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# Analysis of the mango value chain in Bangladesh

Towards a strategic action agenda for the Dhaka city corporations

M.G. (Melanie) Kok MSc, dr.ir J.M. (Han) Soethoudt, D.M. (Vera) Vernooij MSc and S. (Bas) Hetterscheid MSc



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Authors: M.G. (Melanie) Kok MSc, dr.ir J.M. (Han) Soethoudt, D.M. (Vera) Vernooij MSc and S. (Bas) Hetterscheid MSc

Institute: Wageningen Food & Biobased Research

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# Abbreviations

BBS	Bureau of Statistics
DAE	Department of Agriculture of Extension
DAM	Department of Agriculture Marketing
DCC	Dhaka City Corporations
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GoB	Government of Bangladesh
HSC	Higher Secondary Certificate
FLW	Food Loss and Waste
PS	Private Sector
SAU	Sher-e-Bangla Agricultural University
SSC	Secondary School Certificate
WUR	Wageningen University and Research

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# Summary

In terms of production volume, mango is the most important fruit of Bangladesh with an annual production of 1,165,804 metric ton in 2018. In 2011 the food loss and waste (FLW) worldwide was estimated to be one-third of what is produced for human consumption with most losses taking place for the perishable fruits and vegetables food categories. FLW studies about mangoes produced in Bangladesh are scarce. An opportunity for the mango supply chain in Bangladesh is to work towards reducing food losses at various links of the chain in order to increase the amount of food that reaches consumers. This mango value chain analysis of Bangladesh is performed as a first step with the aim to develop a strategic action agenda on the mango supply chain for the four city corporations in Dhaka focusing on identifying the leverage points for reducing food losses for mangoes in order to improve the performance of the mango value chain and thereby to increase the amount of mangoes that reach consumers and enhance food availability. This value chain analysis focusses on the (post-)harvest supply chain till and including retail and processing.

The mango value chain analysis, focusing on Dhaka, is drafted based upon data and information gathered in two literature studies and extensive interviews conducted with individual actors in the supply chain. The interviewees included agricultural producers, intermediaries and truck drivers in Rajshahi, Chapai Nawabganj, Natore, Dinajpur and Kushtia districts, and wholesalers, retailers, mobile vendors and institutional users located in Dhaka North, Dhaka South, Narayanganj and Gazipur city corporation area.

Part of the produced mangoes do not go to the intended market, since they cannot be sold in time or do not meet the right quality. These products are sold at the local market or to mango processors, used for home consumption, given to employees or to charity, used for animal feed, mixed with the soil or go to landfill. Harvesting losses occurred, since it was not possible to harvest all mangoes due to the size of the trees, mangoes were perished or damaged due to the harvesting activity, or mangoes were infected or diseased. Furthermore mango quality is low due to inadequate use of inputs such as fertilizers and pesticide, or since they harvested too late. The amount of unsold mangoes at agricultural producers are estimated at 1.8% of the total production volume. Wholesalers and intermediaries handled the largest amounts of mangoes, while having a relatively small percentage that remained unsold compared to the actors later in the supply chain; 2.9% and 3.5% of the input volume respectively. Most unsold mangoes were found at the end of the supply chain at the retailers (3.7% of the input volume), mobile vendors (5.7% of the input volume) and institutional users (5.1% of the input volume). Part of the unsold mangoes are still consumed at home or given away and therefore still used for human consumption. The real amount of food losses are therefore lower than the amount of unsold mangoes. Mango quality will diminish in time when not stored properly. Fruits that have a low quality at the moment of harvest will perish faster, since small bruises will increase or express itself later in time, and therefore later in the supply chain.

Other challenges in the supply chain can be found in the enabling environment. Transportation faces the hampering effects of high transport costs, bad road communication, and bribes and extortion. Furthermore, mango is a seasonal product and domestic mango is available during the summer only, and cannot be stored longer than 4-8 weeks. Mango is a very sensitive fruit and significant investments to reduce losses and maintain harvest quality is not justified by the current price. Although mango is the king of fruits in Bangladesh, as it is the number one fruit produced in Bangladesh and Bangladesh is the 10<sup>th</sup> mango agricultural producer in the world, the domestic demand for mangoes is low and as a consequence the price is too.

Opportunities and recommendations to enhance the performance of the mango supply chain in Bangladesh are related to creating incentives to invest and improve the quality of mangoes produced, supporting cooperative formation, improving information, communication and transportation systems, starting to brand and stimulate eating more healthy and safe fruits in Bangladesh, and exploring ways to support export.



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# 1 Introduction

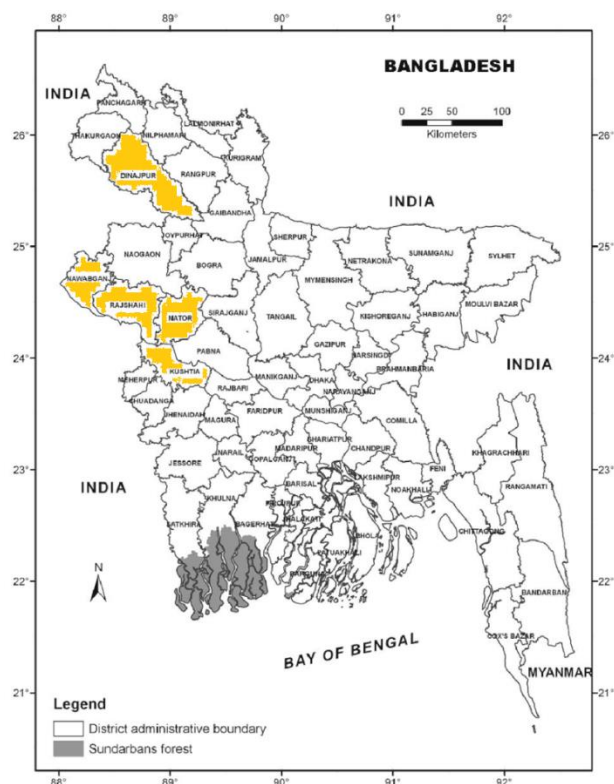
Bangladesh is principally an agricultural based country dominated by crop production. In 2015-2016 the agricultural sector contributed 14.74 % to the country's Gross Domestic Product (GDP), providing employment to about 41% of the labour force (Bangladesh Economic Review, 2017). Increasing population growth and urbanization provide food supply challenges and opportunities to feed the growing (urban) population. In 2018 Bangladesh had 9,202.3 thousand hectares of agricultural land of which 830 thousand hectares under permanent crops. In 2018 7,772.3 thousand hectares (84.5% of agricultural land) was arable (FAOSTAT, 2018).

As the population of the capital of Bangladesh, Dhaka, grew substantially in the last years, the pressure on the food supply increased. Dhaka is among the top 25 cities in Asia and is growing fast both demographically and economically (Zaman, 2019). The 8.9 million inhabitants of Dhaka need to eat food every day and primarily depend on food purchases. Due to this, Dhaka is dependent on food inflows from the rural areas. Large amounts of grain, fish, spices, vegetables, fruits and meat need to be delivered to Dhaka every day in order to meet the demand (Etzold, 2008).

The inflow of food to the city of Dhaka is going on several ways. One way for food entering the city is by the wholesale markets. From a survey conducted in 2009-2010, it is known that raw food is sold at 87 different wholesale markets within the area of Dhaka City Corporation (DCC) (Keck, 2012). These are the major distributional links from which food flows into various channels of the urban food system. The majority of the food that is entering Dhaka, flows in informal markets.

In terms of production volume, mango is the most important fruit of Bangladesh with an annual production of 1,165,804 metric ton in 2018. In that same year, the total area under mango cultivation was estimated at 44,347 hectares (BBS, 2019). In comparison, in 2013 mango production covered around 30,783 hectares of land with a total annual production of 956,867 Metric tons (BBS, 2015). The increase in production can be assigned to the introduction of improved varieties, production techniques and an increased market demand (Miah et al., 2018). Bangladesh mango production is ranked 10<sup>th</sup> worldwide, with 2.61% of the world production in 2019 (Tridge, 2019).

Mangoes grow in almost all of Bangladesh, but the main growing areas are located in the northwestern districts of the country (Figure 1). Division Rajshahi has a total production of 621,311 Metric tons and Rangpur has a total production of 143,577 Metric tons. Districts with the highest production are Rajshahi, Chapai Nawabganj and Natore, all located in Rajshahi division (Table 1). This division covers more than 50% of the total mango production (BBS, 2019). From these production areas, mangoes are transported to major consuming areas, particularly the markets of Dhaka and Gazipur (Matin et al., 2008). Import of mangoes is neglectable compared to the total production and export is almost equal to zero (FAOSTAT).



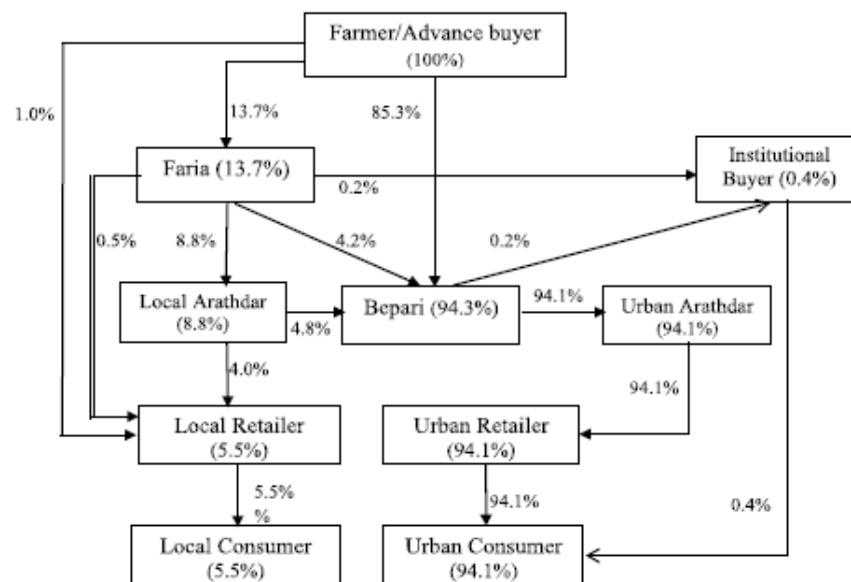
**Figure 1** Top 5 mango production districts (Dey et al., 2008 and BBS, 2019)

**Table 1** Main mango production districts 2017-2018 (BBS, 2019)

District	Division	Production 2017-2018 (tons)	% of national production
Rajshahi	Rajshahi	242,299	21%
Chapai Nawabganj	Rajshahi	203,521	18%
Natore	Rajshahi	66,475	6%
Dinajpur	Rangpur	53,411	5%
Kushtia	Khulna	46,608	4%
<b>Total</b>	<b>Bangladesh</b>	<b>1,165,804</b>	<b>100%</b>

The per capita consumption of fruits in Bangladesh was 44.7 grams in 2010, of which the urban population consumes more fruits compared to the rural population. A sharp increase (38%) took place in the per capita consumption of fruits in the country over the period from 2005 to 2010 (BBS 2010).

A typical agricultural supply chain consists of agricultural producers (farmers), different types of traders and consumers. Traders involved in the mango supply chain in Bangladesh from smaller scale to larger scale are intermediaries (*faria*, *bepari* and *arathdar*), wholesalers (local, divisional and regional) and retailers (local and urban). In Bangladesh, the major channel (85%) used for mangoes is: *agricultural producer/advance buyer* → *bepari* → *urban arathdar* → *urban Retailer* → *urban consumer* (Miah et al., 2018; Rahman, 2018) (Figure 2).



**Figure 2 Flow diagram of mango supply chain from field survey 2015 (Miah et al., 2018)**

In 2011 the food loss and waste (FLW) worldwide was estimated to be one-third of what is produced for human consumption with most losses taking place for the perishable fruit and vegetable food categories (Gustavsson et al., 2011). In order to increase the amount of food that reaches consumers, it is therefore very relevant to study where at various links of supply chains FLW takes place. FLW studies for mango in Bangladesh are scarce. An opportunity for the mango supply chain in Bangladesh is to work towards reducing food losses at various links of the chain.

Additionally, as the majority of food is produced in rural areas (predominantly by smallholder agricultural producers) understanding the flow of food to and within the metropolitan areas, and the interaction between food producers, logistics service providers, wholesalers and retailers, is necessary to facilitate the development of a secure, sustainable and resilient food system for the megacities. Therefore, to support policy makers in the four city corporations that comprise the Dhaka Metropolitan Area (North Dhaka, South Dhaka, Gazipur and Narayanganj), information is required that identifies impediments and opportunities to improve the performance of the mango value chain towards Dhaka. Accordingly, a mango value chain analysis is an important first step creating sustainable and profitable farming and marketing of mangoes in any community. This study was conducted to gather information from various actors participating in the mango value chain to identify impediments and opportunities to improve its performance.

## 1.1 Goal

This mango value chain analysis in Bangladesh is performed as a first step with the aim to develop a strategic action agenda on the mango supply chain for the four city corporations in Dhaka. The ultimate goal is to decrease food loss and waste (FLW) with 5% and increase food availability. A strategic action prioritizes the objectives and concrete steps needed to attain the goals set – usually covering the coming years. It is the common view on and basis for the process towards developing concrete plans to reach the required outcome. Here we identify the leverage points for reducing food losses for mangoes in order to improve the performance of the mango value chain and thereby to increase the amount of mangoes that reach consumers and enhance food availability. In order to achieve the goal we use the food systems approach of Van Berkum et al. (2018), zooming in on the food system activities and food availability in the top five mango producing districts and the four city corporations in the city of Dhaka.

## 1.2 The food system approach

This report is structured following the food systems approach (van Berkum et al. 2018). The food systems approach is aimed at sustainable solutions for sufficient supply of healthy food. System thinking with the help of this approach broadens the perspective when seeking solutions for the root causes of problems. Figure 3 presents an overview of the approach. This strategic action agenda focusses on the (post-)harvest supply chain up to and including food retail and processing. Food consumption is out of scope



**Figure 3 A way of mapping the relationships of the food system to its drivers (Van Berkum et al., 2018)**

The scope of this report is circled in Figure 3, namely the food system activities and food security. The food system activities include the food supply system, which describes the different supply chain actors and their activities, challenges (including FLW) and mutual connection, and the enabling environment, business services, food environment and consumer characteristics.

For the food system activities this report includes the first four aspects of the 'food supply system' namely agricultural production, food storage, transport & trade, food processing & transformation, and food retail & provisioning. Food consumption is out of scope. The value chain is at the heart of the food supply system where value is added in each step (van Berkum et al. 2018). Furthermore this strategic action agenda includes two of the four parts that interact directly with the food supply system: the enabling environment in which the food supply system is embedded (transport, regulation, institutions and research infrastructure), and business services that provide services and goods to the actors in the chain (training, agricultural inputs, technical support or financial services). Out of scope are the food environment and consumer characteristics, as these topics have a direct linkage with the consumer that is out of scope. The box 'food security' includes food utilization, food access and food availability. This food system analysis includes food availability only. Food utilization and food access are out of scope. Within food availability, this report includes all aspects namely production, distribution and exchange.

## 2 Methodology

The analysis of the mango value chain is drafted based upon data and information gathered in two literature studies and extensive interviews conducted with individual actors in the supply chain.

### 2.1 Literature studies

Two literature studies on the mango value chain in Bangladesh were conducted. One study was conducted by Wageningen University & Research (WUR) and included studies conducted in the English language, and international available data and statistics. The second literature study was conducted by Sher-e-Bangla Agricultural University (SAU) and included information from local statistics agencies and governments, and studies conducted in English and the Bengali language. Topics included production, consumption and trade, an economic analysis, the supply chain with their actors and challenges, food losses, and other issues included in a food system analysis like climate and transport.

### 2.2 Extensive interviews

325 face-to-face executive interviews were executed by SAU by field visiting study areas between 16 August 2020 and 22 August 2020. Actors included in the interviews were agricultural producers, intermediaries, truck drivers, wholesalers, retailers, mobile vendors and institutional users (Table 2). In order to ensure the highest level of quality, the following measures were adopted by SAU:

- Recruitment of appropriately qualified and experienced enumerators (Graduate completed and studying Master of Science in SAU and expert in GPS machine and mobile apps system)
- Training on use of the interview techniques and use of tools appropriately including field exercise
- Pre-testing of questionnaire
- Correction of questionnaire according to result found on field tests
- Supervision by core team members
- Sudden visit by core team member
- Day to day checking of collected data in order to ensure proper filling and recording of data
- Preserving telephone number of the respondents to recheck if necessary at the analytical stage.

**Table 2 Definitions actors in the mango supply chain (Hasan and Naim 2018; Hasan et al. 2007)**

Actor	Description
Agricultural producer	People (farmers) who produce mangoes.
Intermediary	People who buy mangoes from agricultural producers or other actors and sell to another. Intermediaries included <i>faria</i> , <i>bepari</i> and <i>arathdar</i> . <ul style="list-style-type: none"><li><i>Faria</i> are intermediaries who collect produce from farmyards, or from agricultural producers in the village or in the local market and sell in local markets to the <i>bepari</i>, or directly to consumers. They have no permanent shop.</li><li><i>Bepari</i> are intermediaries who assemble in local markets and buy from agricultural producers or <i>faria</i> and supply to urban centers. They sell to wholesalers or retailers through <i>arathdars</i> or commission agents. They have no permanent shop.</li><li><i>Arathdar</i> are commission agents who have a fixed establishment and operate between urban <i>beparis</i> and wholesalers or retailers.</li></ul>
Driver	People who drive vehicles (truck) to carry mangoes from one place to another.
Wholesaler	People who buy mangoes from intermediaries or other actors and sell mangoes in bulk amount to retailers or other actors or consumers.
Retailer	People who buy mangoes from wholesaler or other actors and sell mangoes to consumers or to some other actors in small amount.

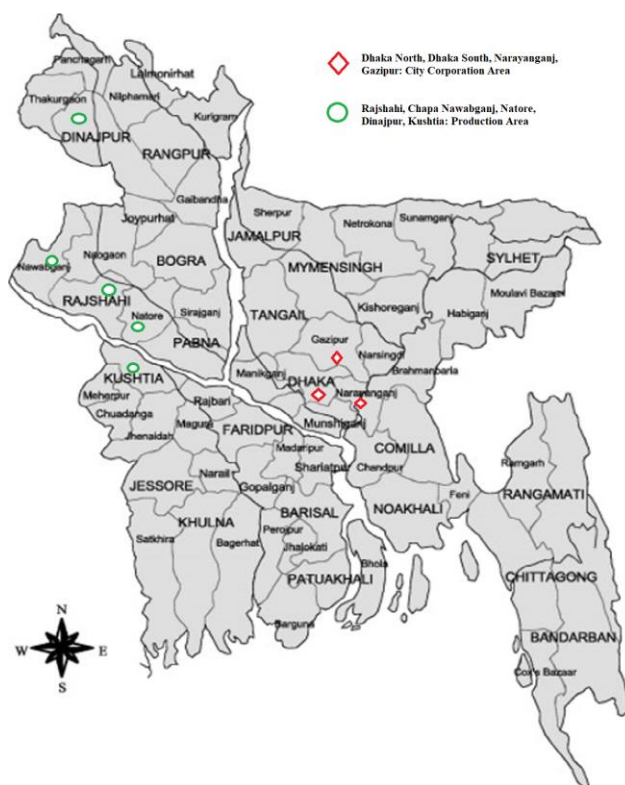
Mobile vendor/vendor	People who don't have any specific location/place to sell mangoes; rather they sell mangoes by moving from one place to another.
Institutional user	Institutes that use mangoes for various reasons.

## 2.2.1 Sampling plan

Table 3 provides the survey area and sample size per type of actor. The actors were sampled from five different production districts, including Rajshahi, Chapai Nawabganj, Natore, Dinajpur and Kushtia and four city cooperation areas, including Dhaka North, Dhaka South, Narayanganj and Gazipur. This is visualized in Figure 4.

**Table 3 Sample size and distribution**

No.	Survey area/ sample distribution	Survey method	Respondents	Sample size
1.	Five selected production area for mango commodity (district which produced highest production of specific commodity). Production areas for mango are Rajshahi, Chapai Nawabganj, Natore, Dinajpur, Kushtia districts.	FGDs/Face to face executive interview	Agricultural producers	60 (12 for each production area)
2.	Five selected production area for mango commodity (district which produced highest production of specific commodity). Production areas for mango are Rajshahi, Chapai Nawabganj, Natore, Dinajpur, Kushtia districts.	Face to face executive interview	Agreed market intermediaries	50 (10 for each production area)
3.	Five selected production area for mango commodity (district which produced highest production of specific commodity). Production areas for mango are Rajshahi, Chapai Nawabganj, Natore, Dinajpur, Kushtia districts.	Face to face executive interview	Truck drivers	15 (3 for each production area)
4.	Four major wholesale markets in each of 4 cities (Dhaka North, Dhaka South, Narayanganj and Gazipur city corporation area)	Face to face executive interview	Wholesalers	20 (5 for each markets)
5.	20 Traditional retail markets from 4 city corporations (5 from each city)	Face to face executive interview	Retailers	60 (3 for each markets)
6.	60 Informal mobile vendors from 4 city corporations (15 from each city)	Face to face executive interview	Informal roadside vendors	60 (15 from each city)
7.	60 Institutional users (15 from each city) Requirements interviewees: - Age between 18-60 year - At least three year work experience in the mango supply chain.	Face to face executive interview	Restaurants, food processors	60 (15 from each city)
<b>Total sample size 325</b>				



**Figure 4 Map of mango value chain survey**

### 2.2.2 Data collection

Seven different structured questionnaire surveys were developed, one questionnaire per type of actor. These were translated into the Bengali language and entered in the Kobo apps tool system - an online electronic data entry recording system. The survey app was developed by using Kobo collection software<sup>1</sup> for data collection and especially as downloadable by a user to an Android mobile device. Kobo Collect is based on the open data kit and is used for primary data collection. The platform is very intuitive and offers comprehensive collection alongside basic mapping and analysis capabilities. Users can export data into more powerful analysis tools and it has a GPS tracking system. Data processing work consisted of cross checking and matching of data. Statisticians oversaw the data processing activities. Data was stored automatically in electronic data entry record system and data storing system.

### 2.2.3 Data Analysis

Kobo apps was developed for data entry. Data analysis was done by Kobo tool apps. Different types of statistical calculations like number, mean, mode, median, percent and standard deviation were used. A simple tabular technique was presented in the study to classify the data into meaningful categories.

### 2.2.4 Validating findings

Findings from the interviews were shared for discussion, feedback and validation in two sessions. One session took place with the Food and Agriculture Organization of the United Nations (FAO) team members and one session took place with four city corporations experts from FAO Bangladesh. Results were incorporated in the recommendations section of this report. All sessions took place online.

<sup>1</sup> <https://www.kobotoolbox.org/>

### 3 Results: Food system activities

This chapter describes the food system activities for mangoes in Bangladesh, which includes the food supply system, enabling environment and business services.

In Table 4 a SWOT-analysis is provided regarding the mango food system activities. This analysis shows the strengths, weaknesses, opportunities and threats related to the food supply system, the enabling environment and business services. These results are further explained in chapter 3.1, chapter 3.2 and chapter 3.3.

**Table 4 SWOT for mango supply chain activities**

Strength	Opportunity
<ul style="list-style-type: none"><li>• Part of the unsold mangoes is still used for human consumption (charity, given to employees, home consumption)</li><li>• Cooperatives play important role (but small % of our sample member of coop)</li></ul>	<ul style="list-style-type: none"><li>• Technical support on production and post-harvest handling to increase the quality of the mangoes through extension services</li><li>• Automated sorting machine</li><li>• Temperature controlled storage facilities within the supply chain</li></ul>
Weakness	Threat
<ul style="list-style-type: none"><li>• High costs for labour</li><li>• Lack of labour</li><li>• High input costs like new plants and fertilizer</li><li>• High use of chemicals found on the fruits (formalin)</li><li>• Low price and profit</li><li>• Rots of mango in the supply chain</li><li>• Bad quality mangoes (damaged, bad colour)</li><li>• Quality decrease within the supply chain</li><li>• Lack of storage facilities</li><li>• High costs for storage</li><li>• High costs for packaging material</li><li>• High cost of transport</li><li>• Heavy workload for manual work like cleaning</li><li>• High costs for automated equipment</li><li>• Agricultural producers are dependent on intermediaries to have access to the market in Dhaka</li></ul>	<ul style="list-style-type: none"><li>• Mango diseases at production</li><li>• Insects during processing mangoes</li><li>• Environmental problems, like heavy rains and droughts, and natural disasters</li><li>• Difficult to receive a loan or credit</li><li>• Credit facilities have high interest</li><li>• Fluctuations of market prices</li><li>• Bad roads and traffic jams</li><li>• Bad road communication</li><li>• Distance to market/selling point</li><li>• Lack of market information and their reliability</li><li>• Bribes and extortion on roads during transport</li></ul>

#### 3.1 Food supply system

Six main mango food system actors are described: agricultural producers, intermediaries (*faria*, *bepari* and *arathdar*), wholesalers, retailers, mobile vendors and institutional users (restaurants, bars and shops that sell prepared food). Table 5 gives an overview of the amount of mangoes that are being handled, what percentages are left unsold, the destinations of these unsold mangoes, and the percentage of actors that sold out all mangoes. The percentages provided in the column under 'sold out' and behind the destinations of the unsold mangoes represent the amount of actors that mentioned it.



**Table 5 Summary table mango supply chain actors, kgs handled, unsold and destinations for unsold**

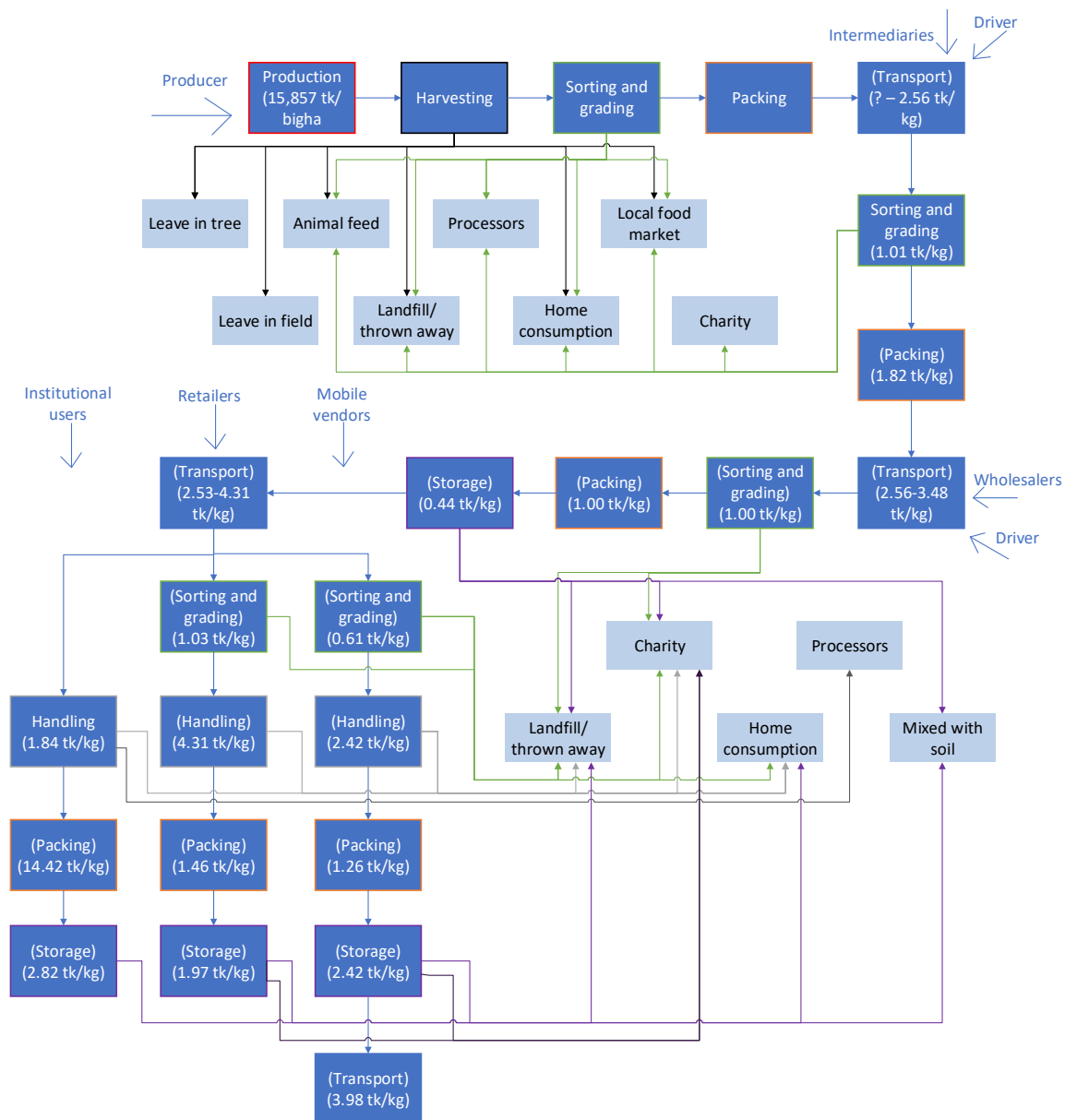
Value chain actors	Kgs handled (average per actor)	Kgs not sold (average per actor)	% unsold (average per actor)	% of actors mentioning to be sold out	1st destination of unsold mangoes	2nd destination of unsold mangoes
Agricultural producers	36,257	668	1.8%	22%	Landfill (65%)	Animal feed (45%)
Intermediaries	175,370	6,108	3.5%	28%	Landfill (60%)	Given to employee (26%)
Wholesalers	295,063	8,479	2.9%	30%	Landfill (65%)	Given to poor or given to employee (both 40%)
Retailers	25,930	972	3.7%	15%	Landfill (68%)	Given to poor (50%)
Mobile vendors	14,592	826	5.7%	27%	Landfill (57%)	Given to poor (50%)
Institutional users	1,504	77	5.1%	67%	Landfill (22%)	Domestic consumption (17%)

Wholesalers and intermediaries handled the largest amounts of mangoes and they had a relatively small percentage that remained unsold compared to the actors later in the supply chain. Most unsold mangoes were at the end of the supply chain at the mobile vendors and institutional users. The lowest percentage of unsold mangoes were at the agricultural producer level, but 78% of them remained with mangoes they could not sell; these were primarily going to landfill and animal feed. Of the other value chain actors, the retailers mostly lacked the ability to sell all mangoes: 85% indicated to remain with unsold mangoes. Majority of the unsold mangoes ended as landfill. Regarding FLW, the definition of Gustavsson et al. (2011) is used. Therefore the percentage of FLW is often lower compared to the percentage of unsold produce.

Every actor in the supply chain increases the value of the product. They perform different activities to differentiate themselves from their competitors, to maximize the margin on the products they sell and minimize their losses and costs.

In Figure 5 a summary of the activities, costs and destinations per actor are shown. When a certain activity is shown within parenthesis this means that the activity was conducted by less than 50% of the respondents. It also visualizes the cost per activity and the destination for unsold mangoes occurring per activity. However, sometimes an activity induces losses, but the destination is not provided. Therefore not all losses can be visualized in the figure.

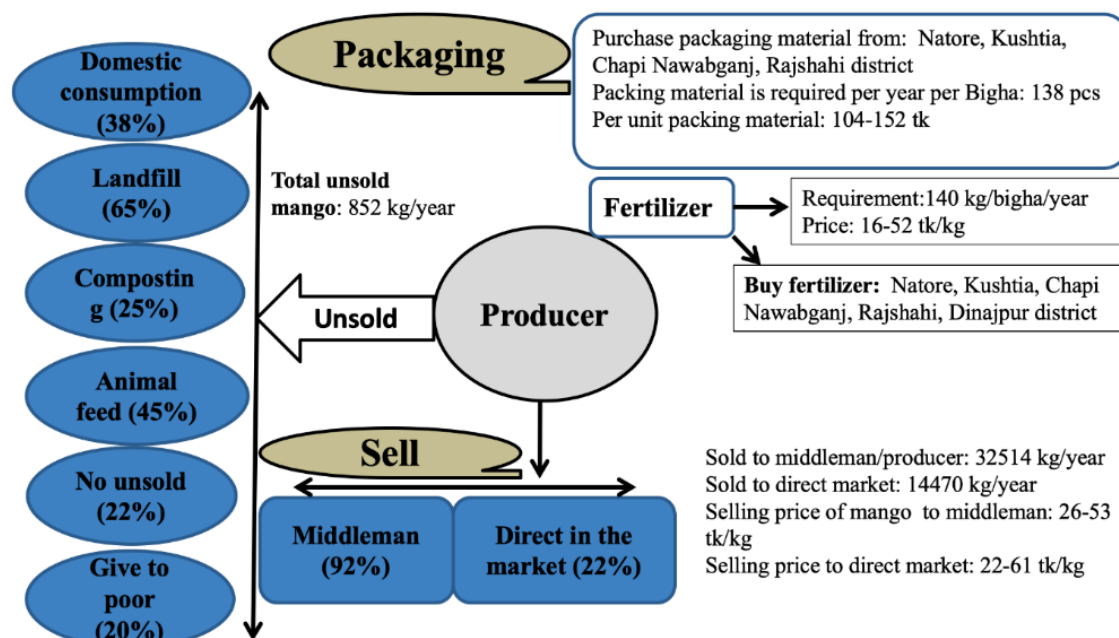
Hereafter the actors are described in more detail.



**Figure 5 Food flow per actor in the mango supply chain**

### 3.1.1 Agricultural producers

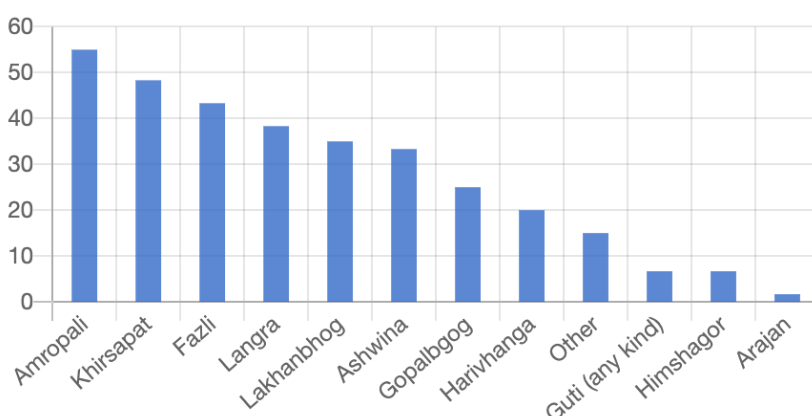
In total, sixty agricultural producers were interviewed (N=60) of which two were female (3.33%). These females also belonged to a female-headed household. On average the agricultural producers were 43 years old and have been involved in the mango business for thirteen years on average. 20% of the respondents received education up to class 5, 20% up to class 8, 20% Higher Secondary Certificate (HSC), 17% a Secondary School Certificate (SSC), 12% was graduated, 10% received a post graduate and 2% (one respondent) was illiterate.



**Figure 6 Agricultural producers value chain overview**

Figure 6 shows the agricultural producers value chain overview. Overall agricultural producers use 44% of their farmland for mango production. This is on average 7.3 bigha (1 bigha = 33 decimal) which includes 270 number of trees on average. Agricultural producers need fertilizer for mango production and packaging material for packing. On average per agricultural producer 35,589 kg/year was sold to intermediaries or direct in the market. On average per agricultural producer 32,514 kg/year was sold to intermediaries and on average 14,470 kg/year was sold direct in the market. 88% of the agricultural producers did not sell all their produced mangoes and it was estimated to be 852 kg/year/agricultural producer. This is an average of 668 kg/year/agricultural producer for the total sample. This means that the total production was on average 36,257 kg/year/agricultural producer of which 1.8% was not sold. These unsold mangoes were used for domestic consumption, given to the poor, animal feed (all not considered as FLW<sup>2</sup>), landfill or composting (considered as FLW). The estimated FLW of mangoes at agricultural producer level is therefore estimated to be less than 1.8%.

Several varieties were produced by the agricultural producers which included Amropali (55% of actors interviewed), Khirsapat (48%), Fazli (43%), Langra (38%), Lakhanbhog (35%), Ashwina (33%) and others (See Figure 7). The different varieties all have their own characteristics and benefits, like average yield, timing of the first harvest after plantation, harvest timing and the height of the trees. The characteristics can be found in Table 6.



**Figure 7 Varieties of mango produced**

<sup>2</sup> Gustavsson et al. 2011

**Table 6 Average yield, starting after plantation, harvesting time and height of the tree**

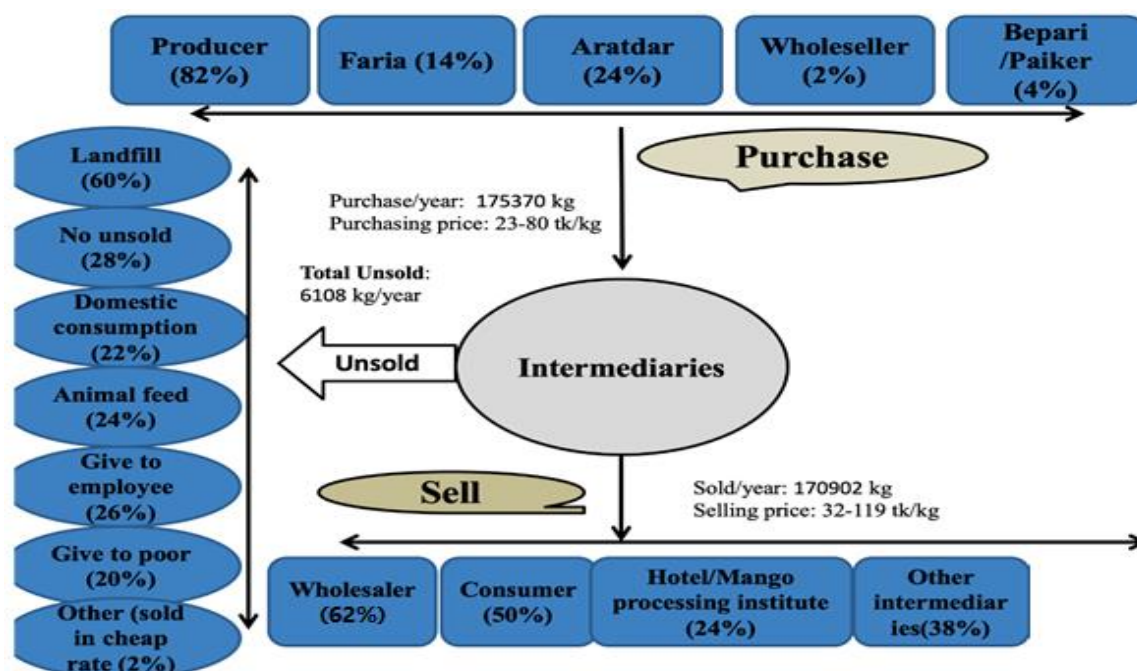
Value	Average yield per Bigha (mound)*	Start harvesting after plantation (year)	Harvesting time	Height of tree (in feet)
Amropali	62.59	2.44	June-July	14.92
Khirsapat	84.89	3.75	May-June	24.20
Fazli	57.85	3.71	July-August	28.08
Langra	48.95	3.77	June-July	24.68
Lakhanbhog	43.10	3.43	June-July	22.48
Ashwina	58.50	3.55	July-August	26.55
Gopalbgog	106.76	3.60	June-July	23.60
Harivhanga	69.42	3.00	June-July	23.33
Guti (any kind)	37.17	3.40	June-July	22.20
Himshagor	113.33	2.50	June	27.50
Arajan	25.00	4.00	July	12
BARI 4	49.25	2.50	July-August	17.50

Bad quality mangoes existed due to all type of activities, including production, harvesting, sorting and grading, and packaging.

Maturity was determined by the agricultural producers based on the growth, colour and date. Other criteria that were considered were sweetness, smell and softness. However, 10% of the personnel engaged in mango harvesting were not trained in checking the maturity level. Agricultural producers start harvesting in the morning till noon. Harvesting techniques used included a cutting device that automatically catch the mangoes, just pick them (when trees are low), fall in a net and caught by a person. Most agricultural producers (62%) mentioned that they had less than 5% losses due to harvesting, 20% of the respondents mentioned losses between 5-10%, 8% of the respondents mentioned between 10-15% and the rest replied that they had losses between 15-20%. Losses occurred due to damages or perished product during harvesting, mangoes that were impossible to harvest, or infected and diseased mangoes which can already occur during production. Destinations included landfill (77%), animal feed (53%), left in the field (15%) and left in the tree (5%). Some of the mangoes were still consumed by human and sold for a lower price (45%) or were used for home consumption (63%). After harvesting, the mangoes were placed in the shade in the harvesting field. Sorting and grading was done by size, colour, weight and shape. 70% of the respondents mentioned that less than 5% of the mangoes were sorted out and excluded from the food chain after sorting and grading. 20% of the respondents mentioned an (economic) loss between 5-10%, 3% of the agricultural producers mentioned a loss between 10-20%, 2% mentioned it was between 20-40% and also 2% mentioned no mangoes were sorted out. The out-sorted mangoes can already have had a bad quality due to causes occurring due to production or harvest. For example, exposure to direct sunlight, rough handling during transferring the mangoes to the shade after harvesting, or due to damages during the activity of sorting and grading and packing. Destination of the out-sorted mangoes included landfill (73%), animal feed (47%), own consumption (45%), food processors (38%) and the urban food market (12%), of which the food going to the last four mentioned destinations are not considered as FLW by Gustavsson et al. (2011). Therefore the amount of FLW is considered lower. Mangoes are packed in plastic crates (80% of the respondents), bamboo baskets (32% of the respondents) or plastic bags (7% of the respondents). Overall a plastic crate or plastic bag contained around 25 kg, while a bamboo basket contained 45 kg on average. In all these activities the very bad quality mangoes, e.g. rotten, are used for landfill. The good quality mangoes were sold on the market in Dhaka and the rest was sold on the local food market or to processors, or used for home consumption, given to charity/employees or used as animal feed.

### 3.1.2 Intermediaries

All interviewed intermediaries (N=50) were male. The profession of the respondents in the study were *arathdar* (48%), *bepari* (40%) or *faria* (12%). The respondents were on average 44 years old and have been involved in mango trading for fifteen years on average. Among the intermediaries, 34% of the respondents passed SSC, 24% were found educated up to class 8, 20% passed HSC, 14% were up to class 5, 2% were graduated and 6% were found illiterate.



**Figure 8 Intermediaries value chain overview**

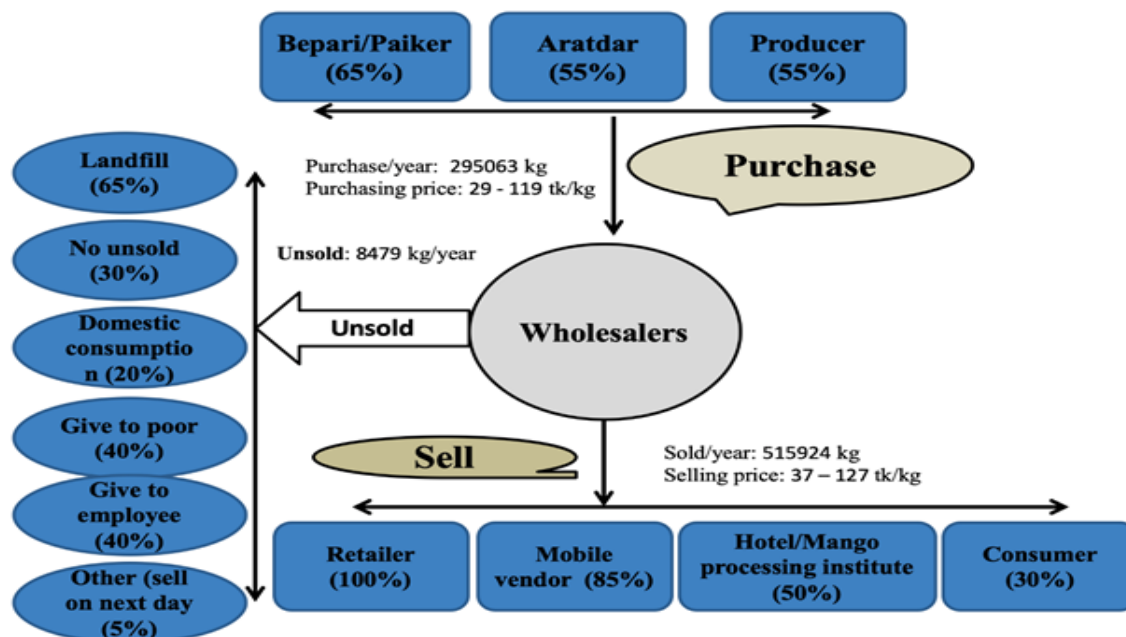
Figure 8 shows the intermediaries value chain overview. Intermediaries add value to the product by arranging the transport from the rural areas to the city of Dhaka and bulking the products. The intermediaries purchased on average 175,370 kg/year from agricultural producers, other intermediaries and wholesalers. However, the amount of mangoes purchased is dependent on the respondent and varied between 500 kg/year till 700,000 kg/year. 62% of the intermediaries sold (a part of) their purchased mangoes to wholesalers, 50% to consumers, 38% to other intermediaries and 24% to hotels. The amount of unsold mangoes was estimated at 6,108 kg/year/intermediary, which is 3.5% of the total input. Destinations of the unsold mangoes included landfill (60% of the respondents), animal feed (24% of the respondents), given to employees or to the poor (26% and 20% of the respondents respectively), used for domestic consumption (22% of the respondents) and sold at cheap rate (2% of the respondents). 28% of the respondents mentioned they had no unsold mangoes.

After purchasing, 54% of the intermediaries sorted and graded the mangoes. In case sorting and grading was performed, they did this based on colour (96%), size (93%), shape (74%), weight (41%) and smell (11%). From the 54% of the intermediaries who sorted and graded the mangoes, most respondents mentioned a loss of less than 5% (59% of the respondents who perform sorting and grading), 12% mentioned a loss between 5-10%, 4% of the respondents mentioned a loss between 10-20% and 2% mentioned a loss between 20-40%. Causes of these out-sorted mangoes can be tracked back to transportation, rough handling or bad quality fruits as input. The out-sorted mangoes were used as landfill, used as animal feed, given to charity or own employees, sold to food processors, used for own consumption or sold in urban food markets.

32% of the respondents used their own packing material. Main reason for using own packing material was that they re-pack the fruits after sorting and grading, or made a larger or smaller pack. Packaging material used included plastic crates and bamboo baskets, which were both filled with around 25 kg of mangoes.

### 3.1.3 Wholesalers

The wholesalers (N=20) that were interviewed in the four city districts of Dhaka were all male. The average age of the respondents was 42 years with on average 14 years of experience. Their education was up to SSC (30%), up to class 8 (25%), up to class 5 (20%), up to HSC (15%), graduate (5%) or illiterate (5%).



**Figure 9 Wholesalers value chain overview**

Figure 9 shows the wholesalers value chain overview. Wholesalers add value to the product by arranging the transport from the rural areas to the city of Dhaka and bulking the products. Wholesalers each purchased on average 295,063 kg mangoes per year from *bepari*, *arathdar* and agricultural producers. Of these purchased mangoes, on average 8,479 kg/year/wholesaler were not sold and went to landfill, given to the poor or employees, or used for domestic consumption. This is 2.9% of the total input. 30% of the wholesalers mentioned they did not have unsold mangoes. All wholesalers sold mangoes to retailers. Furthermore most wholesalers sold to mobile vendors (85% of the respondents), hotels (50%) or consumers (30%).

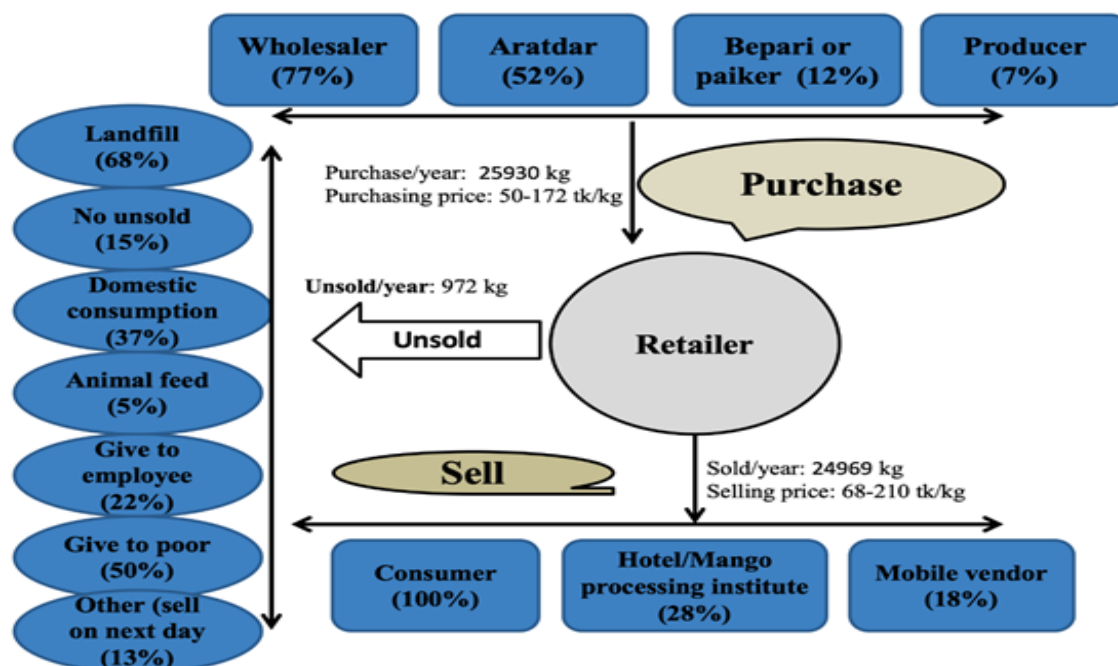
From the interviews it was concluded that 15% of the wholesales sorted and graded the mangoes after purchasing. Sorting and grading was done based on colour, size, shape, smell or weight, of which the first three criteria were used by all wholesalers who sorted and graded the mangoes. They all mentioned they sorted-out less than 5% of the mangoes. Causes of these out-sorted mangoes can be tracked back to transportation, rough handling or bad quality fruits as input. They threw the unsold mangoes to landfill, or gave it to their employees or to charity.

10% of the wholesalers used own packaging material to make a smaller or larger pack. The wholesalers who used own packaging material used plastic crates.

Storage was conducted by 40% of the wholesalers. The wholesalers that stored the mangoes all used a dry, ventilated store house with fan. Five of the respondents with the storage facility, stored the products in small boxes. The others stored the mangoes in plastic crates. They all stored the mangoes for less than a week. Storage was used for different reasons, including waiting for market demand, prevention of product loss, securing a good price or higher profit, or ripening the product. They all mentioned that less than 5% of the mangoes went to another destination than the intended market, which included landfill, mixing with soil, or given to employees or to charity.

### 3.1.4 Retailers

The average age of the retailers interviewed (N = 60) was 40 years with an average work experience of 13 years. Of the respondents, 97% was male (58 respondents) and which 98% lived in a male headed household. Among the interviewees, 35% were found educated up to class 5, 30% had up to class 8, 16.7% were illiterate, 16.7% had up to SSC and 1.7% had up to HSC.



**Figure 10 Retailers value chain overview**

Figure 10 shows the retailers value chain overview. On average, retailers purchased 25,930 kg/year from wholesalers, *arathdar*, *bapari* or agricultural producers. Of these purchased products, on average 972 kg/year was not sold, which is 3.7% of the total input. These unsold mangoes went to landfill (68% of the respondents), was given to charity or employees (50% and 22% of the respondents respectively), was used for domestic consumption (37%) or was used as animal feed (5%). 15% of the interviewed retailers mentioned they had no unsold mangoes and 13% mentioned they sold it the next day. All retailers sold (part of) their mangoes to consumers (100%) and some retailers also sold mangoes to hotels/processing institutes (28%) or mobile vendors (18%).

30% of the retailers sorted and graded the mangoes after purchasing. Size, colour, shape, and smell were determinants for the respondents that conducted sorting and grading. From the 30% that sorted and graded the mangoes, one respondent mentioned that there were no out-sorted mangoes, sixteen respondents said that less 5% was sorted out and one respondent mentioned that a rate between 5-10% was out-sorted. Losses found during sorting and grading can have several causes. One possibility is that the packaging material and way of packing is not optimal in combination with transportation. This can cause bruises and damages. Another possibility is that retailers purchased mangoes that already had a bad quality. If so, the losses occur at the retailer, but were already caused earlier in the supply chain. The mangoes that were sorted out went to landfill, charity, own consumption or given to employees.

7% of the retailers performed an extra handling, which was notching, and in total 15% of the retailers did wash the mangoes after purchasing. Of these respondents, six respondents used a washing machine and three used a towel to clean the mangoes.

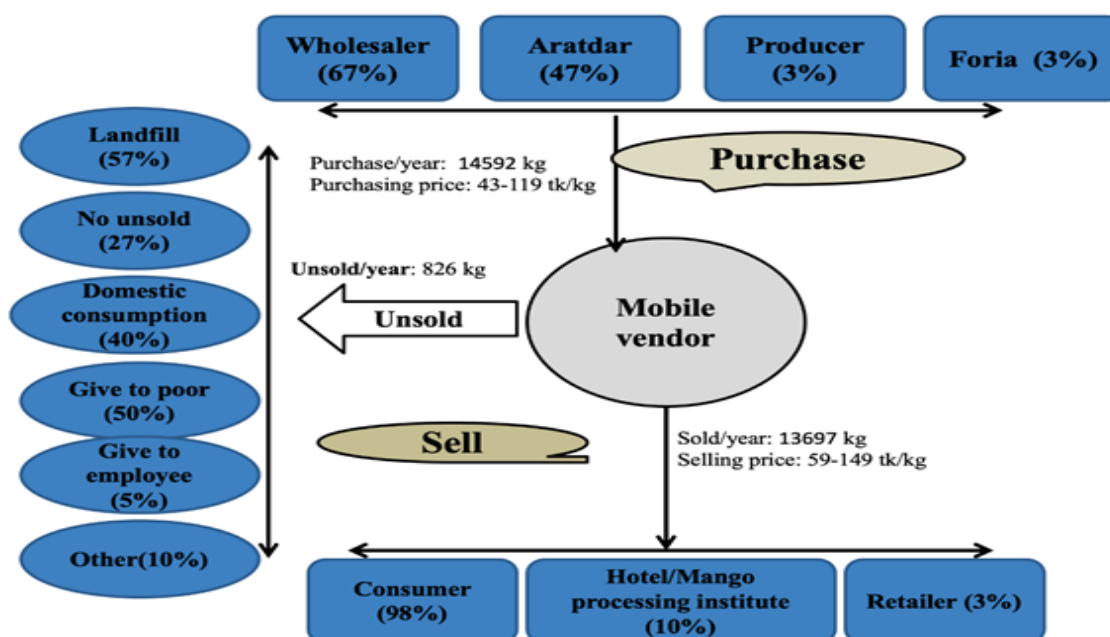
8% of the retailers used their own packaging materials, which was a plastic net bag or plastic bag, to pack loose mangoes together to make a small pack. One respondent mentioned to also use a plastic crate for packaging.

Storage was done by 27% of the respondents. From this group of retailers, 50% used a storage facility that is dry and ventilated with a fan, 44% used a storage facility that is dry and ventilated but without fan and 6% used a storage facility that is a closed store without fan. They almost all stored the mangoes in plastic crates for less than one week to prevent product loss, wait for market demand, ripening the product or to secure a good price. Losses after storage can occur due to bad storage facilities or since bad quality mangoes are stored.



### 3.1.5 Mobile vendor

The average age of the mobile vendors (N=60) was 40 years. 2% of the respondents were female and 3% lived in a female headed household. Almost half of the respondents received education up to class 5 (47%). 23% was educated up to class 8, 3% up to SSC, 2% up to HSC and 25% was illiterate. Mobile vendors worked on average for 10 years in the mango supply chain.



**Figure 11 Mobile vendors value chain overview**

Figure 11 provides an overview of the mobile vendors value chain. Mobile vendors each purchased on average 14,592 kg/year of which 826 kg/year was unsold. This is 5.7% of the total input. Most mobile vendors purchased mangoes from wholesalers and *arathdar*. A small amount of the respondents purchased mangoes directly from agricultural producers or from *faria*. Mangoes that were not sold went to landfill, used for domestic consumption, or given for charity or to employees. 27% of the respondents mentioned they had no unsold mangoes and 10% sold it the next day. Mobile vendors sold mangoes directly to consumers, to hotels or to retailers.

Overall, 12% of the mobile vendors sorted and graded the mangoes after purchasing. They all sorted the mangoes based on size, colour and shape. Less than 5% of the mangoes was sorted out and went to another destination than the intended food chain. Losses found during sorting and grading can have several causes which were equal to the retailer. They mentioned landfill, charity and own consumption as destinations.

Three out of sixty mobile vendors sold the mangoes as cut mango pieces and nine respondents had a washing machine to clean the mangoes. Losses due to handling can occur due to peeling or when people cut off bad parts.

14% of the respondents used own packaging materials. They put on average 5 kg of mangoes in a plastic net bag or plastic bag.

Storage was used by 20% of the mobile vendors. They used a storage facility that is dry and ventilated with fan, a storage facility that is dry and ventilated but without fan or they use a storage facility that is a closed store without fan. They stored it in plastic crates or loose for less than one week to prevent product loss, wait for market demand, to ripe the product, or to secure a good price and higher profit. Of the mobile vendors that stored the product, 92% mentioned they had less than 5% losses due to storage and one respondent (8%) mentioned between 5-10%. Losses after storage can occur due to bad storage facilities or since bad quality mangoes are stored. These mangoes went to landfill or were mixed with the soil. Part of the mangoes was also used for own consumption, or were given to employees or for charity.

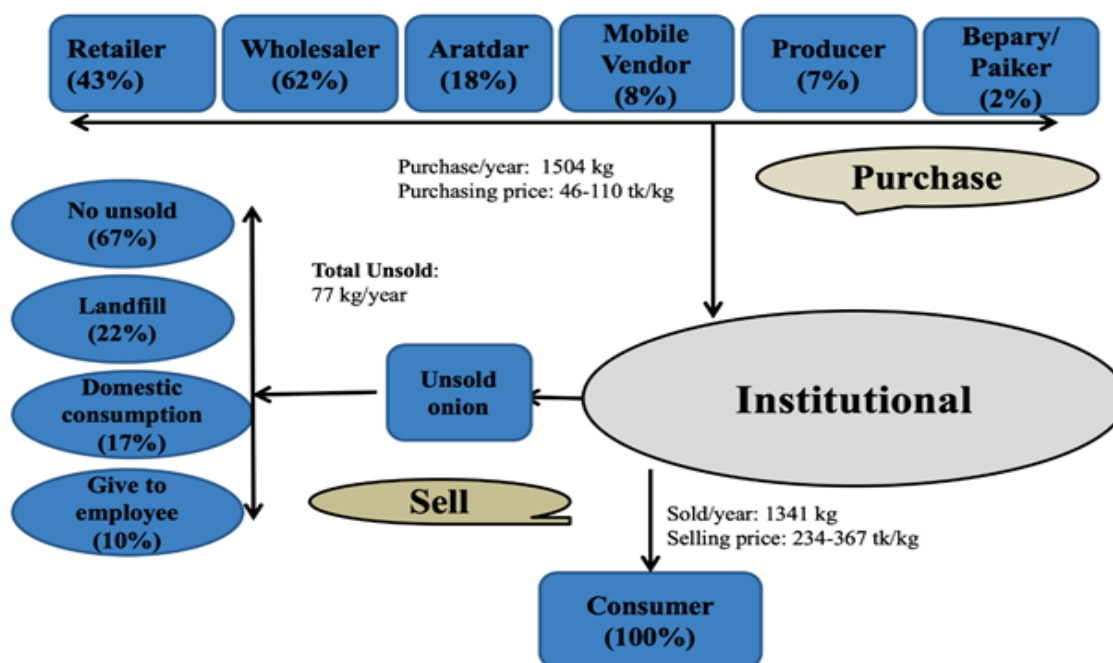


### 3.1.6 Institutional users

Different types of institutional users (N=60) were interviewed (See Table 7). Their average age was 36 year and they had been involved in the mango supply chain for 8 years on average. 97% of the respondents was male and the education level was up to SSC (27%), up to class 5 (23%), up to HSC (17%), up to class 8 (15%) or illiterate (8%). Two out of sixty respondents were female.

**Table 7 Type of institutional users interviewed**

Type of institutional user	Number	Percentage
Mango juice seller	40	67%
Mango bar seller	3	5%
Mango pickle seller	11	18%
Cut mango seller	2	3%
restaurant	1	2%
Service holder	2	3%
Online Food Shop Owner	1	2%
<b>Total</b>	<b>60</b>	<b>100%</b>



**Figure 12 Institutional users value chain overview**

Figure 12 shows the institutional users value chain overview. Institutional users each purchased on average 1,504 kg/year from wholesalers, retailers, intermediaries, mobile vendors or directly from agricultural producers. Of this amount, 77 kg/year (which is 5.1% of the total input) was unsold and went to destinations like landfill, domestic consumption or given to employee. 67% of the institutional users mentioned they had no unsold mangoes.

One respondent mentioned sorting and grading the mangoes. The rest did not.

Institutional users processed the mangoes into juice, ready-to-eat food like mango bars or -pickles, cut mango pieces or they did not process them and sold them as whole mangoes. Respondents used different types of equipment, both manual equipment like a basin or basket to wash mangoes, or a peeler and knife. Mechanical equipment used were juicers or blenders, a washing machine or automatic peeler. Losses due to handling can occur due to peeling or when bad parts are cut off. 5% of the institutional users used own packaging material to re-pack the product after processing or purchase loose products.

Storage is used by 32% of the institutional users. They used a dry, ventilated, temperature controlled storage facilities, or a dry, ventilated room facility with fan.

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The products were stored in small boxes, small pack or sack, plastic crates or loose. The (processed) mangoes were stored from less than one week till more than six months to wait for market demand, prevent product losses, to secure a good price and receive a higher profit, for ripening the product, or to be able to have mangoes all year available. Losses after storage can occur due to bad storage facilities or since bad quality mangoes are stored.

## 3.2 Enabling environment

### 3.2.1 Transport networks

During marketing of mango, 25% of the agricultural producers took the responsibility for transportation, while the other 75% did not transport the mangoes themselves. Their buyers (*bepari* and wholesaler) took responsibility. Different vehicle were used, which included vans, trucks and pickups /mini trucks. 56% of the intermediaries did not transport the mangoes themselves but their buyers did. Commonly used modes of transportation at intermediary level were trucks and pickups /mini trucks.

Many challenges were faced during transportation of mangoes at agricultural producer and intermediary. Agricultural producers indicated primarily bad road communication (25%), high transport costs (23%), market or selling point far away (15%) and unavailability of transport (1.7%). Intermediaries reported high transport cost (74%), bad road communication (70%), far away of market or selling point (60%), bribe and extortion (16%) and unavailability of transport (14%). To overcome from these, intermediaries reported to pay high cost for transportation (76%) and 48% could not sell products in time.

External transporters were also included in this study. The respondents involved in the transportation of mangoes were male (N=15). The average age of the respondents was 34 years with an average work experience of 10 years. 33% of the drivers were found educated up to class 5, 33% up to SSC, 27% up to class 8, and 7% up to HSC. Drivers transported mangoes from different districts of Bangladesh such as Rajshahi (27%), Chapai Nawabganj (20%), Dinajpur (20%) and Kushtia (20%). They usually transported mangoes for *arathdar* (53%), *bapari* (47%), agricultural producers (20%), *faria* (13%) and wholesalers (7%). Their transport destinations included *arathdar* (93%) and wholesalers (69%). About 282,000 kg of mango were transported per year by the mango drivers. All the drivers (100%) indicated they owned the products when they transported it from one place to another. Drivers transported mangoes usually by truck or pickup/mini truck (20%). All of them (100%) transport mango over distances of more than 20 km. The majority of the drivers reported bad road communication (87%), bribe and extortion (87%), and high fuel cost (80%) as the main problems.

Generally within Dhaka, the actors themselves were responsible for the transportation between the buying location to their own location. 65% of wholesalers reported to be responsible for transport from the buying location to own location, of which 25% of the wholesalers transported the mangoes themselves. 53% of retailers transported the mangoes themselves, 68% of vendors, and 60% of the institutional users. Wholesalers used transport vehicles like trucks, pickups and human labour. For retailers the majority used vans, followed by pickup/mini truck, human labour, rickshaw and truck respectively. This is similar for mobile vendors who also mostly used vans. 42% of the institutional users indicated that they transported mangoes by rickshaw and 23% through human labour and vans. Transport challenges are also faced by wholesalers, retailers, mobile vendors and institutional users. They mentioned high transport costs and bad road communication as main challenges. Other common challenges were bribe and extortion (except for institutional users), market/selling point being far away, and unavailability of transport.

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### 3.2.2 Regulations

Agricultural producers were not very familiar with the regulations in the mangoes sector. More than 2/3 of the agricultural producers did not know any regulations. A small percentage (18%) mentioned the bound to sell in a specific date and 3% mentioned an imposed fixed price. Other actors were also not familiar with regulations (55-86% of the respondents). Some actors mentioned an imposed fixed price, time bound selling and bound to sell a certain amount. One respondent, part of the institutional users, respondent that they have to pay 15% VAT.

### 3.2.3 Institutional arrangements

Information between actors is shared and consists of information on market prices and market demand, and quality and safety standards. This information is mainly shared daily or weekly by personal communication or phone. Agricultural producers, intermediaries, wholesalers and drivers (all >80%) used phone calls daily. Other options actors used were social media, the newspaper or television. The main constraints agricultural producers, intermediaries, wholesaler, retailers, mobile vendors and institutional users faced included the reliability of the sources and rumours on demands and prices. The main problems of drivers consisted of no broad band internet, rumours on demand and prices, no phone network, reliability of sources and no online platform available.

The client can have demands related to the products. Quality and safety standards from the client, mentioned by the interviewees, included wishes for dryness, wishes for size, wishes for freshness and used levels of insecticides. Furthermore, some of the actors mentioned that they did not receive quality or safety standards from the client. Intermediaries and institutional users mainly received complaints about the price or about the poor quality of the produce.

Most actors were paid by cash directly (>80%). Some payment was delayed, but payed later without interest. A small percentage of the actors was paid by instalment. While transacting with buyers, agricultural producers faced constraints that included price fiction by buyers, bound to sell for low prices and delayed payments without interest. Constraints experienced by intermediaries, wholesalers, retailers, mobile vendors and institutional users included delayed payment, transaction on credit, payment in instalments or buyer does not pay at all. Prices are set based on: quality/grade, weight or number of packing units, colour, or smell.

## 3.3 Business services

### 3.3.1 Extension services

A small part of the agricultural producers received support from extension services about mango farming and a small percentage took part in some related government program. This included a tree fair and mango production related program workshop. Intermediaries did not receive support from extension services and only one respondent took part in a government program. The other actors did not get any support from extension services and they did not take part in any government program that supported their business.

Cooperatives play an important role in the mango industry. However, more than 2/3 of the agricultural producers that were interviewed mentioned they were not a member of a cooperative. Good points of cooperatives mentioned were that they can solve mango related problems together, and cooperatives can help agricultural producers to get training, loans and a higher price for their mangoes. Reasons to not join a cooperative mentioned included fraud which result in a lack of trust, money loss and time loss.

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### 3.3.2 Agro-chemical providers

Resource constraints related to production included lack of labour, competition for land, and lack of irrigation. Agro-inputs were not mentioned as a resource constraint for the production of mango. The other actors in the mango supply chain mentioned lack of labour, location on the market and access to credits and loans as the main resource constraints.

### 3.3.3 Technological support

Agricultural producers use different type of equipment for mango production, harvesting and handling. For production they used automatic sprayers and pruning machines. For harvesting they used hydraulic ladder and for post-harvest activities they used a sorting machine or washing machine. However not all agricultural producers used these automatic equipment. Some performed all of part of the activities manually. Main problems agricultural producers faced were mango diseases and natural disasters like heavy rains and droughts. Furthermore, they did not use temperature-controlled storage facilities. Intermediaries also faced problems with mango diseases, while wholesalers, retailers and mobile vendors had problems with rotten mangoes.

### 3.3.4 Financial services

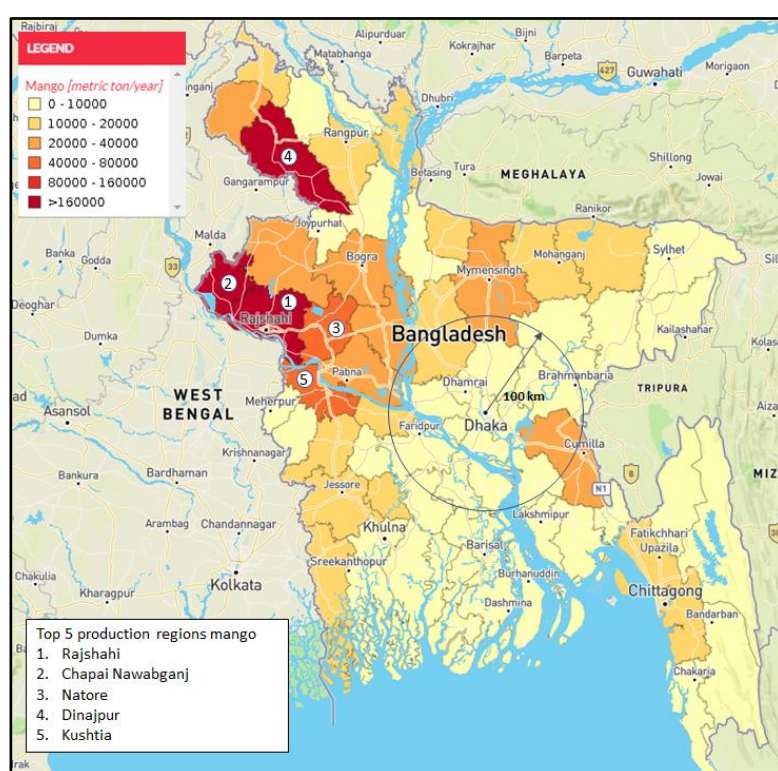
Loans were not commonly used by the different type of actors. Between 8-35% of the actors used loans, with the highest share for wholesalers. The actors received it from a bank, NGO, relative or somity (association). Loans were used for short- and long term family needs, investments on mango farming, for buying products or personal needs. According to the interviewees, loans were paid back with reasonable or high interest.

## 4 Results: Food availability

This chapter describes the food availability as described by the food systems approach of van Berkum et al. (2018). It includes three components: production, distribution and exchange.

### 4.1 Food production

Food production entails how much and which types of food are available through local production (FAO 1996 in van Berkum et al. 2018). The production of mango in Bangladesh is concentrated in the northwest of the country as shown in Figure 13. In 2017-2018 1,165 ktons of mangos were grown, compared to 1,288 ktons and 1,162 ktons in 2016-2017 and 2015-2016 respectively. Mango is not a top 10 horticulture crop, since it represents about 1% of the total horticultural Bangladesh volume. Main crops are rice and potato, together representing 50% of the volume.



**Figure 13 Mango production regions in Bangladesh (2017-2018) (BBS, 2019)**

The main mango production areas are located at the northwest border with India. The top 5 districts cover about 53% of the national production volume as shown in Table 8.

**Table 8 Top 5 mango production districts (BBS, 2019)**

District	Production in kton (2017-2018)
Rajshahi	242
Chapai Nawabganj	204
Natore	66
Dinajpur	53
Kushtia	47

There are many varieties of mango in Bangladesh. The top 3 varieties produced by the interviewees were Amropali, Khirsapat and Fazli, although none of them was dominant. International commercial varieties like Kent, Keitt, Haden and Tommy Atkins are not grown in Bangladesh, hence export opportunities are limited, but present.

Mango is a difficult fruit to manage, and very often (intrinsic) product deficiencies unfold later on in the supply chain. More than 60% of the agricultural producers claimed to have less than 5% product losses more or less confirming the delay in quality issues, that are mentioned by wholesalers and retailers. Losses are identified throughout the mango supply chain in Roy et al. (2019): losses at farm level 4.4%, *bepari* level: 8.43%, wholesale level: 9.21%, retail level: 8.61%.

Hence, at farm level product knowledge and experience, together with the appropriate product treatment, are crucial. In general, most Bangladeshi mango agricultural producers lack all this. An overview:

- Estimating the maturity level in relation to the time to market is an essential part of farm management, where experience or objective measurement is required. But labour is scarce, let alone skilled labour. As a consequence, the quality at market level can be very low.
- Mangoes require temperature control related to time to market and corresponding ripening. Cold storage is absent, so marketability lasts for only very few days.
- Bleeding of the mango is commonly not happening at farm level, and depending on the stem length the latex can hurt the fruit skin at very short notice.
- Hot water treatment (5-10 minutes in 50°C) to prevent anthracnose (disease) is commonly not applied.

Note that mango agricultural producers in Bangladesh use formalin to extend shelf life and sustain quality, whereas wholesalers and retailers mentioned this as a cause for the losses. In Monira et al. (2019) the advantages of formalin are denied based on scientific experiments. The effect of formalin either in any concentration or in mode of application (dipping and spraying) has no significant advantages over control with respect to shelf life and quality during storage. Rather treated mangoes with elevated concentration of formalin went for faster deterioration in overall physical changes (external colour, texture, shelf life, etc.) and changes were all most same for dipped and sprayed samples. Since storage is absent, this deterioration takes place when the mango arrives at the wholesaler and retailer.

To put the local production in perspective, a SWOT analysis is applied based on the results found in the literature studies and interviews (Table 9).

**Table 9 SWOT for Bangladesh mango production**

Strength	Opportunity
<ul style="list-style-type: none"> <li>• Harvest without dropping mangoes on the ground</li> <li>• 80% of agricultural producers use plastic crates</li> <li>• Self sufficiency</li> </ul>	<ul style="list-style-type: none"> <li>• Cooperative structure with trust</li> <li>• Only 10% of agricultural producers part of government program to support mango production</li> <li>• Export as initiated in 2015</li> <li>• Processing</li> </ul>
Weakness	Threat
<ul style="list-style-type: none"> <li>• Market price unstable</li> <li>• Markets are far away</li> <li>• High labour costs</li> <li>• Lack of (skilled) labour</li> <li>• Lack of automated activities (e.g., washing, grading, sorting)</li> <li>• Weak disease control</li> <li>• 95% gets no support from extension services</li> <li>• No storage</li> <li>• No washing</li> </ul>	<ul style="list-style-type: none"> <li>• No standardised quality</li> <li>• Road communication not good</li> <li>• Low reliability of demand volume and price</li> <li>• No proper network for internet or phone</li> <li>• Buyers cooperate to offer low price to agricultural producer</li> <li>• High transport costs</li> <li>• No investment incentive</li> </ul>

Combining elements from Table 8 the following main issues come forward.

**Market price:** According to the results from the interviews the farmgate price for mango during 2020 varied between 24 and 63 Tk/kg ( $\approx 0,24 - 0,63$  €/kg), which is only a little higher than the onion farmgate price (25-56 Tk/kg). Even at this price level the demand is often too low at retail level. Obviously, there is no incentive to invest in farm management. There is enough supply in the country (about 7kg/pp/year,  $\approx 40$  mangoes), import is negligible and mango can be replaced by other fruits in the consumption pattern, whereas onion is a unique part of many meals in Bangladesh.

The price for mangoes is unstable and unpredictable and seems to be influenced or controlled by intermediaries, traders and wholesalers. The mango production region is on the border to India and relatively far away from urban areas like Dhaka, Sylhet and Chittagong. Since transport is expensive, agricultural producers are bound to sell to local wholesaler syndicates, or local markets with low prices. In addition, market price and supply information are often not available to agricultural producers, because internet and phone network are absent or show low performance. And if information is available, it is often unreliable.

*Farm activities:* Although harvesting is done properly, post-harvest activities are limited, whilst mango is very sensitive to diseases, rot and damage. In export markets like EU, prices for mangoes are high because a lot of added value is put into the mango at farm level to arrive in the right condition (quality and ripeness) at the destination market. The throughput time in the domestic mango supply chain from harvest to consumer is short, and ripening is not a relevant activity and hence not controlled by the actors. There are opportunities for export but trust building requires a lot of effort after the fraud that occurred during the last few years.

*Transport:* in Bangladesh transport costs are high. For horticulture the logistic costs at supply chain level are estimated at 50% (Herrera Dappe et al. 2019). There are several reasons for that. Firstly, bribing the police is necessary when you travel over significant distances. Secondly, the road information system is very poor and together with congestion a lot of extra costs are involved. Congestion takes place on the road and at the ferry terminal. In this context it is difficult for agricultural producers to connect to high value markets in urban areas, unless they have some scale. This is especially the case for mangoes, since they are produced relatively far from the main cities at the western border with India.

## 4.2 Food distribution

In Bangladesh the distribution of food (and probably non-food as well) suffers from various non-food related issues. Extortion, bribing, traffic jam, bad road communication and therefore also high transport costs. This in particular affects the mango supply chain, where production is relatively far from the main markets. Drivers go from *Bepari* to *Arathdar* or from *Arathdar* to wholesalers and drive between 100 and 600 km (see Table 10). The common transport mode is an uncooled truck, and since harvest is from June to August, the summer temperature (25-30°C) during long distance trips will have a negative impact on the quality of the mangoes, that require a storage temperature between 9-10°C.

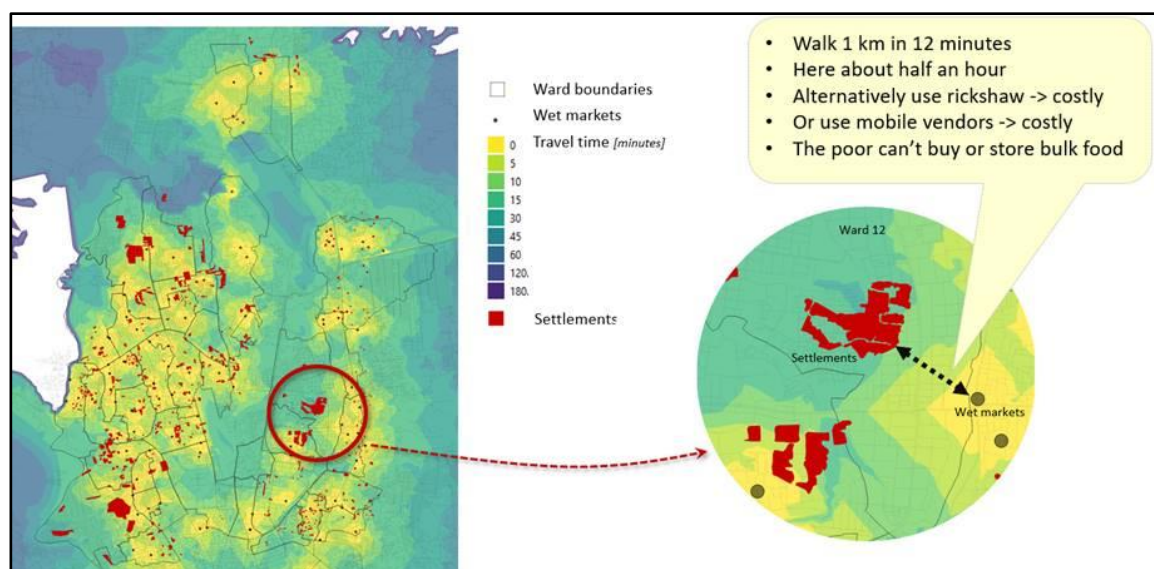
**Table 10 Distances (in km) travelled by the mango drivers in the project sample<sup>3</sup>**

	to	Barisal	Chittagong	Dhaka	Dinajpur	Feni	Gazipur	Khulna	Maniaganj	Sylhet
from										
Chapai Nawabganj		407	561	314				339	294	564
Dinajpur					≈100					
Kushtia				170						
Rajshahi			488	245		404	227			456

<sup>3</sup> <https://www.google.com/maps>, accessed 15-12-2020



In the interviews many of the intermediaries complained that there was no fixed market place for mangoes. Hence, costs and probably wastage will increase, while finding a location to sell. This is most likely a local issue, since in the urban areas like Dhaka there are many wet markets<sup>4</sup>. However, the traveling time for inhabitants to reach these wet markets varies significantly as shown in Figure 14. Clearly a few settlements are more than 30 minutes away from a wet market, probably implying less food availability because of additional costs.



**Figure 14 Travel time (in minutes) to nearest wet market for inhabitants of Dhaka<sup>5</sup>**

**Packaging:** Packaging can have many functions like protection, containment, convenience, communication and product climate control. Mangoes are very sensitive to bruising, and the use of plastic stackable crates helps. Nevertheless, the quality of the roads together with the long distance will commonly cause quality damage when arriving at the wholesalers. The packaging used by the various actors is shown in Table 11.

**Table 11 Most common packaging used by actors in the mango supply chain (interviews)**

Actor	Most common packaging
Agricultural producer	plastic crates (≈25kg), also some bamboo baskets (≈45kg)
Intermediaries	2/3 uses plastic crates, 1/3 bamboo baskets
Wholesaler	plastic crates
Retailer	Purchase loose, then pack in plastic net bag or plastic bag (≈5kg)
Street vendor	Purchase loose, then pack in plastic net bag or plastic bag (≈5kg)
Institutional	Purchase loose, then pack (e.g., plastic (net) bag) (≈12,5kg)

**Transport:** The logistic costs are high, due to bribing and huge traveling times. Truck owners feel compelled to make facilitation payments to traffic police and labour unions to ensure smooth passage through different districts. Especially for long distance deliveries the impact is immense. Congestion impedes normal driving speed, even on highways. The average speed of a truck is between 25-30 km/h on the highway from Dhaka to Chittagong (Herrera Dappe et al. 2019). As presented in Table 12, a detailed analysis on logistics by the World Bank shows that the average truck speed in the country is 19 km/h.

<sup>4</sup> A wet market is a market that sells perishable foods such as meat, fish, fruits, and vegetables. Wet markets can be found around the world, but are especially common in China and Southeast Asia (<https://www.dictionary.com/e/pop-culture/wet-market/>), accessed 15-12-2020

<sup>5</sup> Based on spatial analysis from Wageningen Environmental Research (mail Anouk Cormont, October 29, 2020)



**Table 12 Speed statistics for trucks in Bangladesh (Herrera Dappe et al. 2019)**

VARIABLE	MEAN		MINIMUM		MAXIMUM	
	UNCONGESTED	ACTUAL	UNCONGESTED	ACTUAL	UNCONGESTED	ACTUAL
Distance (kilometers)	113	114	20	20	318	306
Duration (hours)	2.8	18.0	0.7	2.5	7.4	96.2
Speed (kilometers/hour)	40	19	20	0.4	60	36

Source: World Bank analysis.

Also, the river Padma is a logistic bottleneck. It separates West from East Bangladesh and the only connection by road is the Bangabandhu Bridge. The ferries crossing the Padma River that connect the southwest with Dhaka and other divisions in the east are inefficient, with long and uncertain waiting times. Without making extra payments at ferry crossings, it takes trucks 5–24 hours to cross rivers, which results in low utilization rates for trucks and damage to perishable cargo. Therefore, a large number of trucks take the longer route across the Bangabandhu Bridge to reach the southwest districts and the border with India (and vice versa). Currently a new bridge is built that will connect Louhajong, Munshiganj to Shariatpur and Madaripur. The multi-purpose Padma Bridge is expected to be opened in 2021.

Transport for all actors is mainly by road. For short distance it can be by foot, van, rickshaw, pickup or minitruck, whereas for long distance larger (uncooled) trucks are used.

Summarizing, the conclusion is that not much value is added in the mango supply chain. A clear argument is the low prize for mangoes. Whereas it reaches high prices in Europe, the demand of fruit is very low in Bangladesh. Retailers often mention lack of consumers as a major problem and a cause of food loss. There are two causes for that. Firstly, in Karim et al. (2017) and Hassan et al. (2010) it is shown that the fruit consumption was 34 gr/day in 2007 and one piece of fruit/day in 2010. And there are many fruits, and mango is just one of them, although it is the fruit that has the highest production (FAOSTAT). Secondly, consumers fear eating mangoes ripened artificially with calcium carbide because it ruins the quality of the fruit and is hazardous to health (USAID 2016). Strangely, the field survey showed that intermediaries and retailers did consider food safety (e.g., use of pesticides) as a minor selection criterion for the mango, compared to size, firmness and colour.

The SWOT analysis for mango distribution in Bangladesh is shown in Table 13.

**Table 13 SWOT for Bangladesh mango distribution**

Strength	Opportunity
<ul style="list-style-type: none"> <li>Plastic crates are used throughout the supply chain</li> <li>Payment between actors is done at delivery in cash in most cases</li> </ul>	<ul style="list-style-type: none"> <li>Padma bridge reduces lead time and costs</li> <li>Storage in case distance to market is low</li> <li>Focus on varieties that are preferred by consumer (taste) <u>and</u> less sensitive to mechanical damage (road)</li> <li>Branding food safety like 'Bagan Bilash', induced by USAID (USAID 2016); set up safe chains</li> </ul>
Weakness	Threat
<ul style="list-style-type: none"> <li>Bad connectivity between West and East of Bangladesh</li> <li>High transport costs</li> <li>Bribe along the road</li> <li>Bad roads cause quality decay</li> <li>Uncooled transport induces quality decay</li> <li>35% of wholesalers and 33% of retailers mention damaged/rotten mangoes as their main problem</li> </ul>	<ul style="list-style-type: none"> <li>High risks from nature (especially long distance)</li> <li>Increasing population and migration to Dhaka will increase logistic costs and lead time</li> </ul>

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## 4.3 Exchange

Exchange of food entails how much of the available food is obtained through exchange mechanisms such as barter trade, purchase, or loans (FAO 1996 in van Berkum et al. 2018). The production area of mangoes is far away from the main markets like Dhaka, Chittagong and Sylhet. Hence agricultural producers are very dependent on intermediaries, since supply in the local market will be sufficient. About 1 out of 6 sell directly to the market; the rest sells to the intermediaries: *faria*, *bepari* and *arathdar*. Similar to other fruits and vegetables, price and demand information is lacking or unreliable, weakening the position of the agricultural producer even more. Although a cooperative structure could decrease the imbalance of power in the supply chain, there is too much distrust and fraud according to the interviewed agricultural producers.

The intermediaries sell (in general 7 days a week) to all types of actors. Since mango is a relatively small product in the Bangladeshi fruits and vegetables market, in many places fixed market places are absent. This impedes the selling of a very perishable product like mango. In spite of this problem losses are indicated to be about 2.1%, mostly going to landfill.

There are more than 10 mango varieties on the market, all taking a significant share. None of these varieties is present in the EU or US market, where Keitt, Kent, Tommy Atkins and Haden are dominating.

Intermediaries use the phone for selling and retrieving market information. The absence of internet hampers market transparency and the market power, especially if favourable urban markets are far away.

Payment is mainly cash and based on quality. The main quality criteria were size, colour, freshness, dryness and hardness, although objective quality measurements are not operational in the supply chain. A little over 50% of the intermediaries do sort and grade according size and colour, which is costly because of expensive labour. No other value is added to the mangoes, like washing, hot water treatment, ripening, damage protecting packaging, etc. This is a big difference with the EU and US, where the time from agricultural producer to consumer ranges between 8 and 28 days. In Bangladesh it takes maximum a few days to consumption. It is unclear if ripening or particular varieties could increase consumer demand.

Wholesalers had the same modus operandi as intermediaries with respect to working hours and quality criteria, but sorting and grading is more common practice since this is carried out by 85%. This might be induced by the fact that many mangoes have suffered from the long distance transport. Wholesalers proclaimed that rotten mangoes are one of their major problems. 60% of the wholesalers stored mangoes, always less than a week. The reason is market speculation on price and demand. Losses were around 2.9% with, in general, destination landfill.

Although retailers and mobile vendors use the same quality criteria, about 70% and 88% respectively did not perform sorting or grading again. After all, the main transport distance was from intermediary to wholesaler, and that is where damage risk is high. Retailers and mobile vendors only transport their purchased mangoes over a distance less than 5 km. Commonly they did not add any value to the mango; only some notching in 7% of the cases. They suffered a lot from the uncertainty in price and demand, since they usually had no storage facilities. This would not be feasible regarding their daily amount of sales. The losses were about 3.7% for retail and 5.7% for mobile vendors, going to landfill mainly.

The institutional market players purchased from wholesalers and retailers. They applied the same quality criteria as other actors, but did not sort and grade after purchase. This is because mangoes are processed by them (hotels, restaurants, etc.). They crunch, cut and notch mangoes for direct consumption only. Their losses were about 5%, again with landfill as the main destination.

All transactions in the domestic mango supply chain are in cash. A regular problem is delayed payment, in particular by retailers and mobile vendors who indicate a lack of cash as one of their main problems.

In Table 14, the purchase and selling prices are showed. The prices of 2020 are more or less equal compared to the prices of 2019. The prices of some varieties are slightly higher compared to last year, while other varieties are slightly more expensive compared to 2019. Overall the Khirsapat variety is the most expensive and the Guti variety is the cheapest.

**Table 14 Purchase and selling prices for 2020 and 2019**

Price of mangoes in TK/kg	Agricultural producer	Intermediary	Wholesaler	Retailer	Mobile vendor	Institutional user
Purchase price		23-80	29-119	50-172	43-119	46-110
Selling price	22-61	32-119	37-127	68-210	59-149	234-367

*Export:* In 2015 Bangladesh started exporting mangoes to US and EU. The first year 165 tons was exported, which is 0,01% of the production. After an increase in 2016 the export went down in the last few years. Exporters did not buy mangoes from contract agricultural producers with Good Agricultural Practices, but directly from the market at lower prices (The Financial Express, 2017). However, on reaching the importing countries, especially in the US and in Europe, most of the mangoes that were bought from local markets were found to be infected with pests. These mangoes were accordingly rejected and then destroyed. As the rate of rejection rose, the demand for the Bangladeshi fruit continued to fall in the importing countries and was lower than 100 tons in 2019 (The Daily Star, 2020), which is 0,02% of the main exporter in the world, Mexico.

The SWOT analysis for mango exchange in Bangladesh is shown in Table 15.

**Table 15 SWOT for Bangladesh mango exchange**

Strength	Opportunity
<ul style="list-style-type: none"> <li>• Most actors do not require loans</li> <li>• No import dependency</li> </ul>	<ul style="list-style-type: none"> <li>• Explore demand requirements in domestic and international markets to optimize variety selection</li> <li>• Processing options in production region</li> </ul>
Weakness	Threat
<ul style="list-style-type: none"> <li>• Delayed payment and transaction in credit</li> <li>• Weak market position agricultural producer, because lack of good information and power of intermediaries</li> <li>• No added value in the supply chain</li> <li>• Low margin for all actors; low price</li> <li>• Huge price fluctuations disturbing the market</li> <li>• Contracts are absent in the supply chain</li> <li>• Distrust hampers organizational development</li> </ul>	<ul style="list-style-type: none"> <li>• Restricted investment in rural areas with respect to information technology</li> </ul>

## 5 Conclusions

This report presents the results of a value chain analysis for mangoes in Bangladesh, the country's most 'fruitful' fruit in terms of production. This study offers relevant indications for FLW hotspots in the chain. Reducing FLW enhances the amounts of food that reaches consumers, and therefore contributes to improving food availability.

FLW takes place at various links of the value chain. Part of the produced mangoes cannot be sold and cannot go to the intended market. Besides the losses that occurred during production (infected and diseased products), different post-harvest activities resulted in losses. Products that do not have the right quality for the intended market are sold on the local food market or to processors, used for home consumption, given to employees or to charity, or used for animal feed, mixed with the soil or landfill/thrown away.

Losses due to harvesting occurred because sometimes it was impossible to harvest the mangoes (e.g. tall trees). Other reasons were that mangoes were perished or damaged due to the harvesting activity, or infected or diseased. Mangoes will perish when not stored properly or when harvested too late. Fruits that have a lower quality at the moment of harvest will perish faster, since small bruises will increase or express itself later in time, and therefore later in the supply chain. Underlying reasons for low quality mangoes at the agricultural producer level often originate from inadequate use of inputs such as fertilizer and pesticides, or the moment of harvesting.

The percentage of unsold mangoes per actor, together with the causes of losses, can be found in Table 16.

**Table 16 The amount of unsold mangoes and their causes**

Actors	Unsold	Causes
Agricultural producers	1.8% of the mangoes not sold	Harvesting: damaged, perished, infected or diseased fruits or impossible to harvest Post-harvest: exposure to sun, rough handling, damages during the activities
Intermediaries	3.5% of the mangoes not sold	Transport: Damages due to road conditions and packaging Sorting: Purchasing bad quality fruits: causes should be sourced earlier in the supply chain, transportation and packaging, rough handling.
Wholesalers	2.9% of the mangoes not sold	Transport: Damages due to road conditions and packaging Sorting: Purchasing bad quality fruits: causes should be sourced earlier in the supply chain, transportation and packaging, rough handling. Storage: No proper storage facility with temperature control, bad quality already at moment of storage
Retailers	3.7% of the mangoes not sold	Sorting: Purchasing bad quality fruits: causes should be sourced earlier in the supply chain, or transport damages due to road conditions and packaging Storage: no proper storage facility, bad quality already at the moment of storage, or no market on time
Mobile vendors	5.7% of the mangoes not sold	Sorting: Purchasing bad quality fruits: causes should be sourced earlier in the supply chain, or transport damages due to road conditions and packaging Handling: cut off bad parts, peeling losses Storage: no proper storage facility, bad quality already at the moment of storage, or no market on time
Institutional users	5.1% of the mangoes not sold	Handling: cut off bad parts, peeling losses Storage: no proper storage facility, bad quality already at the moment of storage, no market on time

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Wholesalers and intermediaries handled the largest amounts of mangoes and they had a relatively small percentage that remained unsold compared to the actors later in the supply chain. Most unsold mangoes were found at the end of the supply chain at the retailers, mobile vendors and institutional users. The lowest percentage of unsold mangoes was at the agricultural producer level, but still 88% of included agricultural producers remained with unsold mangoes. Of the other value chain actors, the retailers mostly lacked the ability to sell all mangoes: 85% indicated to remain with unsold mangoes.

Specific challenges in the enabling environment also contribute to losses in the mango value chain. Except for agricultural producer level, other actors greatly agree on the hampering effects of high transport costs and bad road communication. Bribe and extortion was faced by 87% of the drivers. There are opportunities in making transport more available under better conditions. Cooperatives play an important role in the mango industry. Agricultural producers are sometimes bound to sell mangoes for low prices due to price fixing further along the chain. In addition to helping to get access to loans and trainings/technical support, cooperatives can play a role in bargaining for better prices for mangoes. Weather conditions can harden mango production through heavy rains and droughts. Mango diseases are a common problem among agricultural producers.

Mango is the king of fruits in Bangladesh. Many varieties can be found, it is the number one fruit produced in Bangladesh, and Bangladesh is the 10<sup>th</sup> mango agricultural producer in the world. Nevertheless, demand is low compared to the production volumes, and as a consequence the price is low too. Domestic mango is available during the summer only, and cannot be stored longer than 4 to 8 weeks. Mango is a very sensitive fruit and significant investments to reduce losses and maintain harvest quality are not justified by the current price. Under current circumstances adding value to the supply chain to avoid quality decay is very difficult. In the next section we however formulated recommendations to enhance the performance of the mango supply chain in Bangladesh.

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## 6 Recommendations

The four Dhaka city corporations are responsible for interventions that can be applied within the borders of their districts and have a regulatory starting point. They have impact on the local (market) regulations, including monitoring, prices, syndicates and food adulteration. However they can also facilitate and stimulate the private sector to invest in new proven interventions or in the implementation phase, and set the agenda for long term goals that have to be implemented in collaboration with the government of Bangladesh (GoB). For this reason the recommendations for a strategic action agenda are provided below can have different potential implementors including the government of Bangladesh (GoB), city corporation (CC), the private sector (PS), or a combination of these actors, dependent on their responsibilities.

### Short-term recommendations:

- Investigate whether branding with respect to food safety is an option to increase demand (and price) in medium and high-end markets in urban areas (CC & PS).
- The government should monitor market regularly and take action against market syndicates (CC & GoB).
- Incentives such as subsidies and loans with low interest from governments or other organizations will increase the possibility for agricultural producers to invest through reducing production and labour costs (GoB).

### Medium-term policy recommendations:

- The government should explore ways to support export. Export seemed to have potential in 2015, but trust needs to be restored and professional supply chains should be built. Training and trade support (fair visits, information on e.g. EU requirements) are crucial. Competition in the world market is from India, Thailand in Senegal, countries that export in the summer as well. It is advised to find out if previous consumer preferences (like in the UK) for Bangladeshi mango varieties still hold, since some competitive edge is required in this value-added market in Western countries (GoB & PS).
- Timely, adequate, and accurate information is the basis for policy formulation and decision making, but there are often major discrepancies in the information and data on agricultural production reported by the two government agencies responsible for collecting it—the Bangladesh Bureau of Statistics (BBS) and the Department of Agricultural Extension (DAE). Measures should be taken to reconcile the data reported by these agencies, improve their quality, and minimize their delivery time (GoB).
- Develop an information and communication system among the agricultural producers (GoB & PS).
- Support cooperative formation and good management. Cooperatives play an important role in the mango industry. However, more than two third of the agricultural producers that were interviewed were not a member of a cooperative. Cooperatives can aid in filling voids related to access to technical support, pricing, access to inputs and finances, and even transport. Trust within the organisation is a prerequisite for success (PS & GoB).

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Long-term policy recommendations:

- Depending on the short to mid-term development of the national and international demand of mangoes, the government should consider to support agricultural producers to grow other products that are suitable in these areas and driven by consumer trends (GoB).
- According to Hassan et al. (2010) the fruit intake in Bangladesh is far below the advised quantity for a healthy diet. Since fruit and vegetables are cheaper than meat and dairy products, the accessibility for Bangladeshi people to fruit in general and mango in particular is fine, which is a favourable condition to stimulate the population to eat more fruit (CC).
- Transportation system and facilities should be developed and the government should take necessary steps to avoid additional costs during transportation. The Padma Bridge is a good example as the first fixed river crossing for road traffic. It will connect the south-west of the country to northern and eastern regions (GoB & CC).
- Improving the quality of the mangoes at the production level ensures a decrease of losses in the rest of the supply chain. Supply chain actors at the end of the supply chains face problems with mango rot and bad quality fruits. This can be solved by paying more attention to production, harvest and post-harvest handling, like handling and storage at the farm level. Effective extension systems to facilitate and educate agricultural producers can improve the quality (GoB, CC & PS).

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The mission of Wageningen University & Research is "To explore the potential of nature to improve the quality of life". Under the banner Wageningen University & Research, Wageningen University and the specialised research institutes of the Wageningen Research Foundation have joined forces in contributing to finding solutions to important questions in the domain of healthy food and living environment. With its roughly 30 branches, 6,800 employees (6,000 fte) and 12,900 students, Wageningen University & Research is one of the leading organisations in its domain. The unique Wageningen approach lies in its integrated approach to issues and the collaboration between different disciplines.

