Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
COVID-19's implications on agri-food systems and human health in Bangladesh

Byomkesh Talukder,*, Gary W. vanLoon, Keith W. Hipel, James Orbinski,⁎,⁎

Abstract

The COVID-19 pandemic in Bangladesh has put agri-food systems and resultant human health under serious pressure and this has thus become a priority concern for the country and its development partners. To understand, describe and analyse the impacts of COVID-19 on agri-food systems, human health issues and related SDGs, this study used systematic rapid literature review, analysis of blogs and news and engagement with key informants. The analysis reveals impacts that can be addressed through a set of recommendations for a coordinated effort to minimize the effects of the COVID-19 pandemic on agri-food systems and related health issues in Bangladesh.

Keywords: COVID-19, Agri-food systems, Health, SDGs, Bangladesh

1. Introduction

As well as the extraordinary public health intervention challenges sparked by COVID-19, there are also critical challenges to keeping agri-food systems functioning in Bangladesh. Agri-food systems are the basis of the rural economy and have a significant impact on national economic growth, contributing 14% of the country's GDP (BER, 2018) and employing 41% of the labor force (BBS, 2018). The agriculture of Bangladesh is centred on a limited suite of crops with 75% of the total cropped area are used for rice cultivation (BRRI, 2014).

In pre-COVID-19 Bangladesh, agri-food systems and the associated human health outcomes were performing progressively better despite vulnerability to natural calamities, climate change, environmental degradation, agri-food system mismanagement and poor logistical infrastructure. By 2019, Bangladesh ranked 4th in the world in rice production (FAO, 2019) and was making significant improvements in producing vegetables, fish, livestock and poultry (FAO, 2017). These improvements were due to investment in agricultural policy and infrastructure such as the introduction of High Yielding Varieties (HYV) of rice, use of modern inputs including chemical fertilizers, pesticides, irrigation, storage systems, use of subsidies, micro-credit supports and marketing capacity (Gautam and Faruque, 2016; Bagchi et al., 2019).

Despite the significant progress in managing agri-food systems in Bangladesh, food security and related health issues remain in a fragile state. The country ranked 83rd in the world in the 2019 Global Food Security Index, which takes account of food affordability, availability, quality and safety as well as relevant natural resources and resilience (The Economist, 2019). Across the population, there are differences in availability and access to an adequate, nutritious diet. Fruit and vegetable consumption is inadequate for most Bangladeshis relative to international recommendations. In addition, as the food systems have begun to modernize, challenges related to food safety and perceived food adulteration have begun to emerge (de Brauw et al., 2020). Declining per capita calorie intake (from 2318 kcal/day in 2000 to 2210 kcal/day in 2016) also remains an issue for the development of Bangladesh (HIES, 2016).

In this context, Bangladesh's food security and related health outcomes are significantly affected by the impacts of the COVID-19 pandemic. The following questions arise: How has the COVID-19 pandemic impacted the agri-food systems of Bangladesh? What are the potential impacts of...
COVID-19 affected agri-food systems in terms of human health outcomes? What potential interventions can address these implications?

2. Methodology

A rapid systematic literature review was deployed to identify significant literature from peer-reviewed articles, gray literature, blogs and news articles. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) strategic process (Moher et al., 2009) used in this review follows four steps: (i) Identification, (ii) Screening, (iii) Eligibility, and (iv) Included (see Fig. 1). Using both Google search and Google Scholar, a search was conducted to identify relevant materials for the study. From the identified materials, screening was conducted to select the literature related to COVID-19, Bangladesh’s agri-food systems, health and interventions to mitigate the impacts of COVID-19 on agri-food systems. After screening, 93 documents were selected for review.

Additional key informant interviews were conducted with ten key informants from Bangladesh in order to verify the findings of the literature review. These key informants were university faculty members, researchers, officers of the Ministry of Food, the Ministry of Agriculture, Fisheries, and Livestock and at the Ministry of Health of the Government of Bangladesh and NGO-based advocates.

3. Results

The findings of the review are grouped in two categories: (i) impacts of COVID-19 on agri-food systems and (ii) implications of COVID-19 for agri-food systems-related health issues. These two impacts are discussed below.

Table 1 Impacts of COVID-19 on agri-food systems and health at global, regional and national levels.

| Agri-food systems disruptions | Health/economic impacts |
|------------------------------|-------------------------|
| Farm                        |                         |
| Supply of agricultural inputs | Intensify existing hunger and malnutrition |
| Workforce and availability of human labour | of hundreds of millions of poor people |
| Food value chain             |                         |
| Starting points of the value chain (farm-to-market, macroprocesses, logistics) | Global food emergency/famine |
| Distribution networks for food, suppliers, and importers and exporters | Universal access to safe and nutritious food |
| Market                      |                         |
| Rural and agricultural food markets | Hampering of the goal of ending of all forms of malnutrition |
| Microeconomic stability and financial markets | Kill or debilitate people |

3.1. Impacts of COVID-19 on agri-food systems

COVID-19 has interrupted farm, value chain and market dimensions of agri-food systems throughout the world (see Table 1). For example, South Africa is facing reduced food security due to economic disruption (Arndt et al., 2020). The people of Bolivia have also faced recent challenges in accessing sufficient quality food to support a sustainable diet. In Ethiopia, after the first incidence of COVID-19, food price inflation increased by 26.9% and the urban food value chain has been disrupted. In India, all value chain points in food and agricultural systems have been interrupted by COVID-19. High Income Countries are also affected. For example, like many high income countries reliant on migrant workers, Finland has had difficulties in hiring migrant workers to harvest and pick berries and mushroom rooms from its forests (FAO, 2020f).

Agri-food systems in Bangladesh have also been impacted by COVID-19 at the farm, value chain and market levels (FAO, 2020f) and COVID-19 has exposed the underlying risks, vulnerabilities and inequalities (IPES-Food, 2020) of these systems. The agri-food supply chain in Bangladesh is a complex web of producers, consumers, agricultural inputs, crop and food processing and storage, transportation and marketing services. This chain has become dysfunctional due to the population’s fear of infection by the COVID virus, social distancing and self isolation, and the impacts of public health interventions like lockdowns and travel restrictions, all of which can decrease food availability and increase rates of food loss and waste (Roy, 2020).

In many cases farmers are not able to sell their products to buyers after harvest (Mostafa, 2020). In some cases, farmers have let their crops rot in the fields, leading to a huge loss. Some farmers are able to sell perishable items locally, but only at significantly discounted rates (Bhuyan, 2020; FAO, 2020c). Lockdown in response to COVID in Bangladesh has meant a loss of income among people throughout the country, with diminished

Fig. 1. Steps of systematic literature review (Moher et al., 2009).
purchasing power and thus demand for fresh produce, fish, poultry and livestock products (for example, see Pictures A & B), affecting producers and suppliers. Now and into the future, reduced food consumption will hamper food production and increase food waste and loss (FAO et al., 2018). These difficulties are causing significant economic loss for farmers, especially small and marginalized ones, and internal migrant workers as well as small scale traders/vendors. As a result, heir agri-food systems-based livelihoods are in critical condition in 2021 (Pothan, 2020). The crisis may lead many producers to shut down production, which will have a negative impact on long-term food availability (NAWGB, 2020), leading to increased food insecurity and poverty (Pereira and Oliveira, 2020).

In country and cross border travel restrictions have particularly disrupted the supply chain of perishable items (NAWGB, 2020). In addition, border closures due to COVID-19 have caused significant interruptions of informal trade flows between Bangladesh and India adding to increased food security in both countries, particularly for the poor (Dihel and Rizwa, 2020).

COVID-19 has reduced food access for the urban poor as staple food prices have increased about 25% (FAO, 2020b). Furthermore, people in vulnerable areas such as Chittagong Hill Tracks lack access to diversified food as their food supply is dependant on supply from other parts of the country (FAO, 2020b). Other vulnerable areas such as the saline intrusion prone areas of coastal Bangladesh are also facing less accessibility of sufficient, diverse and nutritious food.

3.2. Implications of COVID-19 for agri-food systems-related health issues

Beyond food supply and availability issues, COVID-19 has impacted the agri-food-related health of vulnerable groups at global, regional and national levels (see Table 1). UNICEF (2020a) reported a 30% worldwide decrease of vital nutrition services coverage during the pandemic. The effects of the COVID-19 pandemic on agri-food systems in Bangladesh likewise bring a set of health-related impacts, as illustrated in Fig. 2. Because

Picture [A]: A vendor in Dhaka waits for buyers in the early stage of lockdown (Heifer International, 2020). Picture [B]: A empty buyers fish market just after lockdown (CGIAR, 2020). These two pictures indicate that at a formerly busy time there are few customers which is the evidence of the diminishing demand for perishable foods from vendors in the early stage of lockdown in Bangladesh that prevented farmers from selling their products to the vendors.

Bangladesh has recently faced a shortage of labor throughout the entire agri-food system (Zhang et al., 2014) due to growth of employment in the industrial and service sectors, but COVID-19 has made the situation worse as travel restrictions constrain the movement of seasonal labour into the agricultural regions. This causes reduced or halted rice harvesting across the country and has caused economic loss for the poor farmer as well as lost day-wages for vulnerable farm labourers. These farm labourers represent the major sub-group of the 21.8% of Bangladeshi who are living below the national poverty level (ADB, 2020) and who are the most food-insecure population even under normal circumstances.

Travel restrictions and lack of mobility also reduced farmers’ access to agricultural inputs (such as fertilizer, seeds, pesticides, farm equipment), which has seriously hampered agricultural productivity and subsequently farmers’ livelihoods (NAWGB, 2020). Agri-food systems-based rural economies support 63% of the total population of Bangladesh (WB, 2020a) and are essential to poverty alleviation strategies (Irz et al., 2001). A recent survey by the Bangladesh Rural Advancement Committee (BRAC) revealed a 60% increase in extreme poverty across the country since the onset of the COVID-19 pandemic (WB, 2020b).

Most poor Bangladeshis live in rural and urban slum areas (WB, 2014). Day-labourers, poor farmers, vendors, retailers and shop-owners in these areas constitute a majority of these poor; they have faced huge losses due to supply chain disruptions and job losses during lockdown that have made them poorer and more food-insecure (NAWGB, 2020; Pereira and Oliveira, 2020). COVID-19 creates food insecurity through food supply chain disruption, loss of income and purchasing power, and increases in many food prices, there are profound health implications as the vulnerable groups face diminishing access to diversified healthy food diets (i.e., vegetables, fish, milk, meat and fruits etc.).

Consumption of diversified food is essential since it fights against malnutrition by providing essential nutrition and is key to building immunity, protecting against illness and infection and supporting recovery from illness (Webb et al., 2018; EAT, 2019; Calder and Jackson, 2000; UNSCN, 2021). Weak immune systems are more susceptible to infectious (e.g., COVID-19, diarrhea, malaria, dengue) and chronic (e.g., diabetes and cardiovascular) disease (Bagatini et al., 2018; Sompayrac, 2019). Consuming sufficient calories is vital to growth, and maintenance of good health. The increase in grain prices during COVID-19 (USDA and GAIN, 2020) can lead to long-term insufficient caloric intake (dietary energy) which will hamper the normal activity of children and negatively affect their growth and development (Bhattacharya et al., 2004). Thorne-Lyman et al. (2010) found that in Bangladesh grain price and prevalence of child underweight are positively associated whereas grain price is inversely associated with non-grain food expenditures of households. Low dietary diversity are causes of micronutrient deficiencies among children of Bangladesh.

Economists and nutritionists warn that a higher incidence of poverty can lead to falling food consumption and malnutrition among some groups of people (Helthberg, 2009). Reduced food security and reduced access to health services may lead to worse nutritional status, leading to an increase in the number of children with severe acute malnutrition along with maternal and child mortality. Bangladesh already has a 30.8% prevalence of growth stunting because of poor nutrition and reduced caloric intake among children under 5 years of age, a 14.7% prevalence of underweight among children under 5 years of age, and a 8.4% prevalence of wasting among children under 5 years of age (ADB, 2020). In addition, 41.8% of
women are anemic (Rahman et al., 2021). These baseline health measures will likely deteriorate further due to the impacts of COVID-19 on agri-food systems. In the short- to medium-term, micronutrient deficiencies, child wasting and stunting are all expected to surge, stemming the tide of recent progress toward achieving the World Health Organization’s Global Nutrition Targets for 2025 (WHO, 2020).

In addition to these nutrition related health impacts, poor nutrition due to COVID-19 agri-food system impacts can (i) jeopardize cognitive

Fig. 2. COVID-19's impacts on agri-food systems and related health issues. Note: Black arrows indicate impacts on agri-food systems from COVID-19, green arrows indicate decrease of food production due to impacts of COVID-19, blue arrows indicate impacts on food security due to COVID-19 and red arrows indicate health impacts of COVID-19 from impacts on agri-food systems. “+” indicates an increasing impact and “−” indicates a decreasing impact. WASH* = Water and Sanitation for Health.

Table 2
Effects of COVID-19 on food-related important targets within SDGs: 1, 2, 3, 4, 5, 8, 10 & 12.

| SDGs                       | Target indicator                                                                 | Impacts                                      |
|----------------------------|----------------------------------------------------------------------------------|----------------------------------------------|
|                            |                                                                                  | S.B.C. S.A.C. I.O.C.                         |
| SDG 1: No Poverty          | 1.1.1 Proportion of population below the international poverty line, by sex, age, employment status and geographical location (urban/rural) | 21.8%1 40%2 −18.2%                          |
| SDG 2: Zero Hunger         | 2.1.1 Prevalence of undernourishment                                             | 14.7%3 − − −                               |
|                            | 2.1.2 Prevalence of severe food insecurity in the population, based on the Food Insecurity Experience Scale (FIES) | 10.2%3 − − −                               |
|                            | 2.2.1 Prevalence of stunting (height for age < −2 standard deviation from the median of the World Health Organization (WHO) Child Growth Standards) among children under 5 years of age | 28.0%3 − − −                                |
|                            | 2.2.2 Prevalence of malnutrition (weight for height > +2 or < −2 standard deviation from the median of the WHO Child Growth Standards) among children under 5 years of age, by type (wasting) | Wasting: 9.8%3 − − −                         |
| SDG 3: Good Health and    | 3.8.1 Coverage of essential health services (defined as the average coverage of essential services based on tracer interventions that include reproductive, maternal, newborn and child health, infectious diseases, noncommunicable diseases and service capacity and access, among the general and the most disadvantaged population) | 543 − − −                                   |
| Well-being for People      |                                                                                  |                                              |
| SDG 4: Quality Education   | 4.1.1 Proportion of children and young people (a) in grades 2/3; (b) at the end of primary; and (c) at the end of lower secondary achieving at least a minimum proficiency level in (i) reading and (ii) mathematics, by sex | (a) Grade 2/3 (Reading Bangla:25.9%, Math – 13.0%)3 − − − |
| SDG 5: Gender Equality     | 5.5.2 Proportion of women in managerial positions                                 | 10.7%3 − − −                                |
| SDG 8: Decent Work and     | 8.1.1 Annual growth rate of real GDP per capita                                   | 6.91%3 − − −                                |
| Economic Growth            | 8.3.1 Proportion of informal employment in non agriculture employment, by sex    | By sex (Male: 3.1%; Female: 6.7%)3 − − −      |
|                            | 8.5.2 Unemployment rate, by sex, age and persons with disabilities                | − − −                                       |
| SDG 10: Reducing Inequalities | 10.2.1 Proportion of people living below 50% of median income, by sex, age and persons with disabilities | 15.98%3 − − −                              |
| SDG 12: Responsible        | 12.3.1 (a) Food loss index and (b) food waste index                               | (b) Food waste:68.3%4 − − −                |
| Consumption and Production |                                                                                  |                                              |

Source:1ADB, 2020;2Anas and Kuronuma, 2020;3GED, 2020;4Ananno et al., 2020; Note: S.B.C. = Status before COVID-19, S.A.C. = Status after COVID-19, I.O.C. = Impact of COVID-19. “↓” indicates indicator will go down but data are not yet available. “−” indicates indicator will have negative impacts due to COVID-19.
development and generally healthier living in vulnerable children; (ii) hamper children’s concentration and learning ability; and (iii) have a disproportionately larger impact for girls, women and the children of the vulnerable groups which will negatively affect progress in target school proficiencies, and gender equality efforts; and (iv) because of poor health status, lead to decreased economic productivity and increased health care costs (FAO et al., 2018).

Bangladesh is among the top 10 countries with the highest rates of projected age-standardized mortality among selected low- and middle-income countries due to chronic diseases, particularly cardiovascular diseases and diabetes (Ali et al., 2019). While in isolation due to the pandemic, people may rely more on carbohydrates instead of procuring diversified food, a factor that may exacerbate chronic disease.

The deterioration of coordinated efforts to maintain the food supply chain can mean reduced access to food and lead to mental stress, anxiety, uncertainty and fear of famine among the people of Bangladesh. Paul et al. (2020) found that due to livelihood disruptions in Bangladesh, farmers are more stressed than in comparable pre-Covid periods. This, as well as self isolation, social distancing, public health lock down measures such as restricted local, regional and national mobility and travel, and the decreased income of poor farmers and other vulnerable groups due to disruption of the agri-food system, will lead to restricted access to healthcare services, and to safe water, sanitation and possibly hygiene practices.

4. Discussion

The COVID-19 pandemic has caused food insecurity (Mishra and Rampal, 2020) and other damage to social and economic systems (WWF, 2020) and will continue to negatively impact Bangladesh’s agri-food systems and Bangladesh’s food-related health outcomes (as shown in Fig. 2). As such it will have long-term implications for the future sustainable development of the country.

Undisrupted agriculture is vital to achieve many of the United Nations’ Sustainable Development Goals (SDGs) (see Table 2) including ending poverty, promoting zero hunger, sustainable consumption and production practices, and combating climate change (FAO, 2016). The COVID-19 pandemic has had negative impacts on the vulnerable agri-food systems of Bangladesh, and impede Bangladesh from achieving agri-food-related SDG indicators, through increasing undernourishment, decreasing average income of small-scale food producers, decreasing the proportion of agricultural areas under productive and sustainable agriculture, lowering government expenditures on agriculture, increasing food pricing anomalies and resulting in food loss (FAO, 2020a). These impacts will aggravate poverty and health outcomes and undoubtedly negatively affect Bangladesh’s efforts to achieve the SDGs by 2030, as well as other development initiatives and goals (Shammi et al., 2020; Workie et al., 2020).

Considering that nutrition is a central feature of the 2030 SDG Agenda (FAO et al., 2018), COVID-19 will have impacts on SDG 1: No Poverty, SDG 2: Zero Hunger, SDG 3: Good Health and Well-being for People, SDG 4: Quality Education, SDG 5: Gender Equality, SDG 8: Decent Work and Economic Growth, SDG 10: Reducing Inequalities and SDG 12: Responsible Consumption and Production in Bangladesh (see Table 2). Key target indicators of these SDGs related to food and agricultural systems will all be impacted. Even in the early stages of the COVID-19 situation, the “proportion of population below the national poverty line” target indicator has increased to 40% in 2020 (Anas and Kuronuma, 2020) from 21.8% in 2018 (ADB, 2020). The overall negative impact of this target indicator is 18.2%. This will have a massive impact on nutritional security in Bangladesh. The “Prevalence of Undernourishment” target indicator will also be very substantially impacted since it has been projected that the number of cases of wasting could increase from 1.7 million in 2019 to 1.9 million in 2020 (UNICEF, 2020b).

Spatial distribution of food insecurity varies in Bangladesh (see Fig. 3[A]). Food insecurity is strongly associated with poverty, which also varies spatially across the country (see Fig. 3[B]), and food insecurity and poverty are especially prominent across vulnerable zones, including coastal and urban areas, and char (island) and hilly regions (see Fig. 3[C]). From the three maps in Fig. 3, it is clear that vulnerable and poverty-prone areas are more food-insecure under normal conditions. With the impacts of COVID 19 on agri-food systems, food insecurity in these regions is very likely to increase substantively as people in vulnerable zones are mainly farmers and daily wage workers whose income continues to fall (Dhaka Tribune, 2020; Mottaleb et al., 2020; WB, 2020c). For example, the average income of day labourers (rickshaw-pullers, tea-stallers, CNG auto-rickshaw drivers, housemaids, small business owners, mass-transport workers, street hawkers and garment workers) in Dhaka city has dropped with lockdown measures (Sakamoto et al., 2020). Reduced income means that these

Fig. 3. (A) Spatial Distribution of Food Insecurity in Bangladesh based on Hossain et al. (2020) [B] Poverty distribution in Bangladesh based on WB and WFP (2010) [C] Vulnerable zone in Bangladesh based on Haque et al. (2017) and WB (2019).
Fig. 4. A cognitive explanation of the impacts of COVID-19 on agri-food systems and related health and the way to transform these systems. COVID-19 exposed present agri-food system and related health vulnerabilities as shown in Stage-1 (S-1). Without any adaptation and transformation measures, agri-food systems and related health will collapse (Stage-2 (S-2)). It will require a tremendous effort to move to Stage-3 (S-3) post COVID-19. However, if timely and appropriate adaptation and transformation measures are taken, agri-food systems and related health can return to a stable condition as shown in Stage-3 (S-3).

5. Conclusion and recommendations

Bangladesh’s agri-food systems are adapting and coping with the impacts of climate change through several infrastructural-technological initiatives (Mondal et al., 2019) such as income source expansion by introducing diversified cropping practices and introducing ICT (Information and Communications Technology) in sectors of the agri-food system. The lessons learned could be a platform on which a strategy can be formulated to also adapt and cope with the impacts of COVID-19 and future crises in agri-food systems and related health impacts. To this end, Bangladesh needs support from its development partners including from international agencies.

Taking proactive measures to increase economic resilience, enhancing capacity to deal with the impacts described here and reducing the vulnerability of farming communities will go far in sustaining food security and socioeconomic development. To avoid disruptions to agri-food systems and related exacerbations of human health issues, Bangladesh may consider the following measures:

1. Maintain the function and viability of domestic food supply value chains and enhance their resilience through coordinated efforts of different government ministries (including finance, agriculture, fisheries and livestock, planning, local government, rural development and co-operatives, disaster management and health) in utilizing natural, social, financial, human and physical capitals. Ensure government assistance (financial and technological) for food processing, transport and marketing.
2. Take all necessary measures to ensure the normal flow of agricultural inputs (seeds, fertilizer, pesticide, insecticide, medicine, feed, etc.), making use of credit, subsidies and government-managed distribution as needed. Quick procurement and inputs distribution systems should be introduced at the farm level. Labour shortage during rice harvest is an issue for the agricultural sectors of Bangladesh. It should be addressed by ensuring the viability of agricultural labour throughout the country during harvest season, through for example targeted vaccination programs.
3. Agroecology, climate-smart agriculture, circular agriculture and regenerative agriculture could play vital roles in the post-COVID-19 recovery. These approaches can support diversified agricultural systems. Therefore, these should be tested as part of the agricultural extension work.
4. Strong agriculture-based internal markets should be designed and enabled to support all stakeholders.
5. Access to appropriate analytical tools such as simulation models can support informed policy choices for risk reduction in the agriculture sector. Hence, data on agricultural systems such as inputs, food production, prices, trade, market access and nutrition should be collected to allow for better analysis and simulations.
6. Improve the present storage systems capacity by providing mechanization and appropriate technology. Improvement in storage capacities for grains, fruits and vegetables greatly helps in mitigating food security-related vulnerabilities by ensuring regular supply to all sectors of society. The present grain procurement by the government, distribution to the impoverished sections of the society, central storage capacities and cold storage facilities are not efficient.
7. Application of ITC in agricultural sectors of Bangladesh has just been introduced and is gaining support from government and development partners. Digitized agri-food systems under appropriate policy frameworks and using appropriate technology to support farmers in growing and marketing food in sustainable ways can be very effective for ensuring the resilience of agri-food systems and reduced health impacts in the face of present and future risks.
COVID-19 has changed and threatens to continue to change the agri-food systems of Bangladesh. Ensuring food-related human health, and the productivity and efficiency of the agri-food systems and effective food distribution have become top policy priorities in Bangladesh. Multiple levels of government have moved to address these issues. While the Government of Bangladesh has announced a stimulus package of 59 million USD for small and medium sized farmers aimed at keeping businesses running (The Daily Star, 2020), it is not enough relative to the size and support needs of the agricultural sector of Bangladesh. While economic stimulus is important, the success of agri-food systems and related human health outcomes during the pandemic and beyond will be determined by the abilities of food providers and distributors to maintain productivity and to make efficient use of expert-guided planning, community support and government assistance. Bangladesh must continue to reorient and stabilize its agri-food systems to mitigate agri-food system impacts, and the health impacts of COVID-19.

Declaration of Competing Interest
The authors declare no conflict of interest.

References

Aday, S., Aday, M.S., 2020. Impact of COVID-19 on the food supply chain. Food Qual. Safety 4 (4), 167–180. https://doi.org/10.1016/j.fqsaf.2020.

ADBI, 2020. Basic Statistics, Asia and the Pacific. Sustainable Development Goals (SDGs). Poverty Data: Bangladesh Asian Development Bank, Bangladesh. https://www.adb.org/countries/bangladesh/poverty.

Adhikari, J., Timmins, J., Khakha, S.R., Ghale, Y., Oha, J., 2021. COVID-19 impacts on agriculture and food systems in Nepal: implications for SDGs. Agric. Syst. 186, 102990. https://doi.org/10.1016/j.agsy.2020.102990.

Ali, N., Akram, R., Sheikh, N., Sarkar, A.R., Sultan, M., 2019. Sex-specific prevalence, inequality and associated predictors of hypertension, diabetes, and comorbidity among Bangladeshi adults: results from a nationwide cross-sectional demographic and health survey. BMJ Open 9 (9), e025964. https://doi.org/10.1136/bmjopen-2019-025964.

Annona, A.A., Masud, M.H., Chowdhury, S.A., Dabrichiki, I., Ahmed, N., Arefin, A.M.E., 2020. Sustainable food waste management model for Bangladesh. Sustain. Product. Consum. 27, 35–51. https://doi.org/10.1016/j.sproc.2020.02.002.

Anas, M.Z.A., Kuronuma, Y., 2020, May 12. Coronavirus Risks Pushing Millions of Bangladeshis to Starvation. June https://www.dhakatribune.com/health/coronavirus/2020/08/12/covid-19-impac-
tional-poverty-rate-rises-to-29.5-as-of-june.

Dhieh, N., Rizewa, N., 2020. Trade Responses to Covid-19 Food Security Concerns in Bangladesh. Policy Brief. World Bank https://openknowledge.worldbank.org/bitstream/handle/10986/33758/Trade-Responses-to-Covid-19-Food-Security-Concerns-in-Bangladesh.pdf?sequence=1&isAllowed=y.

EAT, 2019. Food Planet Healthy: Diets from Sustainable Food Systems, Summary Report of the EAT Lancet Commission. https://eatforum.org/content/uploads/2019/01/EAT-Lancet_Commission_Summary_Report.pdf.

ERoshkin, V., Gao, T., 2020. Impacts of COVID-19 on trade and economic aspects of food security: evidence from 45 developing countries. Int. J. Environ. Res. Public Health 17 (16), 5775. https://doi.org/10.3390/ijerph17165775.

FAO, 2016. Food and Agriculture: Key to Achieving the 2030 Agenda for Sustainable Development. FAO https://sustainabledevelopment.un.org/content/documents/ 2131Foodandagriculture.pdf.

FAO, 2017. Evaluation of FAO’s Contribution to Bangladesh. Office of Evaluation. Country Programme Evaluation Series. FAO http://www.fao.org/3/BD730/bd730.pdf.

FAO, 2019. Production Quantities of Rice, Paddy by Country. Average 1994–2019. FAOSTAT. https://www.fao.org/faostat/en/#data/QC/visualize.

FAO, 2020a. Factsheets on the 21 SDG Indicators under FAO Custodianship. A Highlight of the Main Indicators With the Greatest Gaps in Country Reporting. FAO, Rome http://www.fao.org/3/c3a95b8a/c3a95b8e.pdf.

FAO, 2020b. Coronavirus Disease 2019 (COVID-19). Addressing the Impacts of COVID-19 in Food Crises (April–December 2020) – May update. Rome. https://reliefweb.int/sites/reliefweb.int/files/resources/COVID-19%20Apparel%20-%20MOY%20Update%202020.pdf.

FAO, 2020c. Keeping Food and Agricultural Systems Alive: Analyzes and Solutions in Response to COVID-19. Accra. https://www.fao.org/c3a8822en/C3A8822EN.pdf.

FAO, 2020d. COVID-19: Channels of transmission to food and agriculture by Schmidhuber, J., Pound, J., Qiao, B. and Food and Agriculture Organisation, United Nations http://www.fao.org. http://www.fao.org/c3a8433en/C3A8433EN.pdf.

FAO, 2020e. Impact of COVID-19 on Dhaka’s Food Markets and Food prices. Situation Report No. 2. FAO https://fclustr.org/sites/default/files/documents/situation_report_2_april 11-19_food_markets_and_food_prices250420.pdf.

FAO, 2020f. Responsiveness of food and agriculture systems to the COVID-19 outbreak on food value chains through efficient logistics. Global Forum on Food Security and Nutrition. Report of activity No.166. http://www.fao.org/3/c19292en/C19292EN.pdf.

FAO, IFAD, UNICEF, WFP, WHA. 2018. The State of Food Security and Nutrition in the World 2018. Building Climate Resilience for Food Security and Nutrition. Rome, FAO https://www.fao.org/3/CA8430EN.pdf.

Baghati, M.D., Cardoso, A.M., Resckhe, C.R., Carvalho, F.B., 2018. Immune system and chronic diseases 2018. J. Immunol. Res., 8653572 https://doi.org/10.11588/2015/ 8653572.

Baghi, M., Rahman, S., Shumbo, Y., 2019. Growth in agricultural productivity and its components in Bangladesh regions (1987–2009): an application of bootstrapped Data Envelopment Analysis (DEA). Economies 7 (2), 37. https://doi.org/10.3390/ economies7020037.

BBS, 2018. Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics, Dhaka, Bangladesh.

BIE, 2018. Bangladesh Economic Review. Finance Division, Ministry of Finance, Government of Peoples’ Republic of Bangladesh, Dhaka, Bangladesh.

Bhattacharya, J., Currie, J., Haider, S., 2004. Poverty, food insecurity, and nutritional outcomes in children and adults. J. Health Econ. 23 (4), 839–862. https://doi.org/10.1016/j.jhealeco.2003.12.008.

Bhuvan, R.V., Gopinath, R., 2020. The COVID-19 pandemic crisis and the relevance of a farm-system for – nutrition approach. Springer Food Secur. 12, 881–884. https://doi.org/10.1007/s12751-020-01071-x.

Bhuyan, M.U.O., 2020. Lockdown disrupts supply chain of agro producers. The New Age https://www.newagebd.com/article/103476/lockdown-disrupts-supply-chain-of-agro producers. 24.03.2020.

BRRI, 2014. Rice in Bangladesh. Bangladesh Rice Knowledge Bank. Bangladesh Rice Research Institute, Bangladesh. http://www.knowledgebank-bri.org/riceinban.php.

Calder, P.C., Jackson, A.A., 2000. Undernutrition, infection and immune function. Nutr. Res. Rev. 13 (3), 3–29. https://doi.org/10.1017/s09545442000100981.

Cardwell, R., Ghazalian, P.L., 2020. COVID-19 and international food assistance: policy pro posals to keep food flowing. World Dev. 135, 105059. https://doi.org/10.1016/j. worlddev.2020.105059.
B. Talukder et al. Current Research in Environmental Sustainability 3 (2021) 100033

Hossain, M.J., Das, S., Chandra, H., Islam, M.A., 2020. Disaggregate level estimates and spatial mapping of food insecurity in Bangladesh by linking survey and census data. PLoS One 15 (4), e0229096. https://doi.org/10.1371/journal.pone.0229096.

Huizar, M.L., Arena, R., Laidi, D.R., 2020. The global food systemic: the impact of food insecurity, malnutrition and obesity on the healthspan amid the COVID-19 pandemic. Prog. Cardiovasc. Dis. https://doi.org/10.1016/j.pcad.2020.07.002.

Huss, M., Brander, M., Kaisse, M., Eihart, U., Bernauer, T., 2021. Improved storage mitigates vulnerability to food shocks in smallholder agriculture during the COVID 19 pandemic. Global Food Secur. 28, 100468. https://doi.org/10.1016/j.gfs.2020.100468.

IPS-Food. 2020. COVID-19 and the crisis in food systems: symptoms, causes, and potential solutions. International Panel of Experts on Sustainable Food Systems http://www.ipes-food.org/img_upload/files/COVID-19_CommuniqueEN.pdf.

Irz, X., Lin, L., Thistle, C., Wiggins, S., 2001. Agricultural productivity growth and poverty alleviation. Dev. Policy Rev. 19 (4), 449–466. https://doi.org/10.1111/1467-7679.00144.

Kim, K., Kim, S., Park, C.-Y., 2020. Food Security in Asia and the Pacific amid the COVID 19 pandemic. Asian Development Bank License: CC BY 3.0 IGO. http://hdl.handle.net/11540/12119.

Larderie, D., Martin, W., Swinnen, J., Vos, R., 2020. COVID-19 risks to global food security. Science 369 (6503), 500–502. https://doi.org/10.1126/science.abb4765.

Mishra, K., Rampal, J., 2020. The COVID-19 pandemic and food insecurity: a viewpoint on India. World Dev. 135, 105068. https://doi.org/10.1016/j.worlddev.2020.105068.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G., Prisma Group, 2009. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med. 6 (7), e1000097. https://doi.org/10.1371/journal.pmed.1000097.

Mondal, M.S., Islam, M.T., Saha, D., Hosain, M.S.S., Das, P.K., Rahman, R., 2019. Agricultural adaptation practices to climate change impacts in coastal Bangladesh. Confronting Clime- mate Change in Bangladesh. Springer, Cham, pp. 7–21. https://link.springer.com/chapter/10.1007/978-3-030-05237-9_2.

Moesley, W.G., Rattenby, J., 2020. The vulnerability and resilience of African food systems, food security, and nutrition in the context of the COVID 19 pandemic. Afr. Stud. Rev. 63 (3), 449–461. https://doi.org/10.1017/ast.2020.72.

Mostafa, I., 2020. Digital Technology Ensures Food Supply in Rural Bangladesh During COVID-19. World Bank https://blogs.worldbank.org/endpovertyinnouvostar/digi- tal-technology-ensures-food-supply-rural-bangladesh-during-covid-19.

Mottalfe, K.A., Mainuddin, M., Sonobe, T., 2020. COVID-19 induced economic loss and ensuring food security for vulnerable groups: Policy implications from Bangladesh. PLoS One 15 (10), e0240709. https://doi.org/10.1371 Journal.pone.0240709.

NAWGB, 2020. COVID-19 Bangladesh multi-sectoral anticipatory impact and needs analysis. Needs Assessment Working Group Bangladesh (NAWGB). Government of Bangladesh, Dhaka https://reliefweb.int/sites/reliefweb.int/files/resources/covid-nawg_anticipa- tory-impact_and_needs_analysis.pdf.

Niles, M.T., Bertonani, F., Belarmino, E.H., Wentworth, T., Biel, E., Neff, R., 2020. The early food insecurity impacts of COVID-19. Nutrients 12 (7), 2096. https://doi.org/10.3390/ nu12072096.

Paul, A., Nath, T.K., Mahanta, J., Sultana, N.N., Kayes, A.I., Noon, S.J., … Paul, S., 2020. Psychological and livelihood impacts ofCOVID-19 on Bangladeshi lower income people. Asia Pac. J. Public Health https://doi.org/10.1177/1010539520977304 1010539520977304.

Porritt, R.E., 2020. Local Food Systems and COVID-19: A Glimpse on India. World Dev. 135, 105068. https://doi.org/10.1016/j.worlddev.2020.105068.

Roy, R., 2020. Mitigating Covid-19 Impacts on Food and Agriculture. https://thefinancialexpress.com/biz/views/mitigating-covid-19-impacts-on-food-and-agriculture-1585922664.

Sakamoto, M., Begum, S., Ahmed, T., 2020. Vulnerability to COVID-19 in Bangladesh and a reconsideration of sustainable development goals. Sustainability 12 (13), 5296. https://doi.org/10.1007/s12043-020-00867-y.

Sakamoto, M., Begum, S., Ahmed, T., 2020. Situation Tracking for COVID-19 Socio-Economic Impacts. UNICEF https://data.unicef.org/resources/situation-tracking-covid19-socioeconomic-impacts-data-viz/.

Sakamoto, M., Begum, S., Ahmed, T., 2020. UNICEF, 2020b. Additional 3.9 million children under 5 could suffer from wasting in South Asia this year due to COVID-19 – UNICEF. Press release. UNICEF https://www. unicef.org/bangladesh/en/press-releases/additional-39-million-children-under-5-could-suffer-wasting-south-asia-year-due.

UNICEF, 2021, January. 30. The COVID-19 Pandemic Is Disrupting people’s Food Environment: A Resource List on Food Systems and Nutrition Responses. Recent News. United Nations Systems Standing Committee on Nutrition https://www.unsco.org/en/news-events/recent-news?news=2029.

UNICEF, 2020a. South Asia Records Worst-ever Recession, Must Prioritize Smart Policies for Infor- mation and Communication Technology for Agriculture in the Prairie Region of Canada: Comparison with U.S. Agency for International Development http://documents1.worldbank.org/cr/s/2014/11/03/S1368980020003493.

U.S. Agency for International Development http://www.usaid.gov/sites/default/files/ documents/1870/USAIDResistancePolicyGuidanceDocument.pdf.

USDA, GAIN, 2020. Grain and Feed Update: Bangladesh. Bangladesh State Department of Agricultur- e, Foreign Agriculture Service and Global Agricultural Information Network. Report Number BG20200206. https://reliefweb.int/sites/reliefweb.int/files/resources/Grain%20and%20Feed%20Update%20October%202020.pdf.

WB, 2014. Bangladesh: New Life for the Rural Poor. Feature Story. World Bank https://www. worldbank.org/en/news/feature/2014/06/30/bangladesh-new-life-for-the- rural-poor.

WB, 2019. 462. https://doi.org/10.1111/jn.12041.

WB, 2019. COVID-Food Security, 4.23_20-ANXEDE.pdf.

WB, 2020b. South Asia Records Worst-ever Recession, Must Prioritize Smart Policies for Infor- mation and Communication Technology for Agriculture in the Prairie Region of Canada: Comparison with U.S. Agency for International Development http://www.usaid.gov/sites/default/ files/SG_policy_brief_on_covid_impact_on_food_security.pdf.

WB, WFP, 2020. COVID-19 and Food Security: Update April 23. World Bank http://www. food-securityindex.eiu.com.

Workie, E., Mackolil, J., Nyika, J., Ramadas, S., 2020. Deciphering the impact of COVID-19 on global food security in the con- text of COVID-19: a scenario-based exploratory analysis. Prog. Disast. Sci. 7, 101021. https://doi.org/10.1016/j.pcd.2020.100120.

WHO, 2020. Situational Report: The Impact of COVID-19 on Food Security and Nutrition. United Na- tions https://www.un.org/unis2/un.org/files/sg_policy_brief_on_covid_impact_on_food_security.pdf.

WHO, 2020a. Situation Tracking for COVID-19 Socio-Economic Impacts. UNICEF https://data.unicef.org/resources/situation-tracking-covid19-socioeconomic-impacts-data-viz/.

Zhang, X., Rashid, S., Ahmad, K., Ahmed, A., 2014. Escalation of real wages in Bangladesh: is the price of food the main culprit? Food Security 6, 461. https://doi.org/10.1017/asr.2020.72.