

## Chapter 13

# Horticultural Research and Development in SAARC Region Towards 2030

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### Abstract

*Horticulture is an important component of agricultural economy for the member countries of the South Asian Association for Regional Cooperation (SAARC). It contributes to food and nutrition security, income diversification for smallholder farmers, job opportunities along the value chain, and an increase in foreign exchange. Nevertheless, the horticulture sector in South Asia faces various challenges: i) inadequate production and supply of nutrient-dense fruit and vegetables to meet daily micronutrient requirement of the people, especially for children of age under five years and women of reproductive age; ii) low productivity of horticultural products due to the use of low-yielding varieties, prevalence of pests and diseases, limited knowledge and skills in crop management, and unavailability of basic input materials; iii) climate change that brings out emerging invasive pests and infectious plant diseases, and abiotic stresses imposed on horticultural crops, thus aggravate already low productivity; iv) food safety concerns of marketed fruit and vegetables arising from overuse of pesticides, improper growing environment, and mishandling of horticultural products; v) post-harvest losses and waste of inherently perishable horticultural products due to factors such as improper handling, and inadequate facilities for storage, transport, and processing; and vi) inadequate marketing linkage and value chain development. To address these challenges for the next decade, we propose a series of research and development (R&D) programs that could be jointly implemented within the SAARC community in association with international and regional agricultural research organizations. The SAARC Agricultural Centre (SAC) is in best placed to facilitate implementation of the proposed research and development programs through the establishment of public and private sector partnerships, and leverage funding.*

**Keywords:** South Asia, horticulture, research, development, collaboration

## **Background**

Horticulture is a branch of agriculture concerned with high value fruit and vegetable crops that are used by people as part of their daily diet, with spices as a way to add flavor and increase appetite, with herbs for health purposes, and ornamental plants used for aesthetic functions that improve living quality. Horticulture is considered as distinct from the production of field crops such as cereals, starchy root crops, plantation crops, and oil seeds, which often are grown under a monocrop system with their products processed and traded in large quantities. Horticulture is usually labor intensive, making use of relatively small land areas and with high economic returns per unit area. Horticulture production supports agribusiness, creating new economic and entrepreneurial opportunities. Horticulture production diversifies and generates farm income, usually to a greater degree than other agricultural products.

Horticultural products are diverse, and play an important role in modern society and economies. Fresh edible horticultural products are nutrient dense foods that contribute to healthy diets of both rural and urban populations. Horticultural products also form the basis of a wide array of processed or partially processed products. An innovative private sector reinvents traditional plant species or preparations as innovative products using fresh fruit and vegetables in convenience foods and components of ready meals to meet the modern busy lifestyles of urban communities. Ornamental plants have high cultural value for humans as indoor and garden decorations in daily life and special events, settings for leisure activity and through urban greenery as an important part of the quality of life.

For low and middle-income countries, horticulture can contribute to food and nutrition security, and create income diversification for smallholder farmers, job opportunities, especially for women and youth along supply systems from seed to retail with value addition in between. As a whole, the horticulture sector may represent a 'picture of the future' for agriculture because it is a sector which is less restricted by measures such as subsidies and tariffs, but sees an increasing demand for higher standards due to health, safety, and broader quality concerns. Thus the sector encompasses the major challenges that South Asian agriculture faces in a world of increasing incomes, tougher delivery schedules, less restrictive conventional trade barriers, and more demanding product standards.

## **Regional Situation in Horticulture Sector**

### **Agroecosystem**

South Asia covers a variety of mountains, plateaus, dry regions, intervening structural basins, and island and archipelago, and has extremely diverse agro-climatic conditions due to major differences in altitude and rainfall as well as in slope characteristics. The

humid and moist sub-humid agro-ecological zones, which benefit from seasonal monsoon rains and more than 180 growing days per annum, are located in Bangladesh and around the northeastern, eastern and southern fringes of India, and cover the central, west and south of Sri Lanka. With large areas of alluvial soils and a high proportion of the land under intensive rice cultivation, these areas support a particularly dense population. The dry sub-humid areas, characterized by 120 to 180 growing days each year, cover most of the Deccan Plateau in Central India. The northwest of India, most of Pakistan and Afghanistan are semiarid or arid with less than 120 growing days. This area also features large year-to-year variations in the rainfall, frequently causing severe floods/droughts over large areas. The hilly areas, which include the foothills and valleys of Nepal, Bhutan, and northern India, are characterized with the terraced cultivation with 120 to 170 growing days. Maldives with a chain of islands is warm and humid but constrained by the poor quality soil for year-round production of crops.

The average size of farm holdings in South Asia varies from less than 0.6 hectare in Bangladesh to 3.1 hectares in Pakistan (Anik et al., 2017); the average farm size of most other South Asian countries remains less than one hectare. Furthermore, less than 50% of cultivated area is under irrigation.

## **Horticulture**

The diversity of agro-ecological conditions and climates across South Asia provides an ideal environment not only for cultivation of a wide range of horticultural crops but also a vast potential for inter-regional trade and industry. The member countries of SAARC have also abundant availability of indigenous fruit, vegetables, flowers and herbs many of which are known for their therapeutic/medicinal and nutritive value and excellent flavor and color. The demand for such produce is likely to increase in the international market both in fresh and processed form. Nevertheless, uneven development or contrasting situations in the horticulture sector is apparent in South Asia, both within and between countries, partly due to the huge diversity of soil types, water availability, climate, and socioeconomic factors.

The region grows a diversity of indigenous and global horticultural crops (Akter & Azad, 2014). The total productions of fruit and vegetables in South Asia have been estimated at 127 and 158 million tons grown in 10.3 and 10.5 million hectares, respectively, in 2017 (FAOSTAT, 2019), in which India accounts for about 73% and 81% for fruit and vegetables, respectively (Figure 1). The export value of South Asian fruit and vegetables reached 60 billion US\$ in 2016 (FAOSTAT, 2019), in which India accounted for 55%. India stands second in the world production of fruit and vegetables after China. The total value of horticultural crops (fruit, vegetables, spices and ornamental plants) reached Rs. 344,900 crore in 2012 (GoI, 2017), which is about 16% of the value of output in India's agriculture. Fruit and vegetables account for nearly 90% of the total horticulture

production. On the other hand, as an archipelago country, agriculture in Maldives, plays a much more limited role in the country's economy, constrained by the limited availability of cultivable land and the shortage of domestic labor.

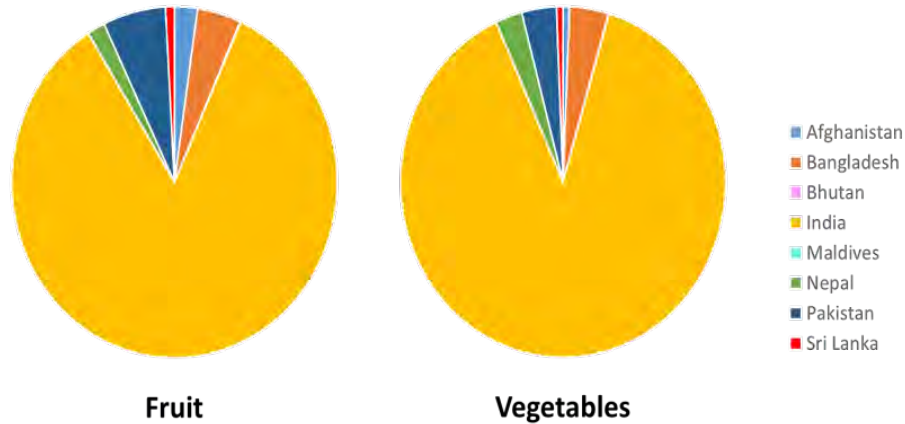


Figure 1. Proportion of fruit and vegetable production in South Asian countries

Source: FAOSTAT (2019)

Most of South Asian countries for the past decade, maintained positive growth in production of fruit and vegetables (Chhogyel & Kumar, 2018; FAO, 2018; Jha et al., 2019; Nabi & Bagalkoti, 2017; Pandey et al., 2017; Perera, 2013; Thapa & Dhimal, 2017; Yousufi, 2016) indicating the increasing role that horticultural crops play in enhancing farmer incomes, alleviating poverty and improving quality of diet. The total population in the region is expected to grow to 2.2 billion people by 2030 (Population Pyramids, 2019). This scenario, accompanied with rising per capita income and increasing urbanization (with 50% of the region's population lives in urban areas) will certainly lead to an increase in demand for fruit, herbs, spices and vegetables.

Bangladesh and Pakistan have the highest import-export ratios of fruit and vegetables (FAOSTAT, 2019), 18 and 20 times of import over export, respectively, implying that fruit and vegetable productions in these two countries lag far behind the domestic demand. Bangladesh has consistent production and area increases over the past 20 years, whereas Pakistan tends to have production and area decrease in the same period. Horticultural crops (fruit and vegetables) in South Asian countries range from 1% to 11% of total cultivated areas (Table 1) with Pakistan having the smallest share.

Table 1. Percent of areas under fruit and vegetables out of total cultivated areas in respective South Asian countries

<b>Country</b>	<b>Fruit</b>	<b>Vegetables</b>
Afghanistan	6.3	6.7
Bangladesh	5.7	6.8
Bhutan	10.4	10.1
India	3.9	4.6
Maldives	-	-
Nepal	8.1	11.3
Pakistan	3.8	1.9
Sri Lanka	7.9	3.3

Source: FAOSTAT (2019) & GoA (2016)

In South Asia, short-season vegetables and flowers are usually incorporated in the rice farming system, rice-wheat farming system, rain-fed mixed farming system, highland mixed farming system, and peri-urban and urban based farming system; whereas fruit trees and ornamental plants are grown in the scattered tree crop farming system. Spices are grown as intercrops with fruit and vegetable crops. However, there are also a few large plantations of mono-cropped spices like black pepper and cardamom.

## **Challenges and Opportunities in Horticulture Sector**

### **Nutrition Security**

South Asia has enjoyed sustained economic growth in the past decade, which will continue with Asian Development Bank’s forecast for 7.2% economic growth in 2019. Ironically, nevertheless, the region suffers from extreme poverty, undernourishment, and the deterioration of its natural resources. It houses more than 27% of the world’s poor earning less than US\$ 1.90 per day, primarily rural, young, and working in agriculture (CGD, 2019). The region has the highest Global Hunger Index score of 30.5, indicating serious levels of hunger (GHI, 2018). And undernourishment is widespread, especially among women and children. Nearly 15% of the population is undernourished. Bewilderingly, 33% of children aged under five are stunting and 15% wasting, and 49% of women of reproductive age are affected by iron-deficiency anemia (GNP, 2018).

Fruit and vegetables are nutrient dense and rich sources of minerals, vitamins, edible fiber, and functional phytochemicals. The regular consumption of a variety of fruit and vegetables is essential for a well-balanced diet. A number of international bodies (i.e., WCRF & AICR, 1997; WHO, 2003) advocate an increase in intake of fruit and vegetables to 400-500 gram per day (excluding potatoes and other starchy root crops). Furthermore, to avoid non-communicable diseases, Afshin et al. (2019) recommended optimal daily

consumption levels of 250 gram of fruit and 360 gram of vegetables, respectively, per person. Unfortunately, the per capita consumption of fruit and vegetables in South Asia remains low (Micha et al., 2015), i.e. 280 gram daily for India (Mukherjee et al., 2016) and only 100 gram daily for Pakistan (Hameed et al., 2016). All South Asian countries had less than 50% of their adolescents consuming  $\geq 400$  g of fruit and vegetables daily (Darfour-Oduro et al., 2018). Only 2.1% of the population in Nepal (Vaidya et al., 2013) and 1.0% in Pakistan (Hall et al., 2009) consumed fruit and vegetables at the WHO-recommended level. While global in scale, the prevalence of micronutrient (vitamins and minerals) deficiencies, also known as hidden hunger, is particularly high in South Asia despite recent successes in health care (Harding et al., 2018). In this connection, Hidden Hunger Index has been developed and employed as a ranked index of countries affected by the severity of micronutrient deficiency. Ruel-Bergeron et al. (2015) reported that South Asian countries were ranked in top half of 149 countries with high Hidden Hunger Index. Among eight South Asian countries, India has the highest score of Hidden Hunger Index (Table 2).

Table 2. Hidden hunger index scores (HHI) by country in South Asia

Country	Ranking (Out of 149 countries)	HHI	Prevalence (%)		
			Stunting	Anemia due to iron deficiency	Serum retinal <0.7 $\mu\text{mol/L}$ )
Afghanistan	12	47.7	59.3	19.0	64.5
Bangladesh	52	29.3	43.0	23.5	21.7
Bhutan	42	33.3	37.5	40.3	22.0
India	6	48.3	47.9	34.7	62.0
Maldives	50	30.0	31.9	48.9	9.4
Nepal	34	35.3	49.3	24.2	32.3
Pakistan	63	26.7	42.0	25.5	12.5
Sri Lanka	75	22.3	19.2	12.6	35.3

Source: Ruel-Bergeron et al. (2015)

Dizon & Herforth (2018) reported that low intake of nutrient-dense fruit and vegetables in South Asia is largely attributed to seasonal fluctuations in prices. Fruit and vegetables are more seasonally and spatially variable than those of energy-dense, low-micronutrient cereals and legumes. Moreover, fruit and vegetables tend to be highly perishable, thus they generally have a shorter shelf life for storage and transportation than cereals and grain legumes. And there are personal factors such as likes and dislikes of certain fruit and vegetables because of their sensory tastes, and social and cultural norms that deter the intake of these nutritious foods (Kehoe et al., 2019).

To address the issue of low consumption of fruit and vegetables, strategies need to be multidisciplinary and coordinated, and should comprise a balance of components to stimulate growth in both demand for and supply of fruit and vegetables. Besides increasing availability, accessibility, affordability and sustainability of fruit and vegetables for the consumers, messages about fruit and vegetable consumption need to be integrated into food-based dietary guidelines, to be country specific and culturally relevant, and coordinated with other messages about healthy diets. South Asian countries could also learn from various campaigns initiated in high income countries for promoting consumption of fruit and vegetables such as “Five A Day for Better Health” and “Fruits & Veggies – More Matters” in the USA, “Go for 2 & 5” and “Eat Brighter Live Lighter” in Australia, “6 a Day” in Denmark, “5 + A Day” in New Zealand, etc. Innovative communication campaigns at consumer level could include web campaigns inviting children to get involved with healthy eating; mobile/internet/video-games; toys/cartoon character or play-way based activities; field days for fruit and vegetables; and catering of hygienic fruit in public gatherings and schools.

On a different perspective, a growing body of evidence has emerged in the past decade that suggest an increased consumption of healthy plant-based foods (e.g., fruit, vegetables and legumes) might be associated with lower emission of greenhouse gases and thus might be more environmentally sustainable (Tilman & Clark, 2014).

### **Productivity**

There are significant differences in yields of fruit and vegetables per unit land area among South Asian countries. India stands out as a country with the highest average yields for fruit and vegetables per unit land area in South Asia, at 13.1 and 15.0 Mt/ha, respectively (Table 3). Nevertheless, average yields of fruit and vegetables for South Asia as a whole are 71 and 50% of Northeast Asia. There are environmental and technological factors that potentially contribute to this gap. Night temperatures in tropical and sub-tropical South Asia are usually high, therefore respiratory losses are also expected to be high, thus resulting lower yield. On the other hand, a single growing season in temperate Northeast Asia is usually long; therefore photosynthetic products (biomass) are also expected to be high, thus resulting in higher yields. Moreover, high temperatures and humidity in the tropical and sub-tropical South Asia likely to increase the prevalence of phytopathogens (e.g. bacteria, fungi, nematodes, viruses, viroids, etc.), pests (e.g. insects, mites, vertebrate pests, etc.), and weeds that affect not only productivity but also quality of horticultural crops.

Table 3. Average yields (Mt/ha) of fruit and vegetables in South Asian countries (2017)

Country	Fruit	Vegetables
Afghanistan	8.5	9.6
Bangladesh	9.7	9.5
Bhutan	6.2	5.2
India	13.1	15.0
Maldives	9.5	1.7
Nepal	9.4	13.3
Pakistan	12.2	12.2
Sri Lanka	5.6	12.6
South Asia	12.3	14.8
Northeast Asia <sup>1</sup>	17.4	29.5
World	13.3	18.8

Source: FAOSTAT (2019)

<sup>1</sup>Includes Japan, South Korea and Taiwan

There are also technological and policy factors that contribute to low productivity of horticultural crops in South Asia. Horticulture has been neglected by public sector, which places emphasis on staple crops. Smallholder farmers remain ill-informed on changes in cultivation practices. As a result, out-of-date farming practices and unavailability of quality inputs are the rule for the horticulture sector, except for some pockets with major private sector investment – high-tech horticulture is, therefore, possible. But these are out of reach for smallholder farmers (Quddus, 2009). As a result, productivity levels are low, prices are high, and fluctuate widely across the year.

In South Asia, more than 95% of the agriculturally suitable land is already under cultivation. Hence, there is hardly any scope for horizontal expansion of land for producing more horticultural crops. But to meet with burgeoning demand for quantity and quality of diverse horticultural products, besides shifting portions of cultivated land for horticultural crops, increasing productivity and profitability per unit land area is the only way. Towards this, there is a need for continuous technology innovation in developing improved varieties for resistance to diseases and pests, tolerance to drought, flooding and heat; improved varieties with short duration and producing good yields under stress conditions; integrated pest management (IPM) including bio-control agents for safer marketed products and environment; integrated soil fertility management; protected cultivation for all seasons; supply system of quality planting materials; improved water use efficiency; organic agriculture; precision management of fruit tree orchards; etc. Furthermore, smallholder farmers will have to acquire a high level of skill and knowledge to fully adopt these new technologies.



## Climate Change

South Asian countries have been identified as some of the most affected countries by global climate change, although their contribution to greenhouse gas emissions has been shown to be low (World Bank, 2013). The impact of climate change can already be seen in the greater variability of the monsoon, increased frequency of tropical cyclones, and faster melting of the Himalayan glaciers. In the region, Bangladesh is one of the most climate-vulnerable and disaster-prone countries because of its geographic location, a flat and low-lying deltaic floodplain, as well as its exposure to various hydro meteorological hazards. Salinity intrusion is affecting agricultural production and is also becoming more intense and frequent. As a result, agricultural gross domestic product over 2005-2050 is projected to decrease 3.1% annually (USAID, 2015).

Much of the agriculture in South Asia is rain fed, so there is a fundamental dependence on rains that come seasonally. The probability of lower crop yields can thus increase with climate change. Crop yields in the region are predicted to decrease in the absence of increased resilience to cope with climate risk between 7 and 10% in the near future (TAAS, 2017). Climate changes have already caused distinctive reduction in production of fruit and vegetables in South Asia (Malhotra, 2017). Thus, smallholders in the horticulture sector are the most vulnerable, as their ability to bear risk is extremely low.

Many fruit and vegetable crops proven to be relatively sensitive to climate changes (Backlund et al., 2008), which raises the prospect of reduced fruit and vegetable availability in the future with contingent public health concerns. **Climate changes have shown to impact on:** i) the suitability and adaptability of prevailing varieties as temperatures change, together with changes in the optimum growing periods and locations for horticultural crops; ii) the re-distribution of current pests, diseases and weeds, and an increased threat of new intrusions; iii) downgrading product quality; iv) increased input costs for chemical fertilizers and pesticides; v) increased risk of spread and proliferation of soil borne diseases, e.g., bacterial wilt in solanaceous crops, as a result of intense rainfall events coupled with high temperatures; vi) increased risk of soil erosion and leaching effects of nutrients and pesticides from extreme rainfall events; and vii) increased irrigation demand especially during dry periods.

Besides, as many fruit and vegetable species rely on pollinators, a complete loss of pollinators because of climate change has been predicted to reduce global fruit supply by 23%, vegetables by 16% and nuts and seeds by 22% with major adverse effects on health (Smith et al., 2015). High temperatures may also indirectly affect fruit and vegetables yields due to decreased labor productivity of farmers. Many fruit and vegetable crops require high labor inputs, especially for planting and harvesting and hence climate change induced heat stress may disproportionately affect the horticulture sector.

To address climate change challenges as well as for economic growth and development of the horticulture sector, investment in research and development must be increased to develop site-specific adaptation/mitigation strategies. This may include the development of climate-resilient varieties; low-cost protected cultivation technologies; multiple cropping systems; smallholder farmer-friendly decision-making technologies; etc. And there are climate resilient agriculture technologies and practices, which enhance productivity as well as adaptation and/or mitigation and present opportunities for scaling up. For this profile, they include:

- Adoption of adaptive crop calendar.
- Use of crop species and varieties that are resistant/tolerant to diseases, pests, and drought, flooding, high temperature, salinity, etc. keeping in view the nature of crop, its sensitivity level and the agro-ecological region.
- Use of quality seeds and planting materials, and improved water use efficiency.
- Site-specific nutrient management.
- Protected cultivation to reduce impacts of extreme weather elements for year-round production.
- Multiple cropping to reduce impacts of climate change, mulching with crop residues and plastic mulches to conserve soil moisture and suppress weeds.
- Integrated pest management including use of bio-control agents and monitoring of emerging diseases and pests.
- Intercropping of vegetables in fruit orchard to suppress weeds and improve productivity.
- Raised bed cultivation to overcome flooding.
- Sustainable land, soil management, and organic farming.

Nonetheless, given the scale of climate change impacts, stand-alone measures for the horticulture sector to adapt to them will not suffice. Resilience needs also to be mainstreamed and embedded into policies and programs such as material subsidies or crop insurance across scales of governance.

### **Food Safety**

Most consumers pay attention to the appearance of fresh produce offered in markets and this means that farmers resort to indiscriminate and excessive use of pesticides to limit economic risks. As a result, food safety issue arises and becomes a particular concern for fruit and vegetable consumers in South Asia. We have conducted a literature survey on food safety concerns related to vegetables in South Asia. Insecticides classified by WHO (2009) as extremely hazardous (Ia) organophosphates i.e. methyl parathion and parathion, and highly hazardous (Ib) organophosphates i.e. dichlorvos, monocrotophos

and triazophos are still used in vegetable production in Bangladesh, India and Nepal; and highly hazardous carbamate (Ib) i.e. carbofuran used in Bangladesh and Pakistan; and their residues detected in marketed produces. On an average, vegetables in India were applied 10 to 15 times of pesticides, resulted in a total of 2 to 5 kg/ha (Kodandaram et al., 2013; Pujeri et al., 2016). Without personal protective equipment and proper application of pesticides, they likely will cause occupational hazards. Besides, pesticide residues contained therein can have both acute and chronic health effects, depending on their type, quantity, function, ways in which a person is exposed (such as eating or direct contact with the skin), and duration of exposure.

In view of the above, governments need to introduce policies that facilitate removal of ineffective or highly dangerous pesticides from the market, and encouragement of the bio-control industry, training of farmers or farm operators on safe use of pesticides and IPM. It is encouraging that many Asian countries are embracing biocontrol measures and speeding up legislation.

Apart from pesticides, high concentrations of non-essential highly toxic heavy metals (As, Cd, Cr, Pb) and pathogenic microorganisms (*Escherichia coli*, *Klebsiella* spp., *Listeria* spp., *Pseudomonas* spp., *Salmonella* spp., *Shigella* spp., and *Staphylococcus aureus*) were found in numerous vegetables grown and marketed in the region (Kuo et al., unpublished results).

Food safety should be taken as an element of food security. Health hazards can arise along any part of the food chain, thus food safety risks need to be reduced by preventing contamination throughout the food production, processing, storage, and distribution chain. Unfortunately, food safety programs on fruit and vegetables in South Asia generally lack some of the critical elements including: identification of the nature and extent of national food safety problems; understanding of the consequences of contaminated food on the population's health status; and, awareness of the urgency for the need to investigate and do research. There is a sound need of cost-effective methods for identifying specific food safety problems of fruit and vegetables, and their impact on the society, and a comprehensive and integrated multidisciplinary approach to food safety. Sharing information, education, and advice among stakeholders across the region are essential to enable food safety programs that reduce the incidence of food-related hazards from producing and consuming fruit and vegetables.

### **Post-Harvest Losses**

Post-harvest losses are typically large for horticultural crops in South Asia. Losses have been estimated from 30 to 50%, varying from crop to crop and country to country (Bhattarai, 2018; Faqeerzada et al., 2018). These substantial losses and the resulting waste usually are caused by: poor practices in both the production stage as well as the postharvest stage with a lack of proper technique for prolonging the shelf life; inadequate

information and skills in harvesting and postharvest handling; smallholder farmers' limited financial resources for adopting improved postharvest management techniques; lack of appropriate and low-cost infrastructures; high transportation costs; poor access of farmers to markets and integration of marketing channels; weakly developed processing sector; non-utilization of horticultural waste; inadequate investment in R&D; and disappointing policy support. Furthermore, a number of causes of postharvest losses could be exacerbated by high temperatures, greater rainfall variability, and more frequent extreme weather events due to climate change.

These postharvest losses have several adverse impacts on farmer's income, consumer prices and nutritional quality of fruit and vegetables. They represent the decrease in the mass, nutritional value and/or quality attributes of nutrient-dense fruit and vegetables intended for human consumption (FAO, 2011). Moreover, prices of seasonal horticultural crops fluctuate greatly and during the period of maximum availability the prices are not remunerative to the farmer. At other times these horticultural commodities are so highly priced that the ordinary consumers find them beyond their purchasing power. Another problem is that fruit and vegetables are not uniformly available and some areas suffer from inadequate supply even when there is a glut in other parts. At present there is a considerable gap between the gross production and net availability of fruits and vegetables due to heavy postharvest losses. For example, despite India being as the world's second largest producer of fruit and vegetables, there still exists huge gap between per capita demand and supply of fruit and vegetables due to enormous waste during post-harvest storage and handling caused by improper bagging without crating, lack of temperature controlled vehicles, unavailability of cold chain facilities in various parts of country for preserving the produce (Raise & Sheoran, 2015), along with a miniscule 2% of the horticultural produce being processed into value-added products (Sachdeva et al., 2013).

There is a need for horticultural products that have good shelf life both before and after retail in order to maintain nutritional and sensory qualities, and to minimize waste. It is essential that traits related to postharvest behavior are taken into consideration from the early steps of new crop design as well as pre-harvest production management. Although not exclusive to horticultural food products, this area is of particular importance for fresh fruit and vegetables. For ornamentals, this is also highly important, and has distinct challenges from food products.

In order to reduce postharvest losses of perishable horticultural crops, cost-effective technologies for storage, processing and transportation have to be developed and adopted. Several post-harvest diseases and pests can be avoided with appropriate pre-harvest treatment. Such recommendations need to be popularized among growers to reduce losses and improve quality. In order to reduce post-harvest losses, there is urgent need to develop and implement appropriate harvesting methods. The maturity indices in

most of the horticultural crops are either not available or not followed by the farmers resulting in harvesting of these crops at varied maturity levels, thereby, a large quantity of produce has to be rejected while sorting and grading due to under or over maturity/ripening.

For smallholder farmers in South Asia, the development and adoption of improved low-cost containers, low or zero energy cool storage, field packing systems, shade covers, and small cold rooms are all practical. Furthermore, simple food processing such as drying, and the canning of sauces and jams are helpful methods for improving the availability outside the growing season of nutrient-dense fruit and vegetables by transforming highly perishable produces into stable, transportable, and storable foods.

On the other hand, to address the increasing demand from urban-based consumers and export markets for high quality horticultural products, there is a clear need for a more holistic, harmonized, and integrated approach when dealing with postharvest losses in the overall context of supply chain. Postharvest innovations such as cooling systems, ethylene controlling technologies, sustainable packaging, IT in postharvest management, vibration and moisture sensors, Coolbot technology, etc. with the context of supply chain, can have a very large impact on the prevention, reduction as well as possible recapture of value in postharvest losses (De Corato, 2019).

The investments in research and scaling of postharvest horticultural technology can have a major impact on reducing post-harvest losses and increasing availability and accessibility of fruit and vegetables, ultimately, improvement in the incomes with the use of existing production techniques without increasing productivity. The future research and extension activities must be toward the maintaining quality especially shelf life, sensory taste, nutritional content, and most important of all, food safety of marketed horticultural products (avoiding pesticide residues, heavy metal contamination, and microbial contamination).

### **Marketing and Value Chain**

Marketing of horticultural products in South Asia includes a number of marketing channels involving the traditional as well as modern marketing networks. For the traditional marketing system, which is the mainstay of the horticulture sector in the region, most horticultural products from the smallholder farmers make it to markets via informal or formal pathways that are dominated by small traders, with relatively little coordination. This entire traditional supply chain is largely supply driven and laden with various constraints and challenges (Negi & Anand, 2015; Rais & Sheoran, 2015; Mallawaarachch & Ahmad, 2018). Except direct transactions between farmers and consumers, the constraints to market horticultural products in either rural markets or urban markets include fragmented connectivity to the market, poor handling, high cost of packaging materials, lack of sorting and grading system, inadequate cold chain

infrastructures, poor transportation conditions, dependency on a number of intermediaries, lack of access to market information, limited value addition processing, etc., which result in substantial postharvest losses of horticultural products. And this leads to poor price returns for the farmers on one end, and exorbitant prices paid by the consumers on the other end. Recognizing the challenges that affect the traditional marketing system of horticultural products, it is crucial for the government to further intervene. Such **important interventions** can come in the form of:

- Increasing public investment in supply chain infrastructures such as cold storage facilities, and transportation facilities and logistics.
- Making rural credit and micro finance easily accessible to the smallholder farmers.
- Encouraging clustering of smallholder farmers into farmers' associations or cooperatives that are equipped with marketing information management and entrepreneurial management skills to enhance economies of scale (Trebbin & Hassler, 2012).
- Establishing purchasing/assembly centers that handle sorting, grading and packing in rural or peri-urban areas, and terminal wholesale and semi-wholesale markets within or near major cities.
- Initiating one-village (or one peri-urban zone)-one-product to increase competitiveness of the product.
- Meeting consumer demand for safety, convenience, quality and nutrition.

The emergence of supermarkets, store chains and export companies over the last decade or so in South Asia has profoundly influenced fresh fruit and vegetable marketing system, and the trend is expected to continue into the foreseeable future because of rising per capita incomes, urbanization, trade liberalization, technological advances and changing lifestyles (Abeysekera & Abeysekera, 2006; Trebbin, 2014; Naik & Suresh, 2018). They employ the strategies of modern marketing systems, which are more direct than traditional marketing systems. The marketing chains are usually well coordinated, and are driven by consumer demand. They are further characterized by centralized produce procurement systems, systematic storage and distribution systems, specialized suppliers who may be farmer groups, contracted farmers or wholesalers, produce quality standards, and the use of advanced information/communication systems. They may affect the traditional marketing systems especially for smallholder farmers and suppliers with little capital and other resources; however, The Economist 2014 reported that supermarkets, which handle fresh fruit and vegetables are struggling to win customers from India's traditional retailing.

## Relevant Policies, Laws and Programs

### Afghanistan

The major national agricultural policies and strategies are the *National Agriculture Development Framework (NADF)- 2009*, and *National Comprehensive Agriculture Development Priority Program (NCADPP)- 2016* (GoA, 2016). One of NADF's four programmatic pillars is increasing production and productivity of crops. And NCADPP's strategic priority for horticulture value chain put in place the following **affirmative action measures**: expansion of the horticulture land-base (horizontal increase); increase productivity per hectare (vertical increase); develop promising value chains; infrastructure and market development; embrace standardization; support the private sector; develop the nursery industry; and expand the area under protected agriculture.

The World Bank's review (2014) considered that the horticulture sector is one the three most promising opportunities as "first movers" of national agricultural policies and strategies for quicker results. And to restore the agricultural sector's productive capacity from the negative effects of more than 20 years of conflicts, the World Bank has provided grant of US\$ 114.60 million for the National Horticulture and Livestock Productivity Project (NHLP) from 2013 to 2020. Increasing horticulture productions and technical assistance support are two of the three components that the project supports. NHLP's horticulture extension activities concentrate on linking rural farm producers with markets by promoting improved production practices through the gradual development of farmer-centric service delivery, and have created about 10,000 full-time jobs. In this connection, the horticulture sector's output has more than doubled in the past decade (Leao et al., 2018).

During the period 2006-2015 the Perennial Horticulture Development Project (PHDP), funded by the EC-EuropeAid Program, has been supporting the Ministry of Agriculture, Irrigation and Livestock of Afghanistan through a process of collection and selection of local fruit varieties in order to improve the private nursery system, as well as perennial horticulture. The PHDP contributed in capacity building at technical and institutional level, fostering the establishment of nursery sector associations, providing expertise and developing the Afghanistan National Nursery Growers Organization (ANNGO) and the apex Afghanistan National Horticulture Development Organization (ANHDO), mainly concerned with value chains (Masini & Giordani, 2016).

In addition, the Asian Development Bank has committed a grant of US\$ 75 million to support the Project of Horticulture Value Chain Development Sector from 2019 to 2024. The project will help strengthen the horticulture value chain by: i) improving the processing efficiency and marketing capacity of domestic agro-business enterprises; ii) modernizing crop production through better planting material, trellising, modern greenhouses, and on-farm facilities; and iii) contributing to the national effort in

establishing internationally recognized brands of horticultural produce. It will increase value addition for horticultural commodities produced in 11 provinces in the central, southern, and eastern parts of the country. As such, the project will contribute to increasing the supply of fresh and processed fruit and vegetables, and expanding exports of high-value fruit, vegetables, and nuts in which the country has a comparative advantage.

## Bangladesh

In 2015, the Government of Bangladesh has adopted the *Seventh Five Year Plan (2016-2020)*, which focuses on developing the crop sub-sector to raise rural income and generate employment opportunities for poor rural people. The development vision of the plan aims at ensuring food and nutritional security, sustainable intensification and diversification of climate resilient agricultural production with increased commercialization and livelihood improvement through technological innovations and use, and linking farming community with markets, both national and international. Attaining crop diversification is considered crucial for increasing productivity, for ensuring human nutritional security, maintaining soil health and increasing cropping intensity, employment and the income of farmers. Furthermore, the *National Agricultural Policy (2013)* aims at promoting diversification by increasing space and production of fruit, vegetables, spices, and other crops under the Crop Diversification Programme, which will gradually be extended. In 2016, a national technical committee was created to guide the overall development of the Second National Plan of Action for Nutrition (2016-2025). The plan stresses on increasing vegetable and fruit production and productivity at national and household levels through integrated horticulture development. The effectiveness of these policies and programs to accelerating diversification towards more nutrient-rich fruit and vegetables requires investment in further research and development among others. In this regard, the Netherlands-Bangladesh Business Platform (Nyenrode Business Universiteit, 2014) reported that: i) prices of fruit and vegetables will rise, as it is not possible to increase the production at the same speed as demand due to limitation of land, limited use of modern technology and managerial capacities; ii) investing to reduce post-harvest losses in fruit and vegetables would mean a lot for the development of the supply chain; and iii) protected horticulture would be a feasible means to overcome heat, drought, heavy rainfall, and salinity problems in safe production of horticultural crops.

Apart from the aforementioned, various acts, bills and policies were enacted in the country that dictate the country's agricultural development and have implications on horticulture. They are: i) *Seed Rules- 1998*; ii) *National Integrated Pest Management Policy- 2002*; iii) *Fertilizer Management (Amendment) Act- 2009*; iv) *Pesticide (Amendment) Act- 2009*; and v) *Bangladesh Safe Food Act- 2013*.



## **Bhutan**

The country is located in an ecologically risky area high in the Himalayan mountain range, with diverse ecosystems. And the agriculture sector is dominated by smallholder subsistence farmers, who scatter in the majority of the arable land. Food production is a challenge and the impacts of climate change are likely to add to the burdens of farming (Chhogyel & Kumar, 2018). The country has already been experiencing some impacts of climate change, such as crop loss to unusual outbreaks of diseases and pests, erratic rainfalls, windstorms, hail storms, droughts, flash floods and landslides.

The Horticulture Division of Department of Agriculture under the Ministry of Agriculture and Forests has set the long term objective of optimizing the contribution of the horticulture industry to the welfare of present and future generation of farmers and consumers with emphasis on improved cash income, food security, higher nutritional standards and export earnings; and the short-term objective of improving the existing management practices and to increase production and quality of those horticultural commodities with a comparative advantage in a sustainable manner in all production environments through interdisciplinary research, extension and marketing.

The expected outputs related to horticulture sector of the *12th Five Year Plan 2018-2023* (DoA, 2019) include:

- Increased vegetable production towards 100% self-sufficiency by the end of the 12<sup>th</sup> Five Year Plan.
- Sustainable citrus production with rejuvenated orchards and at high elevation sites.
- Collection, conservation, production, processing and marketing of medicinal and aromatic plants, and spices.
- Enhanced production and marketing of both cultivated and wild mushrooms.
- Increased commercial production of fruit, nuts and ornamental plants.
- Established repositories for horticultural crop germplasm.

Program activities include research, piloting and scaling of improved varieties, production technologies, plant protection, soil management, protected cultivation, production of planting materials, mechanization, and organic farming,

The Integrated Horticulture Promotion Project in the West Central Region (2016-2021) with financial and technical supports from the Japan International Cooperation Agency aims at promoting horticulture through improving and strengthening research, development and extension system, and ultimately increase the production of horticulture in West-Central region. Expected outputs are: i) appropriate technologies for horticulture farming; and ii) production systems for vegetable seeds and fruit planting materials, involving private sector; and iii) capacity building on horticulture farming, production of planting materials, and research and extension (IHPP-JICA, 2017).

Both the Commercial Agriculture and Resilient Livelihoods Enhancement Programme (2015-2022) funded by the International Fund for Agricultural Development, and the Food Security and Agriculture Productivity Project (2017-2022) financed by the Global Agriculture and Food Security Program have research and scaling activities related to horticulture. They include: i) climate-smart production of vegetables for improved food security and nutrition; ii) increased production of spices, vegetables and citrus through area expansion, increased cropping intensity, and elevated yield level; iii) development and production of climate resilient vegetable seeds; iv) reducing post-harvest losses of fruit and vegetables; v) strengthening nutrition sensitive value chains of selected fruit and vegetables; vi) support of community-driven vegetable market infrastructure; vii) strengthened linkages to domestic and export markets; and viii) capacity building.

## **India**

The country has emerged as world's second largest producer of fruit and vegetables contributing to 10% and 14%, respectively of the total world production (FAOSTAT, 2019). The share of horticulture sector in value of agriculture output and the total exports of agricultural commodities stands at 34% (Bhat, 2017), and 37% (Jha et al., 2019), respectively. All of these indicate the significance of horticulture sector in India. However, the country still bears the brunt of food insecurity and nutrition insecurity. India was ranked 103 out of a total of 119 countries by the Global Hunger Index with a score of 31.1 indicating the country suffers from a level of hunger that is serious (GHI, 2019). Moreover, the country was ranked top eighth out of a total of 149 countries by Hidden Hunger Index (HHI) with a HHI of 48.3 (Ruel-Bergeron et al., 2015). This is very much related to the comprehensive challenges of production and supply of horticultural crops that the country is facing, for the reason horticultural crops play an important role by contributing adequate vitamins, minerals, edible fibers and other health-promoting phytochemicals. These challenges include persistent problem of low productivity because of the larger number of small and marginal farmers, tumultuous weather, seasonal cyclones, occasional drought, demographic pressure, industrialization, supply chain, and unprecedented use of pesticides, and migration of rural masses to urban areas for their livelihood (Bhat, 2017; Neeraj et al., 2017; Negi & Anand, 2015). Beside the dynamic production problems, limited availability of fruit and vegetables because of underdeveloped infrastructure support like cold storages, markets, roads, transportation facilities, etc.; volatile marketing conditions; and inadequate technologies for value addition and processing to minimize the post-harvest loss are the other challenging issues facing horticulture.

There is need to prioritize the development of research, technological up-gradation, infrastructure for transportation and marketing as thrust areas for future development of the horticulture sector in India (Jha et al., 2019). Towards this, the Government of India (GoI) has launched several schemes for the holistic development of horticulture sector.

The main step taken by GoI was the introduction of the *Mission for Integrated Development of Horticulture (MIDH)* to provide a thrust to the development of horticulture sector covering fruit, vegetables, root and tuber crops, mushrooms, spices, flowers, aromatic plants, coconut, cashew, cocoa and bamboo. It is a centrally sponsored scheme with cost sharing with the states. The main objectives of MIDH are: i) to promote holistic growth of horticulture sector through area based regionally differentiated strategies, which includes research, technology promotion, extension, post-harvest management, processing and marketing, in consonance with comparative advantage of each state/region and its diverse agro-climatic features; ii) to encourage aggregation of farmers into farmer groups to bring economy of scale and scope; iii) to enhance horticulture production, improve nutritional security and income support to farm households; iv) to improve productivity by way of improved varieties, quality planting materials, and improved water use efficiency; and v) to support skill development and create employment generation opportunities for rural youth in horticulture value chain from farm to retail. To achieve the abovementioned objectives, MIDH adopts the following strategies and activities:

- Adopt an end-to-end holistic approach to assure appropriate returns to producers.
- Technology development for production, post-harvest management and processing with special focus on cold chain infrastructure for extending the shelf life of perishables.
- Enhance productivity and quality through diversification with high-value crops, protected cultivation, precision farming, and area increase of fruit orchards.
- Improve post-harvest management, value addition and marketing infrastructure.
- Encourage public-private partnership at all levels.
- Support farmer/producer organizations to link with financial institutions.
- Capacity-building and human resource development at all levels.
- Provide financial assistance and subsidies for production of seeds and planting materials, protected cultivation, precision farming, and cold storage and market infrastructure.

Moreover, the National Horticulture Board develops and promotes horticulture, subsidies investment in cold storage facilities, and operates a market information service. Other than the aforementioned, various acts, bills and policies were enacted in the country that dictate the country's agricultural development and have implications on horticulture. They are: i) *National Seeds Policy- 2002*; ii) *Seeds Bill- 2004*; iii) *Pesticide Management Bill*, which may come in effect from December 2019; and iv) *Food Safety and Standards Act - 2006*.

OECD (2018) report suggests a series of reforms including horticulture sector which, if implemented, would help India improve food security for its vast population, advance

the quality of life of its millions of smallholders, overcome severe resource and climate pressures, while generating sustainable productivity growth and creating a modern, efficient and resilient agro-food system that can contribute to inclusive growth and jobs throughout the economy.

## Maldives

Although the country is balancing its food requirements, staple crops, fruit, vegetables and other food items are entirely or largely imported. At present, agricultural production is mainly carried out at subsistence level with horticultural crops such as leafy vegetables, chili, watermelon, coconut, papaya, banana and a variety of root crops. One of activities under FAO's *Maldives Country Programming Framework 2013-2017* was to promote home gardening of fruit and vegetables for family consumption to improve nutritional status of communities, especially for vulnerable groups of children, women and elderly.

In cooperation with FAO, the Government of Maldives has adopted the *Agriculture Development Master Plan (2006-2020)*. The plan focuses on implementing policies that: i) improve food security, nutrition, incomes and employment opportunities; ii) foster gradual commercialization of the agriculture sector through increased production; iii) increase the capacity to generate appropriate technologies and improve farmers' and entrepreneurs' access to them; iv) develop market infrastructure that is supported by functional marketing networks and a market information system; v) provide adequate institutional support; vi) support human resource development; and vii) promote partnerships among the public, private and NGO sectors.

## Nepal

In 2013, the Ministry of Agricultural Development has published the *Food and Nutrition Security Plan of Action* (GoN, 2013). The plan has outlined horticulture as one of the nine program components. The main objective of this particular component is to increase the availability of diverse and nutritious food at household level for domestic consumption as well as marketing, and hence improve household nutrition status. The component is expected to improve household nutrition and income through the production of fruit and vegetables throughout the year.

In 2014, GoN (2014) has also approved the *Agriculture Development Strategy 2015-2035* (ADS), which is an overarching policy adopted by the government to achieve food sufficiency, sustainability, competitiveness, and inclusion. It addresses food and nutrition security of the most disadvantaged rural populations, including pregnant and lactating women. ADS has foreseen good potential in vegetables, fruit, beverages, dairy and meat for import substitution through sufficient production. Also ADS has prioritized high-value vegetables as one of five priority value chain development programs through

extensive and integrated steps that benefit the poor by enhanced investment of producer farmers, cooperatives, public and private sectors with regional impact. Through the U.S. Government's Feed the Future initiative, the *Global Food Security Strategy Country Plan for Nepal*, high-value vegetable value chain is also included under an integrated farming systems approach. Moreover, the United Nations Development Programme is supporting the "value chain development of fruit and vegetables in Nepal," from 2018 to 2022. The goal is to improve incomes of smallholder farmers through value chain development of vegetables and fruit in Provinces 3 and 4.

ADB (2012) reported that the agriculture policy in Nepal encompasses sufficiently the concerns of horticulture sub-sector, but the key concern is the serious and effective implementation of horticulture related clauses. This implies that the organizational structure of horticulture or the investment or the working modalities of the sub-sector have many deficiencies. In this regard, Thapa & Dhimal (2017) recommended that the following areas should be addressed in the future: i) niche fruit, flowers and spice production in larger areas; ii) development of hybrid varieties of horticultural crops especially vegetables; iii) establishment of processing units for ginger, areca nut and large cardamom; iv) establishment of storage facilities for year-round supply and price stabilization of horticultural crops; v) capacity enhancement for horticulturists and extension workers; vi) single door policy for foreign aid and investment; vii) crop insurance policy for commercial farmers; and viii) sanitary and phyto-sanitary measures for exportable commodities. Furthermore, Atreya et al. (2019) estimated that by employing precision and protected horticulture can increase productivity by 3-5 folds over open field condition.

## **Pakistan**

A variety of fruit, vegetables and spices constitute the horticulture sector. Citrus, mangoes, dates and apples dominate fruit production at the national level. Large-scale farmers are involved in the production of mangoes and kinnows (mandarins), often for export, and a large number of smallholders maintain small orchards that contribute to household income. Also, a large number of smallholder farmers are involved in vegetable production due to short production cycles and regular contribution to household income. Major vegetables and spices include potato, onion, tomato, chili, garlic, leafy varieties, and root crops.

Government of Pakistan has given high priority for achieving food security and nutrition for its population through important policy initiatives, which include concept development of National Zero Hunger Program, food security assessment survey, the recent commitment of the Government for Sustainable Development Goals, particularly to the SDG- 1 and SDG- 2 about poverty and zero hunger challenges. A comprehensive

*National Food Security Policy (NFSP)-2017* was prepared to document all these initiatives (GoP, 2017). NFSP measures for the horticulture sector include:

- Introduction of high value fruit crops like olive, pistachio, almond, kiwi, grapes and dates for a range of agro-ecological zones, and up-scaling of fruit plant certification program.
- Development of modern seed industry that includes production of hybrid vegetable seeds, and disease-free fruit planting materials.
- Capacity building for processing, value addition and marketing of fruit and vegetables in terms of human resources, facilities and infrastructures.
- Assuring food safety of fruit and vegetables that entails scaling of IPM and safe use of pesticides to the farmers, production of bio-control agents, analyses and monitoring of pesticide residues, and compliance of national and international food safety regulations.
- Support for fruit and vegetables across the supply chain, including quality assurance, sorting, grading, packing, and product traceability.

Fayaz et al. (2014) advocated that devising food policy for the development of food markets in terms of market segmentation and quality improvements has to be undertaken in response to the positive demand for quality products. Furthermore, Mallawaarachchi & Ahmad (2018) suggested that efforts to modernize food value chain requires greater emphasis on improving entrepreneurial orientation at the growers' end. Regarding food safety of fruit and vegetables, a bill for National Food Safety, and Animal and Plant Health Regulatory Authority has been approved, which will improve the implementation of food safety standards articulated in NFSP (GoP, 2017). Moreover, *Pakistan Horticulture Vision 2030*, initiated by the private sector, deals with the major issues the horticulture sector is facing, including climate change, water management, lack of sectoral knowledge, skill development, adoption of modern technology, and, most importantly, absence of research and development. By effectively implementing roadmap in the vision, it is expected that the export revenue of fruit and vegetables can be enhanced to US\$ 3.5 billion in five years, and US\$ 6.0 billion within 10 years

### **Sri Lanka**

There are several challenges the agriculture sector is facing in the country. They include aspects such as: meeting food and nutrition security of the people; sustainability of the system due to competition, globalization and climate change; technological challenges; and managing soil and environment toxicity and degradation due to the non-discriminate use of agrichemicals and soil erosion. Vegetable production, in particular, suffers from unfavorable weather elements, over use of agro-chemicals, lack of improved varieties, lack of seed production capacity, high pest and disease attacks, high cost of technical inputs and land fragmentation (Weerakkody, 2004). To address these

challenges, the National Agricultural Policy for Food and Export Agricultural Crops and Floriculture 2007 has been updated to strive for food safety that entails organic agriculture/natural agriculture, good agricultural practices, plant protection, safe use of agricultural chemicals, and white revolution (i.e. protected cultivation). Furthermore, Sri Lanka Council for Agricultural Research Policy (CARP) has formulated the National Agriculture Research Policy and Strategy (NARPS) 2018-2027 (CARP, 2017). For the horticulture sub-sector, the NARPS pursues the following strategic plans on fruit, vegetables, and floriculture.

On fruit crops, the strategy is to increase the national fruit supply to ensure increased fruit consumption. This is to be achieved through identification and introduction of diverse native and exotic fruit crops, which could be grown year round under different agro-ecological conditions, and through use of technically sound, economically viable, environmental friendly and socially acceptable technologies. Moreover, identification and linking to value chains are pursued so as to promote production of quality and safe value added fruit products for consumption in local and foreign markets, meeting acceptable standards.

On vegetable crops, focus in on developing high-yielding, demand-driven and climate resilient varieties and quality seeds. Improved varieties are to be adaptable to mechanization and having high degree of tolerance to biotic and abiotic stresses, with quality (high nutritive value, sensory and long shelf life), and suitable to open field and protected cultivation environments for year round production. Technically sound, economically viable and environmental friendly technologies for diverse cultivation environments will be developed to enhance production and to ensure food safety. Moreover, appropriate action will be taken to minimize price fluctuations by enhancing availability of value-added products while reducing post-harvest losses, towards increasing consumption from 100-130 g/day/capita to 200 g/day/capita.

On floriculture, varietal improvement, and development of technologies and innovations for value addition, labor-saving production and quality improvement are to enhance productivity and profitability of floriculture. Local, niche and export markets are to be expanded so as to generate higher incomes for the farmers.

Cross-cutting research areas include plant genetic resources, quarantine services, seed certification, organic agriculture, farm mechanization, food waste management, and capacity building. Sri Lanka is particularly vulnerable to climate-related natural disasters such as floods and drought. To address these issues, the World Bank has provided a US\$ 125 million credit for the Climate Smart Irrigated Agriculture Project from 2019 to 2024 to improve the resilience and productivity of agriculture for more than 470,000 smallholder farmers in six provinces.

Aside from the above, various acts, bills and policies were enacted in the country that dictate the country's agricultural development and have implications on horticulture. They are: i) *Seed Act- 1992*; ii) *Plant Protection Act- 1999*; iii) *Fertilizer Act- 1988*; iv) *Freedom from Hunger Campaign Act- 1973*; v) *Agrarian Research and Training Act- 1972*; and vi) *Control of Pesticides Act- 1980*.

### **Recommendation of Priority Programs for Horticulture Sector**

From the above described, it is apparent that there are common challenges for the development of horticulture section as well as similar efforts have been taken to overcome these challenges among SAARC member countries. And it would be beneficial to all the SAARC member countries concerned to explore certain areas of collaboration. In this connection, we propose that specific future research and development initiatives by SAARC Agricultural Centre (SAC) should address the evolving knowledge and innovation demand of horticulture to reflect the multifaceted societal benefits represented by horticultural crops, products and the related sectors. In addition to identifying research priorities, it is important that researchers, industry and policy makers in the region work closely together using a multi-actor approach along the entire value chain to develop strategies for maximizing the economic and societal benefits from horticulture towards 2030. Approaches could include:

- Establish Operational Groups, Working Groups or Task Forces at regional level that involve those researchers engaged in specific problem areas to support knowledge exchange and encourage collaboration.
- Identify where technology platforms can make a contribution to identification and solving strategies of problems common in the region addressed by research and development in horticulture.
- Better coordinated horticultural research initiatives across SAARC member countries to address the particularly challenging interdisciplinary research and development environment of the horticulture sector.
- Develop regional networks with stakeholders from all sections of the supply chain to understand where plant science can best add value and solve specific challenges. Ultimately, stakeholder groups at national and regional level need to improve collaboration and directed interaction with research policy makers to ensure that the importance and potential of horticulture is understood and promoted, and that horticulture is better integrated into future SAC programs.
- Develop concept notes on priority research and development areas for collaboration with international and regional agricultural research organizations, e.g., WorldVeg, the Asia-Pacific Association of Agricultural Research Institutions (APAARI), CAB International (CABI), the International Centre for Integrated Mountain Development (ICIMOD), Crops For the Future (CFF), etc. as well as private sector partners that



engage in horticulture research and development, and for resource mobilization with regional and international donors, both public and private.

**Specific collaborative research and development program areas** for SAC to facilitate in the region could include some of the following priority areas in stepwise forward action in the next decade:

- 1) National and regional horticulture development strategies (development, follow-up, cross-learning, monitoring, tool to guide investments from public and private sector for infrastructure and market development, research and extension investments).
  - a. National Horticulture Development Teams formed / strengthened to develop the strategy and monitor implementation – yearly meetings to compare notes between countries and cross-learning.
  - b. Facilitating cross regional trade of horticultural products.
  - c. Measure of success: i) increased investment levels by public and private sector in the horticulture sector; ii) greater consumer demands for domestically and regionally produced horticultural products; and iii) increased export value of domestically and regionally produced horticultural products.
- 2) Fruit and vegetables for health initiative
  - a. Promoting diversified and sustainable production and consumption of indigenous and global fruit and vegetables.
  - b. Promoting scientific advancement and “know-how” in production, distribution, and consumption of indigenous and global fruit and vegetables for health benefits.
  - c. Measure of success: i) increased levels of promotion practices; ii) greater public awareness on the health value of fruit and vegetables; and iii) enhanced intake levels of fruit and vegetables.
- 3) Diverse genetic resource base to support the breeding of climate resilient horticultural crop varieties
  - a. Collection and conservation of genetic resources of horticultural plants to prevent erosion of the genetic base for future crop improvement.
  - b. Screening of genetic resources of horticultural products for desirable traits, e.g., pest and disease resistance; tolerance to high temperature, drought, salinity and waterlogging; and nutritional components.
  - c. Using modern high throughput methods for genetic and phenotypic characterization to enable the exploitation of the valuable diversity in form and properties captured within the collection of genetic resources.

- d. Development of pre-breeding materials incorporating novel desirable traits to facilitate prompt uptake by the seed sector.
  - e. Measure of success: i) increased utilization of pre-breeding materials for climate adaptation and improved nutrient contents; and ii) increased area and rate of return of planting with improved varieties.
- 4) Planting materials of horticultural species including underutilized and traditional horticultural crops to enhance diversity of sources of nutrients for maintain good health, and incomes.
- a. Provision of planting materials (seeds and propagules) with high health status.
  - b. Horticulture planting material testing using common protocols.
  - c. Policies to get seed tested, new materials distributed, acceptance of testing schemes across SAARC.
  - d. Measure of success: introduction of new materials, increase in diversity for nutrient sources and incomes, greater quality and pest and disease resistance, etc.
- 5) Integrated cropping systems from farm to consumer for production with minimal resource inputs and waste, and to ensure food safety
- a. Maintaining healthy and sustainable soil systems and efficient use of water and fertilizers.
  - b. Crop management and intervention for enhancing productivity, and predicting maturity and harvesting regimes to minimize waste in the production phase.
  - c. Expand protected cultivation of both fruit and vegetables to increase availability of fruit and vegetables in off-season and stabilize price fluctuation.
  - d. Developing intelligent production automation with the aim of facilitating an efficient use of labor.
  - e. Develop methodologies, standardization, regulatory system and certification of Good Agricultural Practices (GAP) as well as traceability that will be agreed by SAARC member countries.
  - f. Measure of success: increased productivity per unit land area, enhanced rate of return, increased trust of GAP across SAARC and beyond, and stable marketing of healthy and safe fruit and vegetables.
- 6) Sustainable horticulture pest and disease management including bio-pesticides and biocontrol
- a. Objective: reduce crop losses and reliance on chemical pesticides, and increase food safety of marketed horticultural products.

- b. Technological: testing of improved IPM technology, and managing multiple cropping (biodiversity) systems to prevent invasive pests and emerging infectious diseases through agro-ecological approaches.
  - c. Policy: better control of introduction, banning, removal of obsolete pesticides, introduction of bio-pesticides, common policies and approaches across SAARC.
  - d. Measure of success: i) reduced losses of horticultural crops in the production system; and ii) enhanced levels of food safety of marketed horticultural products.
- 7) Monitoring and management of climate-related transboundary pests and diseases
- a. Monitoring of invasive insect pests, e.g. *Tutaabsoluta*, *Spodopterafrugiperda*, and emerging infectious plant diseases, e.g., viroids.
  - b. Establish early warning systems of invasive insect pests and emerging infectious plant diseases.
  - c. Measure of success: i) heightened regional collaboration surveillance, information sharing and early warning; and ii) reduced impacts of transboundary pests and diseases.
- 8) Processing and value addition technology of horticultural crops
- a. Improve postharvest performance for horticultural products that have good shelf life both before and after retailing in order to ensure nutritional and sensory qualities and to minimize waste.
  - b. Develop new products such as semi-processed and health-related edible horticultural products for new domestic and international markets.
  - c. Develop microenterprises for local processing to reduce waste.
  - d. Measure of success: i) reduced levels of postharvest loss and waste; ii) increased income generation and employment from the value chain of horticultural crops.
- 9) Marketing of quality and safe horticultural products in the urban setting
- a. Develop protocols for grading, cleaning, sorting, packaging, bulking, preliminary safety testing, and primary processing for purchasing/assembly centers to create greater availability and affordability of quality and safe horticultural products.
  - b. Create demands for quality and safe horticultural products from the targeted consumers through education and promotion.
  - c. Establish business network for retailing quality and safe horticultural products by forming producers' groups, and linking these groups with retailers, consumers' groups, traders, processing companies, supermarkets, and exporters.

- d. Government support of appropriate market infrastructures, reliable market information systems, and value chain coordination and improvement.
  - e. Measure of success: i) enhanced availability of quality of locally-produced quality and safe horticultural products; and ii) greater demand and longer consumer lifetime for quality and safe horticultural products.
- 10) Capacity building and knowledge management
- a. Conduct short-term in-service training programs, training of the trainers, and long-term degree training on the above improved technologies and systems.
  - b. Create information sharing system and processes in the region.
  - c. Establish web-based horticulture knowledge bank.
  - d. Measure of success: i) progress made in the above nine areas; ii) linkages between data, information and knowledge management; and iii) extent of acceptance of new knowledge and technologies.

## **Conclusion and Way Forward**

The challenges to leverage the horticulture sector for improving food and nutrition security, food safety, economic development and sustainable agro-environment under changing climatic conditions in the SAARC region for the next decade are immense. Even though certain policy issues that affect the development of the horticulture sector fall outside the mandate of research and development, effective research collaborations and networks on commonly targeted areas will be desirable underpinnings for the sector to thrive in dynamic regional and global markets and ever-changing consumer demands. And this calls for partnership among research institutions in the SAARC member countries, international agricultural research centers, advanced laboratories, private sector and other strategic partners to pull together resource and expertise.

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