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Food Systems for Healthier Diets in Bangladesh

Towards a Research Agenda

Alan de Brauw, Jillian Waid, Craig A. Meisner, Fahmida Akter, Bushra Ferdous Khan,
Lalita Bhattacharjee, Md Nazmul Alam, Sabiha Sultana, Md Nazim Uddin,
Foyzul Bari Himel, Kendra Byrd, M Latiful Bari, Shamia Chowdhury,
Shakuntala Thilsted, and Rudaba Khondker

CGIAR Research Program on Agriculture for Nutrition and Health

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AUTHORS

Alan de Brauw (a.debrauw@cgiar.org) is a Senior Research Fellow in the Markets, Trade, and Institutions Division of the International Food Policy Research Institute (IFPRI), based in Washington, DC, USA.

Jillian Waid (jwaid@hki.org) is a researcher, National Information Platform for Nutrition, Bangladesh, and a Senior Scientist with the Potsdam Institute of Climate Impact Research, based in Potsdam, Germany.

Craig A. Meisner (craigmeisner@gmail.com) is a Senior Technical Advisor with the Food and Agriculture Organization of the United Nations (FAO), based in Dhaka, Bangladesh.

Fahmida Akter (fahmida.akter@bracu.ac.bd) is a Senior Research Fellow with James P Grant School of Public Health, BRAC University, based in Dhaka, Bangladesh.

Bushra Ferdous Khan (bushra.khan@northsouth.edu) is a Lecturer with North South University, based in Dhaka, Bangladesh

Lalita Bhattacharjee (lalita.bhattacharjee@fao.org) is a Senior Nutritionist with FAO, based in Dhaka, Bangladesh.

Md Nazmul Alam (n.alam@cgiar.org) is a Program Manager for the CGIAR Research Program on Agriculture for Nutrition and Health at IFPRI, based in Dhaka, Bangladesh.

Sabiha Sultana (ssultana@gainhelath.org) is a Technical Specialist- Monitoring, Learning and Research with the Global Alliance for Improved Nutrition (GAIN), based in Dhaka, Bangladesh.

Md Nazim Uddin (nazim.68@gmail.com) is a Senior Scientific Officer with the Bangladesh Agricultural Research Institute, based in Gazipur, Bangladesh.

Foyzul Bari Himel (foyzul.bari@gmail.com) is a freelance development practitioner, based in Dhaka, Bangladesh.

Kendra Byrd (k.byrd@cgiar.org) is a Nutrition Scientist with WorldFish, based in Penang, Malaysia.

M Latiful Bari (latiful@du.ac.bd) is an Associate Professor with University of Dhaka, based in Dhaka, Bangladesh.

Shamia Chowdhury (s.chowdhury@cgiar.org) is a Nutrition Scientist at WorldFish, based in Dhaka, Bangladesh.

Shakuntala Thilsted (s.thilsted@cgiar.org) is the Research Program Manager for Value Chains and Nutrition at WorldFish, based in Penang, Malaysia.

Rudaba Khondker (rkhondker@gainhealth.org) is the Country Director, Global Alliance for Improved Nutrition (GAIN) Bangladesh, based in Dhaka, Bangladesh.

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ABSTRACT

The national food system of Bangladesh has made substantial progress since experiencing famine in 1974, soon after independence. After the famine, the government placed a strong emphasis on policies required to attain grain self-sufficiency; since attaining self-sufficiency, the production system, policies related to it, and resulting diets have begun to diversify. Nonetheless, undernutrition remains a problem, and fruit and vegetable consumption are inadequate for most people relative to international recommendations. Moreover, as the food system has begun to transition towards a modern one, challenges related to food safety and perceived food adulteration have begun to rise. Further, increased processed food intakes are potentially associated with existing rising overweight and obesity status. Both government interventions and innovations are needed to help shift the national food system to improve nutrient-dense food availability, particularly among the poor, and to limit the increase in processed food consumption.

Keywords: Bangladesh, food systems, diets, food environment

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ACRONYMS

A4NH	CGIAR Research Program on Agriculture for Nutrition and Health
AEZ	Agroecological Zone
AME	Adult Male Equivalent
AVC	Agricultural Value Chains
BARC	Bangladesh Agriculture Research Council
BAPA	Bangladesh Agro-Processing Association
BBS	Bangladesh Bureau of Statistics
BIRDEM	Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorders
BFSA	Bangladesh Food Safety Authority
BROA	Bangladesh Restaurant Owners Association
BSTI	Bangladesh Standards and Testing Institute
CIAT	International Center for Tropical Agriculture
DHS	Demographic and Health Surveys
DLS	Department of Livestock Services
DoAE	Department of Agricultural Extension
DOM	Degree of Milling
EU	European Union
FAO	Food and Agriculture Organization
FPMU	Food Planning and Monitoring Unit
FSNSP	Food Security and Nutrition Surveillance Project
GAIN	Global Alliance for Improved Nutrition
GAFSF	Global Agriculture and Food Security Program
GDP	Global Domestic Product
GLOPAN	Global Panel on Agriculture and Food Systems for Nutrition
GMOs	Genetically Modified Organisms
HIES	Household Income and Expenditure Survey
HKI	Helen Keller International
HLPE	High Level Panel of Experts on Food Security and Nutrition
ICN2	Second International Conference on Nutrition
ICDDR,B	International Centre for Diarrhoeal Disease Research, Bangladesh
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IMPACT	International Model for Policy Analysis of Agricultural Commodities and Trade
JPGSPH	James P. Grant School of Public Health
MOF	Ministry of Food
MOI	Ministry of Industry
NCD-RisC	NCD Risk Factor Collaboration

NCDs	Non-Communicable Diseases
NGO	Non-Governmental Organization
NIPORT	National Institute of Population Research and Training
PFDS	Public Food Distribution System
PPWR	Parboiled Polished White Rice
SAFAL	Sustainable Agriculture, Food Security, and Linkages
SMEs	Small and Medium Enterprises
UN	United Nations
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WFP	World Food Programme
WHO	World Health Organization

1. INTRODUCTION

Adequate diet quality is essential throughout the life cycle for sufficient growth, for mental and physical development, and for minimizing the risks of noncommunicable diseases (NCDs) (Lim et al., 2012; Ng et al., 2014). Yet diet quality is poor among a substantial share of the world's population, a fact that is increasingly acknowledged by governments, civil society, and the private sector (e.g. Second International Conference on Nutrition [ICN2], 2014; International Food Policy Research Institute [IFPRI], 2014; High Level Panel of Experts on Food Security and Nutrition [HLPE], 2017; Development Initiatives, 2017). The prevalence of undernourishment, meaning the number of people who lack access to adequate calories, has begun to slowly increase after a long decline (FAO, IFAD, UNICEF, WFP, and WHO, 2019). Meanwhile, substantial numbers of people suffer from widespread micronutrient deficiencies, and a rapidly growing share suffers from overweight and diet-related NCDs. These challenges are linked, as food systems—whether global, national, or sub-national—do not supply appropriate nutritious and safe foods for healthy lives (Global Panel on Agriculture and Food Systems for Nutrition [GLOPAN], 2016; HLPE, 2017). In many countries, there appears to be a shortage of supply and low rates of consumption of healthy dietary components such as fresh vegetables, fruits, legumes, and nuts. And the consumption of unhealthy dietary components, including sugar-sweetened beverages, saturated and trans fats, sodium, and ultraprocessed meats, is steadily increasing (Imamura et al., 2015).

According to the 2017 Demographic and Health Survey (DHS), Bangladesh had a stunting rate of 31 percent of children under five years of age in 2017, which is high despite substantial recent progress (NIPORT and ICF International, 2019). The prevalence of wasting (acute malnutrition) is reported as 8 percent among the same population. This reduction in undernutrition has been accompanied by a rapid increase in the proportion of Bangladeshis who are overweight or obese. For example, Bulbul and Hoque (2014) report that 14 out of 100 children living in urban areas of Bangladesh are overweight or obese (10 percent overweight and 4 percent obese). As overweight or obesity status is associated with the risk of non-communicable diseases, Bangladesh must urgently address problems of excess consumption.

The Government of Bangladesh, with the support of the United States Agency for International Development (USAID), the European Union (EU), and with technical support from the Food and Agriculture Organization (FAO), prepared a multi-sectoral Country Investment Plan to address hunger and malnutrition (FPMU, 2017). The investment plan delineates five areas in which investments should be made: 1) Diversified and sustainable agriculture, fisheries and livestock for healthy diets; 2) Efficient and nutrition-sensitive post-harvest transformation and value addition; 3) Improved dietary diversity, consumption, and utilization; 4) Enhanced access to social protection, safety nets, and increased resilience; and 5) Strengthened enabling environment and cross-cutting programs for achieving food and nutrition security. This commitment represents an attempt to continue shifting policy away from grain self-sufficiency and to address malnutrition in all forms.

To support this commitment, there is a call for capacity building and research to help implement, learn, and develop a systems approach adapted to the local context (HLPE, 2017). By considering the outcomes of malnutrition from a systems perspective, we can take into account the interactions between different parts of a system to understand how they affect change together rather than simply trying to understand outcomes through isolated components (Oxfam, 2014). Such analysis can help us better understand paths of change and to adjust changes in the system when they are leading to unintended consequences.

In this paper, we identify and discuss the types of work that has been conducted on the food system and issues related to the food system in Bangladesh. For this paper, we applied the following methodology. We initially organized a consultative workshop in April 2018 with key stakeholders who have experience with the food system and agriculture sector in Bangladesh. After that meeting, we collectively selected topics that are applicable for Bangladesh and contributors began to review the nature of the food systems landscape in Bangladesh, identify knowledge gaps, and analyze the literature and existing data sources. Through this process, we performed a literature review and secondary data analysis, and formulated research questions. We then organized discussions with various stakeholders to obtain further input and feedback on a food systems research agenda in Bangladesh. Finally, we circulated our

findings to the key national stakeholders involved, for validation and feedback. A key part of the process was to ensure that the development of the food systems analysis and questions was grounded at every step by national strategies and plans.

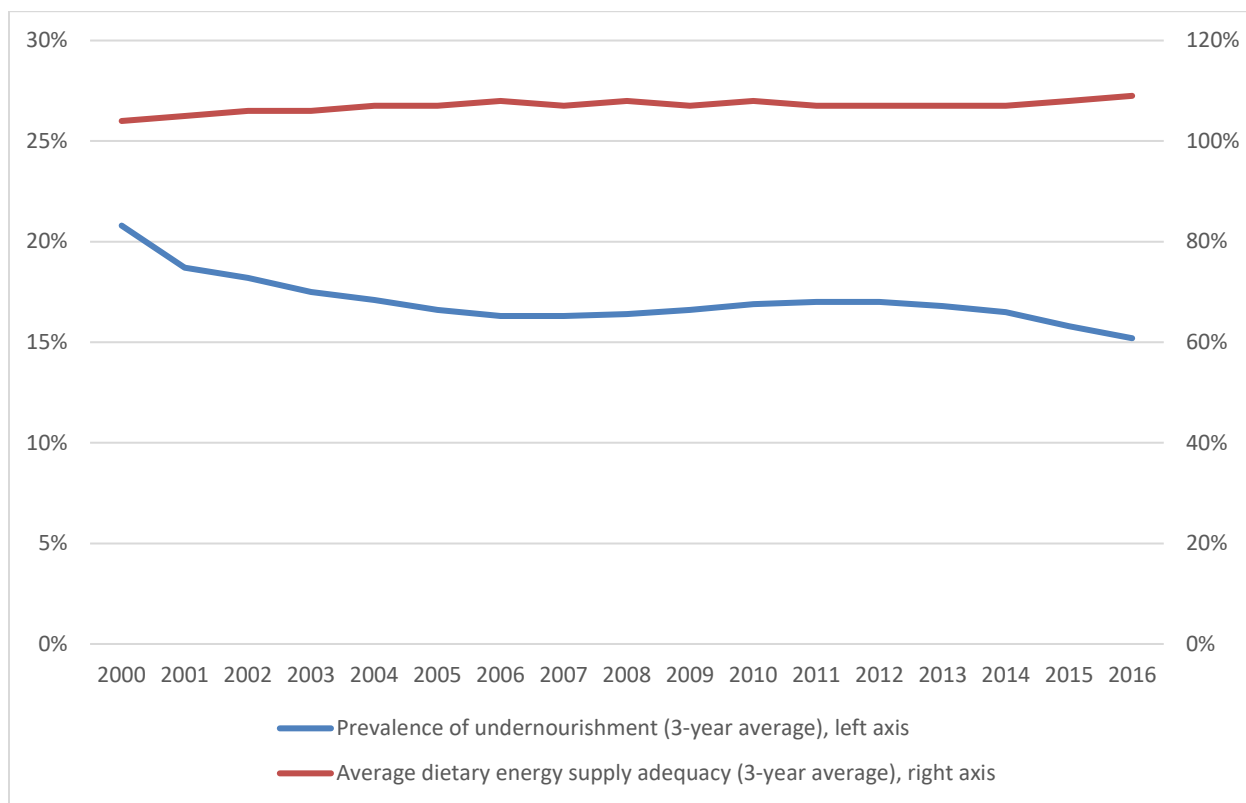
The paper proceeds as follows: The first section focuses on how diet quality can be considered as an entry point for improved health. The second section studies what we know about how people decide what to eat in Bangladesh, and the role the food environment plays in determining what they eat. The third section specifically examines what is produced, and the fourth section studies how agricultural products are traded and transformed into foods people eat. The fifth section briefly describes innovations taking place in the food system. The conclusion reiterates our main findings and consolidates the list of research questions that result from this study, to help guide future food systems research in Bangladesh.

2. DIET QUALITY AS AN ENTRY POINT FOR IMPROVED HEALTH

A healthy diet is the foundation for human health and well-being. A diet deficient in macro and micronutrients impedes physical and cognitive development, contributes to ill health, and, thereby, reduces economic productivity. Optimal health relies on an adequate intake of key macro- and micro-nutrients and phytochemicals. Healthy diets provide food that is safe and sufficient in terms of quantity and quality, providing individuals with essential nutrients in appropriate amounts.

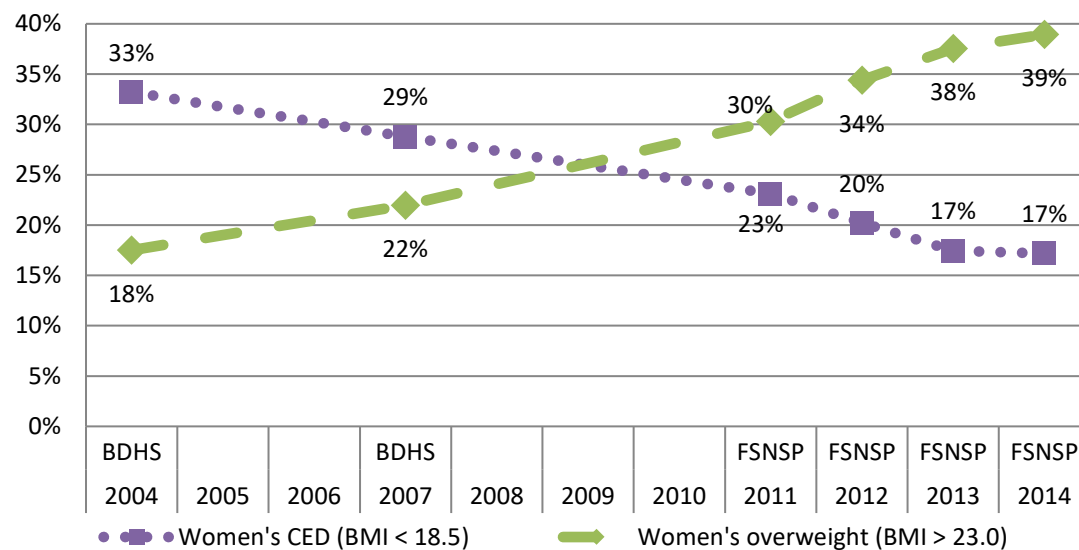
One of first ways people experience inadequate diets is hunger, caused by a lack of energy in the diet. Though the food supply data estimate from the FAO indicates that there is sufficient dietary energy available in Bangladesh to meet the needs of the population (Figure 1, right axis), this energy is not equally distributed. In 2016, about 15 percent of the population lack sufficient dietary energy in 2016, down from 21 percent in 2000 (Figure 1, left axis). This unequal distribution has implications for the persistent stunting prevalence in children less than 5 years old, and the continued prevalence of underweight status; the latter is concerning when viewed alongside concurrent increases in the proportion of adult women who are overweight or obese (Figure 2).

Figure 1. Dietary Energy Availability and the Prevalence of Undernourishment, Bangladesh, 2000-2016



Source: FAOSTAT

Figure 2: Changes in Nutritional Status of Adult Women, Bangladesh



Source: Authors, based on a reanalysis of DHS and FSNSP data

Adequate health also requires diets that provide adequate amounts of nutrients to support human health. A lack of comprehensive dietary information is common in many low- and middle-income countries, including Bangladesh. However, several in-depth dietary assessments have shown low intakes of several micronutrients among women and children. For example, a study in rural northern Bangladesh indicated the overall mean prevalence of micronutrient intake adequacy of 43 percent for children aged 24 to 48 months and 26 percent for their mothers. The prevalence of adequate intakes was below 50 percent for iron, calcium, riboflavin, folate, and vitamin B-12 for children, while intakes were inadequate among women for all nutrients except niacin and vitamin B-6 (Arsenault et al., 2012).

However, a national micronutrient survey in 2011 has indicated a disconnect between dietary intakes of certain nutrients and level of adequacy in the body. While low iron intakes in children have been documented, a number of other studies have found that relatively few children are iron deficient. A nationally representative survey found that on average, 10.7 percent of school aged-children were iron deficient (ICDDR,B, UNICEF, GAIN, and Institute of Public Health and Nutrition, 2013). One explanation for this discordance may be the concentration of iron in groundwater; another trial conducted in a region with low iron in the groundwater found a prevalence of iron deficiency of 35 percent (Merrill et al., 2011; Stewart et al., 2019). With zinc, we find the opposite story between consumption and status. While the dietary intake study in Northern Bangladesh demonstrated that most children are consuming adequate zinc through their diets (72 percent), almost half (48.6 percent) of rural children are found to be deficient when plasma zinc is measured (Arsenault et al., 2012).

To help guide improved diets, the Government of Bangladesh released its first dietary guidelines in 2015 (Table 1, column 1; BIRDEM, 2016). Most of the population does not consume enough food within many of the food categories listed in the guidelines (columns 2 to 5). In fact, a majority of the population consumes less than 75 percent of the daily recommended amounts in the guidelines for several food categories. Consumption of eggs and pulses is particularly low, with over 90 percent of the population consuming less than 75 percent of the recommended amount, and over 80 percent of the population consume less than 75 percent of the recommended amount of milk and fruits. The major

exception is starch consumption; 60 percent of the adult equivalent population consumes more than 625 grams per day, while less than 2 percent of the population consume less than 375 grams. Also notable, more than 10 percent of the population consume levels of fish, meat, oil, and sweets at levels more than 125 percent of the recommendation.

Table 1: Bangladesh Dietary Guidelines and Estimated Consumption of Food Groups

	Dietary recommendation in g/day*	Estimated consumption levels (2010)#			
		g/day per AME	% of dietary guideline	Consuming less than 75% of the recommendation	Consuming more than 125% of the recommendation
Starches%	500	682.8	137%	2%	60%
Pulses	50	15.3	31%	91%	2%
Fish	60	41.8	70%	62%	10%
Eggs	30	6.4	21%	96%	1%
Meat	40	22.0	55%	74%	14%
Vegetables	300	182.9	61%	72%	3%
Fruit	100	38.0	38%	83%	8%
Milks	130	40.4	31%	84%	6%
Oil	30	26.1	87%	47%	17%
Sweets	20	15.1	75%	63%	22%

% Starches combine cereals and other starchy vegetables and fruits such as taro, unripe fruits, and potatoes.

* The dietary guidelines reflect the dry weight of starchy foods but the wet weight of other items. There are multiple guideline levels listed in the official recommendation document. This table utilizes page 35 of the Bengali version (BIRDEM, 2015).

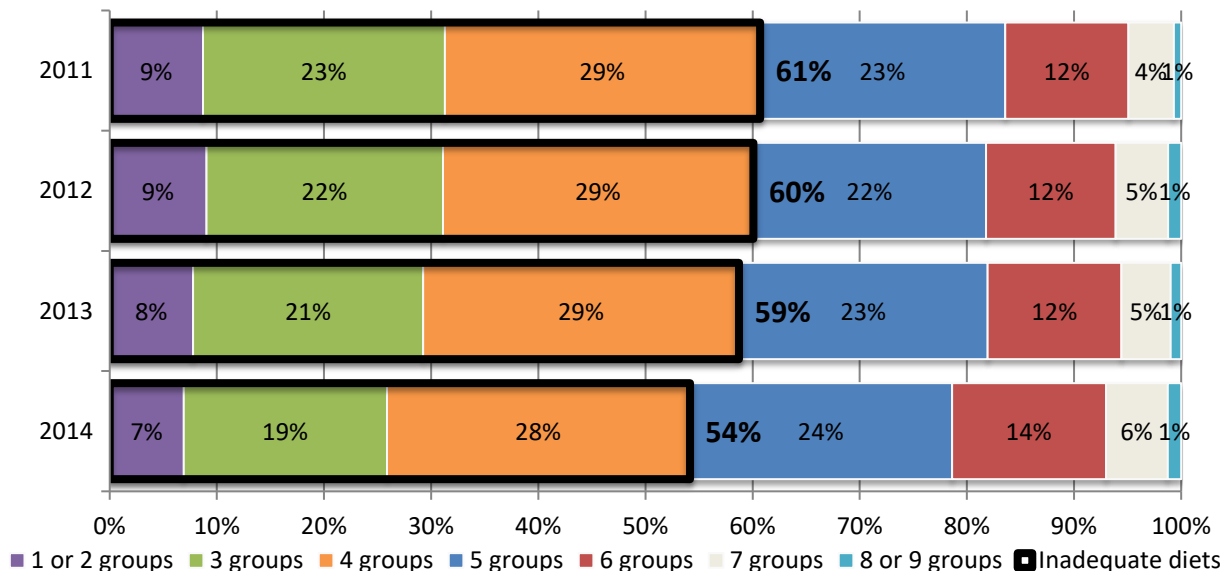
Estimates were derived from the 2010 Household Income and Expenditure Survey. Details of the methods used are contained in Waid et al (2018).

Despite deficiencies in dietary diversity and micronutrient intakes, diets in Bangladesh have slowly been improving. Due to the gap in comprehensive data over time, dietary quality in Bangladesh must be measured using simple indicators and non-optimal datasets. One key metric used to assess diet quality at household or individual level is dietary diversity, measured as the number of broad food groups that were consumed over a specific amount of time, and a diversified diet has a much higher probability of being sufficient in both micro- and macro- nutrients. In recent years, the proportion of women aged 10 to 49 years of age with inadequate dietary diversity declined from 61 percent to 54 percent. In addition, the proportion of women with the least dietary diversity declines from 32 percent to 26 percent (Figure 3,

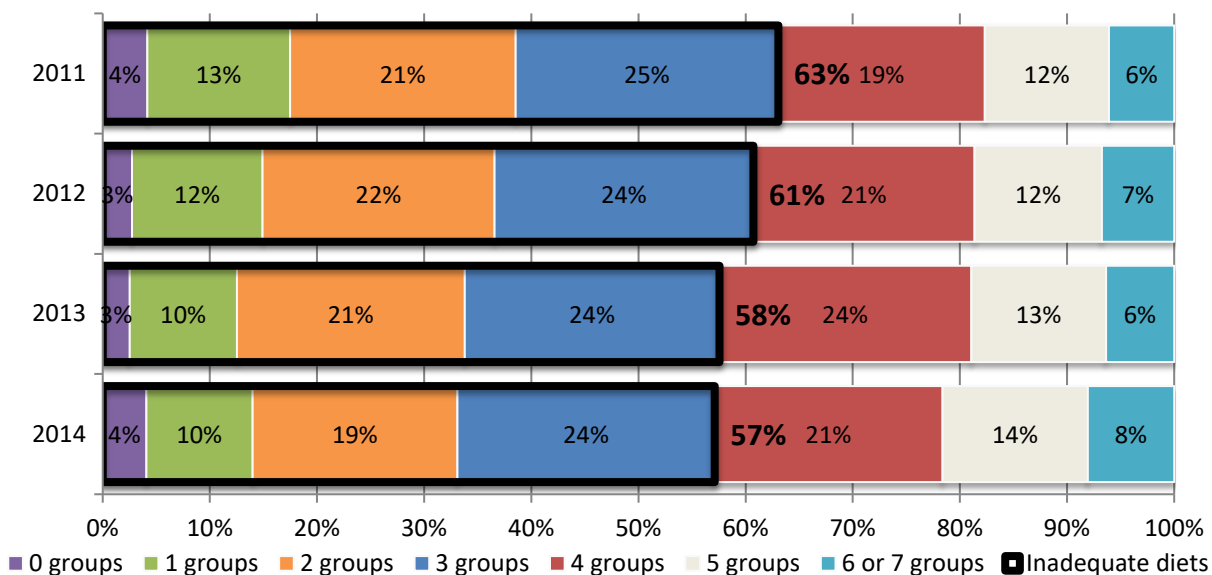
Panel A). Among infants and young children 6 to 23 months of age, the proportion consuming inadequate diets declined from 63 percent in 2011 to 57 percent in 2014 (Panel B).

Figure 3: Trends in Dietary Diversity in Bangladesh Among Key Demographic Groups, 2011-2014

Panel A: Women and Adolescent Girls



Panel B: Infants and Young Children (aged 6 to 23 months)



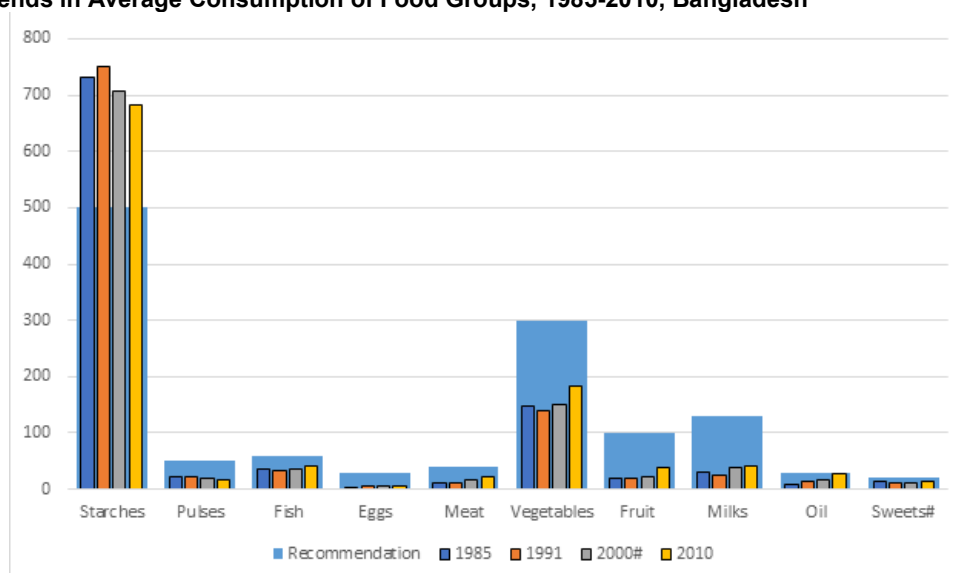
Source: FSNSP

These slow, positive changes are in line with larger shifts in the dietary diversity of the population of Bangladesh as a whole. The overall daily calorie intake per capita decreased from 2308.1

kcal in 2010 to 2210.4 kcal in 2016, due to the substantial decrease in rice consumption (BBS, 2017). Meanwhile, the same data indicate increases in animal source food intake. Beef and chicken intake increased from 6.8 to 7.5 grams and 11.2 to 17.3 grams per capita, respectively, and egg intake nearly doubled (7.2 to 13.5 grams/capita).

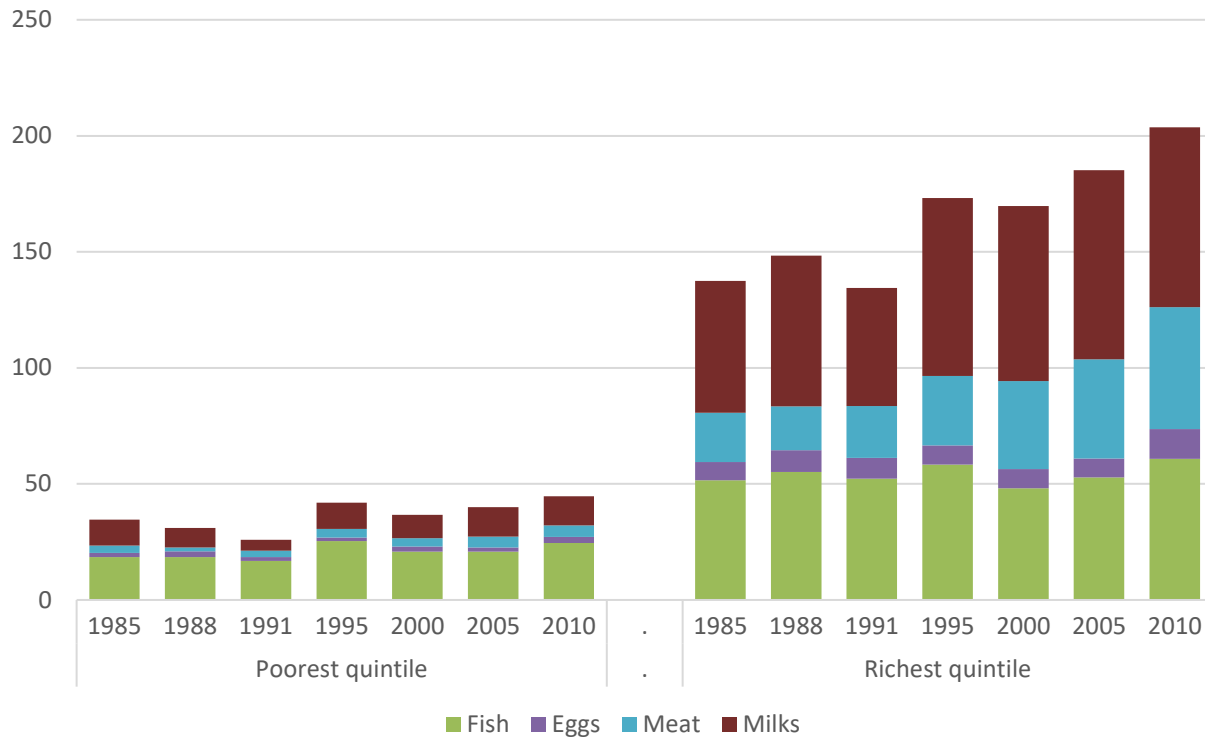
These broad dietary improvements, however, have not been experienced equally among all population groups and changes in drivers of monotonous diets, such as poverty and food insecurity, and inadequate production of non-starch foods, have not resulted in improvements in the diets of certain populations. While the proportion of energy derived from meat, fruits, vegetables, and oil consumed all increased from 1985 to 2010, dietary diversity has not improved at the same rate among all groups (Figure 4). Diets are becoming more diverse among the well-off, whereas those who are in poverty are not experiencing the same change. For example, the average consumption of animal source foods increased from 80 g per adult male to 111 g (sum of the fish, meat, eggs, and milk food groups in Figure 4), but there was little increase for the poorest income expenditure fifth (Figure 5). While the average meat consumption among the richest fifth increased from 137 g in 1985 to 185 g in 2010, the consumption levels of the poorest remained around 40 g for the entire period.

Figure 4: Trends in Average Consumption of Food Groups, 1985-2010, Bangladesh



Source: Estimates derived from 1985 and 1991 Household Expenditure Surveys and 2000 and 2010 Household Income and Expenditure Survey. Details of methods used contained in Waid, et al (2018)

Figure 5. Trends in the Consumption of Animal Source Foods, by Income Fifth, Bangladesh, 1985-2010



Source: Estimates derived from 1985 and 1991 Household Expenditure Surveys and 2000 and 2010 Household Income and Expenditure Survey. Details of methods used are contained in Waid, et al (2018)

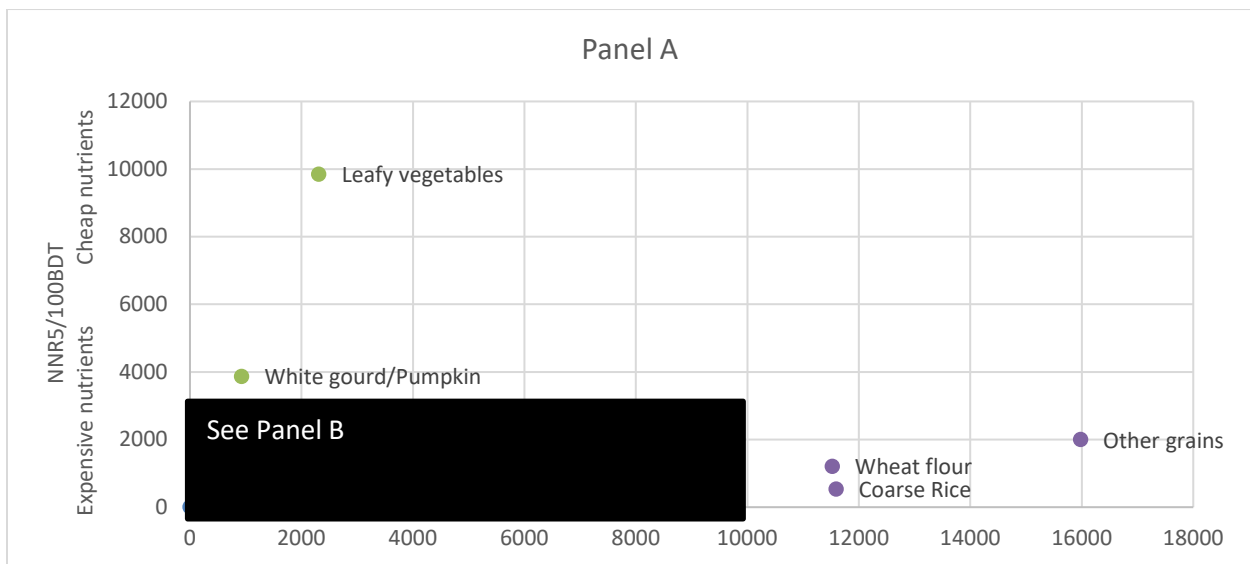
In addition, households do not always react to improving economic circumstances by improving their diets. Nearly 70 percent of households perceived food insecurity in 2011, which dropped to less than 30 percent by 2014. Not surprisingly, actual measures of dietary diversity have improved at a much slower rate over the same period (Figure 5). So, although food preparers no longer feel worried about food provision within their households, they are not necessarily adopting improved diets.

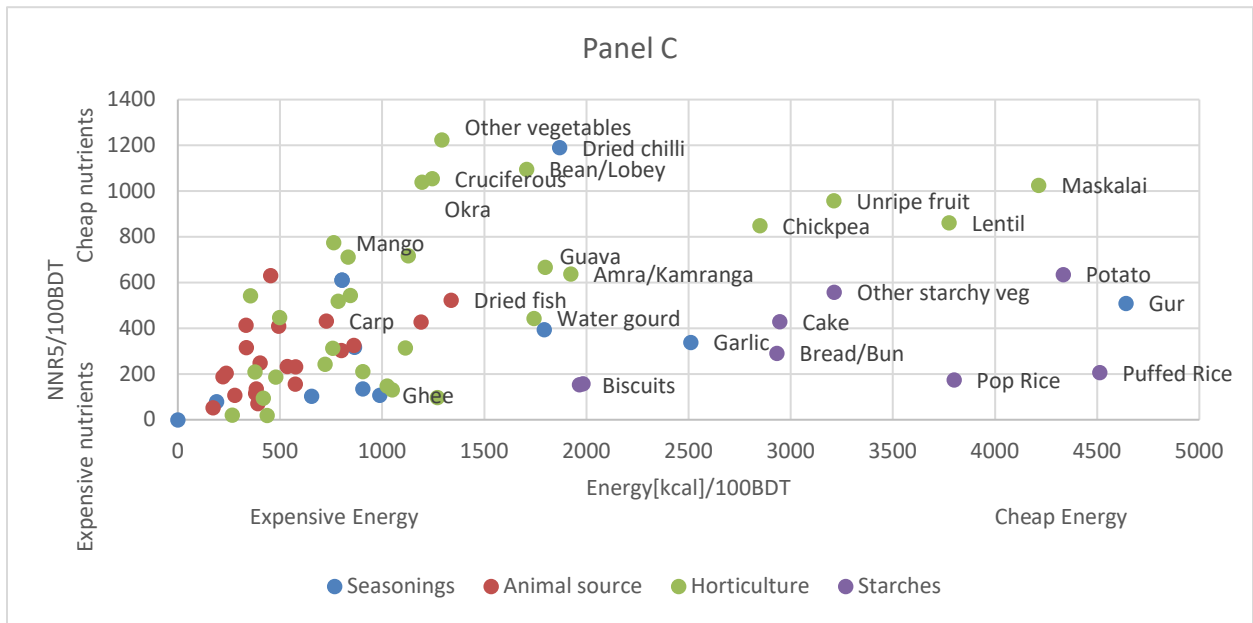
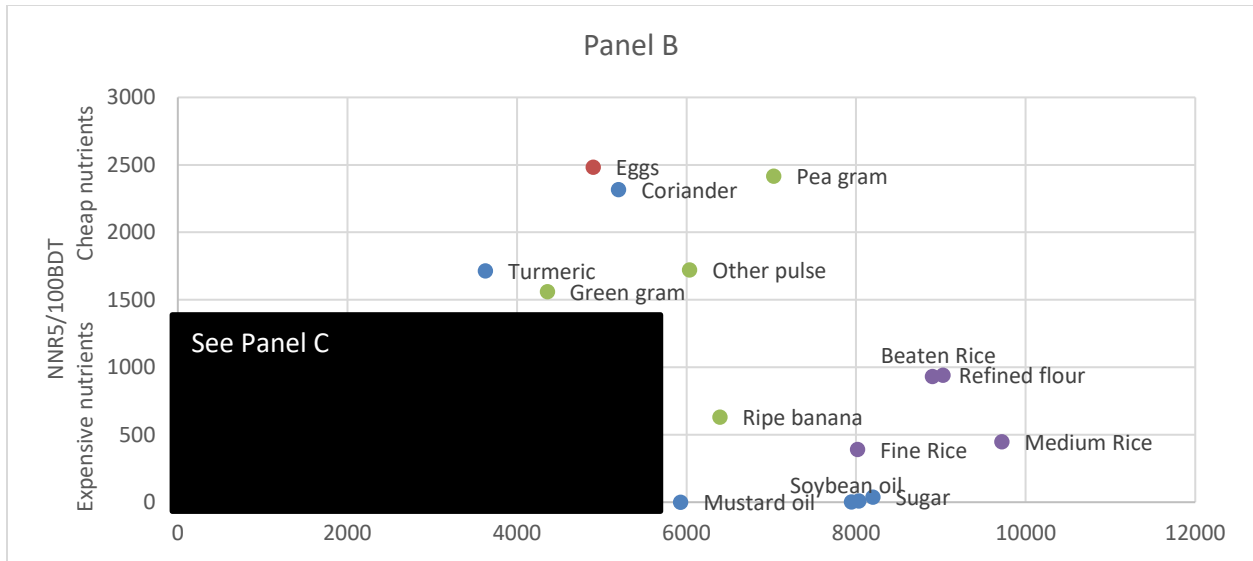
These differences in diet quality between populations are driven by both economic and non-economic constraints such as food availability, food costs, nutrition knowledge, and the nutrient density of foods being consumed. Not all foods, even in the same food group, have the same nutrient density. Nutrient-dense foods are rich in vitamins, minerals and other nutrients important for health, without too much saturated fat, added sugars, and/or sodium. For the remainder of the paper, we consider fruits, vegetables, and animal source foods to generally be nutrient dense, relative to most starches and tubers (with biofortified starches and tubers representing an exception). However, there is a great deal of

heterogeneity of nutrient density within those broad categories. Moreover, nutrient density upon consumption can be affected by food production decisions, food preparation and processing, food storage and preservations. In fact, the low bioavailability of some key micronutrients from foods, such as iron, zinc, and vitamin A, can be substantially enhanced with the right food combinations and with appropriate food processing and preparation techniques. Simple appropriate technology for the preservation of micronutrient rich foods would need further development and promotion for their year-round availability (Tontisirin, Nantel, and Bhattacharjee, 2002).

Similarly, the nutrients per taka spent on food is not equal across food groups or between items within food groups. Figure 6 displays information on the nutrient return per taka spent on food items relative to the energy return. Energy-dense foods such as rice, wheat and other cereals, sugars and oils supply fewer key nutrients than foods such as pulses, eggs and leafy vegetables that have much higher nutrients per taka spent. Few items are inexpensive for both energy and nutrients. The outliers (Panel A) score highly for either energy (grains) or nutrients (leafy vegetables or nutrient rich gourds) but no item is in the top right quadrant of the graph.

Figure 6. Nutrient and Energy Density of Food Items with Reference to Their Cost





Source: Reanalysis of HIES 2010 by FAO & FPMU

On the contrary, foods that have higher nutrient density per taka, such as meat and fresh fish, are usually more expensive (with the exception of dried fish) than eggs, leafy vegetables and pulses, which have good nutrient levels per taka. The diets of Bangladeshis have become increasingly energy dense, and the overconsumption of energy-dense foods can lead to overweight and obesity. It is important to shift food patterns and food system toward less intake of energy-dense foods and increased consumption of

nutrient-dense foods. The consumption of eggs, leafy vegetables and pulses should be further promoted. A clear implication of Figure 6 is that policy effort should be expended on ensuring nutrient-dense foods are more affordable, especially for vulnerable groups.

2.1 Research Questions

Although it remains a policy concern, the previous chapter shows that energy availability is now sufficient and diets are diversifying within Bangladesh, but they are not diversifying among all income groups. Therefore, it is sensible to expend policy effort either attempting to make nutrient dense foods cheaper, so they are more available to the poor, or to target specific nutrient dense foods for the poor. The section also suggests the following research questions:

1. How rapidly will dietary diversity continue to increase on its own? Will it begin to change among the relatively poor?
2. What strategies can be tested to make nutrient dense foods more affordable for the poor?
3. What factors led to changes in energy intakes and the composition of energy intakes between 2010 and 2016?
4. As purchasing power increases and demand shifts away from starches, what replaces them more rapidly—nutrient dense foods or more processed foods? Is this pattern heterogenous by income level or location (rural/urban)?
5. What food combinations should be promoted for better nutrient bioavailability?

3. DIETS AND THE ROLE OF FOOD ENVIRONMENT IN BANGLADESH

Basic economic consumer theory suggests that prices, income, and factors related to preferences drive people to select specific foods they eat. However, the concept of preferences deserves more careful thought; Rani (2014) identifies cultural, social, personal and psychological factors as the four major influences on consumer buying behavior, adding that these factors can cause consumers to develop product and brand preferences. These choices are all made within the food environment, which has recently been defined to encompass the availability, affordability, acceptability, and desirability of foods offered to consumers (Swinburn et al., 2014; Herforth and Ahmed, 2015; HLPE, 2017). The primary aim for the consumer behavior study is to have a holistic understanding of why, when, where, and how people are influenced to buy or consume a certain food item. Whereas the previous section documents how diets have begun to change as incomes rise, the availability, affordability, acceptability, and desirability of foods may also be changing, which could therefore affect diets. In this section, we consider how each aspect of the food environment affects diets, through the lens of consumer behavior. We list all generated research questions in a concluding subsection.

3.1. Diets and Food Availability

Food availability includes physical, economic and social access to foods (FAO, 1996), and the physical accessibility of food depends on distance, time, space and place, daily mobility, and modes of transport at the individual level (Turner et al., 2017). In Bangladesh, there is a lack of national level research on food availability, but several papers have used small surveys to study the accessibility of specific types of foods. In general, more understanding is needed about regional and urban-rural variation in food accessibility, even though some local availability of foods is known anecdotally throughout the country (e.g., coconuts in Barisal).

Market accessibility has a direct influence in food choice and diet diversity. In Kenya, Chege, Andersson, and Qaim (2015) show that market orientation improves nutrition, as farm household participation in supermarket contracts is correlated with increased nutrient intakes of vitamin A, iron, and

zinc due to increases in income and household vegetable production. In a multi-African country analysis, Sibhatu, Krishna, and Qaim (2015) found access to agricultural markets positively affects household dietary diversity, even more so than production diversity. If people have access to a nearby market, they can buy a wider variety of food items.

In Bangladesh, accessibility of more nutrient dense foods has been increasing in general. For example, the proportion of local markets in rural areas with fresh milk available increased rapidly between 2010 and 2014 (HKI and JPGSPH, 2013; HKI and JPGSPH, 2016). Mobile vendors selling vegetables and sometimes fish products increase the accessibility of those products. The introduction of supermarkets or convenience stores makes shopping convenient for some people in urban areas. Currently, supermarkets exist in the major cities, but those are thought to be mainly accessed by higher income populations.

That said, the household within which an individual resides plays an important role in determining the food they consume (GAIN, 2017). Within households, it is thought that males have priority in receiving protein-rich food, but there is little empirical evidence (Harris-Fry et al., 2017). Moreover, women are the first to sacrifice consumption when households face either negative shocks or food insecurity (HKI & JPGSPH, 2016). Therefore, gender discrimination can be a barrier to adequate nutrition within households when amounts of healthier food are constrained.

A main factor changing availability is urbanization, as it changes the choices available to consumers as well as their lifestyles and therefore food purchasing behavior. Bangladesh has been rapidly urbanizing recently (UN, 2018). In general, individual incomes increase when people move from rural to urban areas (de Brauw, 2019), and time available for food preparation changes as well (Seto and Ramankutty, 2016). Urban residents tend to have limited space and fuel resources to prepare and cook food within the household. Consequently, the urban diet is broadly shifting towards pre-prepared and pre-cooked food. Not surprisingly, urban residents are more likely to consume unhealthy amounts of fat, salt, and sugar, and lower the amounts of fiber, vitamins, and mineral intakes (Kearney, 2010).

Although evidence is largely lacking on the effects of urbanization on diets in Bangladesh, reanalysis of HIES data indicates that urbanization has increased the adoption of a more diverse dietary pattern and reduced the adherence to traditional and highly monotonous dietary patterns (Waid et al., 2019). Evidence from other economies undergoing this transition also shed light on what may occur in Bangladesh as urbanization rates rise. Analyzing data from China, Zhai et al. (2009) found that people living in urban areas also consume more animal source foods than those living in rural regions. Further, foreign direct investment by multinational food brands has increased the market presence of processed foods in developing countries. Therefore, high calorie intakes and low energy expenditures in urban jobs have combined to trigger obesity and diabetes in urbanizing developing countries around the world (Kearney, 2010).

Another factor playing a role in changing food availability in urban areas is that trade liberalization has facilitated the expansion of supermarkets. Supermarkets tend to replace central food markets, neighbourhood stores and street hawkers in urban areas. As a consequence, the retail food trade in developing urban centers becomes dominated by the coexistence of major distribution chains and small-scale, ill-organized commercial outlets (De Haen et al., 2003). With rapid urbanization, the supermarket industry is growing rapidly as a new purchase point for middle class and affluent consumers.

3.2. Diets and Food Affordability

Food affordability encompasses both incomes and food prices. Whereas rising incomes were covered in Section 2, Food prices are an important determinant of food choices in Bangladesh and elsewhere. Hirvonen et al. (in press) show that the EAT-Lancet diet, which is deemed sustainable and nutritious by a large, diverse group of scientists (Willett et al., 2019), is largely unaffordable for most people in developing countries. Moreover, prices for more nutrient-dense foods have been rising relative to prices for staples in Bangladesh (Bouis, Eozenou, and Rahman, 2011). Consequently, even as incomes rise relative prices for nutrient-dense foods may keep them unaffordable to much of the population in quantities necessary for a healthy diet.

Evidence suggests that the relative prices of healthy foods such as fruits, vegetables and animal proteins are still high compared to energy-rich cereals, sugars and oils, which particularly constrains food choice among the poor. For example, Akter and Basher (2014) study how price shocks affect household food consumption in lower income, rural households and identifying challenges for the consumption of healthier foods. Although evidence is scarce, given evidence of an increase in demand for highly processed foods and street foods, the implication is that their relative affordability must be increasing over time as well.

3.3. Diets and Food Acceptability

Solomon (2011) defines consumer behavior as the study of processes involved when individuals or groups select, purchase, use or dispose of products, services, ideas or experiences to satisfy needs or desires. An understanding of consumer behavior is important both to agriculture and nutrition interventions and for private sector investments in the food sector (Soethoudt et al., 2013). However, like many developing countries there has been little rigorous research into the factors that drive consumer choice, including preferences, taste, convenience, or other similar factors.

Social factors may play an important role in food intake patterns and dietary habits. Several studies suggest that eating behaviors and food habits are determined by a variety of individual, social, and environmental factors within a given context. Cultural influence also plays an important role in choosing food, and therefore potentially dietary patterns. Several statistics from the DHS survey are consistent with an increase in the consumption of energy-dense foods, especially highly processed carbohydrates.¹ One of the most concerning patterns has been the rise of obesity among women in Bangladesh; according to the 2014 DHS 23.8 percent of women were either overweight or obese. In fact, several studies have begun to address the resulting health problems (e.g. Bulbul and Haque, 2014). This challenge is not unique to adults; the obesity rate is rising among children as well. Though it was only 0.03 percent among boys

¹ Another cause of increasing overweight and obesity status is declining levels of activity; declining levels of activity may also contribute to or cause the rising rates of overweight and obesity that are found.

aged 6-17 and nil among girls in the same age range in 1975, by 2016 it was 3 percent among boys and 2.3 percent among girls (NCD-RisC, 2017).

As rice is the main source of energy in the Bangladesh diet, and it is mainly consumed as parboiled polished white rice (PPWR), there are now a substantial number of big polished rice mills established across the country. However, recent meta-analyses and cohort studies find a statistically significant, positive relationship between PPWR intake and the incidence of type 2 diabetes mellitus (Nanri et al., 2010; Nanri et al., 2010). This point partially explains the large number of people with diabetes in China and India, where PPWR is the primary source for dietary glycemic load. Due to polishing, the degree of milling (DOM) is increased and thus the loss of protein, minerals, free phenolics and flavonoids during the milling process might reach 28.6 percent, 84.7 percent, 65.1 percent and 72.3 percent, respectively (Lamberts et al., 2007; Liu et al., 2015).

Various forms of taboos, misconceptions, and cultural beliefs about certain foods or food practices exist worldwide (Quiroz & van Andel, 2015). In Bangladesh, only a few studies suggest such taboos. Bhuyan et al (1988) first detailed various food items that are restricted during and after pregnancy. Unhealthy food taboos and restrictions are also reported to be placed upon the pregnant women (Kindred, 2013) and children (Mukta et al., 2015) in Bangladesh, so they can be denied access to nutritious foods even when these foods are available within households. For example, many households report delayed feeding of meat, fish, and other nutrient rich foods to weaning infants, instead feeding only rice (HKI and JPGSPH, 2016; Thorne-Lyman et al., 2017). Despite these exceptions, the way that food taboos and beliefs affect dietary practices in Bangladesh are not well studied, particularly in the context of improving food availability detailed in the previous section.

Though no nationwide research efforts describe the way that food acceptability has been evolving, it is clear that food away from home has been accepted by many consumers. According to the HIES, the amount of food eaten away from home increased slightly between 2010 and 2016, and the trend is higher among urban population (39.5 percent) compared to 27.5 percent in rural areas (BBS, 2017). This trend fits more general hypotheses about the way dietary preferences shift towards processed foods

and particularly towards ‘food away from home’ as incomes rise (Pingali, 2007). Within Bangladesh, Mottaleb, Rahut, and Mishra (2017) using HIES data reported that rich households, as well as households with highly educated heads and spouses, spend proportionately less on such food, and found over time this trend continued. It could be they are more likely to hire people to prepare food for them.

Alternatively, such households may be either concerned about food adulteration with food away from home, or the HIES may not enumerate the types of semi-processed and processed foods that affluent households prefer (Mottaleb, Rahut, & Mishra, 2017).

3.4. Diets and Food Desirability

While affordability certainly influences choices related to food consumption, there are a range of other factors related to social norms, culture, taste, knowledge, awareness and individual choices that go beyond affordability into acceptability (Berkman, 1995; Anderson et al., 1998; Kearney et al., 2000; Akter et al., 2017). The sparse evidence in the literature suggests that consumers in Bangladesh appear particularly accepting of prepared foods when available. Several factors, including declining family size, may enable families to eat outside the home on a more regular basis and demand more convenient processed food.

It seems clear that advertising has influenced the desirability of unhealthy foods in Bangladesh. In advertising for such foods, the foods appear as attractive and healthy. A recent comprehensive report by Work for a Better Bangladesh Trust on advertising unhealthy foods focusing on sugar-sweetened beverages, fast-food and packaged chips shows that promotion of these foods is very common in Bangladesh through television and billboards designed to attract young people (WBB Trust, 2016). Further, the media disseminates misleading and sometimes incorrect information about foods such as *horlicks*, soft drinks, artificial or partial juices and fried chicken, which may lead to increased desirability of these products.

A number of studies show that school-going children, adolescents and university students are frequent consumer of processed foods, fast-food and street foods which reflected by the density of such

food outlets around educational institutes and other places commonly visited by adolescents and young adults in urban and semi-urban areas in Bangladesh. Islam and Ullah (2010) find that factors such as brand reputation, cleanliness, and similarity of taste with previous experience all contribute to fast food purchases among a sample in Dhaka. Similarly Goon, Bipasha, and Islam (2014) find that 56 percent of private university students go to fast food restaurants at least once per week. Nipun et al. (2017) find that university students spend 43 percent of pocket money on fast food. And Akter et al. (2017) study consumption among adolescent girls, finding that girls in rural areas drink more milk than girls in urban areas, because fresh milk is more available in the rural context. Anecdotally, food vendors near schools, college or university campus both in rural and urban areas, increase consumption of more processed foods.² However, all this evidence should be caveated as it is based on small, local samples. In general, advertising by fast food restaurants is mostly unregulated in Bangladesh, which may contribute to increasing demand.³

Social norms and empowerment also appear to play a role in determining consumption of food away from home (GAIN, 2017). In particular, unmarried young men and women consume more snacks than their married counterparts. Snack choice among those groups are partially determined by factors such as peer pressure, accessibility, and availability of snacks close to school. Yet being able to eat away from home does not necessarily imply higher total consumption; for example, school-going girls frequently skip breakfast or have small snacks at school. And when girls get married, their food consumption in terms of both quality and quantity changes substantially, as in-laws play an important role in choosing what is available for them to eat.

That said, there are several threats within the food system for desirability of food away from home. Considering more informal food vendors, their awareness and practice of food hygiene appears quite poor. Survey data from Barisal, Paul, Riad, and Chandra et al. (2017) reported that 71 percent of food processors do not use gloves when cutting and processing food; 35.5 percent of processors worked

² Dhaka Tribune (Available at: <https://www.dhakatribune.com/feature/2018/03/21/healthy-alternative-junk-food/>)

³ <https://bdnews24.com/bangladesh/2017/10/11/obesity-spreading-in-bangladesh-children-new-study-blames-junk-food/>

when ill and 54.8 percent of workers lack knowledge about the food-borne disease transmission. Finally, 67.7 percent do not use any protective gear when they work.

3.5. Summary and Research Questions

In general, both the food environment and its impact on diets are poorly researched in Bangladesh. A better understanding of how the food environment influences consumers' food purchasing and consumption decisions is necessary to make the food environment capable to deliver healthier diets. If key factors within the food environment are identified and can be modified, the food system can help provide healthier outcomes among consumers. There is a general lack of research on the food environment impacts on or associations with consumer behaviour and consumer health and nutritional outcomes. There is a general lack of research on how policy affects or alters the food environment. And finally, there is only limited research on understanding how different demographic groups (e.g., gender, age, ethnicity, location, income, education) interact differently with the food environment. The following research questions address these gaps:

1. Are changes in food availability changing intrahousehold allocations of food, particularly to more nutrient-dense food?
2. How is the availability of different types of markets changing the way that people obtain food? How does that differ by socioeconomic class?
3. What role has urbanization played in changing diets, by socioeconomic class and gender?
4. How much does a healthy diet in Bangladesh cost? How is that cost evolving and is it attainable by all socioeconomic groups?
5. Do people of different demographic or socioeconomic groups interact with the food environment differently?
6. What are the perceptions about importance of diet/food for better health outcomes among different age groups (adolescents, adults and old age)?
7. How are social determinants contributing to the rise in overweight and/or obesity status?
8. How rapidly is the consumption of food away from home increasing? Among whom and where is it rising fastest? Does food eaten away from home add to consumption or substitute away from food eaten at home, particularly among adolescents?
9. How does policy in Bangladesh affect the food environment?

4. FOOD SUPPLY IN BANGLADESH

To be available for consumption, food must travel through a supply system. Here, we consider four connected components of the food supply system: 1) the agricultural production sub-system; 2) the storage, transport, and trade subsystem; 3) the food transformation subsystem; and 4) the food retail and provisioning subsystem.

Food supply in Bangladesh is strongly influenced by previous policy decisions. Bangladesh was one of the poorest countries in the world at independence (1971), and three years later, in 1974, it experienced a severe famine. Therefore, protecting consumers and preventing famines became primary policy concerns. Given the concern about ensuring citizens would get enough to eat, it is not surprising that in recent years Bangladesh has become self-sufficient in rice production. The self-sufficiency has allowed farmers to diversify into increased vegetable production, and Bangladesh also has substantial aquaculture and capture fisheries. High value and early season vegetables enter both the rural and urban markets, allowing greater choices for higher nutritional consumption.

Appropriately implemented agricultural policies have allowed greater diversification to the rice-dependent systems, allowing improved nutritional choices to be available and as supplies increased, more affordable food to both rural and urban areas. Unlike other economies in South Asia, subsidies in Bangladeshi agriculture are low, which has allowed the import of rice, wheat, vegetables, and agricultural inputs at prices closer to world prices, making the sector more competitive in general.

4.1. Agricultural Production

4.1.1 Crop Production

Now that Bangladesh grows more rice than consumers demand, rice prices, and therefore profitability, are declining. As a result, land previously used for rice is being converted to higher-value crop or aquaculture investments. Due to the grain production surplus, high value crops such as fruits and vegetables, aquaculture, fodder, and livestock allow for either diet diversification and/or higher incomes potentially allowing the purchase of more nutritious foods, which either must be produced in Bangladesh or

imported. The production of rice has recently continued to increase. In 2018-19, total production was 34.9 million metric tons (Mt), having increased from 32.6 Mt in 2017-18. According to the Ministry of Food (MOF), as of March 2019, public rice stocks were 1.37 Mt, an increase of 33 percent over the previous year. Past and current rice heavy production patterns have been a contributing factor to monotonous diets (Waid et al., 2019).

Fruit and vegetable farming is quite profitable in Bangladesh. According to the BBS (2017), The production of fruits has grown from 4.76 Mt to 5.02 Mt between 2015-16 and 2016-17. Vegetable production has also increased, from 3.87 Mt to 4.05 Mt over the same period. While growth is promising, it does not represent adequate production of either fruits or vegetables for diets, even if everything was consumed in Bangladesh. Fruit production suggests availability of 83 g per capita per day, while vegetable production suggests availability of 67 g per capita per day. Clearly, both either require large increases to meet daily WHO dietary requirements, or substantial net imports of fruits and vegetables are necessary to meet requirements.

4.1.2 Livestock, Poultry, and Fish

Cattle production has been increasing rapidly in Bangladesh over the past decade (DLS, 2019). A recent growth catalyst was a recent ban of Indian cattle from entering Bangladesh by the Indian Prime Minister, increasing the profitability of cattle production. By 2016, the livestock population was increasing; in addition, recent numbers and case studies show that cattle fattening since 2015 is booming with the increase in fodder production and sales in the market. Overall meat production has increased from 1.99 Mt in 2010-2011 to 7.26 Mt in 2017-2018. Similarly, milk production has increased from 2.95 Mt in 2010-2011 to 9.41 Mt in 2017-2018.

Shrimp was originally introduced by growers in the 1960s as a response to salt infusion into the tidal estuaries. Shrimp production grew in southwest Bangladesh, and now represents its fourth largest export. Recent studies have clearly shown that shrimp cultivation has raised the income of those farmers, allowing increased dietary diversity by their families. According to the Yearbook of Agricultural

Statistics (2017), the Annual Fish Production in Inland and Marine Fisheries has increased from 3.8 Mt (2015-2016) to 4.1 Mt (2016-2017).

Changes in production patterns, even within categories, can affect nutrient intakes. For example, Bogard et al. (2017) showed that though the consumption of fish in Bangladesh increased by 30 percent between 1990 and 2010, the intake of iron and calcium from fish did not increase. The lack of a concurrent increase in mineral intakes could be attributable to the increased availability of farmed fish and the decrease of wild-caught fish over the same period, as evidence suggests that in some cases farmed fish species are less micronutrient dense than wild-caught fish (Bogard et al., 2015).

4.2. Production Changes Based on Climate Change

While this report is largely concerned with understanding how the food system can be influenced to provide healthier diets, climate change necessarily interacts with that goal, particularly through the production system. Dramatic changes in the climate may have a direct, long-term effect on Bangladesh's farming system. According to the Global Climate Risk Index, Bangladesh is the most climate change vulnerable country in the world (Harmeling, 2011).⁴ Likely negative effects include sea level rise and saltwater intrusion in southern Bangladesh, mean temperature increases (of 1.7 degrees Celsius by 2050), increased rainfall variability, and an increase in the frequency and intensity of extreme weather events. Clearly, dramatic changes in the climate may have a direct, long-term effect on Bangladesh's farming system.

An analysis using the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) for Bangladesh shows climate change has mixed effects on agricultural production, potentially creating yield increases and therefore land area for some crops, but decreases for others. Specific projected impacts depend on the crop production system in question. Crops that are projected to suffer the most include pulses, wheat, and oilseed-rapeseeds. The model demonstrates overall yield

⁴ A portion of this section has been derived from the climate smart agriculture profile of Bangladesh (CIAT and World Bank, 2017).

declines in maize, pulses, vegetables, jute and wheat, but increases for milk and meat yields by 2050. For example, 2050 pulse yields under the primary climate change scenario are 8.8 percent lower than the projected value if climate change did not occur. Wheat and oilseed-rape seed also experience large yield reductions, of 6.4 and 6.3 percent, respectively. Meanwhile, cattle herd sizes are projected to increase substantially—by roughly 52 percent over 2020—under both the climate change and no climate change scenarios.

In southern Bangladesh, rising soil salinity is the major challenge. According to Dasgupta et al. (2018), it is projected that increased soil salinity will lead to a 15.6 percent decrease in productivity of high-yield rice. Increased salinity can also potentially lead to a shortage of irrigation water for farming during the dry season, therefore depleting potential farm revenue. Moreover, relatively poor smallholders tend to bear the brunt of weather shocks. For example, the drought of 1994-95 led to a decline in the production of grains by about 3.5 million tons and led Bangladesh to import a substantial quantity of rice and wheat (Ismail, 2016).

Shrimp farming in the coastal area may also be affected by climate change. Shrimp tend to be farmed either in a monoculture or after rice. A concern is that as climate change occurs, areas good for shrimp farming that are now coastal may shift to areas that are now inland. Moreover, adapting these systems to climate change will require risk management not only in production landscapes but also in food storage, trade, and transport systems that link to the production landscapes.

4.3. Agro Ecological Zones and Production Diversity

Bangladesh has developed a well-defined agricultural research system, led by the Bangladesh Agriculture Research Council (BARC). The BARC has scientifically divided Bangladesh into 30 Agro-Ecological Zones (AEZ) as per its land, soil, crops, and agro-climate.⁵ The zones are used along with extensive soil fertility mapping to make recommendations about fertilizer that ensure crop and soil sustainability. Much

⁵ These 30 zones have been subdivided into 88 agro-ecological sub-regions, which have been further subdivided into 535 agro-ecological units.

of Bangladesh is composed of rich alluvial soil, deposited by unbridled floods over the centuries. However, flood control is important because the population density is quite high, thus not allowing future silt deposition over the lands as before.

Much of the land in Bangladesh is intensively cropped, as land use averages 196 percent of the area, or around two crops per year. Many areas have three crops per year, with some areas having four or more. With such intensive multi-cropping, the question of sustainability immediately arises. At this point, cropping systems have largely appeared sustainable so long as soil nutrients extracted are replaced by either organic or inorganic fertilizers. Almost all double or multiple cropped lands are irrigated, about five million hectares out of the potential of seven million hectares, allowing for greater cropping choices depending upon commodity price or season.

4.4. Research Questions

The above discussion of the production system suggests the following research questions:

1. How is the production of nutrient-dense foods changing in Bangladesh? What changes to production patterns could be enhanced to fill dietary gaps?
2. Is the cost of production of those foods competitive with imports?
3. How will climate change affect production patterns and what are the implications for diets?
4. What are the trade-offs between healthy food production and ecological measures such as soil and water quality and the carbon footprint of agriculture? What form of trade-offs are acceptable in Bangladesh to produce food needed for a sustainable healthy diet?

5. STORAGE, TRANSPORT, MARKET AND TRADE

5.1. Influence of Existing Storage in the Food System

Due to its history of famines, both in colonial times and just after independence, Bangladesh has developed a large system of public grain storage. Smaller local supply depots are distributed across 475 upazilas and are connected to 13 strategically placed central storage depots and seven silos at sea and river ports; the total capacity of these facilities is over 2 million metric tons. Further, the Public Food Distribution System (PFDS) is the main instrument for executing food policies in Bangladesh. Nonetheless, a recent study suggested close to 50 percent of all grain, mostly rice, is stored at the household level (Dorosh, Kindie, and Smart, 2017). According to the 2011 BIHS, almost all households (92 percent) hold grain stocks, and household grain storage tops out around 500 kilograms per household.

While grain storage is well developed, cold storage is more limited. Privately owned cold storage for potatoes, grown in the north, has rapidly grown recently, but it has not kept stocks and market prices stable (Hajong et al., 2014). Other types of cold storage remain less frequent; a potentially interesting research question would be how cold storage can be placed geographically to most effectively increase the availability of more nutrient-dense foods or maintain nutrient density within harvested crops for longer.

5.2. Impact of Transport, Trade and Marketing System Practices in the Food System

The road network has been substantially expanded and improved since independence. As a result, more than 60 percent of grain moves by road. Though the road network requires resource allocation for maintenance, improved roads have also allowed some innovations in vegetable marketing to develop. For example, battery motorized flatbed van cycles now facilitate affordable, relatively fast grain and vegetable transport to local hat bazaars. Some grain in particular is also transported by cargo train and through waterways. The trading system is also advantageous for the export and import of food. Tariffs are in 2019 are zero for milled rice, though in 2018, they were imposed and non-tariff barriers are not high, so the country has relatively free trade related to the export and import of grain, vegetables, and potatoes.

The main challenge to supply chains, other than underdevelopment, may be government interference in the rice market. The government both sets a procurement price and the timing of government procurement, and these decisions can be political rather than economic. For example, in 2018, procurement of *boro* rice began late, thus growers had already sold their stocks to traders, who in turn obtained higher procurement prices. For rice as well as other crops, local middlemen also play influential roles in determining the price paid to farmers and the onward direction of the supply chain.

5.2.1. Post-Harvest Losses During Transport and Storage

The Sustainable Development Goals have placed emphasis on reducing food loss and waste, which incorporate both post-harvest losses and losses once consumers have obtained food. Current estimates are that about 13.8 percent of food is lost or wasted, based on more recent, more rigorously collected estimates (FAO, 2019). However, losses among fruits and vegetables and other perishables are not as well understood, as many of the higher quality papers written recently focus on grains, legumes and potatoes (e.g. Delgado et al., 2017; Ambler et al., 2018).

Not surprisingly, losses in Bangladesh are suspected to be quite low for grains; one paper shows that rice and wheat stock loss, even in public grain storage facilities, is less than is one percent (Kabir et al., 2019). Similarly, transit losses for grains are thought to be quite low. On the other hand, anecdotally post-harvest loss of fruits and vegetables is quite high. A recently published paper assessed such losses as 12 percent at the farm level and an additional 10 percent in transport and trade, illustrating the decrease in such losses from previous years where it was supposedly more than 30 percent (Kaysar et al. 2016). The lack of cold chains, specifically refrigeration trucks, reduces the potential to transport perishable foods long distances. Assuming these losses are large enough, it would seem likely that improvements in the nutritional content of the food supply and environmental sustainability could result, making such reductions quite attractive. According to DoAE, 35 to 40 percent of total vegetables is wasted from production to consumption levels due to the absence of storage facilities and an improved transportation system.

5.3. Food Transformation

Food transformation can be defined as any method used to change raw ingredients or fresh foods into marketable food products. Food transformation can be as simple as washing and chopping fresh foods, but can include processes such as liquefaction, extraction, emulsification, drying, preserving, any form of cooking, pasteurization, sterilization, packaging, and similar processes. Finally, food processing encompasses the addition of components to food that turn fresh foods into food products. For example, adding chemicals safe for ingestion extends shelf life, or adding vitamins and minerals improves the nutritional quality of the food (fortification).

The food processing sector in Bangladesh represents a substantial portion of the manufacturing sector; it accounts for more than 22 percent of all manufacturing and employs about 20 percent of the manufacturing labor force (MOI, 2012), accounting for two percent of total GDP. Food processors sell their products both nationally and internationally. Export destinations are primarily countries with large Bengali diaspora. In other words, processors largely tap into proven export markets, as penetration in new markets has been low. That said, the export market for several products, such as spices, juices, and snacks, has been growing rapidly.

The sector is primarily dominated by small and medium enterprises with strong linkages to local production and high potential for processing, value addition and export (Hussain and Leishman, 2013). According to the Bangladesh Agro-processing Association (BAPA), small and medium enterprises account for more than 70 percent of the output in terms of volume and 50 percent in terms of value (BAPA, 2014). Still, all major business conglomerates in Bangladesh have invested in agricultural processing and are expanding their operations; their investment is well spread across interrelated markets (agro-machinery and equipment, inputs, post-harvest infrastructure). There are nearly 700 processed food-manufacturing enterprises in the country including homemade processing units, of which at least 30 are processing fruits and vegetables (Latif, Rahman, and Ehasan, 2015). The food-processing sector includes products derived from cereals, pulses and oilseeds, dairy, fruits and vegetables, other animal products, and other food items.

In Bangladesh, food transformation takes place as either primary or secondary processing (Innovision Consulting Private Limited, 2016). Primary processing includes drying, shelling/threshing, cleaning, grading, and packaging of the agricultural products in their basic form. Fresh-cut vegetables, fish fillet, frozen meat are examples of primary processed products. Processors typically do not have heavy investment in machinery, rather, they have basic facilities for cleaning and potentially freezing processed products.

Secondary processing involves the conversion of agricultural products into value added products such as juice, concentrates, pickles, jams, and squashes. Through secondary processing, food ingredients (crops or animal source foods) are transformed into final products through means such as pureeing, pasteurizing, cooking, grinding, fermenting, frying and baking. It often involves both an intermediate and a final processing step. Intermediate processing is used to convert ingredients to an intermediate product, which is then used to produce the final product. After receiving the primary ingredients, each ingredient is first sorted, graded, washed, and cleaned. The first stage of quality control happens here, as ingredients not meeting quality standards are rejected. If needed the product is then peeled, de-seeded, sliced, diced, pulped, and pureed. This intermediate product goes through a final stage, in which it is further processed by different methods such as cooking, baking, grinding, frying or other means. Secondary ingredients are often used in this stage of processing. After the finished product is produced, it is packaged in different containers/packages and distributed through market channels.

To realize opportunities in food processing, a number of challenges need to be addressed. Crop procurement is primarily dependent on middlemen and agents, leading to wastage during transportation and increase in prices of raw materials paid by enterprises. Further, often the crops or foods produced do not meet the specific processor requirements, such as incorrect use of pesticides and/or insecticides. Inappropriate packaging and lack of cold storage facilities can result in high post-harvest losses. While the Country Investment Plan places emphasis on improving training programs and facilities for SMEs and small-scale cottage-based processing, there are also needs for training on quality control, food safety, supply chain management, productivity management, even for the large-scale private sector agricultural

processors (FPMU, 2017). While donor projects (such as the B-SEP Project, GAFSP, and the now closed AVC project) have recently focused on institutional capacity development, much more work is required to develop Bangladesh's food processing industry.

A final challenge is dealing with the large number of SMEs within this space. The large number of SMEs implies that there is competition, which can imply a lack of coordination. As a consequence, innovations on new products by Bangladesh Agricultural Research Institute and Bangladesh Council of Scientific and Industrial Research are not necessarily being scaled up by the private sector.

The food processing industry in Bangladesh is considered a “thrust” industry because of the expansive growth of such industries as well as the aggressive international marketing. However, various policy documents suggest different objectives. For example, the 2016 Industrial Policy has an objective of growing agricultural processing and SMEs, but it does not make clear how it will grow them. The Country Investment Plan suggests the need for more training, as noted above, and emphasizes quality standards for nutritious foods. Although some of these plans already represent impressive coordination between ministries, it is important to also coordinate the different objectives of policies and investment plans so that they do not work against one another.

5.4. Food Retailing and Provisioning

With the exception of the government's PFDS, trade of all agricultural products and food is handled by the private sector. Food retail is a traditional business in Bangladesh and its expansion has been keeping pace with the country's population growth and changes in consumption patterns. However, this expansion has not been structurally organized. Until recently, retail had never been perceived as an industry, but rather as individual or family businesses with very limited scope for organized expansion.

Fresh foods are retailed in five different types of outlets:

1. *Open Air Temporary Shops*: These are the most traditional type of retail shops in Bangladesh, and they are visible both in rural and urban areas throughout the country. Primary commodities like fresh vegetables, fruits, fish, and semi-processed homemade foods are sold in this manner.

2. *Roadside Shops:* These small grocery shops are visible throughout the country. Roadside shops together with the open-air temporary shops constitute around 70 percent of the retail sector business. Typical floor space in a roadside shop ranges between 3 and 10 square meters.
3. *Municipal Corporation Markets:* Shops in municipal corporation markets are arranged according to the kind of commodity they carry, such as fish, meat, vegetables, fruits, and processed foods (or groceries). These shops appear in the semi-urban and urban areas. This category represents about 22 percent of the food retail sector in Bangladesh.
4. *Convenience Stores:* Convenience stores are generally located in more affluent urban areas. Customers are upper-middle to upper-class locals and foreigners. These stores are major outlets for imported food items and high-quality local products and represent about six percent of the retail sector.
5. *Supermarkets:* Supermarket presence has also been growing rapidly in Bangladesh, particularly in the past ten years. In 2015, approximately 200 supermarkets were operating, of which around 40 are located in Dhaka (Lightcastle , 2015). Supermarket turnover in food items is estimated at about two percent of food retailing. Supermarkets sell food ingredients, as well as ready-to-cook, even ready-to-eat frozen food. At present, some supermarkets even sell cooked food or have restaurants within their premises.

Around 48 percent of household consumption expenditures in urban areas are on food and beverage items, mostly for items such as grains (90 percent of which is rice), pulses, vegetables, vegetable oils, salt, fish, meat, and sugar (BBS, 2017). However, with urbanization, decreasing family sizes, and the spread of education and employment among women, a major change has become evident in the food habits of the educated middle- to upper classes. They increasingly consume processed food items such as sauces, jams, jellies, pasta products, soft drinks, and fruit juice. Thus, the basis of a processed food market has been established.

Cooked food is generally retailed in three different types of outlets:

1. *Street Food Vendors*: Street food vendors can be characterized by hawkers or vendors selling ready-to-eat food or drink in the street or other public gathering places. Often vendors use portable food booths or carts, however, they also use temporary shops made out of polythin sheets. The most common type of street food vending involves selling tea and dry snacks, which can be found all around Bangladesh. Another common type involves selling lunch items, primarily among the working class population. Other categories of street food vending involve selling seasonal fruits, traditional snacks, and fried items. There are as many as two million street food vendors in Dhaka (Khan, 2016), while the total estimated number for the whole country is unknown.
2. *Restaurants*: Restaurants refer to more permanent and structured facilities providing cooked meals. They vary from little shacks in village market centers to upscale facilities in posh urban areas. The majority of the restaurants are in large cities such as Dhaka and Chittagong. According to the Bangladesh Restaurant Owners Association (BROA), there are around 55,000 restaurants in Bangladesh.
3. *Fast Food Shops*: Fast food was introduced to Bangladesh in the early 1990s, primarily targeting younger consumers and the relatively wealthy. Prominent fast food items include burgers, pizza, fried chicken, and sandwiches. However, due to rapid urbanization, upper, upper middle class, and even middle class families now frequent fast food shops. As fast food culture is directly related to urbanization, almost all these shops are in big cities such as Dhaka, Chittagong, Sylhet, and Khulna. There are an estimated 4,000 to 5,000 fast food shops in Bangladesh (Harun, Ahmed, and Maniruzzaman, 2013).

5.5. Food Safety and Supply

Foodborne disease is a critical issue for developing countries as such diseases impose a huge burden due to health and productivity loss. Not surprisingly, then, assuring food safety is one of the most important challenges for the food system in Bangladesh. As food safety issues are broadly a larger concern for perishables than nonperishables, concerns about food safety can reduce the nutrient content of foods

consumers choose as they attempt to ensure they do not get sick by choosing foods that are less nutritious but they perceive as safe.

There are three primary ways food safety is potentially compromised in Bangladesh. First, it can be compromised either in the field through contaminated water or soil impurities or through fungal toxins (mycotoxins) that develop post-harvest. Second, it can be compromised at the other end of the value chain, as handling can be unhygienic for food made available either on the street, as fast food, or in restaurants; or packaging chemicals can leech into products. Third, and perhaps most concerning, products can be adulterated during processing in ways that can compromise food safety. We discuss each in turn.

First, crops in the field can be exposed to heavy metals through irrigation, or animal products can similarly be exposed to heavy metals through contaminated food or water. For example, Islam et al. (2017) find that several heavy metals were concentrated in prawn feed, which then leads to concentrated levels of heavy metals in the prawns produced for market, at levels that are above acceptable risk levels. On the other hand, in spite of high humidity, Hoque and Hoffmann (2019) find that at least in storage depots used for Bangladesh's PFDS, there are low levels of mycotoxins and negligible amounts of heavy metals in stored grains. More research is needed to understand how much contamination exists in animal products, particularly from heavy metals.

Second, food safety problems can develop either due to improper food handling or through packaging. Unhygienic practices in food handling are a common phenomenon in the Bangladesh food industry, as many restaurants and fast food outlets cook, process, and otherwise prepare foods in extremely unhealthy environments (Ali, 2013).⁶ Direct contact of foods with packaging materials can result in chemical contamination caused by migration of certain substances into foods. Examples of such health concerns may include bisphenol A or phthalates from plastic materials, 4-methylbenzophenone and 2-isopropyl thio xanthone from inks (Bradley et al., 2013), mineral oil from recycled newspaper fibers

⁶ Unhygienic food processing has negative effects on the economy beyond public health; it also has negative effects on export potential, such as the ban on frozen food exports from Bangladesh to the EU.

(Biedermann and Grob, 2010), or semi-carbazide from a foaming agent in the plastic gaskets (Li et al., 2015) that are used to seal metal lids to glass packaging.

5.5.1. Food Adulteration Concerns

Adulteration and contamination of food constitute a further major public health concern in Bangladesh.

The estimated proportion of adulterated food items in the market varies between 40 to 54 percent (Nasreen and Ahmed, 2014; Rahman et al., 2015). Some adulteration can occur among basic food items to aid the transformation process. For example, calcium carbide is used to ripen mango (Hossain, Akhtar, & Anwar, 2015), and DDT can be used in the processing of dried fish (Hasan, et al., 2014). In addition, certain toxic or undesirable compounds can be formed in foods during their processing, such as during heating, baking, roasting, grilling, canning, hydrolysis, or fermentation (Gupta and Gajbhiye, 2008).

A pressing concern with adulteration is that some additives, such as non-food grade colorants, are meant to make food attractive, but they are unregulated and therefore may be toxic, causing health risks (Mondol, 2017). One study found that in Bangladeshi women with elevated blood lead levels, adulterated turmeric consumption may be partly responsible (Forsyth et al., 2018). Turmeric vendors potentially add adulterants to make the turmeric brighter in colour and more attractive to consumers. Other industrial colorants, such as sudan red, are used to brighten spices and sauces. As the use of these contaminants in food products can potentially cancer, there is a clear public health issue.

5.5.2. Food Safety Policy

Assuring food safety in Bangladesh is a multisectoral responsibility, as at least 15 different ministries have been involved in food control. However, the BSTI is the only food testing and permission giving authority. As such, there are only standards on 187 food items and voluntary guidelines on about 500 further food products, leaving the remainder of the market unorganized. To assure the availability of safe, uncontaminated food through proper practice of scientific procedures through coordination of food production, import, processing, storage, supply, marketing and sales related activities, the Bangladesh Food Safety Authority (BSFA) was established in 2015. The BSFA is now engaged in preparing

additional laws and rules for improving food safety in Bangladesh. However, any laws or regulations that are prepared and passed must also be enforced; limited enforcement would simply ensure the status quo continues.

5.6. Issues Related to Certification and Labelling

The consumption of quality, safe, nutritious food can only be assured if quality and safety control can be started right from agricultural production (manures, fertilizers, livestock feed, waters, pesticides, growth regulators, etc.) through postproduction stages (sorting, grading, washing, packaging, transportation, storage, processing and marketing). An obvious response by either government or industry can be to provide a certification system that production followed appropriate steps, accompanied by a label certifying to consumers that appropriate production processes were followed. Third parties may instead be used for certification if government is not trusted enough by consumers to monitor those processes; alternatively, some international standards have been developed for specific products (for example, fair trade coffee). However, note that third party certification likely adds costs within a value chain, since the third party would require compensation for its service. Therefore, it is important that consumers value the certification, else it would be of limited effectiveness.

In Bangladesh, the Country Investment Plan aspires to meet international standards, such as the Global GAP standards (FPMU, 2017). It also suggests that to start, farmers must use established management practices such as the Good Agricultural Practices, Good Aquaculture Practices, and Good Husbandry Practices. It further suggests introducing and scaling good manufacturing practices and good hygienic practices during food production, processing, preparation and sale of safe and healthy foods. Doing so would help begin to lead to improved traceability for food safety throughout the country, helping reduce contamination.

Unfortunately, there is little evidence in Bangladesh that consumers respond to either food or nutrition labelling. In a small survey in Dhaka, 12 percent of respondents stated they rely on Bangladesh Standard and Testing Institute approval when buying packaged food items (Nasreen and Ahmed, 2014).

In the same survey, 93 percent of respondents stated that they stopped or would stop consuming a food item if they had learned that it was adulterated. It is believed that people typically look at the manufacturing and expiry dates on packaged foods in Bangladesh; however, the literature is quite sparse on how labels influence food choices and consumption.

5.6.1. Organic Foods

Another type of foods that can potentially benefit from certification and labelling are organic foods. While many of the foods currently raised in Bangladesh could be certified as organic, there are currently no local certification standards for raising or selling organic foods in Bangladesh. The market for organic food in Bangladesh is at an early stage with a huge opportunity of growth. There is rapid growth in the demand for healthy food products, which are perceived as safer than industrially produced goods (Ahmed and Rahman, 2015). These points are suggested by studies conducted by Rahman, Omar, and Ullah (2007), Sarker and Itohara (2008), Mamoon and Haque (2013), Mukul, Afrin, and Hassan (2013), and Iqbal (2015). However, they are all are consumer-end studies, and exploratory in design. To identify factors facilitating or inhibiting consumers' adoption of organic foods using a causal study design could potentially be adopted in future research to identify the factors that lead consumers to be willing to pay more for organic foods.

5.6.2. Genetically Modified Crops

Note that Bangladesh does not share an aversion to genetically modified organisms (GMOs) held by consumers in many other countries. Research using the final round of FSNSP data in 2015 suggests that consumer awareness of GMOs is fairly low. When presented with more information about “Golden Rice”—a rice high in vitamin A-- including potential drawbacks, respondents had neutral or positive impressions of the technology and would consider consuming it (HKI, 2015).

For example, Bangladesh released a GMO Bt eggplant in 2013 after decades of research (Shelton et al., 2018). BT Brinjal has already captured an estimated 20 percent of the market for eggplant (Shelton et al., 2018). Two other GMOs, late blight resistant potatoes and Golden Rice, are planned for imminent

release, and GMO varieties of some non-food crops (cotton and jute) are also in the pipeline. Unlike other countries, labelling of GMO products is likely not necessary for the domestic market; however, it would be needed for exporting any GMO products. Research, instead, might consider whether standard cooking methods reduce the bioavailable vitamin A in golden rice.

5.7 Research Questions

The research questions that derive from this section include:

1. How can cold storage be placed geographically to most effectively increase availability of more nutritious foods, or maintain nutrient density within harvested crops for longer?
2. How high are post-harvest losses in non-grain crops like fruits and vegetables? Can they be reduced in a cost-effective manner?
3. What parts of the Country Investment Plan are leading to increased investment in processing of nutritious foods, and how could the next plan be adjusted to increase investment?
4. How much contamination exists in animal-sourced foods, particularly from heavy metals?
5. What proportion of food is purchased at different types of food retail outlets, and how is that changing? How much food is consumed on the street or in restaurants, and how is that changing?
6. Are consumers willing to pay a premium for foods that are labeled as meeting quality certification? If so, what labels are most effective?
7. What factors facilitate or inhibit consumers' adoption of organic foods? Are consumers willing to pay more for organic foods?
8. Do standard cooking methods reduce the bioavailable vitamin A in golden rice? If so, how must cooking methods adjust to retain vitamin A?

6. NASCENT FOOD SYSTEMS INNOVATIONS FOR SUSTAINABLE, HEALTHIER DIETS

Although we have identified several areas in which more knowledge is necessary about the state of Bangladesh's food system, it is clear that public policy alone will not be able to adjust incentives within the food system enough to solve malnutrition problems on its own. Private sector or public-private innovations will also be necessary to improve dietary outcomes. Food systems innovations can be defined as any innovations that either produce or have the potential to produce dynamic effects within the system (de Brauw et al., 2019). By dynamics, we mean that innovations can either produce synergies with other outcomes but may also create feedback on the outcomes of interest through changes in drivers of the food system. In designing food systems innovations, it is important to also understand potential tradeoffs between other outcomes; for example, innovations that would be positive for diets could be harmful to the environment, and such tradeoffs must be understood.

There are few examples of food system innovations within Bangladesh. Two innovations relate to production systems. First is the development of *ghers*, previously exclusively in the southeast, but now also found in the northwest. *Ghers* are ponds dug with wide and tall embankments, offering resilience against flood and cyclone damage and providing an elevated platform on which to grow high value vegetables and other crops even during the monsoon season. The ponds themselves serve as beds for paddy rice and, following rice harvest, prawns or fish can be grown. Climbing vine-type vegetables are also commonly grown on trellises over the pond. Surveys show that many of these *ghers* become a joint family project, involving both husbands and wives, and are highly profitable; from a food systems perspective, they increase the local supply of both vegetables and animal source protein, which can have positive dietary outcomes for both those who manage *ghers* and those who live nearby, through market availability effects (Castine et al., 2017). IFPRI surveys have shown that women's empowerment has increased in rural areas as women work more with their husbands on non-field agriculture such as livestock, aquaculture, or vegetables (Ahmed and Sen, 2018).

A second innovation occurring relates to cattle fattening. Cattle fattening with the use of urea and molasses allows innovative farmers to take advantage of feed for ruminant animals, providing protein through the proliferation of bacteria in the ruminant stomach before entering the other stomachs where the bacteria are broken down into proteins. Studies show that methane gas coming from the cattle is reduced by 30 percent when urea and molasses is used as a feed. Therefore the feedback occurring through cattle fattening is to reduce the environmental impacts of cattle rearing.

Third, the NGO Solidaridad Network has introduced the Sustainable Agriculture, Food Security, and Linkages (SAFAL) project in Bangladesh. This food systems innovation directly works with farmers to adopt technologies to improve productivity and comply with buyer standards, explicitly facilitating linkages to new markets. It has also worked to facilitate the farmer engagement into groups who then can market their products with traders, processors, and/or retailers. The project further provides technical and financial support to individuals in project villages to become service providers for farmers. In the project's second phase, which began in 2018, it established two "village super market" hubs, which serve as fixed points for farmers to sell their products to intermediaries. An impact evaluation (using difference-in-difference methodology) of the first phase found positive impacts on improved practices, agricultural production, and participant income (Consigliari Private Limited, 2016). More evidence is needed to understand how the project has affected local availability of nutritious foods for non-growers.

Finally, a pilot intervention was recently carried out in garment factories that provide lunch and those that do not provide lunch for their female employees to test whether a supplement or a supplement plus lunch can be effective at reducing anemia (Hossain et al., 2019). The intervention found reduced anemia by 32 percentage points in the lunch group and 12 percentage points in the non-lunch group, respectively, relative to a control group. However, the study was only conducted in four factories and was not randomized, plus all women received behavior change communication training in both types of factories, so clearly there is more to learn about whether this type of intervention can affect diets or shift food systems.

In general, more innovations will be necessary in the future to help Bangladesh attain goals set out in its Country Investment Plan. As more information becomes available on the current state of the food system and its dietary shortcomings, more emphasis can be placed on the design of food systems innovations to target specific dietary outcomes, while being mindful of tradeoffs. For example, at present three of the four food systems innovations described target the production system, and only one the food environment, with none targeted at consumer behavior. Therefore, a research question derived from this component is: what component of food systems – production systems, the food environment, or consumer behavior – should be targeted for additional food systems innovations to have the largest effects on diets, without major adverse tradeoffs related to the economy or environment?

7. CONCLUSION

Healthy diets must start with agriculture, beginning from choices related to production and cropping systems, and following through to the ways that foods are processed, preserved, and marketed. All of these steps must take place while food standards are applied, and with safe storage and hygienic preparation and handling. If food systems are oriented more towards nutrition, they can potentially deliver opportunities for people to choose diets with both adequate energy and nutrients.

The potential of food systems for improved nutrition needs to be promoted to contribute to the economic efficiency, conservation of nutrients and enhanced quality and diversity of diets. Nutrition education needs to be integrated through the production, processing and consumption linkages in the food system. Linking community development policies to national programmes for the alleviation of hunger and malnutrition, with an emphasis on increasing the variety of foods consumed, is probably the best strategy for improving micronutrient malnutrition sustainably.

To avoid massive health costs in the future, food systems must be shaped to become more nutrition-sensitive so that they can potentially lead to better diets and improved nutritional outcomes. An understanding of the different food systems elements that encompass potential entry points for innovations is required. This calls for more understanding of the current situation, and then plenty of work designing, planning and implementing programming options and policy enabling environment to leverage the food system to produce and demand safe and diversified diets.

As a first step, in this paper we have identified a large set of research questions that, if answered, could shed light on both how the food system in Bangladesh works, and the rate of change of food system transformation in Bangladesh. Further, it can shed light on the implications of that transformation for diets among all socioeconomic groups. We once again summarize all these questions:

Research Question	Section
1. How rapidly will dietary diversity continue to increase on its own? Will it begin to change among the relatively poor?	Diet as an Entry Point
2. What strategies can be tested to make nutrient dense foods more affordable for the poor?	Diet as an Entry Point
3. What factors led to changes in energy intakes and the composition of energy intakes between 2010 and 2016?	Diet as an Entry Point
4. As purchasing power increases and demand shifts away from starches, what replaces them more rapidly—nutrient dense foods or more processed foods? Is this pattern heterogenous by income level or location (rural/urban)?	Diet as an Entry Point
5. What food combinations should be promoted for better nutrient bioavailability?	Diet as an Entry Point
6. Are changes in food availability changing intrahousehold allocations of food, particularly more nutrient dense food?	Food Environment
7. How is the availability of different types of markets changing the way that people obtain food? How does that differ by socioeconomic class?	Food Environment
8. What role has urbanization played in changing diets, by socioeconomic class and gender?	Food Environment
9. How much does a healthy diet in Bangladesh cost? How is that cost evolving and is it attainable by all socioeconomic groups?	Food Environment
10. Do people of different demographic or socioeconomic groups interact with the food environment differently?	Food Environment
11. What are the perceptions about importance of diet/food for better health outcomes among different age groups (adolescents, adults and old age)?	Food Environment
12. How are social determinants contributing to the rise in overweight and/or obesity status?	Food Environment
13. How rapidly is the consumption of food away from home increasing? Among whom and where is it rising fastest? Does food eaten away from home add to consumption or substitute away from food eaten at home, particularly among adolescents?	Food Environment
14. How does policy in Bangladesh affect the food environment?	Food Environment
15. How is the production of nutrient dense foods changing in Bangladesh? What changes to production patterns could be enhanced to fill dietary gaps?	Agricultural Production

Research Question	Section
16. Is the cost of production of those foods competitive with imports?	Agricultural Production
17. How will climate change affect production patterns and what are the implications for diets?	Agricultural Production
18. What are the trade-offs between healthy food production and ecological measures such as soil and water quality and the carbon footprint of agriculture? What form of trade-offs are acceptable in Bangladesh to produce food needed for a sustainable healthy diet?	Agricultural Production
19. How can cold storage be placed geographically to most effectively increase availability of more nutritious foods, or maintain nutrient density within harvested crops for longer?	Storage, Transport, Marketing, and Trade
20. How high are post-harvest losses in non-grain crops like fruits and vegetables? Can they be reduced in a cost-effective manner?	Storage, Transport, Marketing, and Trade
21. What parts of the Country Investment Plan are leading to increased investment in processing of nutritious foods, and how could the next plan be adjusted to increase investment?	Storage, Transport, Marketing, and Trade
22. How much contamination exists in animal source foods, particularly from heavy metals?	Storage, Transport, Marketing, and Trade
23. What proportion of food is purchased at different types of food retail outlets, and how is that changing? How much food is consumed on the street or in restaurants, and how is that changing?	Storage, Transport, Marketing, and Trade
24. Are consumers willing to pay a premium for foods that are labeled as meeting quality certification? If so, what labels are most effective?	Storage, Transport, Marketing, and Trade
25. What factors facilitate or inhibit consumers' adoption of organic foods? Are consumers willing to pay more for organic foods?	Storage, Transport, Marketing, and Trade
26. Do standard cooking methods reduce the bioavailable vitamin A in golden rice? If so, how must cooking methods adjust to retain vitamin A?	Storage, Transport, Marketing, and Trade
27. What component of food systems – production systems, the food environment, or consumer behavior-- should be targeted for additional food systems innovations to have the largest effects on diets without major adverse tradeoffs related to the economy or environment?	Nascent Food Systems Innovations

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1201 Eye Street, NW
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Tel.: +1-202-862-5600
Fax: +1-202-862-5606
Email: ifpri@cgiar.org