Project Report

Feed the Future Innovation Lab for Horticulture

ASSESSMENT OF CHALLENGES AND OPPORTUNITIES OF HORTICULTURE SECTOR IN SOUTH ASIA

Submitted to

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HORTICULTURE INNOVATION LAB
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Submitted by

FORWARD Nepal

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FORWARD Nepal
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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 Agricultural 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
CO_2	Carbon Dioxide
DEI	Diversity, Equity and Inclusion
DNA	Deoxyribonucleic acid
DFTQC	Department of Food Technology And Quality Control, Nepal
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	Greenhouse Gases
GHI	Global Hunger Index
GI	Galvanized Iron
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
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	Maximum Residue Level
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
OCN	Organic Certification Nepal
OP	Open Pollinated
PCR	polymerase chain reaction
PEN	Pest-Exclusion Net
PhD	Doctor of Philosophy
PMAMP	Prime Minister Agriculture Modernization Project
Pvt. Ltd.	Private Limited

RAPD	Randomly amplified polymorphic DNA
R&D	Research and Development
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 the horticulture sub-sector, especially the fruit and vegetable, is key considering the economical, nutritional, and cultural significance. Further, countries in South Asia are grappling with rising commodity prices, supply bottlenecks, and climate change threats. On the other hand, the diverse agro-climatic conditions and rich diversity in genetic resources of horticultural crops enable this region to produce a wide range of vegetables and fruits round the year. However, the productivity of fruit and vegetable crops is far below the potential of these crops in South Asia due to various factors including the non-adoption of high yielding varieties and crop management practices. Huge efforts are needed to minimize the gap between the demand and supply of quality fruit and vegetables in South Asia especially in Nepal and Bangladesh to enhance the productivity and per capita fruit and vegetable consumption in these countries. Various issues including generation and adoption of production and post-harvest technology along with policy intervention, ware vital for the sustainable growth of the fruit and vegetable sector.

To identify the priorities in horticulture sector especially in fruits and vegetables in the South Asia, a three-day (12-14 September, 2022) regional horticulture workshop was organized in Kathmandu, Nepal in which local and regional leaders representing academia, government, research, private sector, and NGOs working in Nepal and Bangladesh were gathered and thematic papers were presented in 18 priority areas followed by group discussion and feedback collection. Prior to this workshop, short studies through field surveys, focus group discussion, and key informants' interviews were also carried out in both the countries to get the primary data in this regard.

Based on the papers shared in the regional workshop and the reports of direct field studies, the possible research areas in the fruit and vegetable sectors have been identified that includes the enhancement of productivity through the development of improved production practices, technology and innovation, availability of quality seed/ sapling, adoption of high yielding variety, and scientific agronomic practices along with management of pollination, insect pest and diseases. The development of a package of practices for the emerging technology particularly the protected horticulture and soil-less culture for fruits and vegetables and promotion of major indigenous fruits and vegetables of this region are also equally important areas. Proper post-harvest handling practices for the commercially produced fruits and vegetables and processing technology are urgently needed in this region. More importantly, we have to create an enabling environment for youth for optimizing the production and handling of fruit and vegetable through strengthening their capacity and policy interventions.

1. Background

Agriculture is one of the major sectors of South Asian economies contributing significantly to the national GDP of these countries, central to lives and livelihood (Puri, 2022). The right to food and food sovereignty are exclusively provisioned in the constitution of most of the south Asian countries. The national plan, policies and strategy documents of these countries including Agriculture Development Strategy (2015-35) of Nepal 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 plans and policies including APP (1995-2015), ADS (2015-2035) and other periodic and annual plans. Demand for 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 with its negative consequent effects on food security, nutrition and trade imbalance over the years. 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 immediate attention of the South Asia region to focus our programs towards the development of the fruits and vegetables sector. 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 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 and Bangladesh, 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 the 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 that the Horticulture Innovation Lab need to address in South Asia.

In Nepal, micronutrient deficiencies range from 6.2% to 59.0% for different types of micronutrients (Bhandari & Banjara, 2015). Based on national indicators of undernourishment and child wasting, stunting, and mortality, Nepal lies in the serious range on the Global Hunger Index and there is still a gap between knowledge of how to attain good health and nutrition and household consumption practices (Global Hunger Index, 2016). The scenario is similar in India (Venkatesh et al., 2021) and other developing countries (Muthayya et al., 2013). In addition, even nutrition suffers from gender-based inequality in developing countries (Chakraborty, 2021). In South Asian countries, women are neglected when it comes to food and nutrition, often eating less and only after the family has consumed the meal. Dieticians and nutritionists suggested that the per capita daily requirement of vegetables is 300 gram. But vegetable consumption of Nepalese people is very low compared to that, it is seen that deficiency of 60% in relation to vegetable production, and the demand is increasing day by day due to the major shift by people living in the country to healthy food (Bhattarai, 2018). 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 and Keatinge, 2013; Bokelmann et al., 2022). Furthermore, Nepalese people heavily depend on collection of vegetables and fruits from their natural habitat, especially during food scarcity periods which can be an important approach to reduce import of horticultural commodities.

2. Project Management

2.1 USAID

USAID (www.usaid.gov) leads 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) was established in Rampur, Chitwan, in 2010, as 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, livestock, fisheries 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 as well as the Agriculture Science Centers. 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)

The 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 have 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 headed 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 training 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 the 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&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

Focus Group Discussion in Bangladesh

Focus Group Discussion among vegetable growers in Nepal

Household survey with Banana grower, Chitwan

Household survey with Citrus grower, Dhankuta

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. Altogether twenty-nine FGDs (Nepal-17 and Bangladesh-12) were conducted for obtaining both qualitative and observational data. The FGD participants also suggested the appropriate farm-households and the input/output traders for surveys 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. Location/focus area and tools for data collection

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
Kavrepalanchok	-	1	Potato
Mahottari	5	-	
Saptari	5	2	Riverbed farming, mango
Surkhet	17	2	Vegetables, input suppliers
Total	62	17	

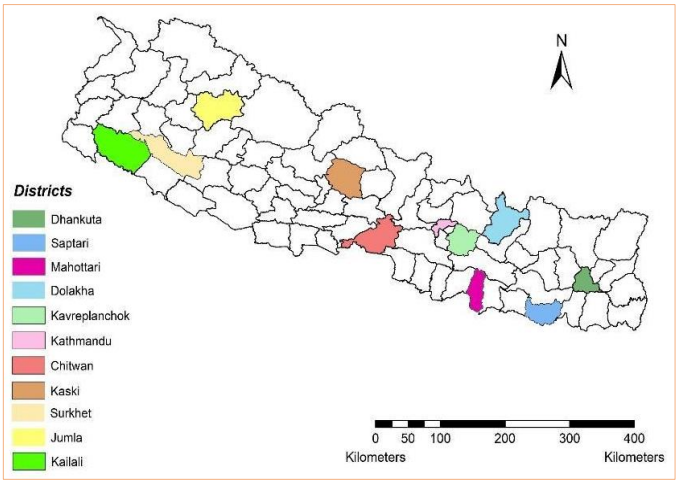


Figure 1. Study districts in Nepal (Chitwan, Dhankuta, Dolakha, Jumla, Kailali, Kaski, Kathmandu, Kavreplanchok, Mahottari, Saptari, Surkhet)	**Figure 2.** Study districts in Bangladesh (Narsingdi, Comilla, Ulokhola Gazipur, Pabna, Sylhet, Tangail, Barisal, Pirojpur, Patuakhali, Jhalokati, Mymensingh)

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 the 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 progress 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&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 thorough 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 the Vice-Chancellor of AFU as Chairperson 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.

Group discussions in regional horticulture workshop, Kathmandu

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

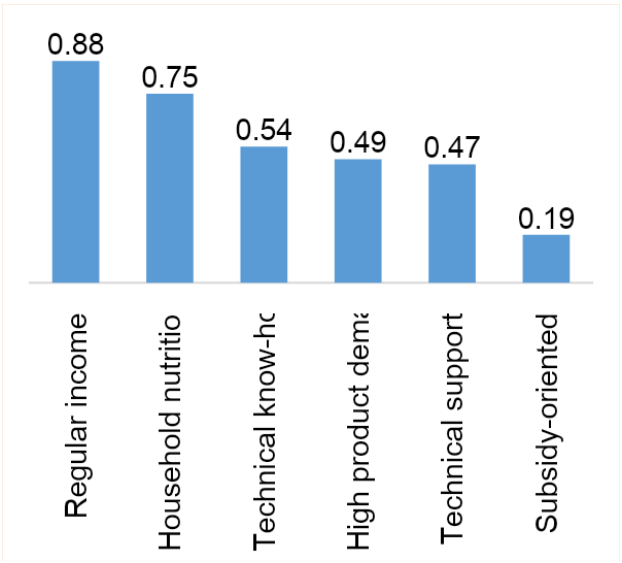
Vegetables are rich sources of vitamins like vitamin A, vitamin B, vitamin C, riboflavin, thiamin, niacin, and minerals such as calcium and iron that also supply different dietary fibers, which are essential for digestion, maintaining good health, and curing nutritional disorders (Terry, 2011). Increment 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 a 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). The vegetable growers are in need of quality seeds of high yielding varieties especially the hybrid ones suitable for the specific agro ecological region. Climate change is another factor 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 the 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).

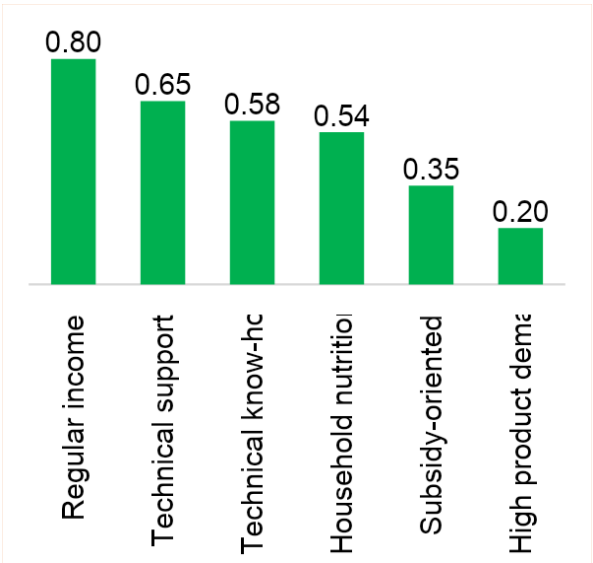
Along with challenges, there are several opportunities in the vegetable sector in South Asia. Diversified agro-ecological zones, distinct seasons, variation in the weather and climate within a year favors the production of vegetables in Nepal to a large extent. Climate and soils of Bangladesh are ideal 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). The commercial vegetable farming is an increasing trend in Nepal (Shrestha et al., 2018). Moreover, vegetable farming allows small land holding farmers to generate

cash in a short period and can help to raise their living standard (Gurung et al., 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 imports than that of export reflect the scope of vegetable farming in Nepal. The per capita consumption of vegetables has increased to 105 kg from 60 kg over the last two decades due to increase in awareness among consumers and rise in production area in Nepal. Farmers are becoming more specialized in production of particular types of vegetables.

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.

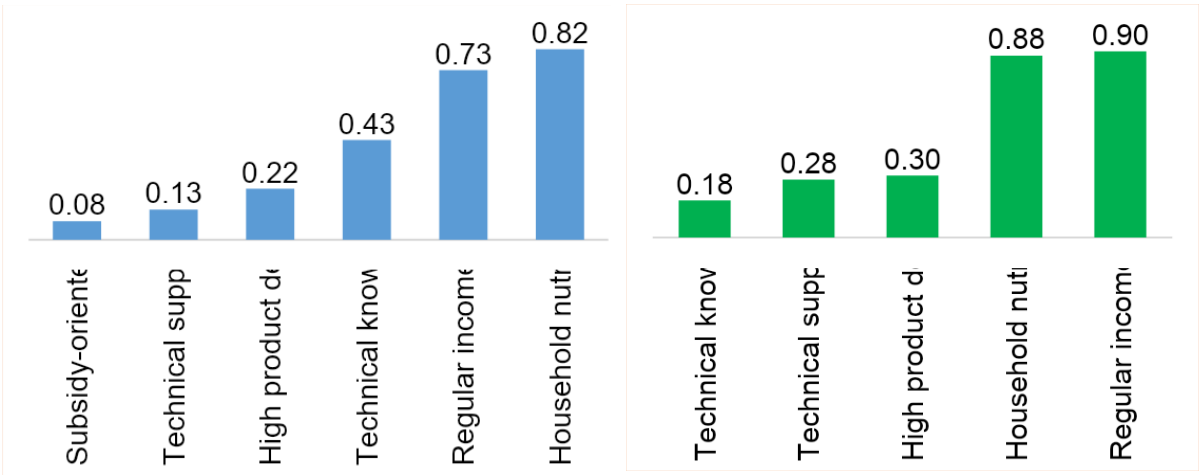


Index value of preferences for fruits (n=27)



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	Akabare 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

- Sustained supply of seeds of high yielding variety
- Serious pest and diseases in certain crops
- 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 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 especially the quality sapling 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 et al., 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 traditional bamboo basket and jute or plastic sacks, which induce physical damage due to bruising and compaction of fruits (Acharya & Shrestha, 2021). Poor postharvest 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 decline, banana bunchy top, guava wilt, guava scab, citrus psylla, fruit fly, 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 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. Forty percent 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

Table 5. Existing and potential vegetables and fruits in Bangladesh

Sub-sector	Major (existing - large scale)	Potential (commercialization)
Vegetables	Wax gourd, country beans, brinjal, bottle gourd, spinach, snake gourd, cucumber, cabbage, pumpkin, potato, bitter gourd, okra, cucumber	Drumstick, sweet gourd, ribbed gourd, lablab bean, capsicum, teasel gourd, yam
Fruits	Mango, litchi, watermelon, jackfruit, Palmyra palm, Malta fruit, lemon,	Dragon fruit, passion fruit, hog plum, custard apple, wood apple, pomelo,

	coconut, hog plum, betel nut, banana, Asian Palmyra palm, pineapple	jujube, green coconut, pomegranate, Amla

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, extension and education 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. Further, the policy recommendation with respect to engagement of youth in enhancing the productivity of fruit and quality sapling facility is urgently needed.

4.4. Gender Equality and Social Inclusion (GESI) in Horticulture Sector

Nepal has high potential 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). Seasonal 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. GESI has been identified and prioritized by the Government of Nepal along with its development partners as an important aspect of social development particularly after the Second People's Movement (Jana Andolan II) of April 2006 (Asian Development Bank, 2012). The Constitution of Nepal (2015) guarantees equal rights and opportunities to all citizens including women, Dalits, Adivasi Janajatis, Muslims, Madhesis, and other excluded or disadvantaged groups.

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 vegetable enterprise-	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 a 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, breastfeeding chambers) in custom yards, 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 an obstacle, though ADS has a policy to increase land ownership of women.

Despite considerable progress in women's participation in various sectors, South Asia ranks the lowest among eight regions in the world with only 62.3% of the gender gap closed in 2022 (Global Gender Gap Report, 2022). Across all South Asian countries, patriarchal values and social norms tend to privilege men and boys' access to opportunities and control over resources. Illiteracy, youth migration, less access of women to land and market, and unavailability of women-friendly technologies are some of the major challenges faced by youth and women farmers in Nepal. The literacy rate of females is 66% (15 years and above) of total women in South Asia, which is low compared to 81% of males (World Bank, 2020). This uneven literacy rate results in unequal access to resources and disproportionate participation of women in quality labor such as agricultural extension workers, input and machinery suppliers, etc. In Nepal, Women's empowerment in Agriculture 2015 reveals that women were over twice as disempowered as men at baseline with a WEAI score of 0.80. Same year WEAI score for Bangladesh in the Feed the Future ZOI is 0.79.

Apart from gender disparity, caste-based and religious discrimination accounts for unequal access in South Asian countries including Nepal and Bangladesh. These social minorities together with

patriarchy further isolate Dalit and marginalized women from opportunities. In South Asia, sexual harassment and violence are normalized, and most of them are not even reported (Orlando et al., 2020), this directly reduces the morale of workers in the workplace such as farms and markets. Data reveals that one in every twenty girls between the ages of 15 and 19 (around 13 million) have experienced forced sex, and violence at the hands of their intimate partners is more than 37 percent in South Asia (UNICEF, 2020a). The recent Covid-19 pandemic has disproportionately affected women farmers (FtF IPM Innovation Lab, 2020). Increased risk of gender-based violence, child marriage risks in health and social protection systems, challenges in the education system due to the closing of schools, and increased risk of the rollout are other increased challenges due to the recent pandemic (UNICEF, 2020b).

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. Youth 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 a high scope of involvement of socially and economically backward groups in horticulture if the 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 into horticultural entrepreneurship if a 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 of high value fruit and vegetables to national and international markets during lean season are the scope for promotion of horticultural enterprise.

So, we have to create an enabling environment for youth for optimizing production and handling of fruit and vegetables including capacity building, skill support, technical training to input suppliers, as well as policy barriers of input supply chain, youth savings group.

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 e.g. Jam, jelly, ketchup, 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 (Table 6 and 7).

In Nepal, although most of the decisions are made mutually in most cases, the decisions related to the market are dominated by male (Table 6). 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 6. 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 7. 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

The Constitution of Nepal 2015 is a big achievement for Nepali women, youth, marginalized communities, and small-scale farmers. Allocation of budget/credit by the government and other development partners to start an enterprise, subsidy in horticultural inputs and infrastructures are some of the efforts from the public sector for the promotion of the horticulture sector. There are other indirect efforts to empower and promote women and marginalized groups in the mainstream such as reservation quota for Dalits, Janajatis, Muslims, Madhesis, women, and other excluded or disadvantaged groups, Education for All (EFA) strategy and scholarships for Dalits and girls, female community health volunteers, etc. Although migration has been a serious issue, the knowledge, skills and experience youth gain in foreign country can be a valuable asset to Nepalese horticultural sector in the future.

To achieve gender equality and social inclusion in the horticultural sector, prioritizing women, youth, poor, and marginalized farmers in all plans, policies, and programs of government are necessary. Similarly, access to productive resources such as land ownership, loan facility, and priority for seeds and fertilizer needs to be increased. Local government needs to have specific policies and resources to recruit more women extension workers and Local Agriculture

Resource persons to provide agricultural services. Gender-responsive planning and budgeting is necessary to promote women farmers for technology demonstration and leadership capacity for dissemination. Likewise, translating the GESI policies into action, and focusing youth in entrepreneurship development and promoting GESI education are the efforts yet to be completed to bring social justice and equality in South Asia.

4.5. Marketing and Value Chain of Fruits and Vegetables

Table 8. 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 fruit and vegetable 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 intake of vegetables and fruits is a key strategy to address the problem of hunger and malnutrition in developing countries (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 Nepal 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. There is limited trained human resource in the government and private sector, no vegetable breeders with the private sector. 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 knowledge 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.

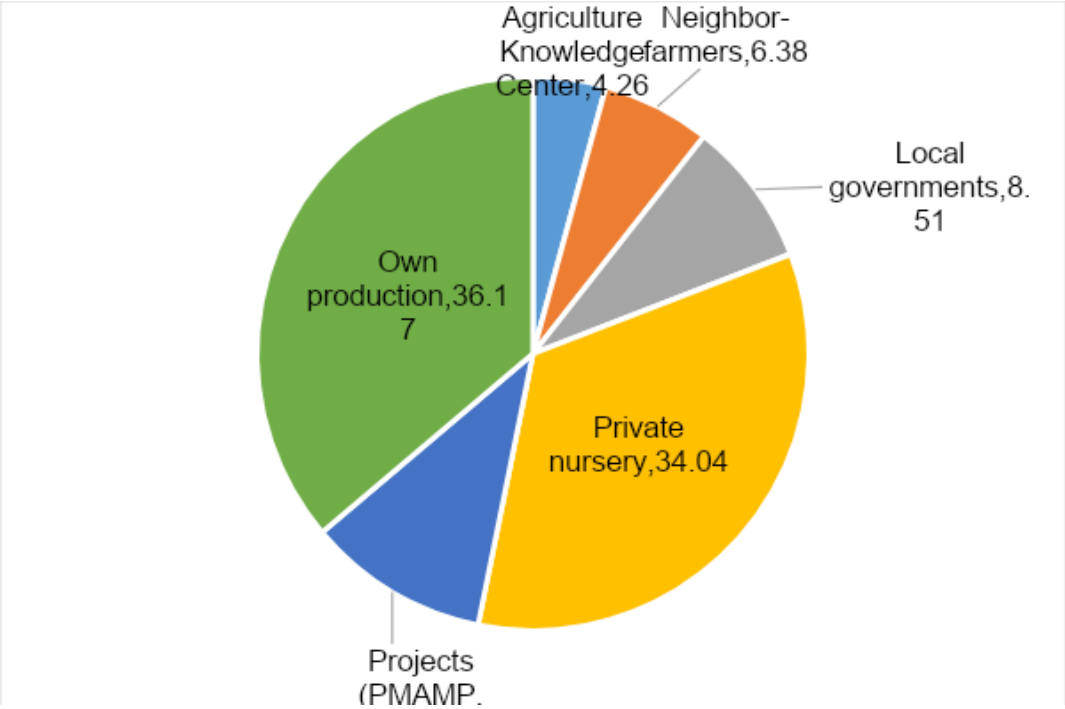


Figure. 5. Source of seedlings and saplings in Nepal (% HH response)

Table 9. Source of seeds and fertilizers in Nepal and Bangladesh

Input type	Source	Response (%)	
		Nepal	Bangladesh
Seeds	Agro-vets	67	61
	Own production	18	30
	Cooperatives	13	-
	Other (i.e. subsidy)	2	9
Chemical fertilizers	Agro-vets	54	100
	Cooperatives	46	-
Farm-yard manure (FYM)	Own production	76	64
	Neighbor	12	-
	Entrepreneur	12	36

Farmers face a great challenge in management of chemical fertilizers, particularly due to unavailability of chemical fertilizers in time and required quantity.

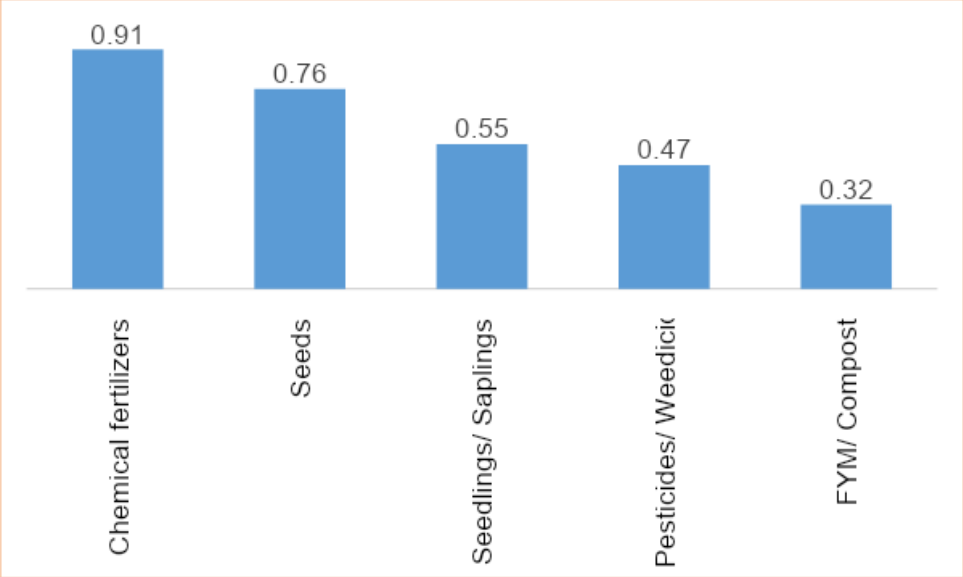


Figure. 6. Problem areas for the input management in Nepal (Index value; n=61)

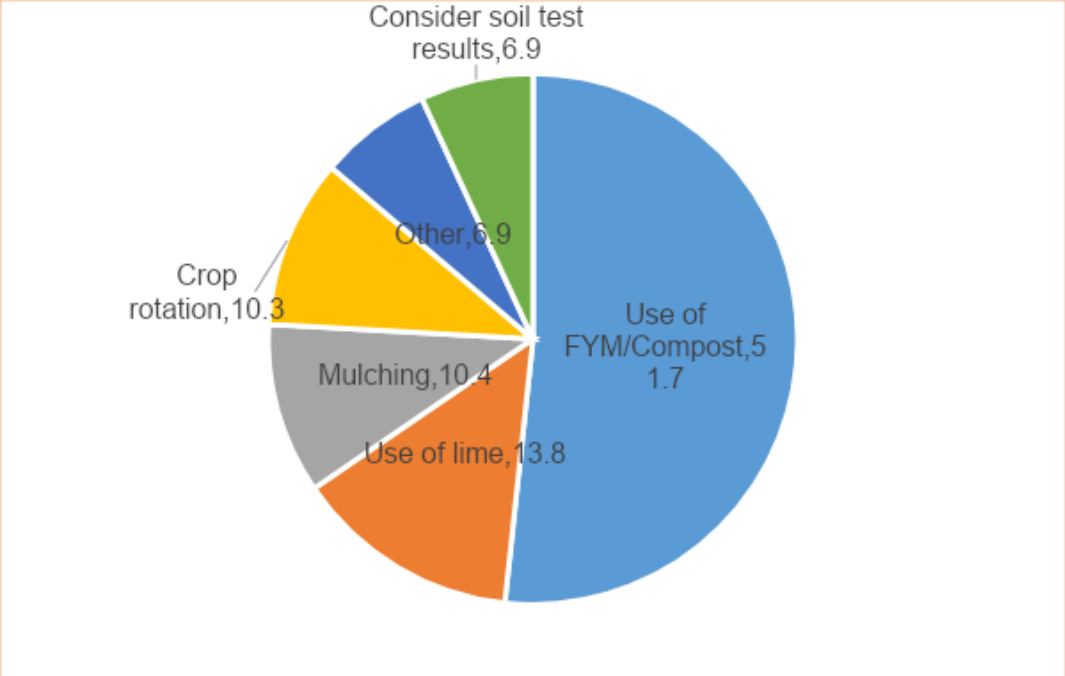


Figure. 7. Different practices adopted by farmers for soil nutrient management (% HH response)

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.

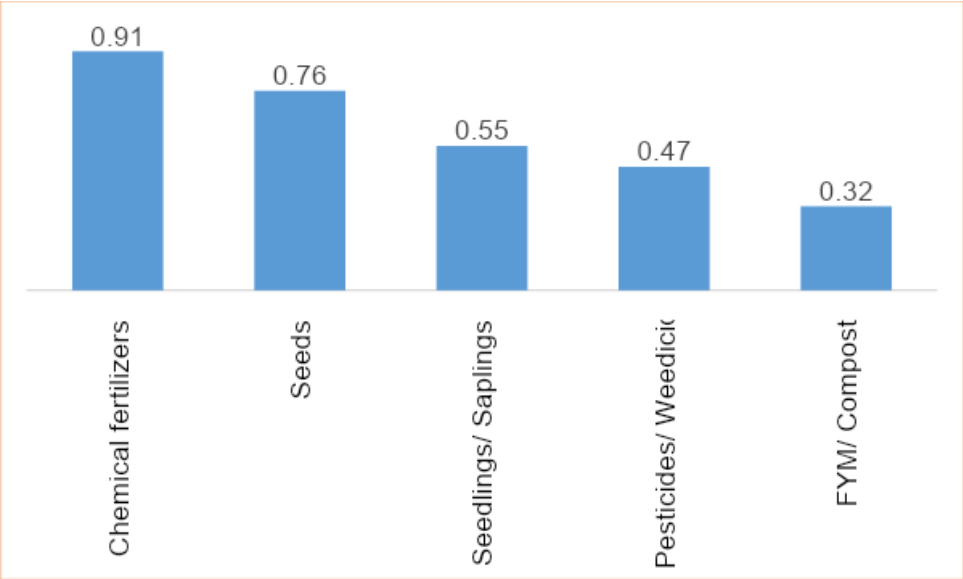


Figure 8. Problem areas for the input management in Nepal (Index value; n=61)

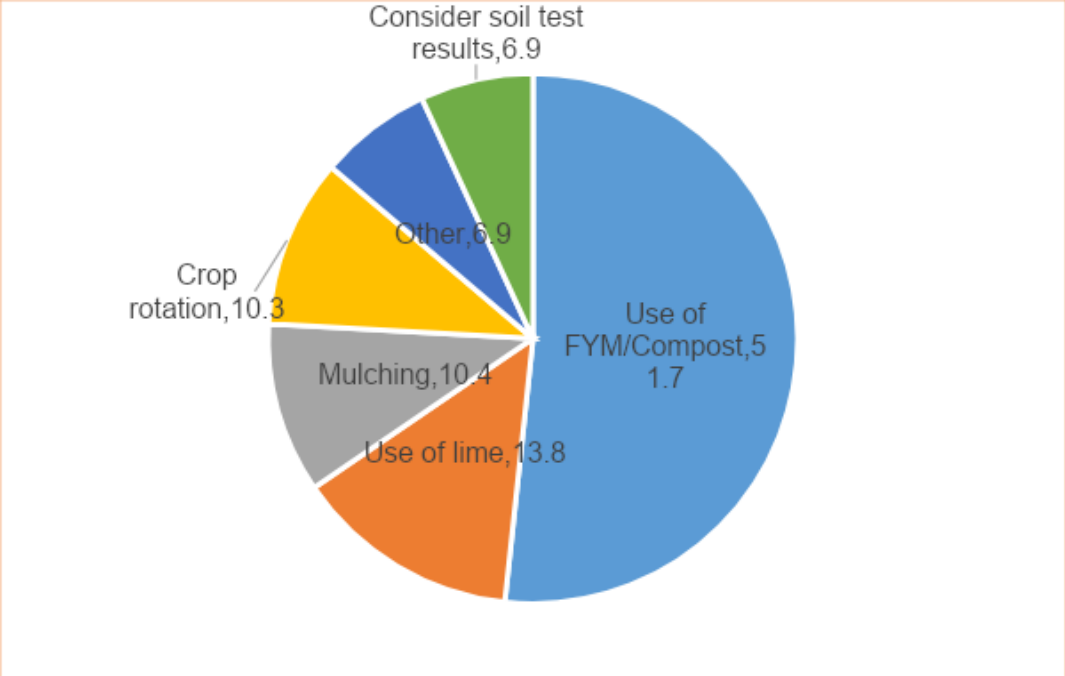


Figure 9. Different practices adopted by farmers for soil nutrient management (% HH response)

Table 10. 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). Chilli, 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 (Poudel 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 pests 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 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 vegetables. 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 detailed 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 crop 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 pollinators 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 staff (90000) followed by Bangladesh (14035), and Pakistan (9749). Private sector extension also plays a 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 the private sector is continuously replacing the dominance of the 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 the South Asian context (Davis et al., 2018). In addition to that, public extension workers are accused of having 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 ғ 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 have 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 chambers. Different types of driers developed at various research institutes include: solar cabinet dryer for vegetables, waste fired dryer, and cardamom dryer. The Government of Nepal is also giving the priority on post-harvest management while 25% governmental subsidy has been 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.

Improvement in the bargaining power of vegetable and fruit farmers in Bangladesh

- Formation of farmer groups/cooperatives and increase their access to market information, and develop their technical skills on post-harvest management of vegetables, including value addition.
- Increase farmers' access to capital market.
- Development of required infrastructure, i.e., storage structure.
- Development and management of virtual markets, i.e., super shop, information and digital technology.

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 reached by modern technologies and chemical fertilizers. 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. In this prospect, 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 growth and development 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 in the 1990s by Lumle Agricultural Research Centre for research, 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

Highly erratic weather conditions demand higher care and better management of crops, which increases the cost of production. The occurrence of pests 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 nematodes. 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.

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.

Protected cultivation is beyond the reach of small and medium farmers because it requires 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.

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.

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. Most of the labor forces are going for foreign employment; therefore, non-skilled labors are scarce during peak seasons. This is hindering the pace of development of protected cultivation.

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) are the major issues related to the marketing whereby the

production pockets have not yet attracted the traders pertaining to the low volume of production and less post-harvest management practices.

b. Opportunities for the promotion of protected Horticulture

The crop productivity has been increased up to 5 to 8 times in the protected cultivation due to the increased harvesting length of the crops, optimized productivity with less insect pest infestation, ambient micro-weather conditions and supportive cultural practices. Plants can be grown anywhere in any season, which ensures 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 intercultural operations and easy management.

Pesticide use reduces up to 90% to protect the crop from pests, which results in low pesticide residue in the products thus contributing to climate change. Uniform and better quality of a product can be obtained due to better growing environment. In protected cultivation, fertilizer use efficiency increases by 30%, and water requirement is reduced up to 50% and with these opportunities, more young and educated growers are being attracted and involved in protected cultivation.

c) Way forward for the promotion of protected Horticulture

Protected horticulture in South Asia is in dire need for contextual research to develop and/or recommend suitable varieties for protected structure or register imported high yielding varieties in a fast track. The sector aspires for research and development in fertigation formulation and subsidy in water-soluble fertilizer. The sector expects reduced tax on materials used in protected horticulture with the recommendation of related government authorities. The government together with academia should focus on skilled human resources development under research, education, and extension for technology generation and dissemination. The agricultural institutions require the revision of the course curriculum to meet the current demand for knowledge with the 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 loan for large farmers. The subsidy scheme should be based on output and it needs to be increased up to 90%, for small farmers. The detailed economic analysis is recommended for protected cultivation in different types of structures whereby repair and maintenance of them should be included in the policy before construction. 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 also 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 initial 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 a 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 the 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 and 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 (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 somatic embryogenesis, bioreactors and 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 to other countries 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 of machinery cannot be used in all soil types. Another major problem is the unavailability of 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 manufacturers.

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.

Challenges in the production and marketing of vegetables and fruits in Bangladesh

Challenges in production	Challenges in marketing
• Difficulty in the adoption of improved technology by farmers • Difficulty in the management of agricultural inputs by farmers • Low farmers' access to quality inputs • Limited extension services • Less mechanization in farming activities • Difficult in soil salinity management • Limited post-harvest processing and storage facilities • Difficulty in flood management and reduce damaged from the floods • Climate change impacts and associated adaptation practices in agriculture	• Limited know-how on post-harvest management practices • Limited access to market structure, i.e., transportation/road, • Excessive involvement of middlemen in the marketing of fruits and vegetables • Low and fluctuating farm-gate prices of vegetables and fruits • Limited traders' access to capital market • Low volume and irregular supply of agricultural produce • Limited involvement of agricultural cooperatives in the marketing of agricultural commodities

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 especially in Bangladesh and Nepal

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 indigenous fruit species
- Suitable post-harvest technologies and handling operations associated costs and benefits
- Extension based farm management and marketing advisory
- Cross-border variety exchange: exchange of the genetic resources of fruits (mango, banana guava, jujube) between Bangladesh and Nepal
- Technology development on new/emerging fruits, i.e., dragon fruit, passion fruit,
- Climate-smart technology and insect/pest management in major fruits (citrus psylla, fruit fly, banana wilt, guava scab)
- Pollination barriers in some fruits (i.e., dragon fruit) and adapt the suitable rootstocks in tree-fruit crops rather than growing in their own root system.

4.19. Priority Research Areas in Vegetables Sub-sector in South Asia especially in Bangladesh and Nepal

- Testing, validation, and dissemination of improved and high-yielding vegetable varieties and production technologies
- Production and promotion of indigenous vegetables (Akabare chilly, Asparagus, *Chenopodium* and beetroot)
- Markets system analysis and market led production
- Development and dissemination of the drought, flood, saline-resistant crop varieties
- Low-cost protective culture and the mechanization technology
- Development of site-specific varieties of fruits and vegetables with broad genetic base to sustainable growth and development of indigenous fruits and vegetables in South Asia.
- Grafting in vegetables (i.e., brinjal, tomato) for the management of disease and pest
- Women-friendly mechanization: development of promotion of women-friendly (i.e., less vibration, less height and weight) for smooth operation of the fields in Nepal and Bangladesh
- Feasibility study of newly/innovated technologies for adoption at the local level

- Identification, validation, and promotion of climate-friendly farming practices
- 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 tomato, 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. Based on the above challenges and exploring the opportunities in fruits and vegetable sub-sectors, following topic are the possible research areas in South Asia with a special emphasis on Bangladesh and Nepal:

- High density planting in apple, citrus, mango, walnut, 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 significantly pronounced. 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 extending the shelf life of fruits and vegetables.
- Disease, pest and physiological disorder management in major fruits:
    - Citrus decline
    - Fruit fly in major fruits
    - Alternate bearing in mango
- Soil tests and integrated plant nutrient management (IPNM)
- Disease and pest management in vegetable crops
- Testing, validation, and dissemination of improved and high-yielding vegetable varieties and production technologies
- Strengthening research on variety development through traditional and speed breeding approaches as well as biotechnological improvements
- Markets system analysis and market led production
- Use of good agricultural practices (GAP) for fruit and vegetables production and processing
- Development and dissemination of the climate resilience variety (drought, flood, saline-resistant crop varieties) employing biotechnological approach

- Low-cost protective culture for year-round high value vegetables
- Development of site-specific varieties of fruits and vegetables with broad genetic base to sustainable growth and development of indigenous fruits and vegetables in South Asia.
- Grafting in vegetables (i.e., brinjal, tomato) for the management of disease and pest
- Women-friendly mechanization: development of promotion of women-friendly (i.e., less vibration, less height and weight) for smooth operation of the fields in Nepal and Bangladesh
- Feasibility study of newly/innovated technologies for adoption at the local level
- Identification, validation, and promotion of climate-friendly farming practices
- Processing of vegetables, value additions and storage of vegetable crops
- Safe and organic vegetable production technology
- Model-based quality vegetable production: Hydroponics and rooftop gardening, home gardening etc.

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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	Chair person, AFU Service Commission
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
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	Director, Shwapno Vermicomposrt (Input Supplier), Moheshworchanda, Kaliganj, Jhinaidah, Bangladesh
18	Dr. Ferdouse Islam	F	Presenter	Representative, Bangladesh Agricultural Research Institute (BARI)

SN	Name	Gender	Participation	Designation, Organization
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, Ishwardi, 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
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

SN	Name	Gender	Participation	Designation, Organization
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
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	Senior Program Specialist (Horticulture), SAARC Agriculture Center
51	Mr. Basanta Marahaththa	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	Proprietor, 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
66	Prof. Dr. Arvind Srivastava	M	Special Guest	Professor and Academic Dean, AFU
67	Mr. Bhola Shrestha	M	Presenter	Organic Agriculture Inspector, OCN

SN	Name	Gender	Participation	Designation, Organization
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. Janelle Beth Larson	F	Special Guest	Associate Professor, Agri economics, Penn State University
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 Ellicott	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
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

SN	Name	Gender	Participation	Designation, Organization
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, WeltHungerHilfe
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

SN	Name	Gender	Participation	Designation, Organization
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
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**	
Narsingdi	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	Babugonj	10	2
Jhalokati	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 Entrepreneur
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 Scientist

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 19. Special Guest: Prof. Dr. Hom Bahadur Basnet, Dean, Faculty of Animal Science, Veterinary Science and Fisheries, AFU	MC: Dr. Ranjana Rawal, Horticulture Scientist, NARC

	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. ● 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. Md Rezaul Karim, BAU Bangladesh 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 ● 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. Shanta Karki, MOALD 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. Hom Nath 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 CEREMONY	
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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