFU
7	Archana Paudel	F	Participant	Student, AFU
8	Maya Gurung	F	Participant	Student, AFU
9	Banita Sharma	F	Participant	Student, AFU
10	Agrim Dhital	M	Participant	Student, AFU
11	Ramesh Upreti	M	Participant	Student, AFU
12	Ajay DC	M	Participant	Student, AFU
13	Phul Prasad Subedi	M	Participant	Senior Research Officer, Central Queensland University
14	Ram Bahadur Khadka	M	Participant	Scientist, NARC
15	Saroj Thapa	M	Participant	Student, AFU
16	Himalaya Subedi	M	Participant	MS Student in Korea and Ex-Staff FORWARD Nepal
17	Sushil Ghimire	M	Participant	Program Manager, WiltHungerHilfe

SN	Name	Gender	Participation	Designation, Organization
18	Yubaraj Bhusal	M	Participant	Student, AFU
19	Shila bashyal	F	Participant	Student, AFU
20	Pradip Regmi	M	Participant	Student, AFU
21	Jenish Shrestha	M	Participant	Technical Officer, Forward Nepal
22	Yam Shrestha	M	Participant	Student, AFU
23	Umed pun	M	Participant	Horticulture Scientist
24	Sudip Devkota	M	Participant	Student, AFU
25	Bhawana Bhatta	F	Participant	Student, AFU
26	Ganesh Bhattarai	M	Participant	Program Officer, ICIMOD
27	Samyam Pandit	M	Participant	Student, AFU
28	Umesh Timilsina	M	Participant	Student, AFU
29	Ashmita Karki	F	Participant	Student, AFU
30	Arun Khanal	M	Participant	Agriculture Officer, MOALD Bagmati Province
31	Biplov Oli	M	Participant	Student, AFU
32	Pustak Raj Ojha	M	Participant	Development Professional
33	Krishna Dahal	M	Participant	Student, AFU
34	Padma Nath Atreya	M	Participant	Chief, Horticulture Research Station, Mustang, and in a training course in Japan now
35	Pragya Poudel	F	Participant	Student, AFU
36	Tika Ram Chapagain	M	Participant	Student, AFU
37	Dambar Khanal (R &D)	M	Participant	MD, R&D Solutions
38	Arjun Subedi	M	Participant	Student, AFU
39	Kabita Sharma Sapkota	F	Participant	Nursing professional
40	Asmita Pandey	F	Participant	Student, AFU
41	Shambhu Thapa	M	Participant	Student, AFU
42	Subash Neupane	M	Participant	Student, AFU

SN	Name	Gender	Participation	Designation, Organization
43	Sita Devi Kandel	F	Participant	Input Supplier
44	Sabin Khatiwada	M	Participant	Student, AFU
45	Manoj Basnet	M	Participant	Assistant Professor, TU
46	Mamata Oli	F	Participant	VITA project Staff, ADBL
47	Binaya Baral	M	Participant	Student, AFU
48	Yam Kumari Shrestha	F	Participant	Senior Horticulture Officer, DoA
49	Juna Kandel	F	Participant	AFU
50	Manish Sharma	M	Participant	Student, AFU
51	Sanjaya Aryal	M	Participant	Student, AFU

Annex 3: Commodity-wise household survey and focus group discussion (FGD)

District	**Number of Farm HHs (survey)**	**FGD**	
		Number	**Crop focus**
Chitwan	10	3	Banana, vegetables, input suppliers
Dhankuta	10	2	Citrus, avocado
Dolakha	5	1	Kiwi
Jumla		1	Apple
Kailali	10	1	Vegetables
Kaski		2	Vegetables
Kathmandu		2	Nepal Horticulture Society, Plant Protection Society
Kavreplanchok		1	Potato
Mahottari	5		
Saptari	5	2	Riverbed farming, mango
Surkhet	17	2	Vegetables, input suppliers
Total	62	17	

Annex 4: Detail of the focus group discussion (FGD) in Nepal

District	Sub-sector	Location of FGD	Number of participants
Chitwan	Banana	Kalika-7, Khole Simal	9
	Vegetables	Bharatpur-15, Fulbari	13
	Input suppliers	Bharatpur-1, Bishal Marg	3
Dhankuta	Citrus	Sahid Bhumi Rural Munipality, Dhankuta	10
Dolakha	Avocado	Dhankuta Municipality	11
Jumla	Apple	Chandannath Municipality, Khalanga, Jumla	7
Kailali	Vegetable	Tikapur-1, Bangaun	10
Kaski	Vegetable	Pokhara-25, Melbot	9
	Vegetable	Pokhara-33, Bagmara	10
Kathmandu	Nepal Horticulture Society	Kirtipur, Kathmandu	5
	Plant Protection Society	Harisiddi, Lalitpur	5
Saptari	Riverbed Farming	Bhangwa-06, Sangrampur	13
	Mango	Suranga-01, Shreepur	11
Surkhet	Vegetable	Birendranagar-10, Ghusra	13
	Input Supplier	Birendranagar-7, Etram	5
Dolakha	Kiwi	Bhimeshwar-08, Charikot	10
Total	16		

Annex 5: Detail of the focus group discussion (FGD), conducted in Bangladesh

Focus Group Discussion (FGD)				Household Surveys
District	Sub-sector	Location Detail	Number of participants	
Narshingdi	Fresh Vegetables	Shibpur	8	2
	Fruits	Monohardi	7	2
	Mixed (Fruits/Veg.)	Raipura	8	2
Barisal	Fruits/Coconuts	Damura Bazar	10	3
Pirojpur	Fruits/Guava	Atghar Kuriana	10	2
Patuakhali	Vegetables/Sorjan methods	Dalbugonj	10	2
Jalokati	Vegetables/Sorjan method	Raiyapur	10	2
Comilla	Vegetables	Bhabanipur	10	2
Mymensingh	Banana	Muktagacha	10	2
Pabna	Fruits/Litchi	Pabna	10	2
Sylhet	Vegetables	Sylhet	10	2
Gazipur	Fruits	Ulukhola	10	2

Annex 6: List of Key Experts Interviewed in Nepal

Key Informant Interview (KII)			
S. N	**Name of Expert**	**Institution**	**Field of Expertise**
1	Purushottam Khatiwada	Retired Scientist, Nepal Agricultural Research Council	Horticulture
2	Ramchandra Adhikari	Retired Scientist, Nepal Agricultural Research Council	Horticulture
3	Ram Bahadur KC	Retired Scientist, Nepal Agricultural Research Council	Horticulture
4	Surendra Lal Shrestha	Current Scientist, Nepal Agricultural Research Council	Horticulture
5	Tika Chapagain	Current Scientist, Nepal Agricultural Research Council	Horticulture
6	Umesh Acharya	Current Scientist, Nepal Agricultural Research Council	Horticulture
7	Kalyani Mishra Tripathi	Professor, Agriculture and Forestry University	Horticulture
8	Durgamani Gautam	Professor, Agriculture and Forestry University	Horticulture
9	Kiran Bhatt	Assistant Professor, Department of Plant Breeding and Genetics, Far-western University	Plant breeding and genetics
10	Bhagawati Adhikari	President, Shree Fulbari Women Small Farmer Agriculture Cooperative	Cooperative
11	Chandra Prasad Adhikari	President, Organic Agricultural Cooperative	Cooperative
12	Badri Mishra	Banana Farm	Farmer
13	Kalu Hamal	Vegetable Farm	Farmer

14	Jitendra Rai	Phalphul Biruwa Nursery	Farmer
15	Radha Rai	Radha Phalphul Krishi Farm	Farmer
16	Mohan Bahadur Thapa	Retired Senior Horticulture Officer,	Horticulture
17	Babu Kaji Thapa	Deputy General Manager, Agriculture Development Bank	Finance
18	Raja Ram Tiwari	Representative, NAMEA	Agriculture product seller
19	Hari Adhikari	Representative, SEAN	Agriculture product seller
20	Shashan Devkota	Nepal Agrovines Pvt. Ltd	Youth Entrpreneur
21	Bhaneshor Pokhrel	Samriddi Agri-farm	Protected Horticulture
22	Meghnath Shrestha	Agriculture and Forest Conservation Research Center Pvt. Ltd.	Hi-tech fruit and vegetable nursery owner
23	Smriti Sapkota	Dream Work Solution	ICT
24	Rajendra Rayamajhi	Prasiddhi Agro Enterprises	Hi-tech input supplier
25	Bikash Dongol	GeoKrishi	Chairman
26	Harish Neupane	Chitwan	Farmer
27	Uma Pandey	Kavre	Farmer
28	Ramesh Uprety	Vegetable farm (Dhading)	Farmer
29	Kiran Dhakal	Baradi	Market association/committee
30	Ram Badal Sah	Retired Senior Horticulture Officer,	

Annex 7: List of Key Experts Interviewed in Bangladesh

Key Informant Interview (KII) in Bangladesh			
S.N	**Name of Expert**	**Institution**	**Field of Expertise**
1.	Md. Alamgir Hossain	Private entrepreneur	Fruits/Vegetable producer
2.	Md. Zilani	Private entrepreneur	Fruits/Vegetable producer
3.	Dr. AKM Quam	BARI	Horticulture
4.	Md. Anowarul	Private traders	fruits/vegetables
5.	Md. Jahirul Islam	Private trader	inputs supplier
6.	Md. Abdus Satar	Private trader	Vegetable
7.	Md. Ripon Pnamarik	Private trader	inputs supplier
8.	Dr. Md. Samim Hossain Malla	BARI	Horticulture
9.	Md. Salim Ahmad	Private entrepreneur	vegetables/Fruits
10.	Md. Abdul Halim	Private	fruits trader

Annex 8. Schedule for the regional horticulture workshop

Time	Content/Paper	Responsibility
DAY 1, Date: September 12, 2022		
8:30-9:30	Registration	Manisha/Srijana
INAUGURATION CEREMONY		
09:30-10:00	Inauguration Ceremony 1. Chairperson: Honorable Prof. Dr. Punya P. Regmi, Vice Chancellor AFU 2. Chief Guest: Honorable Prof Dr Naba Raj Devkota, VC Gandaki University Nepal 3. Special Guest: Prof. Dr. Kalyani Mishra Tripathi, Chairman, AFU Service Commission 4. Special Guest: Prof. Dr. Elizabeth Mitcham, UC DAVIS Horticulture Innovation Lab 5. Special Guest: Prof Dr Surya Kant Ghimire, Chartered Registrar AFU 6. Special Guest: Prof. Dr. William Vance Baird, MSU Horticulture Department Chair 7. Special Guest: Dr. Janelle Beth Larson, Associate Prof Agri Economics Penn State Berks 8. Prof. Dr. Nanda Joshi, Michigan State University, USA 9. Special Guest: Naveen Hada, USAID Nepal 10. Dr. Deepak Bhandari, Executive Director, NARC 11. Ms Sabnam Shivakoti, Joint Secretary, MoALD 12. Dr. Rajendra Mishra, Joint Secretary, MoALD 13. Dr. Rebati Raman Poudel, Director General, DOA, MoALD 14. Special Guest: Prof Dr. Md Rezaul Karim, Bangladesh Agriculture University, Bangladesh 15. Special Guest: Dr. Ferdouse Islam, Representative, BARI, Bangladesh 16. Special Guest: Prof. Jay Prakash Dutta, Dean, Faculty of Agriculture, AFU 17. Special Guest: Prof. Bhargab Dhital, Dean, IAAS, TU 18. Special Guest: Prof. Dr. Balram Kumar Bhatta, Dean, Faculty of Forestry, AFU	MC: Dr. Ranjana Rawal, Horticulture Scientist, NARC

	19. Special Guest: Prof. Dr. Hom Bahadur Basnet, Dean, Faculty of Animal Science, Veterinary Science and Fisheries, AFU 20. Prof. Dr. Arjun Kumar Shrestha, Director, DOREX and Technical Lead of Horticulture Innovation Lab project in Nepal 21. Prof. Dr. Durga Devkota, AFU, Chairperson, FORWARD Nepal 22. Mr. Netra Pratap Sen, Executive Director of FORWARD Nepal	
10:00-10:15	Welcome Speech	Prof Dr Durga Devkota, Chairperson, FORWARD Nepal
10:15-10:45	Horticulture innovation Lab in global prospective and objectives of the workshop	Dr. Elizabeth Mitcham, Director, Horticulture Innovation Lab
10:45-11:15	Current status of Horticulture in South/ South Asia Region	Prof. Dr. Arjun Technical Lead/AFU
11:15-12:20	1. Remarks from MoALD 2. Remarks from BAU 3. Remarks from BARI 4. Remarks from USAID Nepal 5. Remarks from Executive Director, NARC 6. Remarks from Chief Guest	Dr. Rajendra Mishra Prof. Dr. Md Rezaul Karim Dr Ferdouse Islam USAID Nepal representative Dr. Deepak Bhandari Hon' Minister Devendra Paudel
12:20-12:30	Vote of Thanks	Prof. Jay Prakash Dutta, AFU
12:30-12:45	Closing remarks from Chair	Prof. Dr. Punya Prasad Regmi
12:45-12:55	Group photo	ALL
12:55-13:40	Lunch	
	SESSION I	**Session Chair: Ms Sabnam Shivakoti**
13:40-14:25	Theme 1, 2 and 3 Presentation ● Current status, opportunities, constraints and ways forward for the sustainable growth of the fruit sector in South/South East Asia.	 Dr. Md Rezaul Karim, BAU Bangladesh

	● Current status, opportunities, constraints and ways forward for the promotion of the indigenous fruits and vegetables in South/South East Asia ● Post-harvest management of fruits and vegetables in South/South East Asia	Dr. Balkrishna Joshi/ Dr. Tek P Gotame and Prof. Dr. Arjun K Shrestha Prof. Dr. Kalyani Mishra and Dr. Hom N Giri, AFU
14:25-15:25	Feedback collection and Discussion	Rapporteur: Dr. Krishna Poudel, Dr. Prakash Acharya and Mr Umanath Sharma
	Rapporteur will compile the suggestion, feedback and prepare the report along with Session Chair and submit it to Project manager	
15:25-15:40	**Tea Break**	
Session II		**Session Chair: Dr Nasreen Sultana**
15:40-16:25	Theme 4, 5 and 6 Presentation ● Current status, opportunities, constraints and ways forward for the sustainable growth of the vegetable sector in South/South East Asia ● Current status, prospects and way forward for the promotion of vegetable seed production and fruits saplings in South/South East Asia ● Insect, pest and disease management practices on fruits and vegetables in South/South East Asia	Dr. Ferdousie Islam, BARI Bangladesh Dr. Narayan Khanal, CIMMYT Dr. Sundar Tiwari, AFU
16:25-17:25	Feedback collection and discussion	Rapporteur: Dr. Prakash Acharya, Dhan Thapa & Srijana Neupane
	Rapporteur will compile the suggestion, feedback and prepare the report along with Session Chair and submit it to Project manager	
DAY 2, September 13, 2022		
8:30-09:30	Breakfast and registration	
	SESSION III	**Session Chair: Prof Dr Tamanna Hoque**
09:30-10:15	Theme 7, 8 and 9 Presentation	Dr. Shanta Karki, MOALD

	● Current policy and further policy recommendations for horticulture sector development in South/South East Asia ● Food security and Nutrition of fruits and vegetables in South/South East Asia ● Issues of farm mechanization in fruit and vegetable sector in South/South East Asia	Dr. Ujjal Tiwari and Dr. Homnath Giri, AFU Dr. Shankar Raj Barsila, AFU Prof. Dr. Bim Prasad Shrestha
10:15-11:15	Feedback collection and Discussion	Rapporteur: Umanath Sharma, Madhav Lamsal and Dhan B Thapa
	Rapporteur will compile the suggestion, feedback and prepare the report along with Session Chair and submit it to Project manager	
11:15-11:40	Tea Break	
SESSION IV		**Session Chair: Dr. Rebati Raman Poudel**
11:40-12:25	Theme 10, 11 and 12 Presentation ● GESI and Youth entrepreneurship for production and processing of fruits and vegetables in South/South East Asia ● Biotechnological improvements in fruits and vegetable in South/South East Asia ● Current status, constraints, opportunities and way forward for the promotion of protected horticulture in South/South East Asia	Prof. Dr. Durga Devkota Mr Umanath Sharma, AFU Dr. Bhaneshwor Pokhrel
12:25-13:25	Feedback collection and Discussion	Rapporteur: Anju Adhikari, Srijana Neupane,
	Rapporteur will compile the suggestion, feedback and prepare the report along with Session Chair and submit it to Project manager	
13:25-14:25	Lunch	
SESSION V		**Session Chair: Dr Rajendra Mishra**
14:25-15:10	Innovation Network Survey from Innovation Lab for Horticulture	Dr. Elizabeth Mitcham
15:10-15:55	Theme 13, 14 and 15 Presentation	

	● Innovations in the horticultural sector growth in South/South East Asia ● Effect of climate change and adaptation strategies in fruits and vegetables in South/South East Asia ● Contemporary issues of horticulture extension in South/South East Asia	Dr Nasreen Sultana, SAARC Agriculture Center Mr. Krishna Prasad Sapkota, FORWARD Nepal Mr. Ram Hari Timilsina, AFU
15:55-16:15	Tea Break	
16:15-17:15	Feedback collection and Discussion	Rapporteur: Dr Smritteekala Panta, Pramila Wagle, Bishal Shrestha
	Rapporteur will compile the suggestion, feedback and prepare the report along with Session Chair and submit it to Project manager	
DAY 3, September 14 , 2022		
08:30-09:30	Breakfast	
	SESSION VI	**Session Chair: Prof. Dr. Rezaul Karim**
09:30-10:15	Theme 16, 17 and 18 Presentation ● Food safety and quality issues of fruits and vegetables in South/South East Asia ● Current status, constraints, opportunities and way forward for the promotion of organic agriculture in South/South East Asia ● Pollination in horticultural crops with respect to production and human nutrition	Dr. Matina Joshi Baidhya, DFTQC Mr. Bhola Shrestha Dr. Kedar Devkota
10:15-11:15	Discussion and feedback collection	Rapporteur: Pramila Wagle, Bishal Shrestha and Lal Bdr Chhetri
	Rapporteur will compile the suggestion, feedback and prepare the report along with Session Chair and submit it to Project manager	
11:15-11:35	Tea break	
11:35-11:50	Presentation of the selected innovation idea from Youth Innovation Workshop	Ms Swastika Shrestha, Student AFU
	SESSION VII	**Session Chair: Prof. Dr Durga Devkota**

11:50-12:20	Preliminary results sharing Presentation ● Sharing of preliminary results of field study in Bangladesh and Nepal	Dr. Ujjal Tiwari, AFU/Dr. Homnath Giri, AFU
12:20-13:20	Feedback collection and Discussion	Rapporteur: Srijana Neupane & Manisha Shrestha
	Rapporteur will compile the suggestion, feedback and prepare the report along with Session Chair and submit it to Project manager	
13:20-14:20	Lunch	
	CLOSING CERERMONY	
14:20-14:40	1. Chairperson: Honorable Vice Chancellor Prof Dr Punya Prasad Regmi, AFU 2. Chief Guest: Pushpa Raman Wagle, PhD, Member, National Planning Commission, GoN 3. Special Guest: Dr. Deepak Kumar Kharal, Secretary, Livestock Development, Ministry of Agriculture and Livestock Development 4. Special Guest: Prof Dr Elizabeth Mitcham, Horticulture Innovation Lab-UC DAVIS 5. Special Guest: Dr Deepak Bhandari, ED, NARC 6. Special Guest: Joint Secretary, MoALD 7. Special Guest: USAID Mission, Nepal 8. Special Guest: Dr Rebati Raman Poudel, DG, DoA 9. Special Guest: Prof Dr Md Rezaul Karim, BAU 10. Special Guest:: Dr Ferdouse Islam, BARI 11. Special Guest: Executive Director, FORWARD Nepal	
14:40-15:40	Certificate and Token of Love distribution	
15:40-16:40	1. Remarks from Special Guest: BARI 2. Remarks from Special Guest: BAU 3. Remarks from Special Guest: ED FORWARD Nepal 4. Remarks from Special Guest: USAID Mission in Nepal 5. Remarks from Special Guest: MoALD 6. Remarks from Special Guest: NARC 7. Remarks from Special Guest: Horticulture Inn Lab	
16:40-17:00	Vote of Thanks	Prof Dr Arjun Kumar Shrestha, Director, DOREX and Technical Lead of

		Horticulture Innovation Lab project in Nepal
17:00-17:20	Closing remarks	Chairperson Honorable Vice Chancellor Prof Dr Punya Prasad Regmi
17:30	Refreshment and Social Gathering	ALL

Event Management and Coordination:
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Feed the Future Innovation Lab for Horticulture

Workshops in Kenya and Ghana shaping the future of horticulture research in East and West Africa

Posted by Archie Jarman on June 27, 2022

The Feed the Future Innovation Lab for Horticulture recently partnered with the International Centre for Evaluation and Development (ICED) in Kenya and the University of Ghana School of Agriculture in Accra to hold two regional horticulture workshops. This is the beginning phase of a 5-year project cycle funded by USAID, the findings of which will

Located in Nairobi and Accra, the workshop attendees represented a diverse suite of universities, government agencies, private companies, and non-governmental organizations. In Kenya, these included the University of Nairobi, the Kenya Agricultural and Livestock Research Organization, the Ministry of Agriculture (Kenya, Ethiopia, Uganda), the Masii Horticultural Farmers Cooperative Society Limited, and the Retail Trade Association of Kenya (RETRAK). In Ghana, the Ministry of Food and Agriculture, Sea Freight Pineapple Exporters, Sasakawa Africa Association, and the University of Nigeria Nsukka were just a few of the many organizations that attended.

Ghana Regional Workshop Participants

Each workshop was spaced over a multi-day period in which experts gave presentations on a wide range of issues spanning the horticultural value chain--from low quality inputs, post-harvest loss, and food safety challenges to nutrition, gender equity, and youth empowerment. Participants attended both in-person and online, allowing engagement from people around the globe.

These conferences were unique opportunities for horticultural specialists from throughout East and West Africa to share their diverse perspectives and expertise with one another, and the discussions that resulted will inform priorities for future research, capacity strengthening and sector investment that are designed to target local challenges in horticulture. And the challenges, as well as the opportunities, are significant. As experts discussed in both conferences, smallholder farmers face multiple barriers along the horticultural supply chain. Yet there are also numerous avenues for entrepreneurship—from production to market—that may help overcome some of these obstacles.

ICED CEO/President Dr. David Ameyaw in his opening statement remarked, ***"We are thrilled to convene sessions like these, which seek to build knowledge and evidence to address the on-***

horticulture value chain to make systemic, sustainable improvements in the sector."

Some discussion points:

Low quality inputs pose health threats and inhibit marketing potential

High quality seeds and fertilizer are expensive and as such farmers are often forced to purchase lower quality products that may advertise abiotic and biotic resistance but are actually counterfeit. For example in West Africa, 1000 high quality tomato seeds cost about USD$120, an amount of money that could buy enough rice to last a household 4 months. These prohibitive prices, combined with a lack of effective extension services, force farmers to take the word of vendors and middlemen who may have conflicting interests. This also could lead to the use of unregulated pesticides and other chemicals, which not only could have severe adverse health effects but also inhibit farmers from exporting their produce to receive higher prices.

Professor Irene Egyir, Dean of the School of Agriculture at the University of Ghana, giving the welcome address.

Insufficient infrastructure leads to post-harvest loss

Another major barrier discussed at both workshops is inadequate infrastructure. The majority of roads in both regions are unpaved, leaving them susceptible to monsoon seasons--which typify many countries throughout East and West Africa. This makes it difficult to transport produce from the field to market, resulting in produce traveling on vehicles for extended periods of time without refrigeration, causing significant post-harvest loss. While the perishability of fruits and vegetables can present significant infrastructure and transportation issues, it also provides opportunities for research into new technology and small businesses that might help communities overcome these issues.

Harnessing horticulture's potential: Engaging youth and women

Despite numerous challenges, the horticulture sector in Sub-Saharan Africa also holds incredible potential and there are people—like the conference participants--working all over Africa to address these issues with the goal of improving farmer livelihoods. Kwasi Korboe, CEO of Girsal Ltd., a non-banking financial institution in Ghana that provides agricultural loans, pointed out how financing the horticulture sector is becoming increasingly attractive as the popularity of horticultural crops grows globally. Not only do they have significant nutritional and health benefits,

Nairobi, Kenya: Women are taking the lead in horticulture research across the continent. From L-R: Edna Barendse (Finca Verde, Uganda), Dr. Jessica Ndubi (KARLO), Dr. Marie Rerieya (ICED), Dr. Lusike Wasilwa (KARLO), Roberta Blankson (ICED), Dr. Jane Ambuko (University of Nairobi, Dr. Alice Ruto (Ministry of Agriculture), Wambui Mbarire (RETRAK)

Given this potential, there is significant opportunity for youth engagement in the sector, as discussed by Mrs. Gifty Kafui Mensah, Executive Business Director of Maphlix Trust Ghana Ltd., at the Accra conference. Much of Sub-Saharan Africa is currently experiencing a large out-migration of young people as stable, secure employment opportunities are extremely difficult to come by, especially for young women. Yet if the horticultural value chain is to keep up with advancing technology, it needs innovative young minds who can employ techniques such as remote sensing, drone technology, online learning platforms, and online stores to sell produce. The rapid spread of cell phones in Sub-Saharan Africa means that even people located in some of the most remote areas of the continent receive cell service and are often well-versed in how to use a smartphone, especially young people. The greatest barrier to entering the horticulture market for youth is not lack of technological know-how but access to land, with 75% of Ghanian youth and 59% of Kenyan youth reporting no land access. This is especially severe for young women, since in many countries land inheritance--often the sole method of acquiring land—is prohibited for women. Mrs. Mensah stressed the importance of making available equal access to agricultural trainings, technologies, and machineries so that young women can contribute their vital skills to the sector.

Exciting, albeit bumpy, road ahead

The success of both conferences and enthusiasm of attendees signals the importance of horticulture in these regions. The Horticulture Innovation Lab is encouraged by the incredible amount of talent and dedication in this sector. Moving forward, local experts will be critical in turning the rich discussions at the workshops into horticulture research projects. The Horticulture Innovation Lab is committed to a locally led, globally supported model and these regional workshops represent the first phase of this approach. In the next phase, requests for proposals will be developed with a priority given to regionally based experts and leaders.

come!

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Feed the Future Innovation Lab for Horticulture

Workshop in Honduras highlights the importance of knowledge-sharing to strengthen the horticulture sector in Central America

Specialists attended from throughout Honduras, El Salvador, and Guatemala.

Posted by Siobhan Rubsam on June 30, 2022

Last week marked another successful horticulture workshop in Honduras, one of four regional conferences taking place this summer that are the first stage in the Feed the Future Innovation Lab for Horticulture's USAID-funded 5-year project cycle. Zamorano University, a non-profit agricultural university, hosted the event at their 10,000-acre campus in the Yeguare valley, only 30km from Tegucigalpa, the country's capital. Enthusiasm ran high amongst the 45 people attending, who traveled primarily from Honduras, Guatemala, and El Salvador, to discuss challenges and opportunities for fruit and vegetable value chains in Central America. Participants

The Zamorano campus boasts 10,000 acres of forests, herbariums, and campus buildings that is conveniently located only 30km from the capital of Tegucigalpa.

Taking place over a 2-day period, the workshop consisted of both presentations and breakout sessions that gave participants a chance to discuss what they believed were the most important issues in the horticulture sector in their regions. This information then fueled the larger group discussion on how to address these challenges and create opportunities for advancement within the horticultural value chain, focusing on key topic areas such as local access to fruits and vegetables, women and youth participation in horticulture, access to regional and international markets, Integrated Pest Management (IPM), postharvest management, and value-added products.

Dr. Celia Trejo, Director of the Department of Science and Agricultural Production at Zamorano University, Honduras.

While participants acknowledged that the challenges—such as increasing costs of inputs, energy, and transport--are many, they also discussed the horticulture sector's incredible potential to benefit the people of Central America. However, in order for this potential to be harnessed, there are several actions that need to take place: knowledge-sharing amongst public and private actors in the sector, shifting exports to local and regional markets to increase local access to fruits and vegetables, increasing local demand for fruits and vegetables, and about critical steps the government is taking to boost the country's horticulture sector, including holding a country-wide census—the first in 30 years—to evaluate over 40 supply chains, and building extension programs into Honduran universities to boost their prevalence and efficacy throughout the country.

Dr. Laura Suazo, Minister of Agriculture for Honduras, discusses government strategies to bolster the horticulture sector in the country.

It was not only the participants' sharing of expertise that made the workshop so successful—it was their passion for advancing horticulture within their communities and countries that made discussions so engaging and productive. And of course, none of this would have been possible without Zamorano University's leadership and hosting on their beautiful campus.

Thank you to all our presenters, participants, and Zamorano University for such a rich foundation on which to build rigorous and impactful research in the next several years in Central America.

Article Type

Blog

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Feed the Future Innovation Lab for Horticulture

Feed the Future Innovation Lab for Horticulture

South Asia Horticulture Workshop focuses on strengthening gender equity and the fruit sector as the region become increasingly threatened by climate change

Posted by Siobhan Rubsam on October 20, 2022

Feed the Future Innovation Lab for Horticulture

The South Asia regional horticulture workshop, hosted by FORWARD Nepal in September, wrapped up a series of four very successful workshops that took place in each of the regions Feed the Future Innovation Lab for Horticulture will conduct research in: East Africa (Kenya), West Africa (Ghana), Central America (Honduras) and South Asia (Nepal). The 3-day workshop featured experts in the horticulture sector from both Nepal and Bangladesh, with representatives from universities, NGO's, research institutes, private industry, and government agencies creating a rich dialogue of diverse perspectives that highlighted a few major themes.

Advancing the fruit sector depends on improving varieties

There is significant potential for fruit production in South Asia, but in order for this to be harnessed, farmers need access to improved varieties. The Catch-22 is that Nepal and

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reason for this is that to save on expense farmers will utilize their own seeds to create the next round of fruit saplings--which by nature cannot retain all the features of the parent plant--instead of buying from a nursery. This can lead to trees that are susceptible to viruses and other diseases, and cannot produce the product quality necessary for market, especially for export. Biotechnology was proposed as one solution to this problem. Dr. Bahneshwor Pokrel spoke about the potential for micropropagation of fruit tree varietals, specifically, in order to create lab-grown cultivars that will stay true to their original characteristics. Innovations like these may be necessary to meet the growing demand for fruit both regionally and internationally, and as South Asia becomes increasingly threatened by climate change, fruit orchards may be a sustainable and profitable solution to increasing forested land area in places like Bangladesh which currently fall below recommended levels.

Fruit consumption in Nepal is increasing, as evidenced by fruit carts popping up on street corners in cities.

Gender equity quintessential to a prosperous horticulture industry

There is currently a massive outmigration of men in South Asia–both to cities and to other countries–which has left women to manage farms. The 10% increase of women in agriculture has exposed severe gender disparities that inhibit their participation in the sector. For instance, they don’t own their own land (only 21% of land is women-owned), can’t obtain loans, have limited knowledge of and comfort with farm equipment, and don’t have access to infrastructure

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since the very fate of agriculture in some areas depends on it. Presenters stressed that in order for this to happen, women farmers need more support from the government in the form of subsidies that are tailored specifically to help them. Despite the barriers before them, women in South Asia are becoming leaders in the fight to protect their countries against the onslaught of climate change. A striking example of this comes from Ms. Swastika Shrestha, a student at the Agriculture and Forestry University (AFU) in Nepal who was selected to give a presentation on an innovation she was testing that uses plant-based alternatives to plastic packaging for fruits and vegetables.

Prof. Dr. Durga Devkota, from the Agriculture and Forestry University (AFU) in Nepal, presented on the potential of Gender Empowerment and Social Inclusion (GESI) and youth entrepreneurship in the fruit and vegetable sector in South Asia.

Adapting the horticulture sector to a present and future of climate change

Nepal and Bangladesh are two of the most vulnerable countries in the world to climate change, according to various ranking criteria. Nepal--with its steep terrain and heavy monsoons--is highly prone to natural disaster, especially as temperatures continue to climb. This will cause flooding and erosion events to become more frequent and more severe, with particularly devastating impacts on remote villages with little access to the rest of the country. Bangladesh, on the other hand, consists of very low-lying land that is highly affected by ocean flooding,

Feed the Future Innovation Lab for Horticulture

The extreme climatic conditions of both countries will only increase in intensity with climate change, but there are also a lot of people, like those that attended the conference last month, who continue to research and innovate new climate adaptive ways for agriculture to meet a growing population (25% of the world's population now lives in South Asia). In some ways, South Asia is taking the lead in sustainable agriculture, for example Nepal's National Organic Accreditation Body. This is a government-run program that certifies entire states as organic. However, presenters at the conference pointed out that in order for this system to work, government agencies on the national, regional, and local level need to improve their communication channels. They also stressed the importance of increasing research and extension on organic production, as current knowledge of organic practices and inputs is limited. For example, farmers may brand their products as organic as long as they are not using chemical fertilizers or pesticides, even if they are not abiding by organic standards. There are also farmers who only have access to older, unsafe pesticides that are highly toxic. This is one of the many reasons researchers at the workshop emphasized the importance of a robust extension system where agents receive skill-specific training rather than a more generalized focus.

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Breakout groups have been a key feature of all the regional workshops, facilitating discussion between people of diverse backgrounds and expertises.

Thank you to everyone who attended in-person and remotely, especially all those who gave such compelling presentations. So many important insights surfaced during this conference that will inform the future of horticulture research in the region. Special thanks to FORWARD Nepal for hosting and making it such a success! We are excited to continue working with our Nepali and Bangladeshi partners over the coming years.

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Feed the Future Innovation Lab for Horticulture

Online Innovation and Scaling Course from CGIAR

Home • Blog • Online Innovation and Scaling Course from CGIAR

Posted by Archie Jarman on March 28, 2022

Online Scaling Course Offered By The CGIAR - *Significant Contribution to the Gender and Scaling Module by the Horticulture Innovation Lab's Erin McGuire!*

Achieving impact at scale is one of the greatest challenges facing the research and development community, and the term 'scaling of innovation' is increasingly popular in the world of public research and development.

Pilots never fail, Pilots never scale...

if this sounds like what is happening in your organization, then this course provides a starting point for improved innovation and scaling performance

As part of CGIAR's commitment to achieving the Sustainable Development Goals, innovation and scaling concepts are centrally positioned in the CGIAR 2030 Research and Innovation Strategy, and in the new CGIAR Initiative portfolio. To support Initiative teams and partners to develop a

“We noticed interest in, and a need for innovation and scaling capacity strengthening across the organization, which basically kicked off the development of the course”, says Marc Schut, senior innovation and scaling advisor and scientist working with CGIAR and Wageningen University. “We then conducted a needs assessment among CGIAR scientist, innovation and scaling experts and managers, which informed the key content and format of the online course”, he adds.

The course covers 6 Modules that answer questions such as:

- What do we mean with innovation?
- How do innovations scale as part of packages?
- How do we ensure (gender-)responsible scaling?
- How do we measure the Scaling Readiness of innovations?
- How to develop evidence-based scaling strategies with partners?
- Why investing in innovation portfolio management?

The course introduces basic innovation and scaling concepts, applies these concepts to a real CGIAR case study on banana disease management in Rwanda. Content is provided through short reading materials, video snippets and quizzes. “It was clear that colleagues wanted something short and interactive that focusses on the innovation and scaling basics, that they can do on their desktop and mobile devices at their own pace and time”, explains Nikki Tierney, an instructional design who supported the design and development of the course.

Feedback by a course participant:

“The best gain for me was to understand the basic concepts of scaling, such as Innovation Packages, Scaling Readiness, etc. It is a good introductory course, especially for people that want to familiarize themselves with state-of-the-art innovation and scaling topics. Also, the case study was helpful to see how everything is connected.”

The result is a course that is free, takes approximately 3 hours, and provides a certificate to those who successfully complete it. By hosting the course on the online learning platform thinkific it is accessible to audiences internal and external to CGIAR.

future – the course becomes part of CGIAR talent development programs which will also help us to receive feedback and constantly improve the quality of course", Schut concludes.

The online course on innovation and scaling was developed by experts representing Wageningen University and the CGIAR under the Research Program on Roots, Tubers and Bananas (RTB). An animated video explaining the course in 2 minutes can be found here: https://www.scalingreadiness.org/courses/. The course can be directly accessed through: https://innovationandscaling.thinkific.com/courses/innovation-and-scaling.

Please contact Dr Marc Schut (m.schut@cgiar.org), Innovation and Scaling Advisor and Scientist with CGIAR and Wageningen University for any questions or feedback.

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FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

POLICY BRIEF: FUNGAL TOXINS AND FOOD INSECURITY

In 2004, a prolonged drought in Kenya led to a maize scarcity. Starving villagers resorted to consuming moldy maize that would normally have been discarded or used for animal feed. In the Makueni District in Kenya 317 people from 1 to 83 years old fell ill after eating the moldy grain and 125 of them died.[1] **They were poisoned by aflatoxin – a potent toxin produced by the fungus infecting the grain.** Grains and other dried foods are commonly contaminated with fungal toxins, including aflatoxin; the maize consumed during the 2004 drought had aflatoxin levels as high 8000 ppb. Codex's standard maximum level of aflatoxin in maize for human consumption is 20 ppb. Daily consumption of commodities severely contaminated by aflatoxins causes pulmonary edema, abdominal pain, and liver damage.[2] Chronic exposure to lower levels of mycotoxins can cause liver cancer, immunosuppression and impacts physical and cognitive development in children.[3]

The world is facing grain scarcity again. The conflict in Ukraine has compounded an already challenged global agricultural market resulting from the COVID pandemic. Ukraine alone is the fourth largest producer of the world's maize, and Russia and Ukraine account for 40% of the world's wheat production.[4] The conflict in Ukraine is also driving up the price of fertilizer. National commodity markets will be strained to maintain consumer supplies. Under this strain, it is critical for governments to take steps to prevent aflatoxicosis due to the consumption of contaminated commodities.

A health campaign to elevate public awareness of the dangers of mycotoxins, including aflatoxins, should be urgently mobilized. The campaign could include a warning of both acute toxicity and of chronic toxicity from mycotoxins. The potential for acute aflatoxicosis is heightened now, but reducing aflatoxins in dried commodities is a perennial challenge demanding government action.

Education is needed about the tools for controlling aflatoxin contamination, along with an awareness campaign about the dangers. The blue-green spores of the fungus are sometimes visible on dried foods, but infection is often invisible, so visually identifying and removing contaminated product is not a reliable preventative measure. Growers and marketers need to limit infection during production and limit fungal proliferation after harvest. **Dried foods need to be properly dried immediately after harvest and kept dry in storage and all handling steps before dried foods are eaten.**

In a government sponsored awareness campaign, low-cost postharvest tools that should be made easily accessible to growers and traders could be highlighted. The **Feed the Future Innovation Lab for Horticulture's DryCard** costs only USD$1.50 and reliably indicates if a commodity is dry enough to prevent fungal growth. It is also reusable. The **Horticulture Innovation Lab's Pallet Dryer and Chimney Solar Dryer**, and the **Feed the Future Innovation Lab for the Reduction of Postharvest Losses (PHLIL) Grain Dryers** are low-cost drying technologies that offer significant advantages over traditional drying methods. Hermetic storage such as **Purdue's Improved Crop Storage (PICS bags)** or **GrainPro's** bags prevent well-dried commodities from re-absorbing moisture.

Increasing public awareness of the lethal dangers of aflatoxin exposure combined with sharing information on the available tools to combat it are actions that governments should take. Governments may also want to consider monitoring dried foods in the market for aflatoxin contamination and excessive moisture content during this time of global food insecurity.

- For more information about the DryCard, Chimney Dryer, and Pallet Dryer visit www.horticulture.ucdavis.edu
- For more information about PHLIL's Dryer visit www.k-state.edu/phl/
- For more information about PICS bags visit www.picsnetwork.org and for GrainPro bags www.grainpro.com

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For more information, visit http://horticulture.ucdavis.edu.

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Feed the Future Innovation Lab for Horticulture

Welcoming our new International Advisory Board!

Posted by Siobhan Rubsam on July 20, 2022

Board members will provide crucial guidance to the Horticulture Innovation Lab over the coming years.

The Feed the Future Innovation Lab for Horticulture at the University of California, Davis is excited to welcome our International Advisory Board (IAB)! Comprised of a diverse set of experts in the world of horticulture, agro-economic, agro-social, nutrition, and policy research, our members will provide critical advice to our Management Entity in the coming years. They will offer guidance on all major aspects of the program, from project development and implementation to assessing program progress, and ensuring the Horticulture Innovation Lab's research, research leaders, and programs are locally led, equitable, diverse, and inclusive. Our members hail from institutions and organizations across the globe in both the public and private sector, an essential blend for the successful scaling of horticulture research globally.

"The Horticulture Innovation Lab is excited to welcome such a high caliber of international advisory board members, including outstanding experts in the broad field of horticulture for development. We look forward to working closely with this group as our locally led, globally supported program is developed and rolled out."

-Dr. Elizabeth Mitcham, Director

IAB Members: Who are they?

Five members work in the four priority geographic regions our program works in: West Africa, East Africa, Central America and South/Southeast Asia. They will provide technical expertise to the overall program, ensure research projects selected for implementation will accurately reflect the greatest challenges and opportunities of horticulture in their prospective regions, and inform our global network of lessons learned locally.

should be supported, to earn attractive incomes from their farming activities. Fruit and vegetable losses in the value chain needs to be reduced. This calls for the collaboration of all stakeholders within the horticulture value chain."

-Dr. Anna Lartey

West Africa/Nutrition: ***Dr. Anna Lartey*** is currently a professor of nutrition at the University of Ghana and brings decades of experience in the field, from her research in Sub-Saharan Africa to her time as a Director of Nutrition at the Food and Agriculture Organization (FAO) of the United Nations.

East Africa/Crop Systems: ***Dr. Lusike Wasilwa*** is the current Director of Crop Systems at Kenya Agricultural and Livestock Research Organization (KALRO), where she focuses on how biodiversity can contribute to food, nutrition, and income security.

Central America/Ag Extension: ***Maria Ester Bucaro*** is the Chief of Party for Counterpart International Guatemala and a seasoned leader in food security and agricultural programs, including her role as one of the first women to implement the country's rural agricultural extension system.

South / South East Asia/Youth + Private Sector: ***Kushal Naharki***, a Nepalese youth activist, has worked extensively in agricultural extension and for multiple youth empowerment NGO's in Asia and the U.S. ***Dr. Mary Ann Sayoc*** brings both a private and public perspective through her current position as the Public Affairs Lead for East-West Seed Group in Thailand and past work leading Philippine government agencies as Regional Director of the Department of Agriculture and Executive Director of the Agricultural Training Institute.

Consortium Scaling Partners: Cultivating New Frontiers in Agriculture (CNFA) and the International Fertilizer Development Center (IFDC) help our program align research deliverables for broad dissemination. ***Vincent Roger*** is the current Director of Program Development for CNFA West Africa and he brings extensive experience developing business models that will encourage agribusiness investment in Africa. ***Dr. Latha Nagarajan*** is an active member of the IFDC and the current Director of the SOILS (Sustainable Opportunities for Improving Livelihoods with Soils) Consortium, where she focuses on evaluating and assessing agricultural technologies adoption, input market interventions, and policy research.

Innovation Lab Partner/ Evaluation*:* ***Dr. Jan Middendorf*** is the Associate Director of the Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification (SIIL) at Kansas

CGIAR / Gender: ***Dr. Hazel Malapit*** works at the International Food Policy Research Institute (IFPRI) as their Senior Research Coordinator, where she coordinates and implements gender equity tools to ensure women are empowered throughout the value chain.

IAB members will drive HIL's highest priorities: Locally led development + Diversity, Equity, and Inclusion

The inclusion of this board, especially our regional representatives, in decision-making processes will ensure a more equitable, localized rollout of projects in each of the priority regions and will help guide on the ground research. Additionally, this body will be tasked with how to bring greater diversity, equity, and inclusion to every aspect of the Horticulture Innovation Lab's work – from identifying challenges, awarding projects, implementation, and disseminating results. We are excited to work with this exceptional panel of experts over the coming years and are grateful for their contributions—past, present, and future—to positively impacting smallholder farmers around the world.

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USAID Awards UC Davis $15 Million for Global Horticulture Research Program

Horticulture Innovation Lab Aims to Empower Smallholder Farmers

by Matt Marcure | September 29, 2021

Amrita Mukherjee of the UC Davis Horticulture Innovation Lab trains village leaders in Bangladesh about handling practices for vegetables after harvest. (UC Davis) base $15 million investment over the next five years, with up to $34.5 million total funding possible, to support a global research program led by the University of California, Davis, that advances fruit and vegetable production, handling, and consumption.

The Feed the Future Innovation Lab for Horticulture will work with and promote local leadership in communities across the globe to advance horticultural and social innovations for nutritional and financial security. This competitive five-year program was first awarded to UC Davis in 2009 and renewed in 2014.

“Horticulture offers big health, economic and environmental benefits,” said Elizabeth Mitcham, program director and a UC Cooperative Extension specialist in the Department of Plant Sciences. “UC Davis will be leading an outstanding global consortium that will be able to make big impacts on developing sustainable, local expertise and innovative technical and social solutions to empower horticulture producers and their communities.”

UC Davis will be joined in a consortium with Florida A&M University, Michigan State University, Texas A&M, and World Vegetable Center, along with subject matter experts from Penn State University and Making Cents International, to help manage this program.

The Horticulture Innovation Lab will focus their efforts in West Africa, East Africa, South/Southeast Asia and Central America. At the forefront

UC DAVIS

market-oriented production and post-harvest handling methods that provide smallholder farmers and other stakeholders in fruit and vegetable value chains more income, as well as improved access to fruits and vegetables to better nourish their families and communities.

Locally led, globally supported

Within the UC Davis-led consortium are partners and specialists with expertise in horticulture, agronomics, agri-sociology, agribusiness and agri-policy. The Horticulture Innovation Lab will convene these global, regional and local experts to determine research needs in each geographical area. Once these research needs are defined, the team will emphasize a holistic, locally led approach to build community resilience and to support inclusivity.

“We asked ourselves, ‘how do you effect change in a system now that overcomes immediate challenges and those yet to present themselves?’” said Erin McGuire, associate director of the Horticulture Innovation Lab. “We need to understand the implications of our projects and to work closely with local leaders and community members to ensure a pipeline of appropriate innovations now and in the future.”

Building on fertile grounds

Fruits and vegetables provide vital nutrients for healthy communities, empower women and youth, and improve overall sustainability in that the Horticulture Innovation Lab did during its first 10 years.

As a direct result of the Horticulture Innovation Lab's work, more than 750 horticultural technologies are now available for transfer and scaling in communities across the globe. More than 32,000 farmers are applying or using these technologies as a result of the lab and its network's collective work, and more than 13,000 hectares of land are under new management practices.

The Horticulture Innovation Lab produced a number of innovative technologies, including a chimney solar dryer that more efficiently dries and preserves fruits and vegetables for long-term storage, and a simple tool called the DryCard that lets farmers know if food is safe for dry storage.

Additionally, researchers facilitated the adoption of improved agricultural methods, such as drip irrigation in Guatemala, and conservation agriculture for vegetable production and a packinghouse in Cambodia, that led to climate and social resilience.

The Horticulture Innovation Lab is a part of Feed the Future, the U.S. government's initiative to combat global hunger and poverty. It brings partners together to help some of the world's poorest countries harness the power of agriculture and entrepreneurship to jump-start their economies and create new opportunities.

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For more information, visit feedthefuture.gov.

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