Scoping study on fruits and vegetables; results from Bangladesh

An assessment of investment opportunities for the Bill and Melinda Gates Foundation

Haki Pamuk, Mohammad Jahangir Alam and Thomas Tichar

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Scoping study on fruits and vegetables

Results from Bangladesh

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Wereldwijd lijdt een op de drie mensen aan een of meer vormen van ondervoeding. De teams van de Bill & Melinda Gates Foundation die zich bezighouden met landbouw en voeding, in samenwerking met het Britse Department for International Development (FCDO), willen het potentieel van groente- en fruitketens onderzoeken om het aanbod van voedzame voedingsmiddelen te vergroten en te versterken, en om de lokale marktkansen voor meer inkomsten te vergroten, speciaal voor vrouwen. Dit rapport belicht de conclusies van een onderzoek in Bangladesh en identificeert verschillende oorzaken en mogelijke interventies om de fruit- en groentesectoren te verbeteren en daarmee de consumptie te verhogen.

Currently, one in three of the world's population suffer from one or more forms of malnutrition. The Agricultural Development and Nutrition teams at the Bill & Melinda Gates Foundation, in collaboration with the UK's Department for International Development (FCDO), seek to investigate the potential of vegetable and fruit supply chains to increase the supply of and strengthen demand for nutritious foods, as well as increase local market opportunities for increased income, especially for women. This report highlights the conclusions from a study in Bangladesh, and identifies several root causes, as well as opportunities for interventions to further develop the fruit and vegetable sectors, and with that enhance consumption.

Key words: fruit, vegetables, food system, nutrition, supply chains

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Preface

The world's population is expected to increase by 2 billion persons in the next 30 years, from 7.7 billion currently to 9.7 billion in 2050. In spite of progress made in the past decades, the number of people being undernourished is on the increase again. Globally, 462 million are underweight, while 1.9 billion adults are overweight or obese. This contrast highlights well one of the most prominent global challenges imposed on our food systems, which is: how to make available, accessible and affordable healthy food to all.

To meet the growing demand for food and improved nutrition, food production and its nutritional value need to be enhanced. Compounding this issue is the pressure that existing agricultural systems place on the environment. Although there is scope to bring new land under cultivation, for example in Africa and Latin America, this has the knock-on effect of damaging the climate, biodiversity, natural habitats and more generally the integrity of the Earth's environmental system. The challenge of achieving global food and nutrition security is underscored by Sustainable Development Goal (SDG) 2: "End hunger, achieve food security and improved nutrition, and promote sustainable agriculture."

Fruits and vegetables play a key role in achieving above mentioned goals. This was acknowledged by the Bill and Melinda Gates Foundation (BMGF) and the Foreign, Commonwealth & Development Office (FCDO) which realized that more knowledge on the current state of fruit and vegetable consumption, trade, processing and production worldwide, and notably in low- and middle-income countries, is needed. For that purpose, Wageningen University & Research was contracted to conduct a global scoping study including deep dives into selected countries. After more than a year and a half of research, we are happy to present a number of research outputs that address comprehensively the state of art and main challenges associated with fruits and vegetables. The reports take us through all aspects of food systems in which fruits and vegetables play a role, from consumption to production, but also around the world, from Nigeria to Nepal. The study provides BMGF and FCDO with a clear set of recommendations as to priorities for philanthropical investments that have the goal of enhancing consumption of and economic benefits from fruits and vegetables.

Fruits and vegetables play a key role in meeting current and future food system challenges. With this research we know better where we are and what is needed to address these challenges. I hope our work contributes to setting in motion food system changes urgently needed.

Prof.dr.ir. J.G.A.J. (Jack) van der Vorst
General Director Social Sciences Group (SSG)
Wageningen University & Research

Summary

Background

The Agricultural Development and Nutrition teams at the Bill and Melinda Gates Foundation (BMGF), in collaboration with the UK Foreign, Commonwealth & Development Office (FCDO), seek to investigate the potential of vegetable and fruit supply chains to increase the supply of and strengthen demand for nutritious foods, as well as market opportunities for increased income, especially for women.

A global scoping study of the horticultural sector in West Africa, East Africa and South Asia was conducted. The Phase I study was based on available literature and secondary data and identified so-called leverage points for interventions in the food system to promote the production, trade, and consumption of fruits and vegetables. To test the validity and feasibility of the identified leverage points in specific contexts, seven deep-dive country studies have been performed in seven countries in Bangladesh, Burkina Faso, Ethiopia, India, Nepal, Nigeria and Tanzania.

This country study provides a better understanding of current trends in the horticulture sector of Bangladesh. The main objective of this study is to investigate what kind of investments policymakers can make to achieve systemic changes in the food system for healthier diets and more economic opportunities for women. BMGF and FCDO plan to utilize the study findings to identify potential investment options for enhancing the sustainable and inclusive development of the horticulture sector in Bangladesh.

Method

We investigated key questions on fruit and vegetable production and consumption that were identified during Phase I. To provide answers to the questions, the study focused on three fruits (avocado, jack fruit, mango, pineapple) and three vegetable crops (okra, pumpkin, tomato), which are selected on based on their: 1) economic potential in terms of production; 2) importance for nutrition; and 3) empowerment opportunities for women and women's involvement in the value chains for the selected fruits and vegetables. To answer the questions for the selected value chains, we used a mix of information sources, including five focus group discussions (FGDs), nine key informant interviews (KIIs), external data sources, a review of existing literature. We triangulated the answers from different information sources.

Key findings

Bangladesh produces a variety of fruit and vegetables. The production of vegetables has been growing steadily in recent years, while the growth in fruit production stagnated due to the fruit sector being constrained by high production losses and limited use of good agricultural practices. Other barriers to fruits and vegetable production include lack of irrigation and access to processing, poor road infrastructure, and lack of storage facilities. In Bangladesh, fruit and vegetable production is rainfed and seasonal, leading to high prices in summer and low prices in winter. Moreover, producers perceive that input prices have risen over the past years, increasing the cost of production.

The majority of produce by the fruit and vegetable sector is traded in informal markets, which involve many value chains actors from farms to customers. There is limited coordination, trust communication, and information sharing among those value chain actors, which decreases the fruit and vegetable chains' efficiency, increases the losses, and puts upward pressure on their market prices.

Fruit and vegetable consumption is not sufficient in the country compared to international standards. The insufficient consumption is mainly due to high consumer prices and concerns about safe consumption. While urban vegetable consumption has grown in recent years, fruit consumption in rural and urban areas and vegetable consumption in rural areas have not, mainly because consumers find fruit expensive. They prefer food items that provide high energy (e.g. grains, rice, etc.) rather than fruits and vegetables. Farmers sell their fruits and vegetables when prices are high, at the expense of not consuming at home. Due to high prices, especially in the summer season, low-income consumers cannot consume sufficient fruits and vegetables. Food safety issues also negatively affect consumption, despite the modern regulation that the Bangladesh government has on food markets and food safety issues introduced recently. This is due to the lack of awareness about those regulations and efforts by the authorities.

Women's involvement in fruit and vegetable retailing and processing is limited, although they play an important role in post-harvest activities and other production activities in homestead gardens. To empower women in the sector, NGOs coordinate with the government pilot business models on women's corners in wet markets, women producers' groups and associations. There are also initiatives of online marketing via women. Bangladesh government and other stakeholders is planning to introduce those models and initiatives in many regions around the country.

To improve the nutritional outcomes in Bangladesh, the government implements various programs and interventions; women are the focal point as their nutrition level is lower than men's. Those programs include training programs at the workplace and upscaling homestead, urban and rooftop gardening that primarily target women. Many NGOs are involved in the implementation of these programs. Almost all programs include interventions on increasing consumer awareness about dietary diversity and the importance of fruits and vegetables in the diet. Moreover, the government implement mass media programs to inform consumers on the benefits of dietary diversity and benefits of fruit and vegetable consumption.

Providing access to affordable, safe fruits and vegetables and increasing consumer awareness are key policy areas to improve fruit and vegetable consumption in Bangladesh. Implementing good agricultural practices by producers and improving coordination among value chain actors is critical to improving the affordability of fruit and vegetables in the market. Our report provides examples of existing organized value chains in Bangladesh that improve coordination between farmers and retailers. Food safety concerns can be eliminated by efficiently implementing existing food safety standards and increased awareness about those standards.

1 Introduction

1.1 Background

The Agricultural Development and Nutrition teams at the Bill and Melinda Gates Foundation (BMGF), in collaboration with the Foreign, Commonwealth & Development Office (FCDO) in the United Kingdom (UK), seek to investigate the potential of vegetable and fruit value chains to increase the supply of and strengthen demand for nutritious foods, as well as increase local and export market opportunities for increased income, especially for women.

The research teams first conducted a global scoping study of the horticultural sector in West Africa, East Africa and South Asia, using information from available literature and secondary data. The study identified so-called leverage points for interventions in the food system to promote the production, trade and consumption of fruit and vegetables. These potential leverage points were formulated in general terms only. To test the validity and feasibility of the identified leverage points in specific contexts, seven deep-dive country studies have been performed in seven countries in Bangladesh, Burkina Faso, Ethiopia, India, Nepal, Nigeria and Tanzania. This report describes the findings of the Bangladesh country study.

1.2 Objective of this report

This study investigates the current trends, bottlenecks and opportunities in the horticulture sector of Bangladesh. The Bill and Melinda Gates Foundation (BMGF) and UK's FCDO plan to utilize the findings of this study to identify potential investment areas that can enhance the sustainable and inclusive development of the horticulture sector in Bangladesh. We also expect that policymakers in countries outside Bangladesh can use the findings to transform their respective food systems to provide healthier diets and more economic opportunities for women in these countries.

1.3 Research questions

The 'Global fruit and vegetable scoping study' identified 30 questions to help us understand the major leverage points to improve fruit and vegetable production in developing countries. Table 1.1 lists those questions and shows the corresponding sub-section in Section 4 of this report in which each question is answered.

Table 1.1 *List of the research questions*

Section	Questions
4.2	How does seasonal variation in weather influence fruit and vegetable production, yields and market prices (disaggregated by fruit and vegetable category)?
4.2 and 4.4	What are the main causes and their volumes of production losses, and where do they occur?
4.2	What are the main barriers for farmers to increase the production of fruits and vegetables?
	What keeps farmers from intensification? Do female producers face greater barriers than male producers, and are there examples that have addressed these barriers?
	Are quality inputs and services accessible, and is the enabling environment supportive to intensification?
4.3	How much are the production costs, and can we compare them across the seven countries?
	What happens to the farm gate price when costs are reduced?
	What happens to the income of farmers when farm gate prices are lower?
4.4	Does value chain efficiency result in lower farm gate prices and/or consumer prices? Data on prices: farm gate and consumer prices
	What are the risks, costs and types of coordination for the key fruit and vegetable categories? How can more efficiency be achieved and are there examples of such enhanced efficiencies?
	Are there examples that more secured markets (more formal) are beneficial to smallholder farmers?
	How should farmers benefit from such arrangements?
	How do traders and processors (male and female) connect to consumers? Are they organized to support each other?
4.5	What examples are there of women succeeding? Are these exceptions or at scale in the different levels of the fruits and vegetables value chains?
	Are there examples of traders and processors (male and female) that are capable of responding to consumer needs by developing innovative food products?
	What are conducive conditions for information sharing, and what is the role of trust (as social construction of exclusivity)?
4.6	Has the introduction of new fruit and vegetable varieties contributed to more fruits and vegetables consumed?
	Trends on fruit and vegetable consumption: are these dependent on season or geographical location (production/ non-production areas), and can these trends be disaggregated by different types of fruits and vegetables?
4.7	Why are prices to consumers of fruits and vegetables higher as compared to other domestically produced food crops? Are there differences between categories of fruit and vegetables and what explains these differences?
4.8	Are there examples of successful integration of women in profitable production and value chain operations? What explains these successes and is there evidence of them being scaled up?
	What business models work best for women's inclusion and leadership?
	If fruit and vegetables become more commercial (or scaled up) will the income be controlled by women?
4.9	Inventory of relevant standards (public/private)
	How are the standards enforced?
	Do consumers trust standards? How is it appreciated by other stakeholders in the food system?
4.10	Are there specific policies and strategies formulated and implemented for improving diet quality among different consumer categories, and do they include strategies on fruits and vegetables? Is there evidence of their impact?
	How have policies enabled women to address systemic constraints that they face, and to successfully access sufficient nutrition?
	Inventory of innovative examples implemented, who is implementing it? Are consumers' motives taken into account?
4.11	What are consumer motives and barriers to (not) consume (specific) fruits and vegetables, such as indigenous vegetables, for different household members?
	If everything is as planned (available, affordable, acceptable) will consumers increase fruit and vegetables intake in their diet, according to the recommendations?

1.4 Approach

We began our analysis with the production, export, consumption trends, seed sector and women's roles within the horticulture sector of Bangladesh. We then answered key questions on fruit and vegetable emerging from Phase I (see Section 3.3 for an overview of the questions), using evidence from focus groups discussions (FGDs), key informant interviews (KIIs) and existing studies. While answering the questions, we have also highlighted the innovations or examples of good practices, projects and policies that we came across.

Collecting information about all horticultural products that were available in Bangladesh was not within the scope of this study, due to time and budget limitations. Therefore, the study focused on three vegetables - tomato, okra and pumpkin - and three fruits - mango, pineapple and jackfruit - value chains. We selected those value chains because all had high production and potential to provide nutrition in Bangladesh (please see Section 3.3 for the selection details). Moreover, some of those value chains employed many women or projects existed targeting those value chains to empower women involved in them, making the selected value chains relevant to answer gender-related questions of our study.

We used FGDs, KIIs, a review of existing studies on fruits and vegetables in Bangladesh and external data sources in this study. In total, we have conducted nine KIIs and five FGDs. Our key informants were experts or managers from the Department of Agriculture Marketing of the Ministry of Agriculture, food safety experts from Bangladesh Food Safety Authority (BFSA), a nutrition expert from Bangladesh Institute of Research and Training on Applied Nutrition (BIRTAN), Solidaridad and ActionAid in Bangladesh, Bangladesh Horticulture Association and Hortex Foundation and PRAN Food Limited - a big horticultural product processing company. Table 1.2 shows the details of the FGDs. One of the five FGDs was with consumers, and the remaining four were with farmers, traders, processors and transporters from selected value chains at the locations indicated in the Table. Four FGDs were mixed groups, and one was a women-only group. The women-only group was composed of pumpkin farmers in Rajshahi as a pumpkin farming project predominantly focused on women in this region. This women farmer group helped us to understand the challenges that women farmers face.

Table 1.2 *FGD details*

Value chain/consumer	Participants	Location	Division
Mango	Mixed farmer group and value chain actors (traders, processors, transporters) (mango)	Rajshahi	
Pumpkin	Women farmer group	Rajshahi	Rajshahi
Pineapple and jackfruit	Mixed farmer group and value chain actors (traders, processors, transporters) (pineapple and jackfruit)	Tangail	Dhaka
Okra and tomato	Mixed farmer group and value chain actors (traders, processors, transporters) (okra and Tomato)	Kushtia	Khulna
Consumers	Consumers living in the city	Mymensingh	Mymensingh

1.5 Reading guide

The study is organized as follows. In Section 2, we summarize the production, export, consumption trends, seed sector and women's roles in the horticulture sector of Bangladesh. Section 3 explains the selection of value chains to answer the research questions and the details of FGDs and key informants conducted in this study. Section 4 provides the answers to the research questions, and Section 5 concludes with some investment recommendations.

2 State of play

2.1 Country profile Bangladesh

Bangladesh is a highly populated country with a fast-growing economy. It is one of the world's most densely populated countries, with an estimated population of 164.6 million (BBS, 2018) and an area of 148,460 square km spread over eight divisions.[1] The population is expected to grow further and reach 223 million (209 million under low variant and 251 million under high variant fertility) as of 2061 (BBS, 2015).[2] The country has made good progress in various economic and social indicators over the past decade. Following a decade-long average gross domestic product (GDP) growth rate of 6.6%, Bangladesh has achieved 8.15% GDP growth in Fiscal Year (FY) 2018-19, the highest among the Asia-Pacific region (MOF, 2020). This strong growth enabled Bangladesh to elevate itself into the lower middle-income country status of the World Bank in 2015 by, and fulfil all three eligibility criteria for graduation from the least developed country (LDC) in 2018 (MOF, 2019). The per capita national income has reached US$2,064 in FY 2019-20 from US$1,751 in FY 2017-18 (BBS; MOF, 2020). As a result of high economic growth, the poverty rate reduced to 21.8% in 2018 from 38.4% in 2006 (MOF, 2019).

Figure 2.1 *Bangladesh map*

[1] Those 8 divisions are Barisal, Chittagong, Dhaka, Khulna, Mymensingh, Rajshahi, Rangpur and Sylhet.

[2] 223 million is estimated under main scenario, medium variant fertility. In the low variant fertility it is assumed that fertility remains 0.5 births below the total fertility in the medium variant. High variant is projected under 0.5 births above the total fertility in the medium variant.

Agriculture is a major sector in Bangladesh, and is characterized by mixed farming systems integrating crop, livestock, fisheries and forest sub-sectors (Faroque, 2011). The share of agriculture in GDP was about 13% in 2019, which decreased from 17.1% in 2009. Yet, the sector plays a vital role in the country, employing 39% of the active labor force. The government, therefore, strongly supports the sector. For instance, subsidies to the agriculture sector have increased 15 times from about US$88 million in 2006 to 90 billion Bangladeshi Taka (BDT) (about US$1,084 million) in 2019. The agriculture sector has been given a prominent place in all planning documents of the Government of Bangladesh, such as the National Agricultural Policy (NAP) 2018, Vision 2021, National Food Policy (NFP), Plan of Action, National Plan of Action for Nutrition (NPAN), Sustainable Development Goals and Delta Plan 2100.

Food and nutrition security and limited dietary diversity are important challenges the country still faces. Approximately 25% of the population in Bangladesh faces food insecurity and 36% of children younger than five years of age suffer from stunting, a common measure of chronic malnutrition (USAID, 2018). Undernutrition is enhanced by poor dietary diversity, with 70% of the diet comprising cereals and inadequate protein and micronutrient intake according to the international standards (Magnani et al., 2015).

2.2 Overview and trends analysis for horticultural produce in Bangladesh

Bangladesh is an important producer of fruit and vegetables globally due to its tropical location, fertile land and moisture-rich loamy soil. These factors allow Bangladesh to grow a vast range of fruit and vegetables, including more than 90 vegetables and 60 fruits. Bangladesh has two major fruit and vegetable production seasons: the winter vegetable season is from October to March, and the summer vegetable season is from April to September. About 60% of vegetables are produced in the winter season, and 40% are produced in the summer. The value-added of fruit and vegetable production to the agricultural sector is about 10%[3] of the total agricultural value added in 2018/2019. The Food and Agriculture Organization (FAO) of the United Nations reports that, as of the 2017/2018 season, Bangladesh is ranked third in the list of vegetable-producing countries globally (FAO, 2019), with about 3.9 million t of vegetables in FY 2017-18 (BBS, 2018).

2.2.1 Area and volume of fruit and vegetable production

In Bangladesh, vegetable and fruit are usually produced in small mixed farming systems in, including homestead gardening. Using 2008 agricultural census of Bangladesh (BBS, 2010), we estimate that small fruit and vegetable farms that are smaller than 1 hectare - cover about 53% of total fruit and vegetable cultivated land in Bangladesh. Rest of the land reserved for fruit and vegetable cultivations is used by middle- and large-sized fruit and vegetable farms. About 37% of those vegetable farms have access to irrigation (FAO, 2014).

With rice and other cereals occupying over 75% of the country's 8.5 million hectares of arable land, the land for vegetable cultivation in 2010-2020 has been increasing. In addition to the increasing land, vegetable farming is growing as a result of policy support, farmers' adoption of hybrid seeds, home gardening and the cultivation of off-season and all-season vegetables. Farmers also receive a higher return from vegetable farming than low incentive rice production (Ahmad 2017). As of 2018-2019, value added from fruits and vegetables production to the overall Bangladesh economy is about 2% of gross value added in terms of GDP.[4]

Over the past 20 years, vegetable production has been steadily rising globally due to the growth in productivity and land used for vegetable production (Figure 2.2). From 2004 to 2019, vegetable production increased from about 2 million to 6.3 million t. Simultaneously, the area used for vegetable production increased from about 333 thousand ha to 651 thousand hectares, implying a slower growth

[3] We calculate this fraction using BBS (2020).
[4] Our estimates using data from BBS (2019). Details are available upon request.

in land used for vegetable production than the growth in production itself. The larger growth in vegetable production than the growth in land used for the production implies that the vegetable sector has experienced an increase in productivity per unit of land (yield) over the past 15 years.

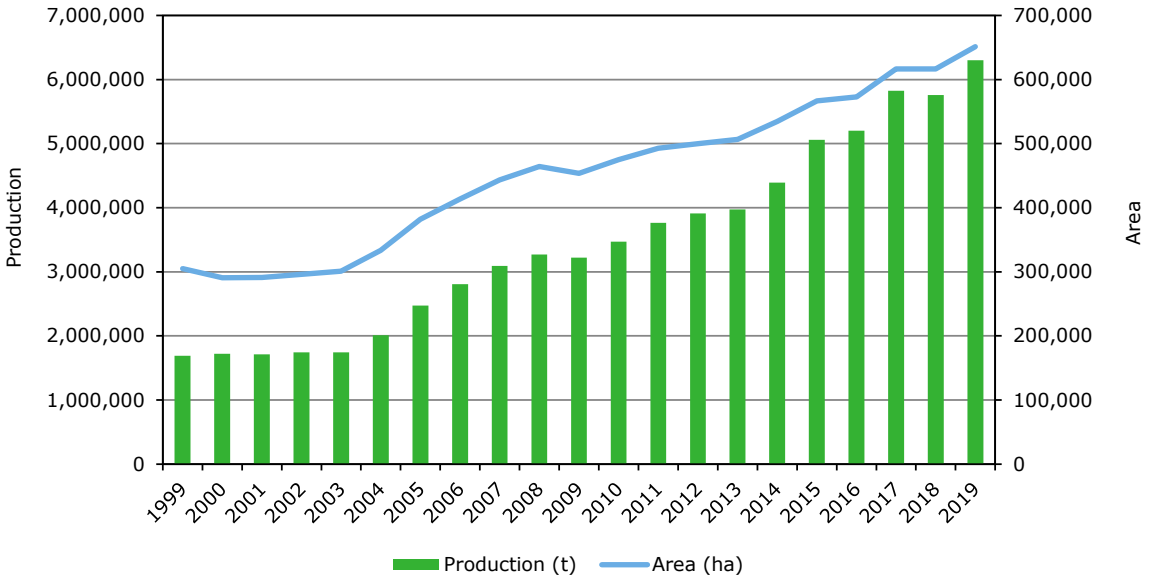

Figure 2.2 *Area (ha) and production (t) of vegetables in Bangladesh by years*
Source: FAO database.

According to FAO, the growth in the production of fruits from 2010-2019 is 25% and the current yield is 10.4 t/ha. Detailed numbers show that fruit production increased from 2005 to 2019 reaching 4.8 million t. Area under fruit cultivation also increased, but at a slower rate from 0.40 to 0.47 million ha (see Figure 2.3).

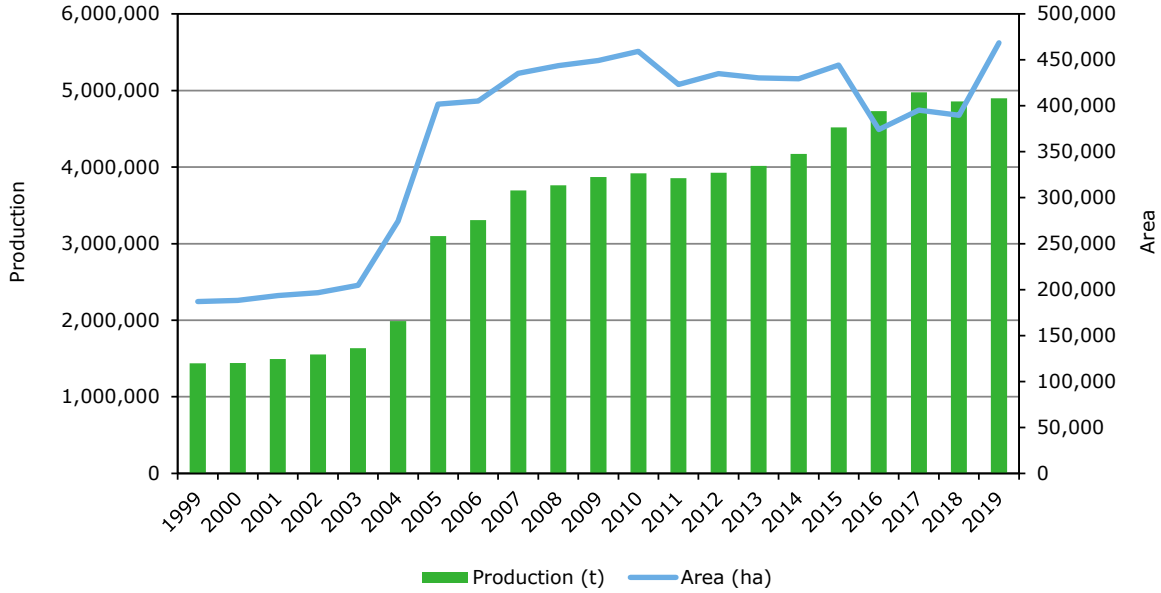

Figure 2.3 *Area (ha) and production (t) of fruits in Bangladesh by years*
Source: FAO database.

Figures 2.4 and 2.5 show the variety of vegetables produced in Bangladesh as of 2017-2018. In the summer season of 2017-2018, farmers cultivated wax gourd in the largest area (31%), followed by

green papaya (14%), taro (7%), brinjal (6%), pumpkin (4%) and okra (4%) (Figure 2.4). In the winter season, they cultivated brinjal in the largest area (13%), followed by tomato (10%), radish (8%) and green beans (8%) (see Figure 2.4). In the summer season of 2017-2018, the total vegetable production was about 2.37 million t; 0.89 million t higher than the production in the winter season.

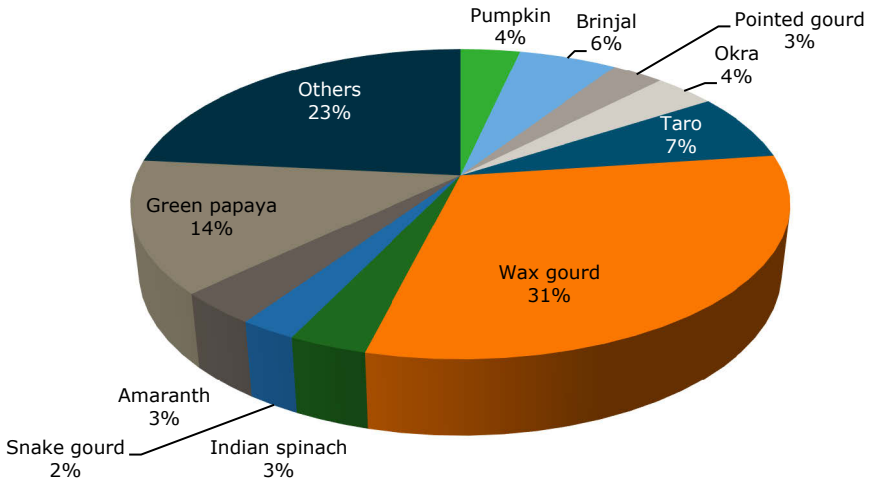

Figure 2.4 *Distribution of area under summer vegetables during 2017-2018 season*
Source: BBS (2019).

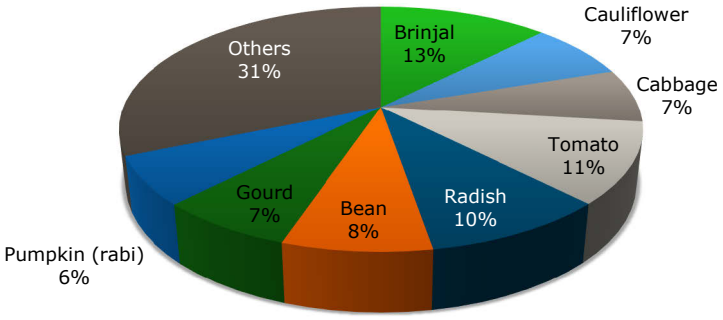

Figure 2.5 *Distribution of area under winter vegetables during 2017-2018*
Source: Yearbook of Agricultural Statistics (BBS, 2019).

Mango, jackfruit and banana are the major fruits produced in Bangladesh (Figure 2.6). The production of those three fruits constitutes over 60% of total fruit production in 2018. Green coconut, guava, watermelon and pineapple are the other major fruits produced in the country. Limes and lemons, orange, pomelo, and ber (kul) are other important fruits produced in the country.

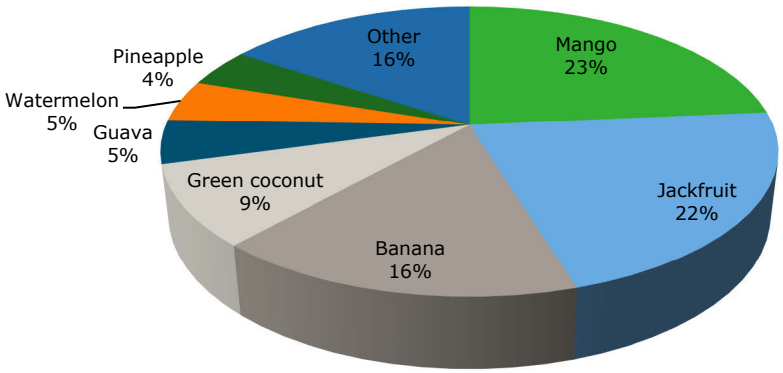

Figure 2. 6 *Distribution of fruit production during 2017-2018*
Source: Yearbook of Agricultural Statistics (BBS, 2018).

2.2.2 Production areas

In Bangladesh, fruits and vegetables are produced in almost all districts with varying production volumes depending on the season. Figures 2.7, 2.8 and 2.9, respectively, report the total amount of summer and winter vegetable and fruit production by divisions in Bangladesh during FY 2017-18. The highest quantity of summer vegetables was grown in the Khulna division (Figure 2.7), and the greatest amount of winter vegetables was cultivated in the Dhaka division (Figure 2.8). Mymensingh, Barishal and Sylhet divisions have low-level vegetable production when compared to other regions. Rajshahi division has the highest fruit production (1.1 million t), and the lowest amount of fruits were grown in the Sylhet division during FY 2017-18 (Figure 2.9).

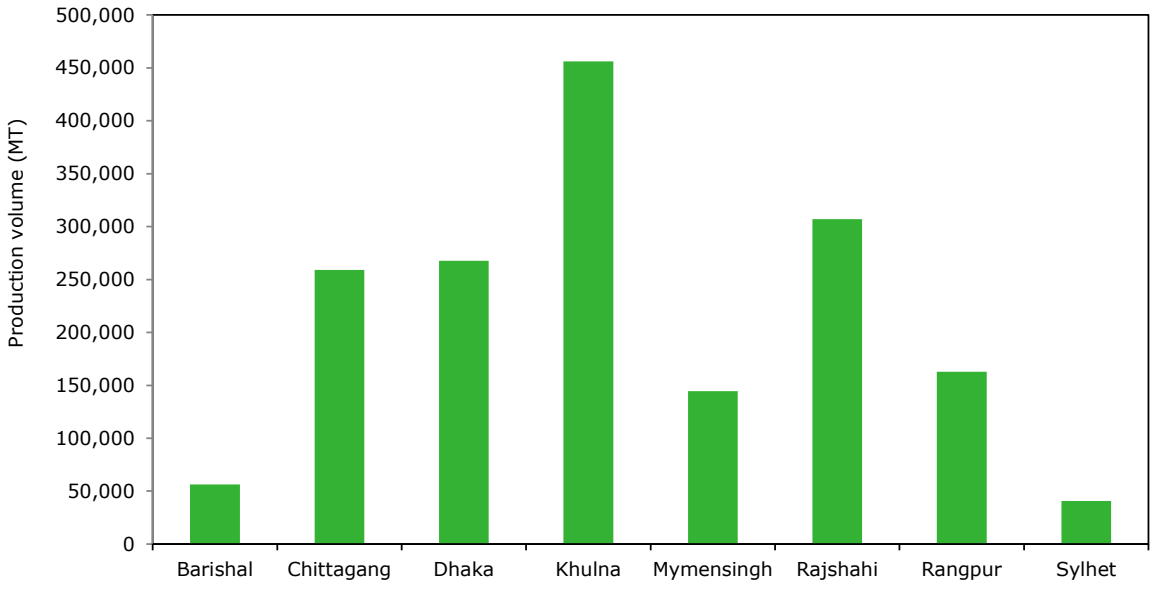

Figure 2.7 *Production volume (t) of summer vegetables in different divisions during FY 2017-18*
Source: Yearbook of Agricultural Statistics (BBS, 2018).

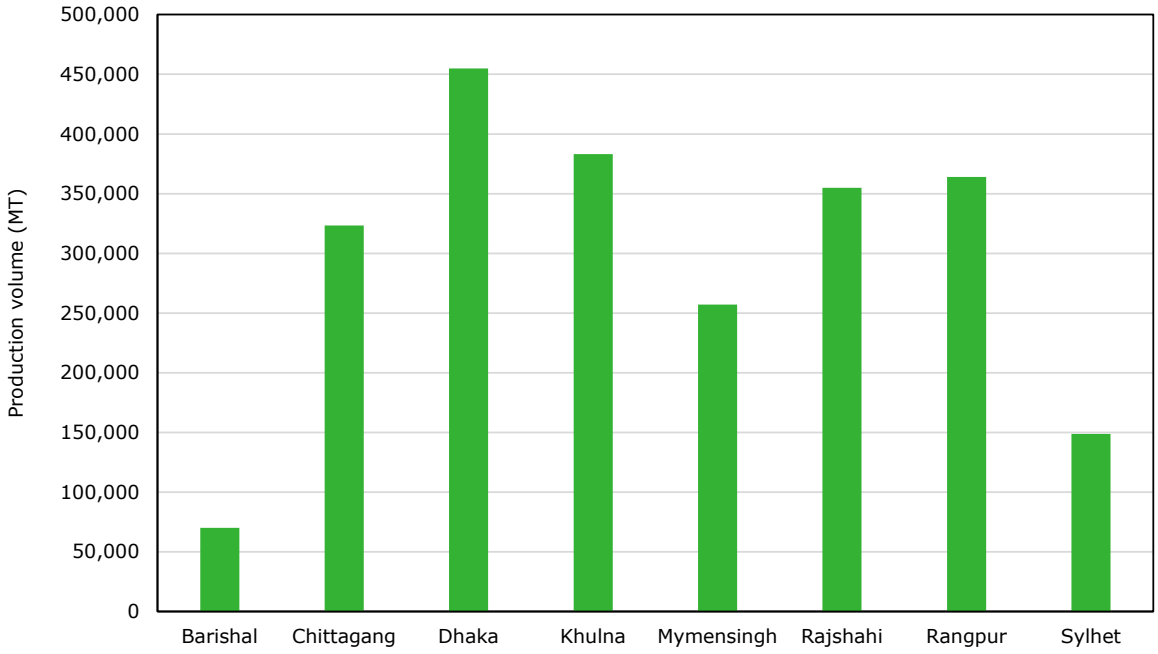

Figure 2.8 *Production volume (t) of winter vegetables in different divisions during FY 2017-18*
Source: Yearbook of Agricultural Statistics (BBS, 2018).

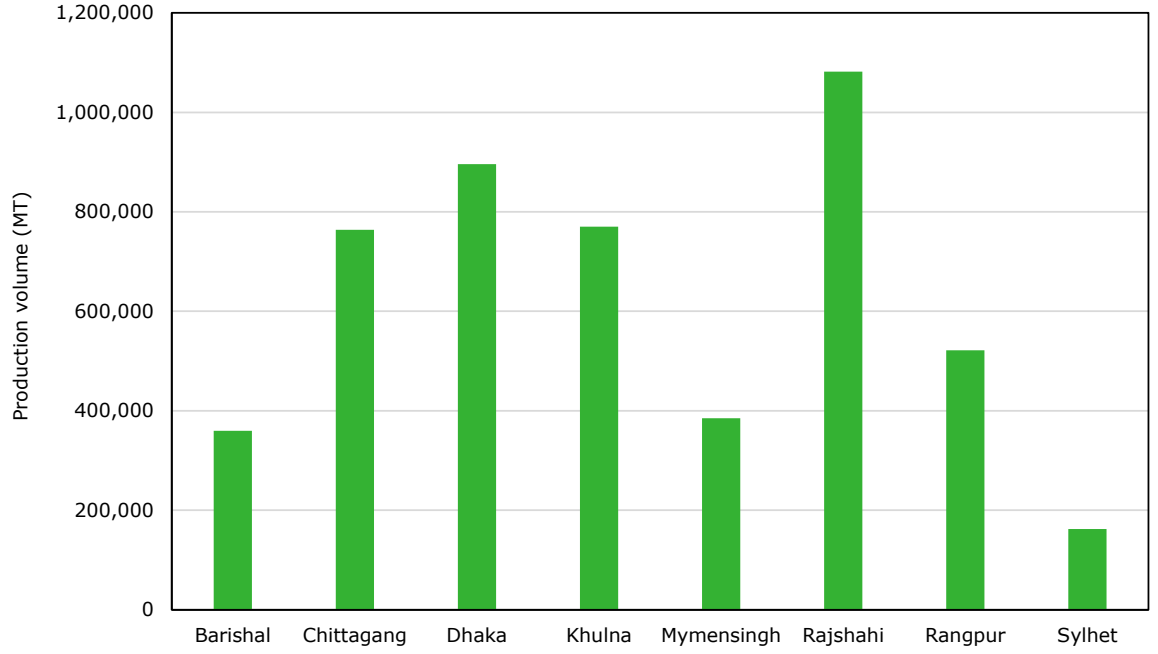

Figure 2.9 *Production volume (t) of fruits in different divisions during FY 2017-18*
Source: Yearbook of Agricultural Statistics (BBS, 2018).

2.2.3 Consumption of fruits and vegetables

Fruit and vegetable consumption in Bangladesh is below the minimum dietary requirements defined by FAO and the World Health Organization (WHO) (FAO/WHO, 2014). In Bangladesh, as of 2016, the per capita fruit and vegetable consumption is 203.8 g/day (BBS, 2018). About 167 g of this originates from vegetable consumption, and the rest is from fruit consumption. These are below WHO and FAO's recommended consumption of fruits and vegetables in total (400 g per person, per day) (FAO/WHO, 2014). It is also important to note that with current population growth, the demand for vegetables to reach minimum recommended levels of balanced nutrition is estimated to be 16.16 million t in 2030,

18.47 million t in 2040 and 21.12 million t in 2050 (Basak et al., 2015). Table 2.1 show the distribution of vegetable intake by vegetable. Thirty-six g of 167 g per person, per day vegetable consumption comes from leafy vegetable consumption, while the rest comes from non-leafy vegetable consumption.

Table 2.1 reports the per capita, per day calorie intake (kcal) from fruits and vegetables in Bangladesh, and the share of those calorie intakes from fruits and vegetables in total calorie intake in 2016 and 2010 at the national level. The table shows that significantly less calories come from leafy vegetable consumption than non-leafy vegetable consumption. Household Income and Expenditure Survey (HIES) (2016) reports that the total calorie intake from fruits and vegetables, and their share, did not significantly from 2010 to 2016. We present more detailed fruit and vegetable consumption trends in Section 4.7.

Table 2.1 *Per capita, per day calorie intake (kcal) from fruits and vegetables*

Food items	2016		2010	
	Calorie intake (kcal) per capita, per day	% of calorie intake out of total calorie intake from all food items	Calorie intake (k.cal) per capita, per day	% of calorie intake out of total calorie intake from all food items
Leafy vegetables	21.9	0.99	20.6	0.89
Others vegetables	69.4	3.14	68.4	2.95
Total vegetables	91.3	4.13	89.1	3.84
Fruits	25.0	3.72	31.1	2.85

Source: HIES (2016).

Consumers purchase fruits and vegetables primarily from wet markets and street vendors. We use data from Snoek et al. (2021) to roughly estimate the fraction of households that visit wet markets, street vendors (including mobile door-to door-vendors), farmers markets, supermarkets, and neighbourhood stores to purchase fruits and vegetables. Using that data, we roughly estimate the importance of these retails channels in the sales of fruits and vegetables to find that 51% of fruits and vegetables are sold in wet markets, street vendors sell 31%, and 14% are sold in neighbourhood stores. Direct supply to consumers through farmers markets constitutes only 4% of total sales.

2.2.4 Export markets

Fruits and vegetables produced in Bangladesh are exported to more than 40 countries globally. As of 2017/18, the major fruit exports are dried, fresh or processed coconut, pineapple, mangoes and apples, and major exported vegetables include seed potatoes, tomatoes, leeks, cauliflower, pumpkins and cabbages. Vegetables, specifically, constitute an important share in the total agricultural exports from Bangladesh. Exports within the fruit and vegetable sector were volatile from 2008 through 2009 and 2018-19, as shown in Figure 2.10. The figure shows that the exports of fresh fruit and vegetables from Bangladesh developed from about US$61 million (0.2 million t) in FY 2008-09 - equivalent to 0.4% of total exports of Bangladesh - to US$209 million (0.9 million t) in FY 2013-14 – equivalent to 0.7% of total exports of Bangladesh. However, the exports decreased afterwards, because European Union (EU) restricted the imports of fruits from Bangladesh. Specifically, the decrease in the export of fruit is drastic after FY 2013-2014, with a decrease of about US$61 million.

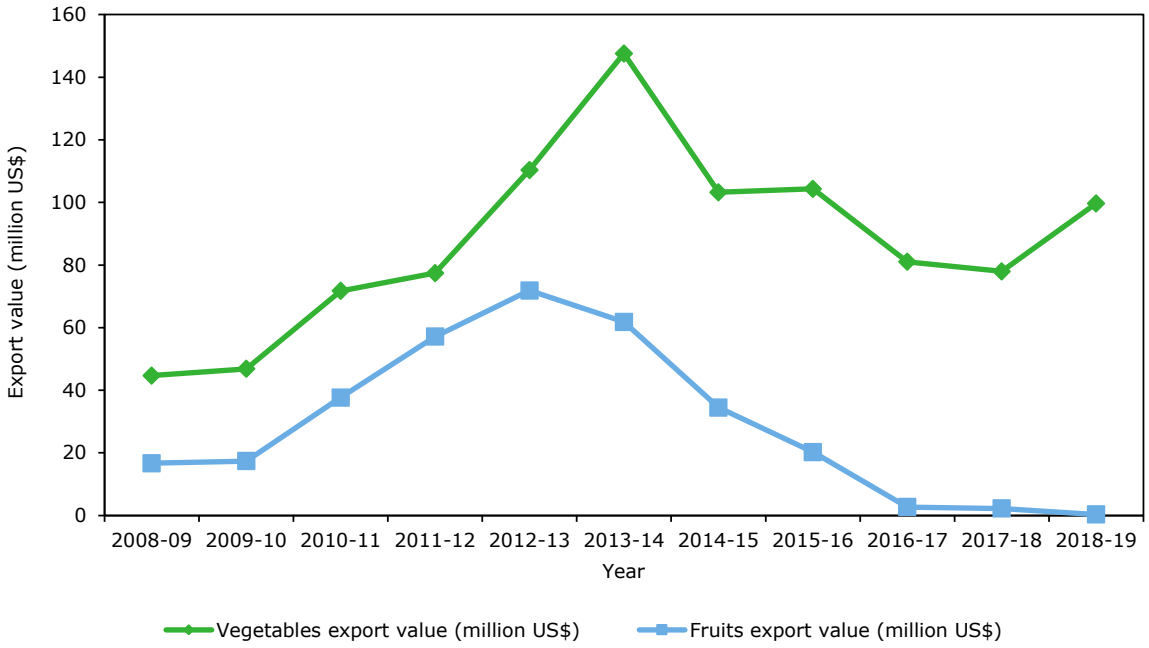

Figure 2.10 *Exports of fresh fruits and vegetables from FY 2008-09 to FY 2018-19 (million US$)*
Source: Hortex Foundation 2019. Retrieved 30 September 2021, from http://www.hortex.org/10_years_Export_data_on_fruits_vegetables_potato.pdf

As of 2015-2016, the major export markets of Bangladeshi fresh vegetables were three countries in the Arabic peninsula (Saudi Arabia, Qatar and Kuwait), the UK and Malaysia (Figure 2.11). India remained the only major export market of Bangladeshi fresh fruit (Table 2.2).

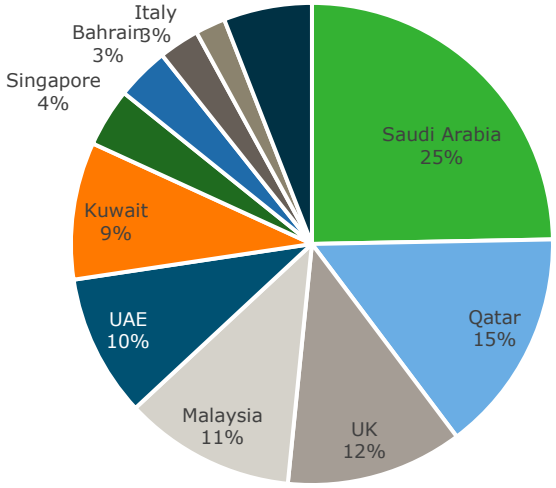

Figure 2.11 *The percentage of top export markets in total exports of Bangladeshi fresh vegetables, FY 2015-16*
Source: Hortex Foundation, Bangladesh (2016). Retrieved 30 September 2021, from http://www.hortex.org/produces.htm

Table 2.1 *Top ten export markets of Bangladeshi fresh fruits, FY 2015-16*

Export market	Export value (thousand US$)	Percentage (%) countries of total export value
India	18,240	90.16
UK	740	3.65
Malaysia	630	3.11
Vietnam	480	2.37
Indonesia	70	0.34
Saudi Arabia	30	0.14
UAE	9	0.04
Singapore	2.8	0.01
Saint Barthelemy	2.7	0.01
New Zealand	2.4	0.01
Total 10 countries	**20,207**	**99.84**
Other 5 countries	2.3	0.16
All 15 countries	**20.24**	**100**

Source: Hortex Foundation, Bangladesh (2016). Retrieved 30 September 2021, from http://www.hortex.org/produces.htm

2.2.5 Seed system

Bangladesh is a country with a relatively well-developed seed sector in which the public sector continues to play an important role, complemented by an emerging private sector. Within the seed sector, the vegetable seed is prominent and a key driver for developing the private sector. The Bangladesh Agricultural Development Corporation is the largest seed producer and supplier in the country, mandated by the government to produce large quantities of seed. Agricultural research institutes are responsible for developing improved varieties of crops, and the majority of plant breeding and seed production activities take place in the public domain. The National Seed Policy, passed in 1993, played an important role in involving private companies in the cereals seed business. However, there is an increasing need to create a favorable enabling environment to encourage seed companies to invest in research and development in other crops, including vegetables (Schreinemachers et al., 2021; Access to Seed Index).

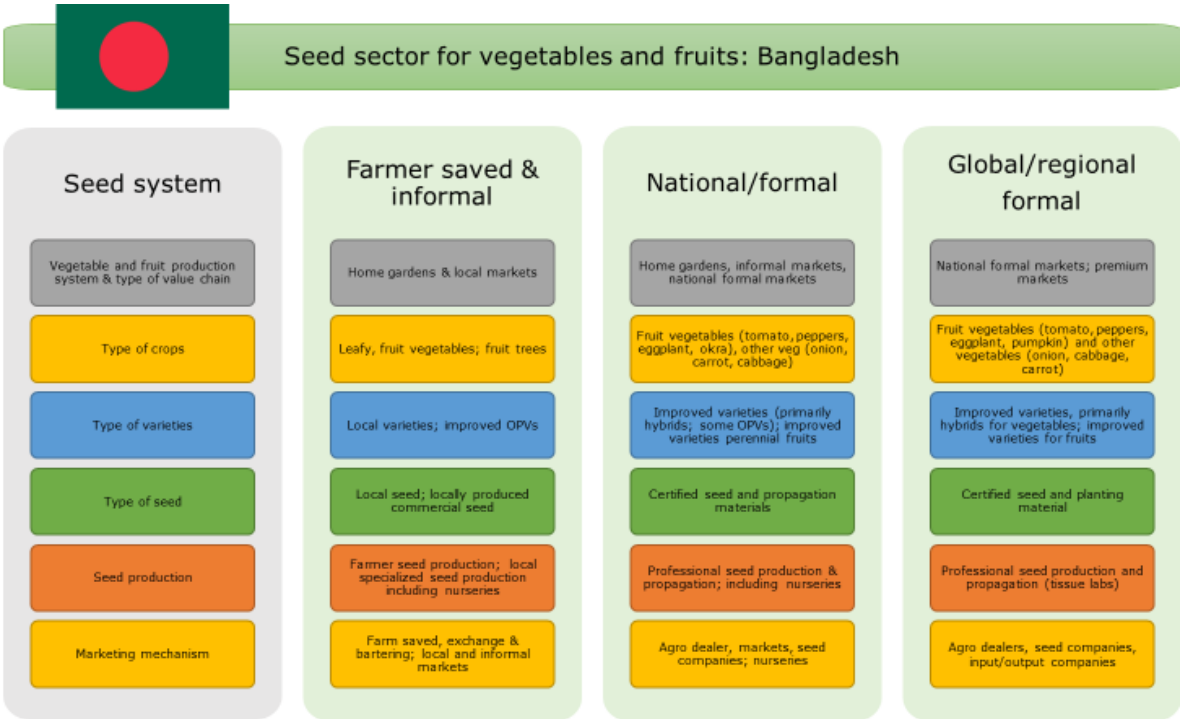

Figure 2.12 *Summary of seed sector for vegetables and fruit in Bangladesh*

Global, regional and national companies are operating in Bangladesh. The three national companies have complete seed value chains in the country, operating throughout the entire process, from breeding to extension. Smallholder farmers are involved in more than 90% of seed production activities by some regional and global companies. The private sector involves a wide array of global, regional (e.g., India), national, and more locally operating seed companies. The seed companies cater to varied markets, for example the global and national companies target commercial vegetable production with hybrid varieties. Some of the seed companies also cater for small-scale farmers, adapting the hybrid varieties, which are not expensive, and size of the packs. Where the global, regional and few national companies have their breeding programs, other national and local companies mostly depend on vegetable varieties from the public sector.

For less commercially attractive vegetable crops and fruit trees, public agricultural research institutes are critical for varietal development and the seed supply chain. However, the development of breeding stations, funding of breeding programs, seed processing centers to ensure quality seed and the provision of extension services are areas of improvement. The public sector engages in different types of public-private partnerships to produce early-generation seed for the vegetables, tissue culture labs and other propagation schemes for fruit trees. It should be noted that this applies for those vegetable crops if hybrid seed varieties as technology are not available, or when reproduction systems and limited markets do not favor private sector investments. In those cases, research institutes are linked for seed supply with more commercial seed value chain operators, such as local seed companies, non-governmental organizations (NGOs) and nurseries, each with a distinct production and marketing system. In this manner, the seed sector provides a diversity of commercial vegetable and fruit producers with quality seed and planting materials of improved varieties.

Farmers of home gardens or those engaged in some informal marketing of fruits and vegetables use multiple seed sources. They may use farmer-seeded seed, that is produce by farmers themselves, or planting material (fruit trees) from neighbors or informal markets or nurseries. For some vegetables, they may purchase small packs from regional or national companies. They would then opt for quality seed that may be open-pollinated or hybrid varieties, typically depending on the investment they are willing and able to make in purchasing vegetable seed. With a wide array of seed systems from farmer saved seed system that farmers keep some seeds from their own production, which is a farmer seed to global commercial seed systems, the seed sector of Bangladesh, particularly for vegetables, is well-developed. Still, the roles of the public sector and informal seed systems remain important and, therefore, supporting the development of seed system needs to be pluralistic.

2.2.6 Gender and role of women

With (seasonal) migration of predominantly men to cities or abroad, as in other countries, women play a larger role in agricultural production, and only in exceptional cases in processing or marketing. As we will discuss in Section 4 of this report, for households wherein men and women work together, the agricultural production is not easily distinguished by gender, though women additionally play the more traditional role of housekeeping and child-caring, giving them longer working days. Socio-cultural norms restrict nearly all women from moving independently to more distant, formal markets. However, NGO and public policy programs have been supporting women to sell in local markets by reserving 'women's corners', for their use.

Various programs have also built women's technical capacity for micro-scale production. Though programs that have supported women to go beyond this into leadership roles (of producer groups or small businesses) are not widespread, they point to opportunities to upscale. Despite women's roles in rural, and specifically fruit and vegetable production, the opportunities for them to benefit from this are still in their early stages. Building the support structure, addressing cultural norms around mobility that restrict movement to socialize without their husband and linking them to more formal production groups (as is done in other livelihoods sectors) will be key to empower women in agriculture. Initiatives to link female producers to consumers through e-commerce has shown early-on successes and helps address mobility constraints. This has major potential to be scaled up.

Women face also barriers to reducing nutritional stunting, whereby socio-cultural norms prioritize men, their parents and the children to be fed before women can eat (see Section 4 for detailed discussion on this topic). Both women's roles in production and value addition, and women's access to nutrition are recognized as significant challenges which NGOs and policymakers actively work together to address.

3 Selection of fruits and vegetables

This section explains the six major fruit and vegetable value chains that will be examined to answer the emerging questions from Phase 1 of the 'Global fruit and vegetable scoping study'. The next sub-section will explain the selection procedure and introduce the selected fruits and vegetables. Then, we will introduce the method that will be used to answer the research questions and our method to answer those questions.

We used a two-stage procedure to determine three fruits and three vegetables that we focus on in this study. First, we decided on the economic potential of fruits and vegetables, which will form the long list of fruit and vegetables. Then, we assessed the potential contribution of long-listed fruits and vegetables to the nutrition level in Bangladesh and women's involvement in the value chains to identify the short list of fruits and vegetables that we will focus on in this study.

The vegetables identified as having high economic potential, and thus belonging to the vegetable long list, were pumpkin, eggplant, okra, cabbage, cauliflower and tomato. Meanwhile, mango, pineapple, jackfruit, banana and guava fruits were the long-listed fruits. To reach this long list, we compared the production levels of various fruits and vegetables in 2013 and 2018 (the latest data available) and used an expert opinion to determine the economic potential of these fruits and vegetables in Bangladesh. Figure 3.1 shows the production of fruits in 2013 and 2018, and Figure 3.2 reports the same for vegetables, allowing us to detect fruits with high production levels and growth. Mango, jackfruit, banana and green coconut are the most highly produced fruits in the country, followed by guava, watermelon and pineapple. Tomato, brinjal (eggplant), cabbage, radish, cauliflower and pumpkin are the six vegetables with the highest production. The production for most of these top fruits and vegetables has grown from 2013-2018. We further discussed the economic potential of the long-listed fruits and vegetables with horticulture sector experts from Bangladesh University, who confirmed the list as accurate. They also stressed the importance of pineapple production in the tribal areas and pumpkin production in the regions with sandy land.

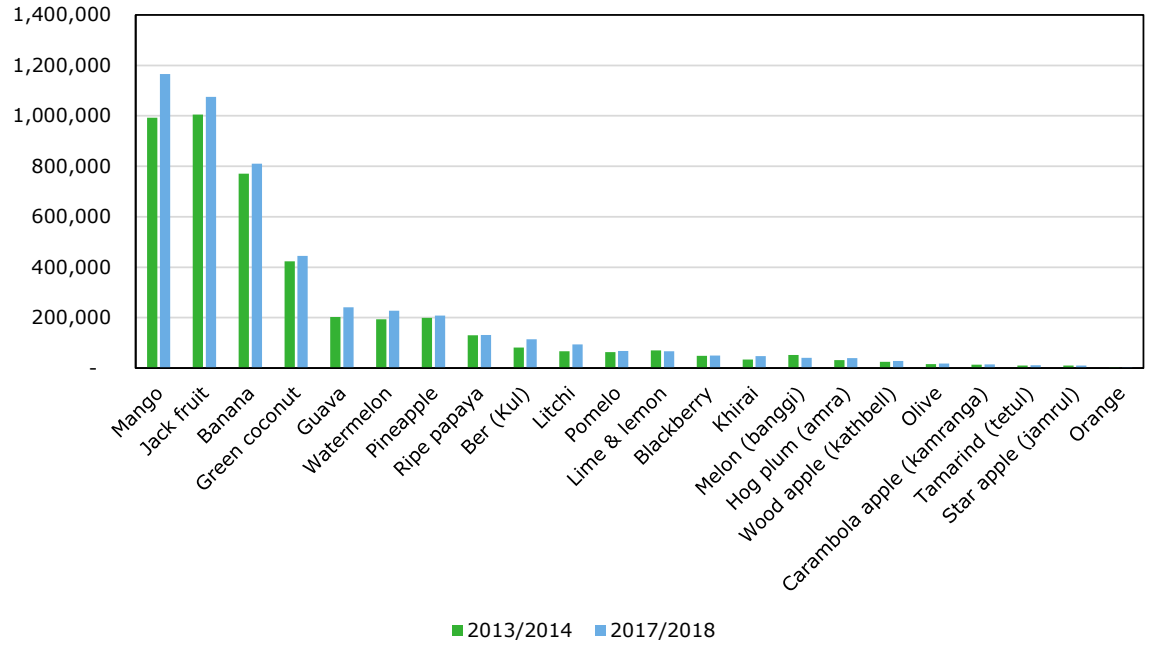

Figure 3.1 *Fruit production (t) in Bangladesh, 2013/14 and 2017/18*
Source: BBS (2019)

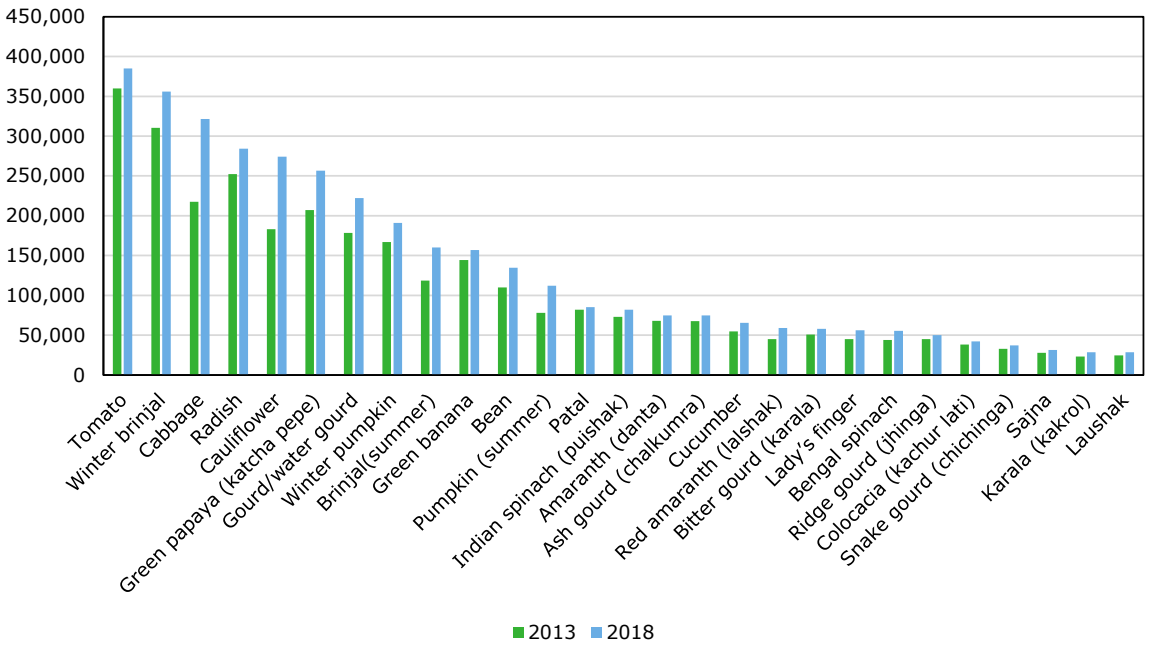

Figure 3.2 *Vegetable production (t) in Bangladesh, 2013/2014 and 2018/2018*
Source: BBS (2019).

For the short list, we chose pumpkin, okra and tomato as the selected vegetables and mango, pineapple and jackfruit as the selected fruits. All these crops have high economic potential. Some have contribute to the nutrition in Bangladesh and some projects specifically targeted women producers of these fruit and vegetable chains. All long-listed crops are widely consumed in Bangladesh. In particular, orange pumpkin consumption can help address vitamin A and folate deficiencies, and mango consumption can improve vitamin C and folate intake.

Next, we checked whether there are projects that target the long-listed fruits and vegetables and work to empower women at the same time. We found projects (Pumpkins Against Poverty, LOOP project, USAID Horticulture Project) to empower women through the pumpkin, tomato and okra value chains. Also, we learnt that tribal women are involved in the production of pineapple. Due to their contributions to nutrition or role in empowering women, mango, pineapple, pumpkin, okra and tomato are included in the short list. We also added jackfruit to the short list, as it has high output in Bangladesh, is one of the fruits the country plans to export and has huge processing potential, indicated by sector experts. We have validated this with confirmation from the President of the Horticulture Association in Bangladesh and two other horticulture sector experts at Bangladesh University.

4 Research results

4.1 Introduction of the selected fruit and vegetable supply systems

This section introduces the actors and functions of the tomato, okra, pumpkin, mango, pineapple and jackfruit value chains. The literature review and information gathered from FGDs indicates that the actors and their roles are similar in those chains. Therefore, we give a general summary below for all chains.

4.1.1 Description of actors

Value chain actors are involved in supplying inputs, producing, processing, marketing and consuming agricultural products, They can be directly involved in the value chain (farmers, traders, retailers and consumers) or indirect actors who provide financial and non-financial support services, such as credit organizations, business services, government, researchers and extension agents.

Agriculture value chain analysis initiates at the input supply level. Inputs such as seeds, fertilizer, pesticides and farm implements are supplied by cooperatives, the Department of Agricultural Extension (DAE), seed companies Bangladesh Agricultural Research Institute, formal traders (i.e., Bangladesh Agricultural Development Corporation), and farmer-to-farmer exchanges. Quality of fruit and vegetable seeds is crucial for increased production. About 50% of farmers in Rajshahi and Kushtia use hybrid varieties supplied by DAE and different private companies in vegetable production. About 25% uses the seed produced by farmers themselves, and the remaining 25% use non-branded local seed from the local market. The majority of farmers used subsidized fertilizer (Di-ammonium Phosphate [DAP] and Urea) depending on the land size allocated to vegetables. The farmers purchase pesticides and herbicides from different sources. The major suppliers of pesticides, herbicides and chemicals are private traders and cooperative shops.

The major private actors in agricultural value chains are different processing companies such as PRAN, BDFood, ACI Limited, Building Resources Across Communities (BRAC). Some Civil Society Organizations are active in agricultural value chain activities. These include Solidaridad, BRAC, ActionAid, Oxfam, Development Alternatives Incorporated (DAI). The major funders of agricultural development projects include USAID, World Bank Group, Nuffic, UKAid, the Bill & Melinda Gates Foundation, the EU (e.g., European Civil Protection and Humanitarian Aid Operations). The major government agencies that focus on the agricultural value chain include Department of Agricultural Extension (DAE), Department of Agriculture Marketing (DAM), BIRTAN, Department of Livestock Services, Department of Fisheries, Hortex Foundation, Bangladesh Agricultural Research Council. In addition to major NGOs and informal financial institutions, the Bangladesh Krishi Bank (BKB) and Rajshahi Krishi Unnayan Bank (RAKUB) leverage formal credit to the actors in the agricultural value chain including farmers, entrepreneurs and traders with a low interest rate.

The typology of the value chains actors in the horticulture sector is as follows:

Farmers
Farmers are the primary actor in the value chain. The majority of farmers are smallholders with mixed farming systems who are not cultivating exclusively fruits and vegetables, but rather produce multiple crops. Two categories of farmers were noticed in production areas: subsistence farmers and small commercial farmers. Farmers decide on the input, seeding and harvesting time, consumption and sales amounts. They performed most of the value chain functions from farm input preparation through to post-harvest handling. The major value chain functions that farmers performed included land preparation, growing/planting/fertilization, irrigating, protecting from weed, pest/disease, harvesting

and post-harvest handling and marketing. Most farmers sell the majority of their fruits and vegetables during harvesting time, keeping only a small amount for home consumption and seed, particularly in the case of pumpkin. All farmers, both subsistence and market-oriented, produce some vegetables for the market and usually sell to wholesalers at farm gate and village markets. They also sold to different actors such as rural collectors/commission agents, bepari (please see below), consumers and retailers (with varying sales volumes) at the local market.

Aratdar
Aratdars are independent operators at primary markets, assembling and transporting vegetables from smallholder farmers to larger markets and sometimes functioning as commission agents. They play an important role in the speedy delivery of fresh vegetables from farmers and local wholesalers to the downstream wholesalers and retailers. Aratdars negotiate transactions between buyers and sellers and also help them through their business premises on receipt of commission. They have fixed establishment in the market and operate between wholesaler and retailer. They typically self-finance by employing both laborers and the other staff on a daily wage and salary basis to perform various functions in the vegetable market. Usually, they rent space at the wholesale market and do not take possession of the product.[5]

Beparis
The Beparis are big non-licensed traders handling a large volume of fruits and vegetables. Some of these traders are big growers, particularly in mango and pineapple. They purchase fruits and vegetables from the Aratdars. In the peak season, big traders sell pumpkin, okra and tomato to the big traders of distance markets, while in the off-peak season, they sell fruits and vegetables as retailers or wholesalers do.

Wholesalers
Wholesalers buy vegetables from rural collectors, Aratdars and directly from farmers and sell them to larger market centers and retailers with better financial and information capacity. Wholesalers are the major buyers as they buy large volumes of vegetables at a time from farmers. They mostly purchase from farmers and local traders. There were no licensed wholesalers in our study areas. Sometimes wholesalers bought fruits and vegetables from farmers through commission agents who represent them in fruit and vegetable buying activities. They have better storage, transport and communication access than other traders.

Processors
There only a few major processing companies such as PRAN, BDFood, ACI, BRAC. Processing of vegetables to preserve and value addition is not commonly practiced.

Retailers
Retailers are key actors in the fruit and vegetable value chain within and outside the study area. They are known for their inadequate capacity for purchasing and handling products and low financial and information capacity. These actors are the last link between farmers and consumers. Wholesalers occasionally act as retailers. There are two types of retailers in the study area: local retailers and central retailers. Local retailers are located close to the farmers and purchase vegetables either from farmers or wholesale traders. Conversely, central (urban) retailers in major cities mostly purchase from wholesalers and sell to urban consumers. The supermarkets and shops are mainly in the major cities and commonly purchase fruits and vegetables from wholesalers. During the FGDs, the participants reported that consumers purchase only a small amount of pumpkins, tomato and okra. Consumers typically buy products from retailers, as they offer according to the requirement and purchasing power of the buyers.

Consumers
Consumers are the final purchasers of fruits and vegetables, generally from retailers for consumption purpose. Fruit and vegetable consumers are individual households, hotels and restaurants.

[5] Depending on the value chain in question, they may also have the function of a large wholesaler.

Enablers and facilitators

In Bangladesh, many institutions support the fruit and vegetable value chain in one way or another. The most common support providers are DAE, BRAC, Association for Social Advancement (ASA), local cooperatives, Syngenta, private transporters. The support service providers include sector-specific input and equipment providers, financial services, extension services, market information access and dissemination, technology suppliers and advisory services. Some service providers' services extend beyond one function, while others are limited to a specific function. For example, the DAE provides agricultural extension services to producers. The DAE office provides advisory services, facilitates access to inputs, and provides technical support in seed bed preparation, fertilizer application, crop protection and post-harvest handling. The FGD participants reported that farmers receive extension services, but sometimes these are inadequate to improve the technical skill of the farmers. The most common loan sources were cooperatives, relatives and friends, as these sources do not require any collateral. The NGOs (Grameen Bank, BRAC, ASA etc.) and banks (BKB, RAKUB) provide technical services and offer credit support. However, the farmers are not receiving good services regarding financial issues.

4.1.2 Role of women

In Bangladesh, women involvement in fruit and vegetable value chains varies by crop and production stages. Both KIIs and FGDs show that mango is a male-dominated cash crop where women involvement is generally limited to the post-harvest process and grading. More women are involved in weeding and post-harvesting in pineapple than mango For instance, in the Tangail region, where we have conducted our FGDs with pineapple producers, about 80% of tribal women are involved in pineapple production activities and half of the weeding is done by women. For both mango and pineapple, though, no women are typically involved in trading and processing.

Our qualitative evidence shows that women are more involved in vegetable production than fruit production. For instance, our FGDs with pumpkin and tomato producers show that female members work more than men during the production stage, as male members have to work as wage labor to others. Homestead vegetable gardening, which NGOs and the government have introduced to rural areas in Bangladesh since the 1970s, plays a key role in horticulture production. Generally conducted in small plots around households, homestead gardens allow women to contribute to household income and nutrition. However, the gardens' close proximity to their homes means that this activity does not increase their social mobility.

The social norms about the socialization of women also limit access to markets by women, except in the sale of by-products. In the six fruit and vegetable value chains that we studied in Bangladesh, the role of women in the marketing and trading of products is much more limited than that of men. The FGDs revealed that men are primarily responsible for carrying and selling fruits and vegetables to the traders and markets. Rahman et al. (2020), who study the perception of women in vegetable production in Northwest Bangladesh, confirm this finding and show that 4-6% of respondents perceive that women involves in selling vegetable products. However, according to the same study, 35% are perceived to be involved in selling by-products of fruit and vegetables.

4.1.3 Dominant types of value chains

The FGD participants reported that there are four distinct value chains through which fruits and vegetables are marketed and find their way to end consumers:

- Chain I: Farmer-Aratdar-Bepari-Wholesaler-Retailer-Consumer
- Chain II: Farmer-Aratdar-Bepari-Retailer-Consumer
- Chain III: Farmer-Aratdar-Retailer-Consumer
- Chain IV: Farmer-Retailer-Consumer

The majority of these value chains are informal. The maximum amount of product moves through Value Chain I, followed by Chains II, III and IV, respectively. However, Chain I has the longest distance over which the fruits and vegetables must travel before reaching the customers, and the products move between the hands of many actors. For example, in Chain IV, the farmers sell to local

retailers in production areas, from whom the local consumers then purchase the fruits and vegetables, but their trade volume is comparatively low.

On the other hand, in Chain I, fruits and vegetables reach the consumers in the consumption area, such as Dhaka, the capital city, through different market actors. We expect that the longer the chain, the higher the consumers' price is for the same quality products. The longer the value chain is, the more marketing costs, wastage and market risks are involved.

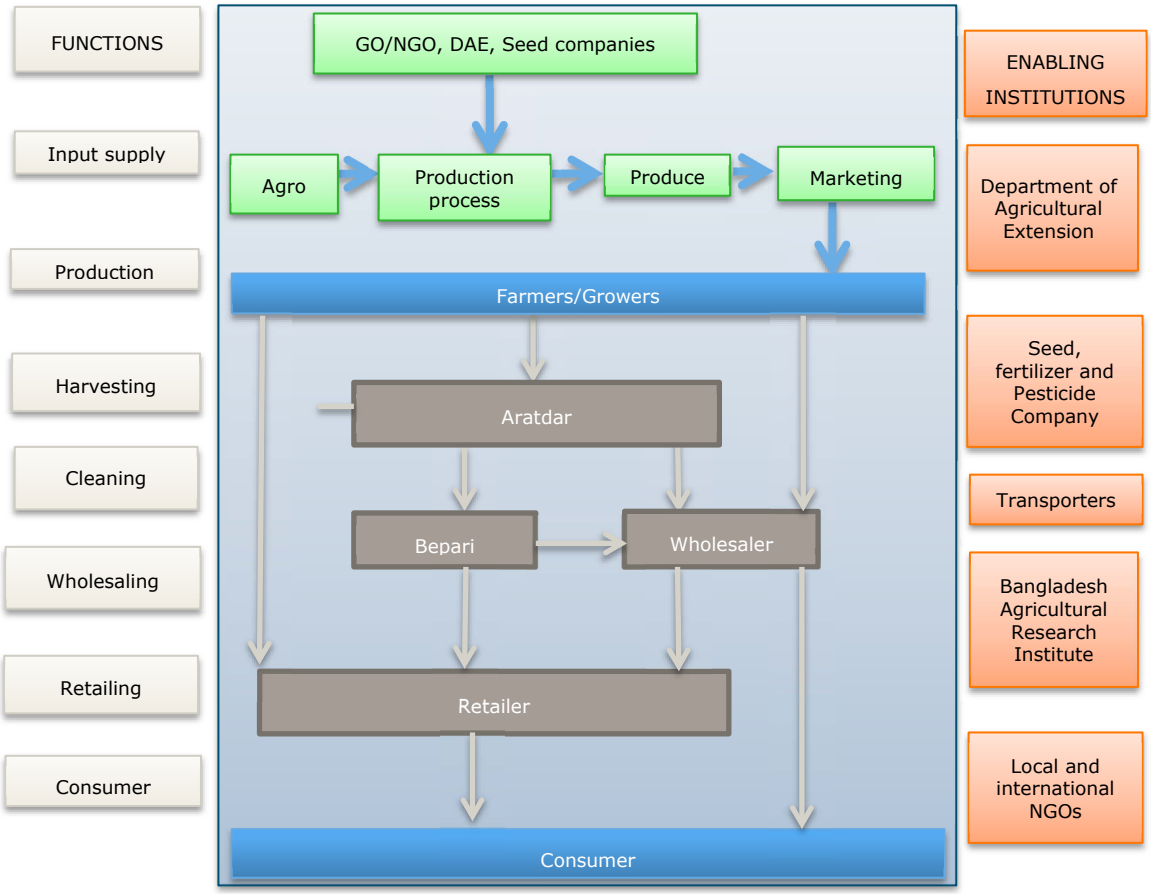

Figure 4.1 *Fruit and vegetable value chain structure*

4.1.4 Enabling environment

To ensure food and nutrition security and agricultural productivity, the country has formulated the NFP, National Plan of Action for Nutrition (NPAN), NAP 2018 and its plan of action, and the National Agricultural Extension Policy (NAEP). The major policy interventions and focus areas of the policy documents and plans are as follows:

- NFP includes agriculture research and extension interventions, use and management of water resources, adequate supply of sustainable agricultural inputs, agricultural credit and insurance, and physical market infrastructure development.
- NPAN aims to improve the nutritional status of all categories of people, including men, women, children, adolescent girls and older adults. In the NPAN, there is a focus on women's nutritional status, breastfeeding and nutritional counselling during their anti-natal and the post-natal period, awareness-raising regarding intake of proper nutritional food and hygiene practices, and capacity building on cooking practices for food of a higher nutritional quality. According to NPAN, related policy guidelines should address all localities, including people living in Charland[6] and hilly areas, as

[6] Charlands are sandy areas within river channels or next to it emerged as a result of erosion and accretion in the rivers. Usually poorest communities live next to those areas and they are prone to the effects of climate shocks (e.g., floods, drought and cyclones. https://www.preventionweb.net/publications/view/9738

these areas are lagging in terms of economic development. NPAN also suggests that pesticide-free fruits and vegetables should be grown in farmers' homestead land to improve the intake of organic produce and ensure proper extension services in the Charland areas by DAE.
- The NAP has highlighted the following major policy interventions: agricultural extension, women in agriculture and agricultural cooperatives. Development of charland friendly climate smart crop technologies and comprehensive women's engagement in income-generating activities through agro-based homestead products such as preparing pickles, jam, jelly, etc., are within the scope of the document.
- The major policy guidelines in the NAEP are related to strengthening the supply of quality seeds and other inputs, emphasizing homestead gardening and efficient and effective dissemination of technology.

This policy framework enacted by the government defines the extension services and infrastructure that fruit and vegetable producers have access to. The emphasis of these policies on homestead production, women, and nutrition directly concerns the fruit and vegetable sector, as fruits and vegetables are the major crops produced in the homestead by women and are necessary to improve dietary diversity and nutritional outcomes.

4.2 Increase in production leads to lower fruit and vegetable consumer prices

4.2.1 Seasonal variation

Bangladesh has three distinct production seasons:
- Rabi (winter) season from November to February;
- Kharif-I (summer) season from March to June;
- Kharif-II rainy season from July to October.

There is high seasonality in the production of fruits and vegetables in Bangladesh (Table 4.1). For instance, the main season for vegetable production is Rabi, which is dry and cool. This is followed by summer when summer varieties of vegetables are produced. The varieties of vegetables produced during the wet season are limited to raised homesteads, high land and floating beds (AVRDC, 1990). The supply of fruits and vegetables is high in winter and low in summer (Kharif-1 and Kharif-2). Of those vegetables examined in our study, the lady's finger is grown in Kharif season, tomato is grown in rabi seasons and pumpkin is grown in both seasons. Among the selected fruits, mango, jackfruit and pineapple are harvested in the Kharif season from May to August.

Table 4.1 *Seasonal variations in the harvest periods for selected fruits and vegetables*

	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Tomato	X	-	-	-	-	-	-	-	-	-	-	X
Pumpkin	X	-	-	-	-	X	X	X	X	-	X	X
Okra	-	-	-	-	-	X	X	X	X	-	-	-
Mango	-	-	-	-	X	X	X	X	-	-	-	-
Pineapple	-	-	-	-	X	X	X	-	-	-	-	-
Jackfruit	-	-	-	-	X	X	X	-	-	-	-	-

Source: Prepared from BBS (2019), page 156.

The price and availability of the selected fruits and vegetables are strongly related to seasonal production. Figure 4.2 shows the monthly price index for selected fruits and vegetables in 2018, indexing May price to 100 and comparing the monthly prices. This table demonstrates that the prices vary by seasons, especially for tomato, okra and mango. As they are not available in the wholesale market, May-September prices are shown for jackfruit and mango. These findings confirm our learning from the FGDs and KIIs, which confirmed that the selected fruits and vegetables' prices are high early

in the production season and lower later on. They state that this fluctuation is mainly due to the limited processing and storage facilities, and there is a rush in the market to sell the produce in the early season, so prices quickly drop thereafter.

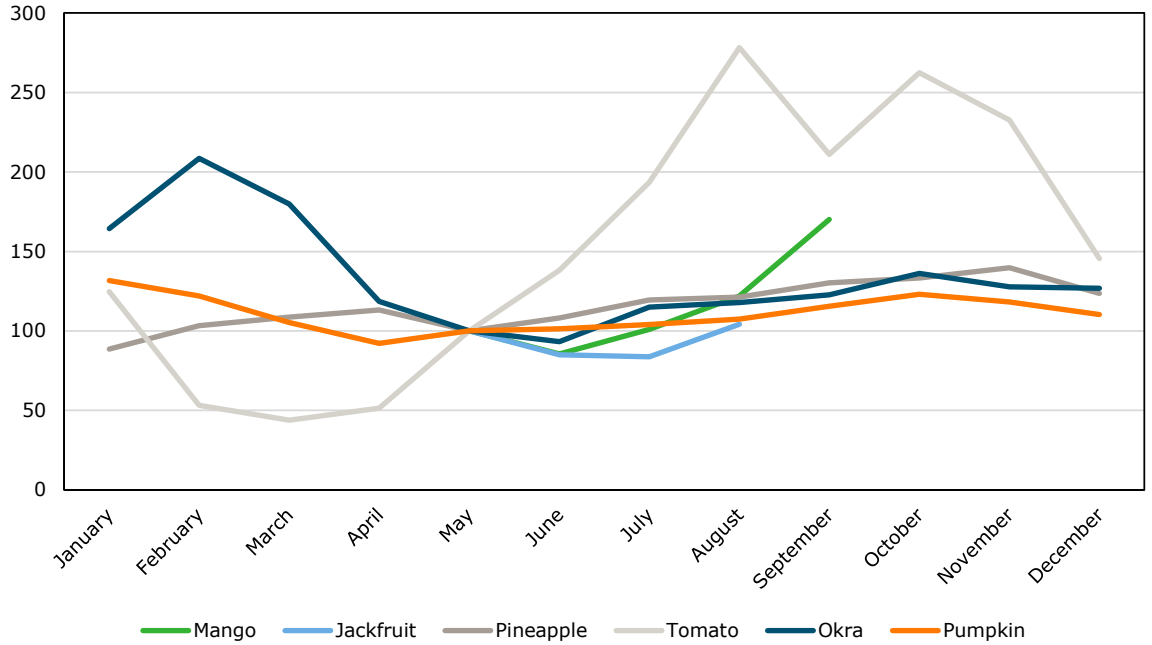

Figure 4.2 *Monthly wholesale market price index for selected fresh fruits and vegetables in 2018, May 2018=100 for all fruit and vegetable*
Source: Own calculations using BBS (2019)

We conclude that there is high seasonality of horticulture production in Bangladesh. The high seasonal price variability also reflects this, as it implies that consumers do not have good access to affordable fresh produce in the off-seasons, with negative implications on the nutrition level of households. This seasonality in production also points to an opportunity for farmers to earn high profits from off-season production (for instance, see off-season tomato case in Section 4.4.2.2).

4.2.2 Main barriers for farmers to increase production

4.2.2.1 Limited access to high-quality seeds and other inputs

A lack of high-quality seed is a barrier to increased production for all value chains in the horticulture sector. We learned from our key informants that quality seed for the overall horticulture sector is not sufficiently produced in the country, and most high-quality hybrid seeds are imported. Findings from all our FGDs with producers of six value chains confirm this, as producers claim that they could increase their production if they could access high-quality seeds and greater yielding varieties. However, these varieties are usually not available or are too expensive for the producers.

Access to and affordability of quality pesticides and fertilizers varies by region and value chain. Bangladesh's government highly subsidizes Urea and subsidizes imported phosphate and potassium to some extent (Altaf Alam and Wing, 2018). However, access to high-quality fertilizers is still a challenge for mango, tomato and okra farmers. Mango farmers who participated in our FGDs in Rajshahi and Khulna divisions still experience a significant challenge in accessing the high-quality fertilizers they would like to use because the input dealers in the region cannot supply the amount of fertilizer they demand. This is mainly due to the fixed government allocation of fertilizers. When farmers demand more, the dealers are unable to supply from their jurisdiction and must find supplies from other regions, which is not officially allowed and thus costs more. Moreover, tomato and okra

farmers from Kushtia claim that the locally produced Triple Superphosphate (TSP) is not of sufficient quality in their region, indicating regional variation in the quality of the local inputs.[7]

Access to pesticides is a greater problem in pumpkin value chain than tomato and okra value chain. Pumpkin farmers find the pesticide prices high, while tomato and okra farmers claim they cannot reach high-quality pesticides due to a lack of accessibility in their localities.

4.2.2.2 Limited knowledge of good agricultural practices

The limited knowledge of farmers on good agricultural practices (e.g., using the correct amount of pesticides and fertilizers) limits their productivity and makes it a challenge to improve production. There is evidence that the low educational level, lack of knowledge and lack of training cause an overuse of pesticides among vegetable farmers in Bangladesh (Akter et al., 2018). Our FGDs and KIIs with sector specialists confirm this. The participants in the mango, tomato and okra FGDs reported that they need better training on fertilizers and farming, and pineapple producers highlight excessive use of plant growth promoters. The participants in the interviews suggest that although the pesticide use decreased as a result of the Pesticide Act legislated in 2018, many fruit and vegetable farmers still use high levels of pesticide and fertilizer, increasing the cost of production.

The qualitative evidence from KIIs and FGDs conducted among mango and tomato producers suggests that women's knowledge of good agricultural practices is lower than that of men. This may be because women did not benefit from the extension services to the degree that men benefited until the 2000s, but benefited more equally starting from 2000s. There are examples of programs that introduce good agricultural practices to women, examples of which are provided in Section 4.8.

4.2.2.3 Poor infrastructural, logistics framework and lack of processing

Lack of irrigation, lack of processing industry, poor road infrastructure in some areas and limited access to storage facilities are all factors that discourage farmers from increasing production. For instance, Charland area pumpkin producers lack access to irrigation to improve their production. They also do not have access to roads to carry the pumpkin to the closest main roads to meet with the traders. For tomato production, a lack of storage facilities close to the fields to keep the tomato fresh is another challenge to improving production (Sarma et al., 2019). Meanwhile, mango producers indicated that they also do not have access to storage facilities and the jackfruit producers expressed that they do not have access to processors and, therefore, there is not enough of a market to expand the production.

4.2.2.4 Access to finance and land titles problems for women

The women farmers from all FGDs and some other experts who participated in the KIIs shared that the main barrier to intensifying production for women farmers is the lack of institutional and formal financing (e.g., bank credit). The women farmers told us that they face difficulties applying for a loan because formal institutions want land titles as collateral, which women don't typically have. Empirical evidence shows that many Bangladeshi women lack this. Only about 12% of rural women own land jointly or alone. Because women are less likely to receive land as an inheritance, they face difficulties registering their land. Social mobility norms restrict them from registering their land at government offices etc. (Solotaroff et al., 2019). For this reason, when they need to invest in the land they control, they need to have the signature of their husbands or male members of their family as guardians, and submit the papers in their name. Even when they manage to receive the credit, though, the formal credit disbursement system is time-consuming and they don't often receive the loan when they need it. Women, therefore, rely more on financing from their savings, loans from self-help groups or microfinance from NGOs (Solotaroff et al., 2019). According to the KIIs, the microfinance or loans from self-help groups that women can access cannot intensify the production, as they are small and short-term, not suitable for investment.

4.2.2.5 Social norms about women

Women farmers are much less integrated into the markets. The information from key informants shows that this is mainly due to social norms in Bangladesh, restricting the social mobility of women

[7] This is not across the country. The DAE is regularly monitoring the quality of inputs and the complaints of farmers about the quality of TSP are reduced over the past years substantially.

(T. Ahmed and Sen, 2018). Aregu et al. (2018) study the gender norms in six rural villages in Southwest Bangladesh and explain that women's mobility is low because men from the villages do not approve of women's mobility outside the village, especially alone. Thus, the women's primary productive role is within the household and homestead (e.g., in vegetable gardens) close to the house, while men are perceived to be the breadwinners. Nevertheless, there are examples of NGO-led programs that try to organize women and increase their mobility. We provide those illustrative examples in Section 4.8.

4.2.3 Production losses

The miscoordination between government offices and producers in determining the harvest time (in the case of mango production) and preventing bird attacks, and excessive use of growth hormones seems to be the major reason for production losses limiting the availability of fruits and vegetables for consumption in the market. The DAE fixes the harvesting duration based on the maturity index. But the farmers opined that different varieties of mango are not ripened at the same time; some varieties of mango mature early, and others late. As a result, participants in the FGD with the mango producers and value chain actors reported that they face losses as they couldn't harvest mango before the harvesting date. An Upazila Agricultural Officer in Rajshahi region added that an average of 20-30% of mangoes are usually lost due to the harvesting period determined in the beginning of the season. Meanwhile, the participants in the pineapple and jackfruit FGD reported that excessive use of growth hormones cause production losses, as well as bird attacks in the field before harvesting. They reported that loss occurs from the harvesting through to the retail level, and it accounts for a quarter of total production in the entire value chain.

In summary, limited access to high-quality inputs and limited knowledge of good agricultural practices are the two major challenges of horticulture producers in Bangladesh. Moreover, we observe that poor infrastructural and logistics framework and a lack of processing cause high production losses and discourage farmers from expanding their production. For women in particular, we observe that lack of access to land titles and thereby financing by women and social norms limiting their mobility constrains the women in expanding their horticulture production. These obstacles reduce the population's access to affordable fruits and vegetables and limit women empowerment in the country. In addition, production losses due to poor coordination between farmers and government, bird attacks and excessive use of growth hormones decrease the affordability of fruits and vegetables.

4.3 Reduction in cost price will make the production of fruits and vegetables more profitable

4.3.1 Cost of production

Table 4.1 presents the total production costs and cost-benefit ratios of the selected fruits and vegetables in Bangladesh as estimated by previous studies, with the exception of jackfruit as the production costs of which, to our knowledge, have not been studied. These total production costs include all input costs, human capital, land rent costs and cost of capital used. The results show that all selected fruits and vegetables are profitable. Okra is the most profitable of all, while profitability is lowest for tomato and pineapple. One of our key informants stated that farmers receive a good price for okra when compared to tomato. This is because the okra supply is lower than the tomato supply.

A few important notes regarding the cost of producing selected fruits and vegetables are as follows: i) the cost of production for mango varies greatly, and our results reflect the costs for producing BARI Aam-3 variety; ii) pumpkin, pineapple, okra and tomato producers who participated in our FGDs perceive their production costs as high, stating that although the government provides fertilizers as a subsidy, there was mismanagement in fertilizer distribution and price, which increased the overall tomato and okra production cost. Many fertilizer dealers used to sell fertilizers at higher prices than the prices announced by the government; and iii) pineapple and jackfruit farmers who participated in the FGDs had to borrow from BKB or NGOs to cover the high production costs.

Table 4.2 *Total production costs of selected fruits and vegetables from the literature*

Product	Data year	Cost (US$) per ha[8]	Cost (US$) per kg in the study year	Cost-benefit ratio (sales/ costs)	Margins ((sales – costs) / sales)	Estimated cost (US$) per kg in 2020.[9]	Study area	Reference study
Okra	2012	2,091	0.10	2.6	62%	0.16	Dhaka, Comilla, Gazipur	Rashid (2012)
Tomato	2014	3,118	0.20	1.2	17%	0.26[10]	Mymensingh, Rajshahi, Cumilla	Hasan et al. (2020)
Pumpkin	2016	791	0.03	2.4	58%	0.04	Rangpur,Gaibandha	Khatun (2016)
Mango	2017	1,226	0.24	1.7	41%	0.29	Gaibandha	Rahman et al., (2019)
Pineapple	2017	4,411	-	1.25	20%		Khagrachori, Satkhira, Bandarban, Naogaon	Akter et al., (2020)

4.3.2 Effect of cost reduction strategies

We have not detected a cost reduction strategy in the value chains we have studied. Therefore, it was not possible to test whether a cost reduction reduces farm-gate prices. Farmers who participated in our FGDs report that they have not experienced a reduction in their production costs, and indicate that farm gate prices change based on the volume of production. Instead of cost efficiency, improvements in production volumes and high prices helped farmers to increase their income. Farmers also report that the cost of production has increased, and the price of the product (i.e., pineapple) also increases, keeping the income stable.

To summarize, our results on costs are three-fold. First, we conclude that the production of all selected vegetables is profitable. Specifically, farmers can be encouraged to start okra and pumpkin farming, as producing those vegetables is more profitable than others. Second, costs for selected fruits and vegetables have not decreased over the years. Third, increased efficiency in value chains might decrease the consumer prices for selected fruits and vegetables (especially tomato, pineapple and jackfruit), as farmers do not earn the majority of consumer prices. Still, other actors in the value chains earn more than farmers (with the exception mango farmers).

4.4 Efficient value chains can lead to lower fruit and vegetable consumer prices

4.4.1 Increase value chain efficiency

We found evidence that increased efficiency in value chains can decrease consumer prices. This is primarily because farmers' share in consumer prices is low as compared to other actors in the value chain. We find that the farmers' share in consumer prices for the selected fruit and vegetable value chains varies between 33%-61% (Table 4.3). In the tomato value chain, the FGD participants expressed that there was a difference between farm gate price and retail price due to the careful operations that must be observed during the post-harvest stages as a result of the tomatoes' perishable nature. Table 4.3 show that farmers' shares in the tomato value chain are similar to those of farmers in the other selected fruit and vegetable value chains. This might imply that the implications of the perishability of tomatoes is also true for other fruits and vegetables. We, therefore, believe that any improvement in the value chains and decreases in the costs of value chain operations from farm gate to the consumers will be reflected in the prices of the produce.

[8] For 2014 the exchange rate is 82 BDT/US$ in 2012, 77 BDT/US$ in 2014 and 2016, 85 BDT/US$ in 2017

[9] To estimate cost per kg in 2021 we inflate cost per kg in the study year using the consumer price index (retrieved from the World Bank database) in Bangladesh. We estimate the consumer price in 2014-2020 as 39%, in 2012/2020 as 61%, 2016/2020 as 25%, and in 2017/2020 as 18%. We use 83.2 BDT/US$ exchange rate for the calculation in 2020.

[10] Estimated cost per hectare in 2020 is US$4,053.

Table 4.3 *Farmers' share in consumer prices*

Product	Famers' share	Reference study for farmers' share
Tomato	33%-45%	Hoque et al. (2018) Siddiq and Basher (2019)
Okra	54%	Karim and Biswas (2016)
Mango	61%	Matin et al. (2008)
Pineapple	44%	Siddiq and Basher (2019)
Jackfruit	44%	(Siddiq and Basher, 2019)

We also learned from our KIIs and FGDs that value chain efficiency lowers consumer prices. For instance, FGD participants report that when homogenous farmer groups are aggregated under larger (local) clusters, farmers do not have to decrease prices when value chain efficiency improves. An example of value chain efficiency was detected in the mango value chain, organized by the Sustainable Agriculture, Food Security and Linkages (SaFaL) project of Solidaridad (see Box 1 for details). This example demonstrated that farmers organized into groups received better prices as a result of the project and the grading mechanism it introduced.

Box 1: How does SaFaL improve value chain efficiency?

Solidaridad, in partnership with the Embassy of the Kingdom of the Netherlands in Bangladesh, conducts the SaFaL program in Southwest Bangladesh. The program aims to improve production quality and safety through a collaborative approach with multiple stakeholders and different business models. With support from entrepreneurs and the DAE, the SaFaL program works with 200 mango and 500 vegetable producers. https://www.solidaridadnetwork.org/news/leading-exporters-join-with-solidaridad-to-scale-safe-mango-export/

The grading and auction of mango at wholesale places is not common in Bangladesh. So, the program developed a business model to improve value chain efficiency where the mango from all farmers is graded and separated into three grades in the wholesale market: Grade 1 for export markets, Grade 2 for premium local markets (e.g., supermarkets) and Grade 3 for other local markets. Grade 1 products are automatically offered 5-7 BDT/kg more than Grade 3 products where Grade 3 products' price was determined in the wholesale auction centres. This guarantees that value chain actors reduce their costs by carrying high quality products properly, with minimum production losses. Efficient value chains also ensure premium prices for the farmers. With this efficient value chain, a farm can take steps to generate competitive advantages, improve efficiency and increase profit margins. It also allows them to determine where they can reduce their costs.

4.4.2 Coordination in the fruit and vegetable supply chains

4.4.2.1 Coordination and risk management in fruits and vegetable supply chains and risk management in fruit and vegetable value chains

The KIIs and FGDs indicated that farmers face different risks and costs that could be eliminated with better coordination among the value chain actors. The first is the price risk, meaning that farmers are unsure as to the price they will receive from traders. Moreover, farmers do not know when other farmers will supply a high amount of the same products, and prices will fall as a result of the high supply. The second is the transportation risks, which arise from farmers' uncertainty as to when the traders will come to collect the produce. As a result of this uncertainty, products can wait for a long time on the field before being collected, worsening its quality (see Box 3 for an example of this lack of coordination).

Box 2: Coordination examples from the FGDs conducted for this study

Pumpkin farmers from Godagari Upazila at Rajshahi district reported that they did not have any contractual arrangement private sector processors, but were interested in creating one as they believed that it would support them in price fixation, provide assurance for selling their produce, ensure better prices and reduce post-harvest losses. They were also interested to come under formal association, though there was no such arrangement in their locality.

Mango farmers in Bagha Upazila at Rajshahi district have to contract with the Fruits and Vegetables Exporters Association, which offered contracts according to demand. The producers also sometimes entered into verbal agreements with large traders or Aratdar. Under the Good Agricultural Practice system, one committee was formed with 30 people from where the export organization purchased mangoes. However, there was no formal association involving traders, processors and producers.

Tomato and okra farmers of Kushtia district stated that they had no proper knowledge on how to contract with processors. Due to the perishable nature of their produce, no company was interested in entering into a contract with them and thus there was no such contract between the producers and the traders or processors. However, the farmers were interested in such a contractual relationship because they thought it would ensure better prices.

An association between pineapple and jackfruit farmers and buyers in Madhupur Upazila at Tangail district exist, named Idilpur Bohumukhi Anarosh Chasi Somiti, Garo Bazar Kachamal Somiti. However, problems in the association existed as a result of a lack of compliance with rules and regulations.

We found that the farmers and traders who participated in our FGDs are generally not members of any formal associations involving farmers, traders and transporters, which would serve as a coordination mechanism among the value chain actors (see Box 2 for further details). Instead, traders and farmers usually call each other through phone calls. They claim that this increases the waste along the value chain, and they have to bear the costs of transportation, waste, packaging costs and labor costs. For instance, pumpkin farmers say that they sometimes cannot find adequate transport service providers, and the pumpkin waits in the field. Mango farmers who participated in the FGD cultivate many mangoes every year, however, they cannot coordinate their activites with traders and other value chain actors and cannot export large amounts. They do not trust other actors along the export value chain (see Section 4.5.2 for a more focused discussion on trust).

The experts from the KIIs confirm the same, and state that there is no coordination among the value chain actors except those contractual farming examples provided in Section 4.4 and the off-season tomato case in Box 3. They added that this causes an oversupply of fruit and vegetable, decreasing their prices. The private processing company representative who participated in our KII also indicates that the limited coordination is a bottleneck for establishing a jackfruit processing industry, as the efficient processing of jackfruit would require sufficient numbers of farmers to grow the same jackfruit variety. However, currently, farmers from the same region grow different varieties and make it challenging for the industry to process jackfruit.

4.4.3 Post-harvest losses in transportation

The production losses occur mostly in the transportation stage, followed by the storage stage. This happens because the farmers and actors downstream face problems transporting vegetables from the production region to the consumers' markets. Results from FGDs and KIIs show that these problems include:

- Arranging vehicles from farms to local markets and produce's long wait times in the field;
- Not using cranes during transportation;
- Involvement of too many intermediaries and vehicles, and therefore the transfer of fruit and vegetable from one intermediary to another;
- Lack of knowledge about proper loading and unloading; and
- Lack of cold storage.

Box 3: Off-season (summer) tomato production in Dadpur

The tomato prices in Bangladesh decrease substantially in certain periods of the winter season due to oversupply. Specifically, the producers do not coordinate with each other in terms of the growing and harvest times and so supply large amounts of tomato at the same time (weeks) of the year. Therefore, prices fall substantially and some harvest is lost as there is not sufficient cold storage to store the surplus.

A KII participant told us that the off-season (summer) tomato producers in Dadpur village at Jessore District address this problem with a good coordination mechanism among farmers. The farmers are organized in an association and use poly shed greenhouse, increasing their yields. The farmers follow a planned seeding and cultivation schedule, and do not sow at the same time. Rather, they sow 1-2 weeks earlier or later than each other. As a result of this coordination, they flatten the production time and do not oversupply the market. These farmers also sort, wash, dry and grade properly, and use plastic crates for transportation. The farmers' organisation coordinates the tomato sales, and farmers sell directly to retailers and receive prices close to the retail prices.

In Bangladesh, post-harvest losses in the fruit value chain range from 23% to 43% and in the vegetable value chain, from 27% to 34% (Hasan, 2010). Our FGDs provided additional data on production losses, specifically that the volume of losses ranges from 20-25% in the case of pumpkin. However, this volume of loss varies by vegetables as well as value chain actors. In pumpkin production in the char areas of Rajshahi, women producers reported facing problems in getting vehicles. As a result, they used a van to carry pumpkin from the fields to the nearest paved road and they were selling their produce directly to the traders (Bepari) from the field.

The traders in the okra and tomato FGDs reported that they faced production losses of tomato equal to approximately 15-20% during the transportation stage. As most producers sell their produce either at the farmyard or nearest local markets to traders, the loss occurred when traders carry to the produce retailers, increasing the price of products at the retail level. In addition, the traders and laborers have little knowledge of proper loading and unloading practices; sometimes, the traders load more than the vehicles' carrying capacity, causing wastage of perishable produce, such as tomatoes. Production losses also occur at the storing stage. Due to the lack of storage and cooling facilities, this loss generally ranges from 10-15% in the fruit and vegetable value chains.

4.4.4 Secured markets: Contract farming example in Bangladesh

Secured markets organized through contract farming address the coordination risks between the processors and farmers. In Bangladesh's fruit and vegetable sector, the secured market through contract farming or formal markets is typically between big processors and farmers, where farmers sell the products directly to the companies. To shed light on whether farmers benefit from this arrangement, we spoke with a big processing company procuring fruit and vegetable through contract farming. The company processes mango, pineapple, tomato and other fruits and vegetables into fruit juice, tomato paste and other products sold in domestic and international markets. The company's contract farming model is explained in Box 5. The model has several advantages for the farmers. First, the company believes that farmers get a higher price because they receive a price close to or equal to the market price and do not pay transportation from the aggregation point to the market. In addition, removing traders from the value chain, farmers gain a high fraction of the final price of their produce. The company also believes that this contract farming model is better for farmers than going to the local markets and selling there independently, as farmers have to pay toll fees to sell in the market.

Box 4: The contract farming system of fruit and vegetable processing company in Bangladesh.

To procure mango tomato, pineapple for processing, the processing company uses an agricultural hub system established around lead farmers. Every hub has around 1000 farmers and 1 hub leader in different locations. The hub leader is selected by other farmers according to the criteria of the company including land access, financial insolvency, and business experience. Smallholder farmers involved in the process by the field supervisors, organizing meetings with farmers for the selection of the lead farmers. Smallholders share their opinion in those meetings and select lead farmers are selected by the small farmers. Lead farmers organize access to inputs (distributed by the company) and training of farmers and are responsible to aggregate the amount of produce at the end of season, which agreed in the beginning of the season. In the harvest time farmers are offered the average weekly price of the two nearby market prices. Every week this price is updated. The company also compensate the lead farmers' cost of transportation from the field to the aggregation centers.

We conclude that there is potential to supply high quality fruits and vegetables (produced by good agricultural practices) at affordable prices in different seasons, improving the value chain efficiency. First, organized coordination among value chain actors and contract farming could improve value chain efficiency. Second, improved coordination among value chain actors, cranes and cold storage can decrease post-harvest losses. As a result, the improved coordination and decreased post-harvest losses could supply affordable and high-quality fruits and vegetables to consumers at affordable prices.

4.5 Communication between actors

4.5.1 Linkages of traders to consumers

There are two main channels through which fruits and vegetables reach consumers. First is the traditional wet markets where over 90% of consumers purchase their fresh fruits and vegetables (Snoek et al., 2021). Our study confirms that this is similar for all selected fruits and vegetables. These traditional markets are not well organized, and the communication between traders, processors and consumers is very limited. The sellers in the market rent their places from marketing committees and pay a toll fee. Our key informants also confirm that the communication among traders and retailers is rather limited. However, they add that there are rumors of so-called syndicates to decrease the competition for producer. According to the informants, those syndicates shares producers between each other before they offer prices for the produce. Our FGDs only detected informal farmers' organizations among pineapple producers and traders but no formal farmers' organization, confirming that there is no formal system.

The second is an organized market involving big processors, supermarkets and export markets, governed through contract farming. They directly translate consumer preferences as demands to their contracted producers. For instance, during our conversation with a private sector processing company, serving both domestic and export markets, they explained that they contract and train farmers to reach a certain standard. They have laboratories and facilities to reach the high standards that their customers demand.

4.5.2 Information sharing

KIIs show that there is not enough trust among actors in the value chains. This is one of the reasons for high production losses in the value chain. For instance, mango producers do not trust the contract between themselves and export associations (Fruit and Vegetable Exporter's Association) to trade mango. This is because the trading contracts not official stamped by the authorities. As a result, farmers do not trust the buyers, and in return, buyers do not trust mango producers. That means a proper coordination mechanism is absent. The findings from the FGD with pineapple and jackfruit value chain actors are similar, and also indicate that trust between and commitment among the value chain actors is absent.

We conclude that the lack of communication, formal associations and trust among actors are obstacles to improving the value chain efficiency, and are also partly responsible for increasing retail prices and decreasing nutrition levels in Bangladesh. We note that the organized horticulture market overcomes those challenges through direct communication of processors and retailers with farmers.

4.6 Consumption trends and varieties in fruit and vegetable crops

4.6.1 Consumption trends

Fruit and vegetable consumption trends of rural and urban households in Bangladesh differ. Moreover, the consumption trends change by household characteristics, knowledge about fruit and vegetables' nutrition level and seasons. Levels of fruit and vegetable consumption are highest for educated, wealthy, educated, female Bangladeshis (Karim et al., 2017). Meanwhile, Snoek et al. (2021) find that poor households eat fruits less frequently than middle- and high-income households in Dhaka, but the poor and middle-high income households eat vegetables at the same frequency. Figures 4.3 and 4.4 compare fruit and vegetable intake in 2010 and 2016 in urban and rural areas. Both fruit and vegetable intake decreased from 2010 to 2016 in rural areas, while vegetable consumption increased in urban areas. According to our estimations from EPB (2016), rural households produce most fruits and vegetables, but only consume 16-19% of their produce (Figure 4.5). Producers who participated in the FGDs indicate the quantity of home consumption is linked with the market price; if they receive a better price from selling their produce in the markets, they reduce home consumption and sell them instead to generate income. This implies that increased availability of produce in urban markets may be at the expense of rural people's fruit and vegetable consumption, especially when there is a fruit and vegetable supply gap in urban markets. The consumers who participated in our consumer FGD confirm these consumption patterns and indicate that there has been no significant change in their fruit and vegetable consumption over the past five years. From KIIs and FGDs, we learn that the consumption of selected fruits and vegetables are seasonal, as these products are cheaper and more available in the harvest seasons.

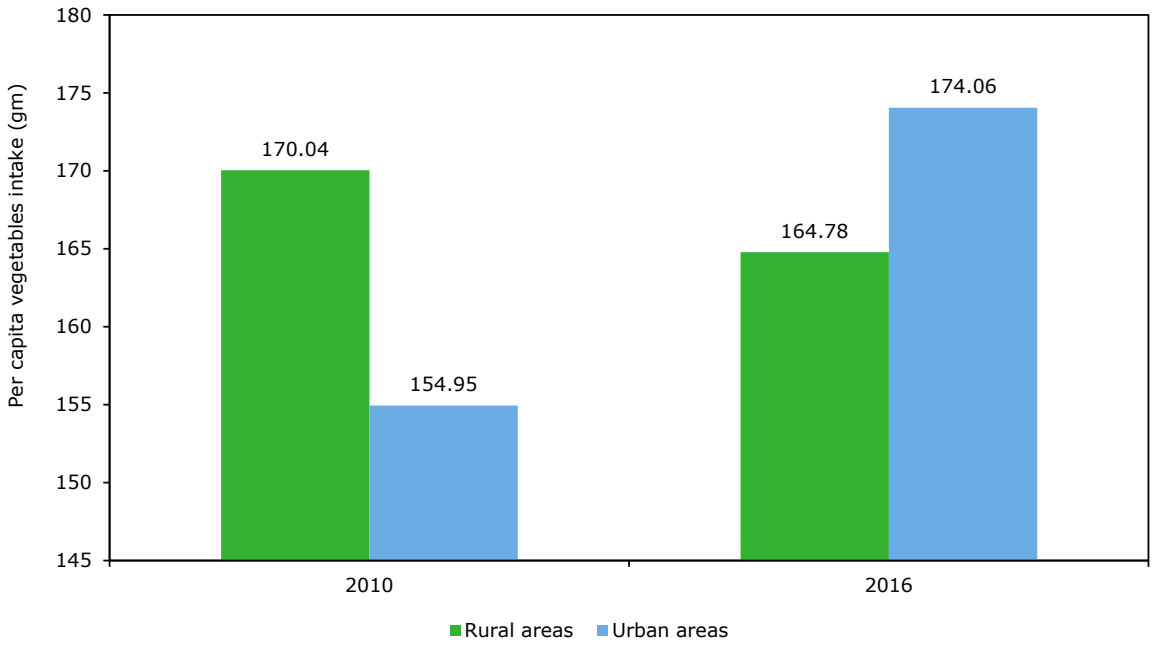

Figure 4.3 *Average per capita, per day vegetable intake (g) in rural and urban areas, by year*
Source: HIES (2016).

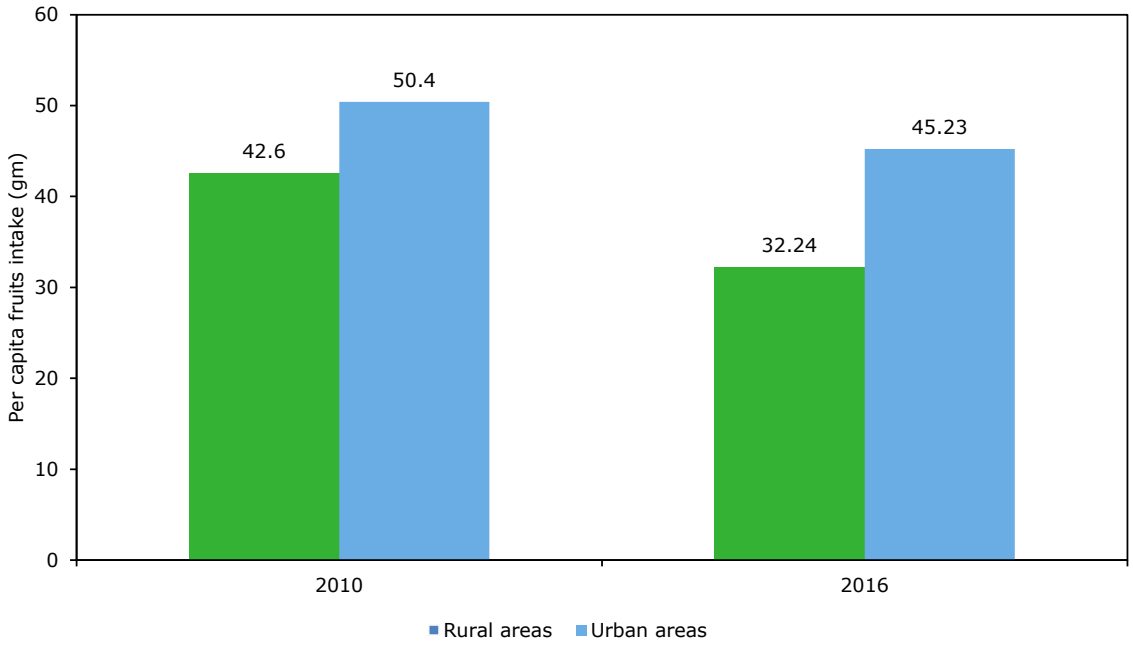

Figure 4.4 *Average per capita, per day fruits intake (g) in rural and urban areas*
Source: HIES, (2016).

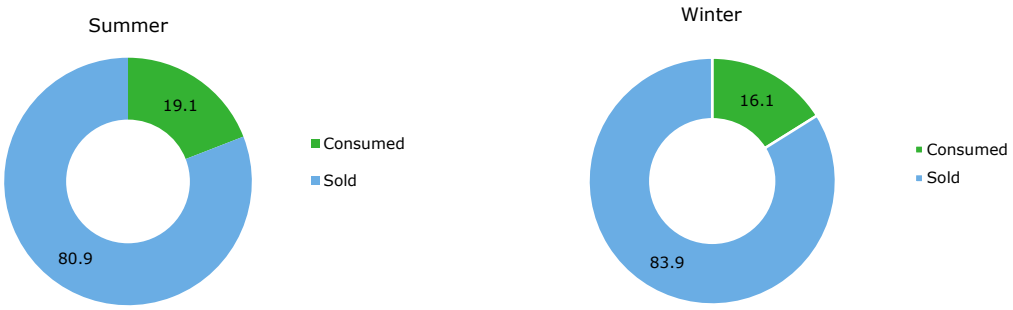

Figure 4.5 *Fraction of vegetables sold and consumed by farmers*
Source: EPB (2016).

As of 2013, brinjal, white gourd/pumpkin and cauliflower/cabbage are the most preferred vegetables (Table 4.3), and mango, jackfruit and banana (Table 4.4) are the most preferred fruits in Bangladesh. An 1998 study by Miah and Sabur assessing fruit and vegetable consumption in the Gazipur district in Bangladesh found that mango, jackfruit and banana were the most preferred fruits at that time, showing that the consumption patterns for fruits did not change significantly from 1998 to 2013. Yet, the participants of our FGDs indicate that they consume certain fruits like sweet guava more, as they learnt about the nutritional value of those fruits. This implies that knowledge about the nutrition content of the fruits and vegetables is an important factor in increasing the consumption of those fruits and vegetables (see related discussion on nutrition content and fruit and vegetable consumption in Section 4.11).

Table 4.4 *Distribution of vegetables intake for the Bangladeshi population, 2013*

Item	g/person/day	Item	g/person/day
Brinjal	21.1	Snake gourd/ridge gourd	7.85
White gourd/pumpkin	12.0	Tomato	7.15
Cauliflower/cabbage	11.5	Radish	5.36
Water gourd	10.9	Balsam apple	4.28
Potal	10.3	Ladies finger	3.26
Bean/lobey	9.73	Other vegetables	11.67
Arum/ol-kachu/kachurmukhi	8.90	Leafy vegetables (all)	36.1
Green banana/green papaya	8.24	Total vegetables	167

Source: Nahar et al. (2013).

Table 4.5 *Diversity of fruits intake among the Bangladeshi population*

Item	g/person/day	Item	g/person/day
Mango	11.66	Grape	0.72
Jackfruit	10.21	Amra/Kamranga	0.54
Ripe banana	6.38	Litchi	0.33
Guava	2.63	Palm	0.30
Apple	2.50	Black berry	0.28
Melon/Bangi	2.56	Safeda	0.095
Ripe papaya	1.63	Bedana	0.067
Pineapple	1.26	Others	2.95
Orange	0.77	Total fruit intake	44.98

Source: Nahar et al. (2013).

Table 4.6 *Per capita, per day calorie intake (kcal) from fruits and vegetables, 2017*

Country	Cost of healthy diet (mean across ten guidelines)	Cost of least cost F&V (mean across ten guidelines)	% of the cost of a healthy diet accounted for by F&V
Bangladesh	**3.41**	**1.17**	**34%**
Burkina Faso	3.66	1.08	30%
Ethiopia	3.73	1.46	39%
India	3.27	1.26	39%
Nepal	4.13	1.72	42%
Nigeria	3.57	1.21	34%
Tanzania	2.62	0.86	33%
GLOBAL	3.77	1.46	39%

Note: Data shown are the average costs (US$) per person, per day for a healthy diet as defined by food-based dietary guidelines

Source: Herforth et al. (2020)

Table 4.6 compares the cost of a healthy diet and the cost of least cost fruit and vegetable that a consumer can consume in a healthy diet in Bangladesh with other selected countries and the global average. In Bangladesh, a healthy diet and recommended fruit and vegetable consumption costs less than the global average.[11] Compared to other selected countries, the cost of fruit and vegetable consumption is higher in Bangladesh than Burkina Faso and Tanzania, but lower than in other selected countries.

[11] Note: These results are based on analysis of the 2017 ICP dataset to find the lowest cost foods in each country. National datasets may have additional foods that may be lower or higher cost at different times and places in the country. The proportion of the Cost of a Healthy Diet is based on the mean cost of ten different national food-based dietary guidelines. The mean cost may differ from the median cost, which was reported in the SOFI 2020. (http://www.fao.org/publications/sofi)

4.6.2 Introduction of new fruit and vegetable varieties

In our FDGs, we detected that several new varieties of selected fruits and vegetables have been introduced in Bangladesh over the past ten years:

- Pumpkin: women producers report two new hybrid varieties of pumpkin. These are Sweety and Kalomanik. The lead farmers who are training other fellow farmers came to know from their fellow farmers and sometimes from the DAE of the Ministry of Agriculture.
- Mango: FGD reports many new varieties of mango, including BARI-4 (Gouromoti), Haribhanga, Katimon and BARI-11. Amropali is a variety that has been famous for many years, and is commercially produced. Farmers learn about these varieties from their fellow farmers and sometimes from the DAE.
- Tomato: the FGDs of tomato and okra producers and value chain actors reported that 'Bijlee-11' from the United Seed (a seed company) is the newly introduced variety of tomato. There are two other new varieties of tomato; Beautiful and VL. The dealers' shops introduce the new varieties.
- Okra: no new variety is introduced in the case of okra, rather, the traditional variety is still produced.
- Pineapple: the pineapple farmers in the FGD report that different varieties have been introduced, such as Honey Queen pineapple and MD-2.

The direct impact of these new varieties on the consumption of fruits and vegetables is difficult to identify. However, pumpkin and mango producers believe that the consumption of pumpkin and mango has increased over the years due to the improved taste and nutritional value of the new varieties. Many farmers reported that they sell and simultaneously consume their own produce.

In summary, there are various fruits and vegetables available and consumed in Bangladesh, including new varieties introduced throughout the past ten years. Yet, vegetable consumption per capita increased only in the urban areas of Bangladesh, and fruit consumption did not increase in rural nor urban areas. This implies that fruit and vegetable consumption in rural areas should be improved in order to improve nutrition in these regions. The anecdotal evidence in this report shows that informing consumers about the nutritional importance of fruits and vegetables may contribute to an increase in their consumption.

4.7 Prices of fruits and vegetables are always higher compared to other food categories

4.7.1 Price perception about fruits and vegetables

Typically, rural consumers, who are also producers of fruits and vegetables, and urban consumers have different opinions about the perceived price of fruits and vegetables compared to the prices of other food groups. The majority of rural producers who participated in our FGDs purchase more fruit and vegetable than they sell. They perceive that the price of fruits and vegetables is comparatively higher than fish/meat when they purchase for family consumption despite the fact that they receive a lower price for fruit and vegetable when they sell them. The only exception is the pineapple and jackfruit producers, reporting that local fruits and vegetables in their regions are relatively cheaper than other daily commodities. The participants in the consumer FGD who must purchase all food items like rice, pulses, meat, vegetables, fruits, etc. state that vegetables are cheaper than other food items, but fruits are expensive.

4.7.2 Factors influencing consumer prices

We detect three main factors that increase consumer prices of fruits and vegetables. First, the pricing of the fruits and vegetables depends on seasons and the supply of produce in those seasons, as increased supply leads to a decrease in prices (see Figure 4.2). For instance, one of our key informants said that okra producers earn better because there is not a large supply of okra in the domestic market, as opposed to tomatoes, for example. This is also confirmed by the high cost-benefit

(price) ratio for okra, as reported in Table 4.1. Second, the prices and seasonal variability in prices depend on regional production (Mahmoud et al., 2005). Third, the costs that value chain agents bear change by types of fruits and vegetables, and this is reflected in consumers' prices. For instance, farmers' and middlemen's share of prices varies by types of vegetables. For instance, in the tomato value chain, farmers and middlemen's share constitutes 40% of consumer prices, primarily because the middleman does sorting and cleaning (Siddiq and Basher, 2019). Moreover, KII interviewees also suggest that for highly perishable products like tomato, the risk of loss is higher for the middleman than other value chain actors. It is because majority of the production loss in the value chain is experienced when the products are carried by middleman. Therefore the cost of middleman is high, increasing the market prices.

We conclude that seasonal production patterns, the high costs and risks assumed by value chain actors from farm to markets and regional characteristics are the factors with the greatest influence on fruit and vegetable prices in Bangladesh. In addition, consumers' perception of fruit prices as higher than other food groups contribute to the decreased fruit consumption in Bangladesh.

4.8 Women participation in fruit and vegetable production and value chain operations

4.8.1 Examples of women in fruit and vegetable production and value chains

There are several initiatives by NGOs that address the social norms, lack of access to land and limited knowledge on good agricultural practices, that hinder women's involvement in fruit and vegetable value chains. For instance, ActionAid Bangladesh, a leading NGO in Bangladesh aiming to empower women, has implemented three different policies in two projects - POWER[12] and Making Market Work for Women[13] - to address their limited market integration. The first is the establishment of collection points for the fruits and vegetables produced by women at community levels, to support women who cannot go to the market. ActionAid determined and trained the lead farmers who would organize the collection of produce and bargain on behalf of the group with traders and other buyers.

Women in Bangladesh are not homogenous in terms of education, social status and ethnicity. Some women (e.g., more educated women and those of certain ethnicities) in society are socially more mobile and can go to the nearby markets to sell and produce. For those women, ActionAid organized 'women corners' in the markets in collaboration with the local governments. Interested women can go to the women corner in the market and sell their fruit and vegetable there. These places are reserved, and also have specific toilets and resting areas suitable for women. The women corner model has also been adopted by the government in their farmers markets and there are plans for these models to be upscaled. Farmers markets are an initiative by World Food Programme together with the Bangladesh government. The government creates markets where farmers can directly sell their products to the consumer without the involvement of traders or commissioners. Recent data collected by one of our key informants from a farmers market in Dhaka shows that about a quarter of the involved retailers are women, and there is anecdotal evidence about the positive effect of those markets on the incomes of vegetable-producing women (DuBois, 2020). The Ministry of Agriculture plans to upscale the women corner practice in 38 farmers markets that will be established all around the country in the coming ten years.

For instance, ActionAid's Making Markets Work for Women program connects women producing chemical-free vegetables including okra, tomato, pumpkin, puffed rice, rice lentils, milk, eggs and provides them with training in good agricultural practices. Under the project, the women sell the products to the retailers through e-commerce websites such as Parmeeda, Market Bangla and Abaad.

[12] You can see more details about the POWER project here: http://powerproject.actionaid.org/wp-content/uploads/2017/07/POWER-flyer.pdf

[13] Please see details of the project here: https://www.netherlandsandyou.nl/binaries/netherlandsandyou/documents/publications/2017/04/30/bangladesh-mmww-fs/Bangladesh_MMWW+FS.pdf

These women are organized through 30 women unions established by the project, including three women leaders. These leaders receive pre-orders from the online platforms, collect the produce from the union members and sell it to the buyers, who collect the products by their mode of transportation on a specified day. The money is then deposited to the union's joint account or transferred through mobile money to the union. The same leaders are responsible for distributing received payments to the other members of the union.[14] To facilitate this model, ActionAid prepared a memorandum of understanding signed by both online platforms and women unions to solve the trust issue between the two sides. The model is suitable for scaling up because the products sold target businesses reaching middle-income consumers through online platforms, a growing marketing channel in Bangladesh. Moreover, the model integrates women with the market, while women do not have to interact socially and therefore violate social norms. We also found that the Agricultural Marketing Department develops a similar application for farmers who uses good agricultural practices to market their products to the businesses, demonstrating the scalability of the initiative.

Solidaridad Asia implemented Solidaridad Asia's SaFaL program with financing from the Embassy of the Kingdom of the Netherlands in Bangladesh. This program provides an example of how the lack of knowledge on agricultural practices of women farmers can be addressed, and how women farmers can be linked to commercial (domestic and export) markets. The program involved many women producing horticulture products in homestead gardens. These women were trained on good agricultural practices, including the maturity index for mango, farm record-keeping and horticulture products. A lead women farmer in the program, Shikha Rani Chakravarti, attracted special attention by training 120 other women farmers on better farming practices. She received a prize for her efforts from the Prime Minister of Bangladesh.

The Pumpkins against Poverty project, financed by Practical Action, aims to improve the condition of landless women. Landless women constitute 70% of participants, while 30% are men. The project targets 50,000 people in Bangladesh, 70% of whom have no land of their own. These people can grow 600 pumpkins a year on sandy and typically unproductive land using a technique called sandbar cropping, which allows pumpkins to be grown on the sandy, barren soil left behind when floodwaters recede. The project supports farmers in gaining tenure of temporary sand bars and creating better markets to sell their pumpkins.

There is also anecdotal evidence about the growing sales of homemade food delivery services through Facebook e-commerce. As of 2020, about 1 million women in Bangladesh use Women and E-commerce groups on Facebook to access their markets, and most of those women provided homemade food delivery services.[15]

4.8.2 Business models for women economic empowerment

Using the examples above, we detect three different business models improving women's participation in fruit and vegetable value chains and that could increase their control over the income.

- Access to markets through women's corners, as enacted by POWER and the Making Markets Work for Women project (see Section 4.8.1 for details), and implemented by the Ministry of Agriculture. This model is for individual female smallholders, either married or widowed. As long as the rural women can overcome their mobility constraints, they can sell their produce at the market.
- Producer groups and clusters as enacted under the SaFaL and POWER projects (see Section 4.8.1 for details). In this model, women do not go to the market, but can benefit from aggregation and selling their produce collectively.
- Union structures connected with online platforms (see Section 4.8.1) that organize women and act as a virtual aggregator and avoids middlemen (and husbands) linking women producers directly to consumers. Women do not have to travel, and there is no conflict with the mobility norms. Moreover, there are no travel risks and it is safer as the cash transfer is electronic.

[14] One of our key informants explained this program to us. For more details please also see this link: https://www.thedailystar.net/frontpage/news/selling-bulls-online-relief-female-farmers-1937309

[15] The reference for the news article is here https://www.dw.com/en/bangladesh-more-women-create-online-businesses-during-pandemic/a-56076990

Our study could not reveal factors to scale up those models successfully in Bangladesh and other countries. Further research is needed to investigate those factors.

4.8.3 Public policies

We also detect three public policies that concern rural women's empowerment and their integration into the markets. The first is the National Women Development Policy initiated in 2011, which suggests several activities to empower women in Bangladesh (Women and Children Affairs, 2011). Many experts emphasize that this policy stimulated the inclusion of women in government programs concerning food production and nutrition. They stated that 30% of any rural program's participants should be women. If women do not participate in those programs, it is impossible to get funding from the government or approval for the project or program. The second initiative that will influence women's retailing and trading activities is the Agricultural Marketing Act that is expected to be legislated in 2021. This act will include a women's quota in wet market committees, through which more women are expected to be involved in wet market management, ensuring women's role in the markets. Third, the Ministry of Agriculture in Bangladesh hopes to replicate the model proposed by the Pumpkins against Poverty project which targets landless women (and men). The Ministry expects that this policy will support poverty alleviation by helping tens of thousands of people overcome hunger and increase their income.

We conclude that there are three examples models in Bangladesh - women's corners in wet markets, women producers' groups and associations, and online marketing via women – with the potential to empower women through fruit and vegetable value chains. There is also a good public policy framework supporting these programs and involving women actively in different programs. One must explore the factors for the successful upscaling of those initiatives to implement these models in Bangladesh and other countries.

4.9 Public enforcement of standards will enhance food safety for consumers of fruits and vegetables

4.9.1 Relevant standards

Various laws and acts define the rules for food safety, food additive regulations, pesticides and other contaminants, labelling, facility and product registration, certification and testing requirements, and import procedures, copyrights, and trademarks in Bangladesh (GAIN, 2019). This study will focus on two groups of acts and regulations concerning food safety and pesticide use that, according to the sector experts we talked to, directly concern fresh fruit and vegetable production and consumption. We will also highlight the use of private standards by the private sector.

Box 5: Expert views on food safety issues concerning our selection of fruits and vegetables

We talked with sector experts about the food safety issues concerning the selected fruits and vegetables, who held greater concerns for some produce than others. For instance, jackfruit is nearly free of any contamination, as producers do not need any chemicals in jackfruit production, and is therefore a very safe fruit. Meanwhile, reports of excessive use of growth promoter in pineapple production has raised concerns as to whether the overuse of growth promoter poses a health risk. In mango, okra and tomato production, there is sometimes too much pesticide use. In addition, there were reports of overuse of some chemicals in tomato production, but lab tests did not detect evidence of this.

The first is the Food Safety Act which was legislated in 2013 and came into effect in 2015. This act defines the rules and roles of public administration and food safety principles for processed and unprocessed food items, including fruits and vegetables, in Bangladesh. This act was followed by several regulations on food safety, such as:

- Food Safety (Contaminants, Toxins and Harmful Residues) Regulations (2017);
- Food Safety (Food Hygiene) Regulations (2018);

- Food Safety (Food Processing and Administration System) Rules (2014);
- Food Sample Collection, Testing and Analysis Regulations (2017);
- Formalin Control Act (2015);
- Use of Food Additives Regulations (2017).

The BFSA, established in 2013, oversees the implementation and monitoring of the aforementioned regulations. Our key informants explained that this authority is primarily responsible for monitoring fresh or processed fruits and vegetables once they reach the markets or the processing stage. However, it is the responsibility of the Ministry of Agriculture to monitor the safety of fruits and vegetables on farms.

A major concern with regard to the safety of fruits and vegetables in Bangladesh is pesticide residue. Sometimes, producers do not cease using pesticide with sufficient time before the produce is harvested for chemical residue to wear off. As a result, the fruits and vegetables are still coated in the pesticide residue at the time of harvest. Monitoring the correct usage of pesticide is the Ministry of Agriculture's responsibility. There is a second group of acts and regulations applied to this concern, including:
- The Pesticide Act (2018),
- Pesticide Rules legislated in 1985 and amended in 2010,
- The Pesticide Ordinance (2007), and
- The Food Safety (Contaminants, Toxins and Harmful Residues) Regulations (2017).

The Ministry of Agriculture monitors fruit and vegetable farmers to ensure that they are using the correct types and quantities of pesticides, and are compliant with the Pesticide Act through farm visits.

The experts we communicated with indicated that Bangladesh has organized and modern standards for the safety of fresh fruits and vegetables, but that the implementation of those standards is imperfect. They expressed that the BFSA and Ministry of Agriculture should improve their resources (e.g., rural offices) to implement those regulations efficiently, and improve traceability of packaged fresh fruits and vegetables in Bangladesh to make monitoring easier.

In addition to those public standards, some private sector companies implement their own safety standards. For example, the major private sector fruit and vegetable sector company we interviewed has laboratories in their facilities to implement European market standards, as the company exports to this market and must therefore comply with its regulations. Moreover, traders exporting fruits and vegetables (such as mango) to foreign markets use the import market standards (e.g., residue levels) as private standards and inspect the producers they procure from the markets.

4.9.2 Consumer trust in local standards

Our FGD with urban consumers shows that consumers are not aware of any public or private standards on food safety. However, other studies show that consumers in Bangladesh are highly concerned about artificially ripened fruits, while experts suggest that they observe a decrease in those artificially ripened fruit cases. Snoek et al. (2021) find that fruits are perceived as less safe than other food groups (such as chicken, fish, other meat and vegetables) in Dhaka. They found that the households who participated in their study had personally experienced or heard of, from the media, artificially ripened and adulterated fruits, which caused fear among the households. Other studies on food safety issues in Bangladesh published over the past ten years also confirm that there has been adulteration of fruits and vegetables through different chemicals, including calcium carbide, ethephon, formalin, and injections of colors and sweeteners (Alam et al., 2015; Hezbullah et al., 2016; Noman Mohammad Atahar, 2013; Shaheen et al., 2016; Sobhani, 2018). The experts from Bangladesh admit that there were issues surrounding the artificial ripening of fruits, but they perceive that, over the last five years, artificial ripening of fruits has decreased as a result of the increased public awareness and improved monitoring of markets for those activities.

We conclude that there are sufficient policies and standards in Bangladesh for food safety, but that their enforcement is inadequate. Consumer awareness is on the rise and has, in some cases, served to

hamper fruit and vegetable consumption. If not improved, frequent reporting of pesticide residue will negatively impact consumption, with negative effects on public health.

4.10 Nudging and the public extension will improve fruit and vegetable consumer awareness and consumption preferences

4.10.1 Policies and strategies

Two important documents define the nutrition policy framework in Bangladesh: the National Strategy on Prevention and Control of Micronutrient Deficiencies and the Bangladesh (2015-2024) Second National Plan of Action for Nutrition (NPAN2). The strategies and plans in these documents are implemented through a multi-stakeholder/multi-ministry approach to improve nutritional intake in Bangladesh. The government's plan aims to improve dietary diversity by decreasing rice and wheat consumption and increasing the consumption of other food groups such as (vegetables, fruits, meat, dairy, etc.). However, there is not a specific policy that targets to improve exclusively fresh fruit and vegetable consumption.

4.10.2 Systemic constraints for women and illustrative examples

Anaemia, underweight, overweight and micronutrient deficiencies are major nutritional challenges that Bangladeshi women face. The Bangladesh Demographic and Health Survey-2014 (NIPORT et al. 2016) shows that 50% of pregnant women and 40% of non-pregnant/non-lactating women had anaemia. The survey also finds that 57% of non-pregnant/non-lactating women are zinc deficient, and 22% of non-pregnant/non-lactating women are B12 deficient.[16] Furthermore, the survey indicates that 19% of women between 15 and 49 years old and 31% of adolescent girls between 15 and 19 years old are underweight, and while underweight is a challenge for some women, 24% of adult women are overweight.

The low socio-economic power of women and pervasive cultural norms in Bangladesh might be a factor, among others, that leads to low nutritional outcomes among women in Bangladesh. For example, a report by Helen Keller International and James P. Grant School of Public Health (2016) used data from 27,072 households in Bangladesh in 2014 to investigate the food security and nutrition levels of households and their members. The report found that when a household member had to reduce consumption, the adult women in the households were much more likely to reduce their own consumption than adult men. When two household members had to reduce consumption, adolescent girls typically joined the adult women and reduced their consumption. Blum et al. (2019) provide qualitative evidence on the factors behind this occurrence, as their anecdotal evidence from rural Bangladesh shows that women usually eat after the male and older household members, and eat only what is left from those male members.

4.10.3 Illustrative examples

Our KIIs and FGDs suggest a few examples of strategies that government agencies and NGOs implement to improve nutritional outcomes. We summarize those strategies that may prove interesting for policymakers who would like to improve fruit and vegetable consumption in Bangladesh and other countries. However, we note that the examples below do not necessarily target exclusively women or aim to improve fruit and vegetable consumption only, unless otherwise indicated. This is primarily because the Bangladesh government's main aim concerning fruits and vegetable consumption is to improve dietary diversity, and increasing the consumption of fruit and vegetable is part of that strategy. In the same vein, there is no direct strategy of the Bangladesh government to improve access to fruit and vegetables. Nevertheless, improving pregnant and lactating women's health and nutritional outcomes is part of the government strategy, and there are examples (e.g.,

[16] Please see Khatun et al. (2013) and USAID (2018) for further details.

urban gardening) of women within households being used as an entry point to improve the overall fruit and vegetable consumption in the households.

The first example is the nutritional plate designed by the Food Planning and Monitoring Unit of the Ministry of Food and USAID through the SHIKHA project, which promotes dietary diversity, especially for pregnant women (Figure 4.6).[17] This plate visual is used in government programs to illustrate dietary diversity to various program beneficiaries, such as in their nutrition training programs across the country, as we learnt from our KIIs. This plate is designed according to consumer preferences in Bangladesh. For example, the Leadership to Ensure Adequate Nutrition project, in line with NPAN2, aims to improve maternal and child nutrition for pregnant and lactating women, children under 5 and adolescent girls from poor households. Poor women use this nutritional plate in their training with the women.[18] When used to train pregnant women in rural Bangladesh, these nutritional plates support improvements in portion sizes and dietary diversity. Family members of the women are also shown to have begun to consume a healthier diet (Alam et al., 2020).

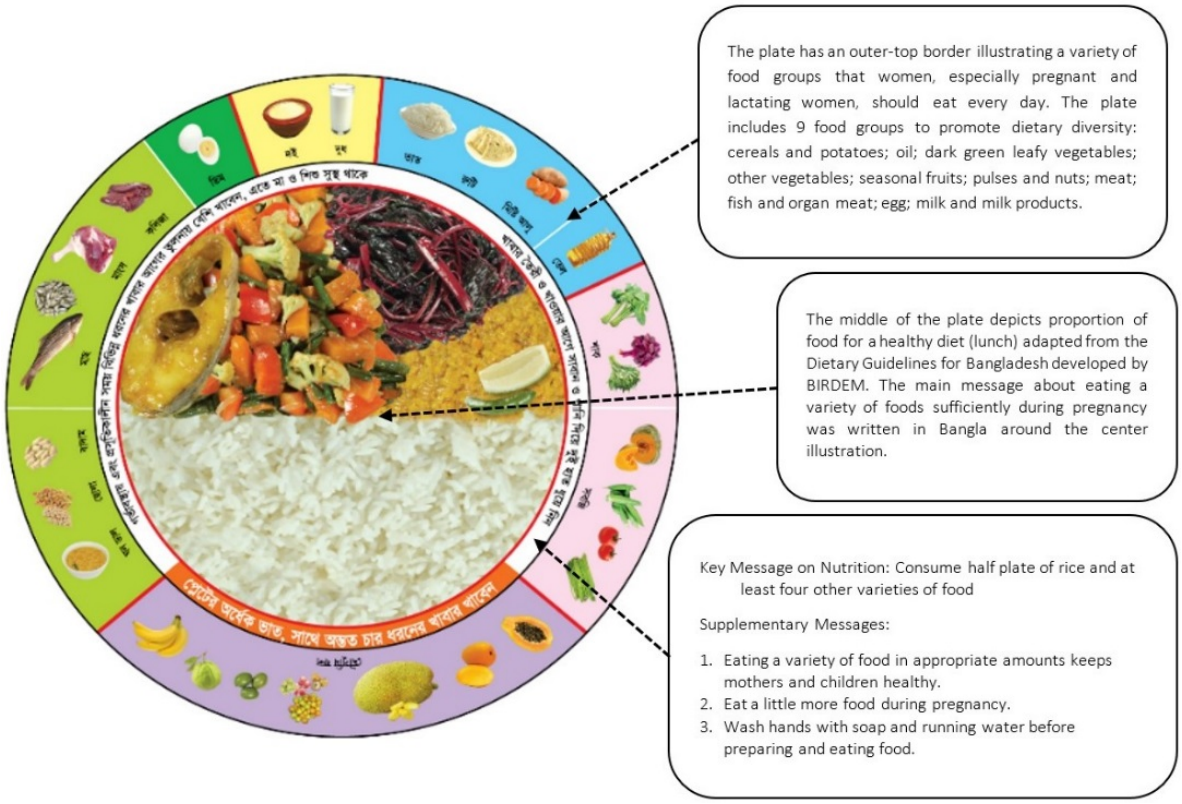

Figure 4.6 *Nutritional plate designed in Bangladesh*
Source: Food Planning and Monitoring Unit of Ministry of Food, http://fpmu.gov.bd/agridrupal/healthy-food-plate-effective-tool-nutrition-counselling-bangladesh

The second is the nutrition programs in workplaces, such as garment factories in which the majority of employees are women. A study among garment industry workers in Bangladesh showed that anemia was especially common among working women; about 77% of female factory workers in this industry had anemia (Khatun et al., 2013), higher than the overall population average discussed above. In our in-depth interview, we learnt that to address low nutrition outcomes among working women, the government nutrition trainers visit companies that accept or request training for their workers on nutrition issues. Moreover, there are larger-scale programs to address this issue, such as that of GAIN and NewForesight with garment workers in Bangladesh (Speelman et al., 2019). The program

[17] For more details please see http://fpmu.gov.bd/agridrupal/healthy-food-plate-effective-tool-nutrition-counselling-bangladesh
[18] Please see https://static1.squarespace.com/static/570d5f2220c647767aea3ec5/t/5da44fc7bc05e525b7c226a1/1571049416639/BNG+LEAN+project.pdf to learn more about the Leadership to Ensure Adequate Nutrition program.

introduced a nutritious lunch, including rice fortified with iron, folic acid, vitamin A and B and zinc, a weekly supplement for Iron Folic Acid. The program also provided nutrition training to the workers and management, which reduced anemia rates among women, improved hemoglobin concentration and enhanced women's knowledge on vitamin- and mineral-containing foods (Hossain et al., 2019).

The third example is the rural (or homestead) and urban gardening projects that target women in Bangladesh. Home gardening interventions are widespread in the country to improve access to and consumption of fruits and vegetables by women and their families, and empower women. The interventions typically involve gardening practices, distribution of vegetable seeds and fruits seedlings and nutrition training. The gardens are usually near or close to the home where, especially landless, women can easily access and conduct horticulture production on a small scale. For instance, The World Vegetable Center, Hellen Keller International and BRAC. has been implementing home gardening projects with rural women in Bangladesh since 1990 The evaluation of one of the center's USAID-funded projects, implemented with over 3,000 women, showed that the home garden improved the production of especially green leafy vegetables by the program participants, and increased the diversity of vegetables eaten in the households (Schreinemachers et al., 2014). A review study summarizing the effects of home gardening in Bangladesh confirms this finding, showing that, after engaging with home gardens, rural women increased their green leafy fruit and vegetable consumption. As a result, households have a more diverse diet (Iannotti et al., 2009). Over the past ten years, there have also been efforts to expand those gardens in urban Bangladesh (see Figure 4.7). For example, the DAE implemented the 'Integrated Quality Horticulture Development Project' in 2013 to introduce horticulture gardens on rooftops in Dhaka (Safayet et al., 2017), and FAO implemented a similar project from 2015-2017 (FAO, 2017). Recently, The anecdotal evidence of the program suggests that the program improves households' vegetable consumption.[19] The participants of our consumer FGD also confirmed the role of those homestead gardens in their fruit and vegetable consumption. All the FGD participants produced various fruits and vegetables, including sweet gourd, tomato, chilli, brinjal, bean, Indian spinach and fruit trees like jackfruit, mango and guava.

Figure 4. 7 *Example of urban rooftop gardening*
Source: Safayet et al. (2017) page 59.

In addition to these concrete examples, the Government of Bangladesh also uses mass media to encourage healthy, nutritious and diverse diets, as well as fruit and vegetable consumption, as

[19] Please see this note for details http://www.fao.org/3/ca4545en/ca4545en.pdf

described by members of our FGDs. Thus, we found that both the government and private sector are working to promote adequate consumption of fruits and vegetables.

We conclude that nudging a public extension, especially targeting women, can improve fruit and vegetable consumption in Bangladesh. The country already has extensive public programs on improving nutrition, especially for disadvantaged women. These programs also include interventions and components such as the nutritional plate visual, homestead and urban gardening, media campaigns and workplace nutrition training and interventions to encourage households to increase their dietary diversity. These interventions have the potential to improve the consumption of fruits and vegetables in the country.

4.11 Increased food safety, consumer awareness and responses to consumer preferences lead to higher acceptability of fruits and vegetables

4.11.1 Fruit and vegetable availability, affordability and acceptability

Greater access to affordable fruits would improve fruit consumption in Bangladesh. However, we cannot confirm this is the case for all vegetables. The participants in our consumer FGD state that an increase in their income will result in an increase in their consumption of fruits, meat and fish, but vegetables are not included in this list. This implies that fruits are considered a luxury food in Bangladesh, and while vegetables are a dietary necessity, consumers assume that they already consume enough. Other studies on fruits and vegetable consumption in Bangladesh support this finding. For example, while vegetable demand in Bangladesh does not change by household income much, fruit demand changes (Huq and Arshad, 2010). COVID-19 negatively decreased fruit consumption among poor households in Dhaka to a greater degree than among the middle and high-income consumers. In contrast, the effect of COVID-19 on vegetable consumption was similar between poor and middle-high income consumers (Snoek et al., 2021).

An increase in demand for fruits and vegetables by the improved availability and affordability will not be the same among all fruit and vegetable. For instance, our FGD participants expressed that when affordable, they will increase their consumption of fruits, specifically mango which is preferred over jackfruit and pineapple. Moreover, four consumers (out of 10) indicated that they would eat more pumpkin if their incomes improve, while three indicated that they would increase their tomato consumption. Two indicated they would eat more okra if their income improves.

4.11.2 Consumer motives and barriers

Households in Bangladesh consider price, nutritional value, freshness and safety when they consume fruits and vegetables (P.K. Sarma, 2020; Snoek et al., 2021). We detect two barriers to improving the consumption of fruits and vegetables, if these products are more available and affordable for all households. First is the perception of fruits as unsafe compared to the other food items. Poor consumers interviewed in Dhaka indicated that they fear adulteration in fruits and vegetables, and their confidence in the safety of fruits is lower than all other food groups, including vegetables, meat and rice. (Snoek et al., 2021). The second barrier is a lack of public knowledge on the importance of consuming fruits and vegetabless. Our FGD with consumers suggests that as awareness is raised by different NGOs, such as BRAC, Cooperative for Assistance and Relief Everywhere (CARE), etc., among farmers about the nutritional value of fruits and vegetables, participants are changing their consumption patterns. The experts who participated in our KIIs stated that especially middle-income households should be targeted by information campaigns on the nutritional value of vegetables to improve vegetable consumption, as these consumers generally do not eat enough vegetables despite being able to afford it. Changing perceptions about fruit and vegetable safety and improving consumer knowledge on their nutritional value will improve overall fruit and vegetable consumption in Bangladesh.
We conclude that improved availability, affordability and acceptability of fruits and vegetables would increase fruit and vegetable consumption. The increase in the consumption would be higher among

fruits than vegetables, depending on the preferences and perceptions of consumers. For example, some fruits and vegetables would be consumed more than others as consumers prefer them or believe they are more nutritious. Therefore, to increase fruit and vegetable consumption further, additional campaigns on their nutritional value and improved access to the most preferred fruits and vegetables are two viable strategies.

5 Conclusion

5.1 Main findings

Bangladesh is a fast-growing economy with a high population and increasing demand for fruit and vegetables. The consumption of fruits and vegetables is lower than international standards, despite the wide variety of fruits and vegetables the country is able to produce due to its environmental conditions. The country's vegetable production has been steadily growing in recent years, while the growth in fruit production was halted by export bans. The majority of fruits and vegetables are traded in informal markets, which involve many value chains actors from farms to the customers. (e.g., farmers, aratdars, beparis, wholesalers, processors and retailers). Only a few farmers trade, export and sell their products through contract farming with well-organized retailers (e.g., supermarkets).

The enabling environment for fruit and vegetable production is organized by various government food and agricultural acts and strategies, which determine the extension services and nutrition policies concerning fruits and vegetables. The women in this sector are primarily involved in post-harvest activities and other production activities in homestead gardens, rather than retailing and processing.

5.1.1 Production

Fruit and vegetable production in Bangladesh is seasonal, and therefore market prices fluctuate and are usually higher in summer than winter. Farmers also experience some production losses due to miscoordination between government offices and producers in fixing harvest times, bird attacks and excessive use of growth hormones. Lack of access to high-quality seeds, fixed allocation of fertilizers and limited farmer knowledge on good agricultural practices are the major barriers to increasing fruit and vegetable production. In addition, lack of irrigation, an insufficient processing industry, poor road infrastructure and limited access to storage facilities are also barriers to increase production. Furthermore, women farmers have limited access to financing due a lack of land titles, and are further disadvantaged by mobility norms which restrict their participation in value-addition activities in the value chain.

5.1.2 Costs and value chain efficiency

The costs and profitability of producing fruits and vegetables vary by several factors. The first of these is supply, as the profitability of a product is higher when its supply is low. However, our study does not detect a change in production costs as a result of changes in supply, and we cannot therefore provide evidence as to whether farm gate prices decrease with reduced production costs. On the contrary, farmers in the FGDs indicated that production costs have increased over the past years due to increased input prices. In addition, we find some evidence that improving value chain efficiency might decrease fruit and vegetable retail prices. These efficiency gains can result from improved coordination among value chain actors or decreased post-harvest losses. For example, introducing modern transportation methods (e.g., plastic cranes), decreasing the number of actors involved in transportation or improving access to cold storage might decrease those post-harvest losses. We find some evidence that a lack of trust and miscoordination increase the price and transportation risks for the actors. To minimize those risks, one can learn from the contract farming example (please see Box 4) between big processors and smallholders in Bangladesh.

5.1.3 Communication between value chain actors

A lack of communication and information sharing among chain actors hampers efficiency, as it forms barriers between effective translation of consumer needs to producers and thus prevents the development of novel food products that meet consumer needs. Most farmers, traders and processors are not organized to support each other, and information sharing between value chain actors is very limited. There are two main channels through which fresh fruit and vegetable reach the consumers.

The first is the wet markets to which value chain actors supply products. These value chains are not organized, and there is mistrust among the actors which decreases the efficiency of the value chain. The second route fruits and vegetables take to consumers is organized markets through which big processors and modern retailers use contract farming to connect with producers. These organized markets overcome the challenges with information sharing that exist in the wet market value chains by facilitating direct communication between processors and retailers with farmers. However, despite the benefits of this framework, we found that very few farmers are linked to organized markets through contract farming.

5.1.4 Consumption trend and prices

We found that urban consumption of vegetables improved in recent years, while fruit consumption in rural and urban areas remained generally the same, and vegetable consumption in rural areas decreased. The improvement in the urban consumption of vegetables may be related to the recent introduction of new vegetable varieties in Bangladesh. However, consumers perceive vegetables, and even more so fruits, as expensive. Rural farmers sell their fruits and vegetables when prices are favorable, but this is at the expense of their own dietary diversity. Prices also affect consumption, as seasonal production patterns, high input costs and risks such as perishability that value chain actors incur from farm to market increase fruits and vegetable prices and thus reduce consumption as they become too expensive for consumers.

5.1.5 Business models and policy framework to empower women in fruit and vegetable value chains

We detect three models that can empower women in fruit and vegetable value chains: women's corners in wet markets, women producers' groups and associations, and online marketing via women. All three models implemented by NGOs, in cooperation with the government, can improve women's socio-economic positions. In addition, the public policy framework in Bangladesh supports the involvement of women in the production and marketing of produce.

5.1.6 Food safety

The Government of Bangladesh legislated modern laws and regulations over the past ten years to regulate the food market and food safety in the country. The BFSA monitors the implementation of those regulations in markets, food processing factories and among retailers. The Ministry of Agriculture is responsible for monitoring the use of pesticides and chemicals by farmers, which is of growing importance as increasing consumer awareness of food safety issues associated with pesticide residues has begun to hamper consumption. However, there is also a lack of awareness among consumers of the government's current regulations and efforts to monitor food producers.

5.1.7 Strategies to improve consumers awareness of fruit and vegetable consumption

Bangladesh's government has a rich nutrition policy framework, including various programs and interventions to improve food intake and dietary diversity in the country. The programs emphasise women because, on average, women's nutritional outcomes are lower than men's due to cultural norms. To address this issue, the government and NGOs involve women in different nutrition projects. In addition, many NGOs support the government's policy framework by increasing consumer awareness on the importance of dietary diversity through nutrition training programs at the workplace and upscaling rural (or homestead) gardening and urban gardening projects, especially those targeting women. The government also implements mass media programs to encourage households to eat more fruits and vegetables.

Overall, our findings show that improved consumer awareness and access to cheap, safe fruits can improve fruit and vegetable consumption in Bangladesh. To improve fruit and vegetable affordability, improving value chain efficiency through increased coordination among value chain actors is key. To circumvent safety issues, existing food safety standards should be implemented efficiently.

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