Vol.11(11), pp. 208-224 November 2019
DOI: 10.5897/JAERD2019.1081
Articles Number: FC05D4462303
ISSN: 2141-2170

http://www.academicjournals.org/JAERD

ACADEMIC JOURNALS

Journal of Agricultural Extension and Rural Development

Full Length Research Paper

Current scenario and challenges of agricultural production to future food security in Bangladesh

Momotaz[1*], Tanjinul Haque Mollah[2], Anannya Mazumder[2] and Takaaki Nihei[1]

[1]Department of Regional Science, Graduate School of Letters, Hokkaido University, Hokkaido-060-0808, Japan.
[2]Geography and Environment, Jahangirnagar University, Dhaka-1342, Bangladesh.

Received 18 July, 2019; Accepted 8 October, 2019

Ensuring food security is a global challenge that can be mitigated by improving agricultural production. From the last few decades, many developed nations have introduced modern and sustainable agricultural system to abate this challenge. Now, developing countries also demand the blessings of sustainable agricultural system to face this globally burning issue. The purpose of this study is to examine the current agricultural system of main crops and challenges of food security of Bangladesh. Therefore, on the basis of present scenarios of agricultural productivity, some suggestions have been proposed to combat the food security challenges. Mainly agricultural related secondary data published by the government of Bangladesh were analysed to conduct this research. All over the country, farmers are facing challenges of storage facilities, lack of modern agricultural machineries, unfriendly market policy of agro-products, less empathy of governments and natural disaster. Last few year's potato productions has been increasing noticeably because of soil fertility, due to farmer's well-mannered adaptation strategies to climate change, high yield crop seed, using optimum fertilizer, farmer's dearness etc. On the other hand, Jute, the world second largest product also declining the production which contributes 4.66% to economic growth. However, Government's initiatives can ensure food security and sustainable agricultural system of Bangladesh. In this context, farmer friendly agricultural policies, introducing modern technologies, as well as inventing climate adaptive new crop species can be helpful to achieve food security. This research gears towards realization of present agricultural productivity scenarios and to take proper measures by the decision makers of Bangladesh.

Key words: Crop calendar, cropping pattern, hazards, irrigation.

INTRODUCTION

Bangladesh is the world's eighth densely populated country which is fifty times higher than that of the US and six times higher than even that of China (Ministry of Land, 2016). Its total land area is 14,570 km^2 where 60% of the total land area is used as cultivated area (BBS, 2016)*. The population is still increasing by 1.37% every year (BBS, 2017), however, the cultivated land is decreasing simultaneously. The agricultural land is converted by the uncontrolled urbanization, industrialization as well as with the increasing of human activities (Ahmed, 2013). These land to human ratio decreasing phenomenon is the serious encounters of food security in Bangladesh (Roy

*Corresponding author. E-mail: momotaz_ju38@eis.hokudai.ac.jp.

et al., 2019). For food security, the country still depends on the import of food grains where crop production is higher than before, implying that demand is more than production. In 2008, Bangladesh imported 11.5% of total availability and it is also predicted that until 2021, the demand of staple food will also exceed supply which indicates that demand will also remain higher than production (Begum and D'Haese, 2010).

Agriculture of Bangladesh is constrained due to climate change induced hazards (drought, flood, salinity, riverbank erosion etc) and by a number of challenges such as in adequate management practise, population growth, unfair crop price, insufficient credit facilities, loss of arable land, lack of investment in agricultural research (Mondal, 2010; Ghose, 2014). In addition, Karim et al. (2017) indicated that availability of quality seed, market access facility, lack of storage facility and slow technology transfer also slow down the agricultural development process. In all, Shelley et al. (2016) added soil fertility, pest: insect, pathogens and weeds, extreme temperature stresses, and multiple stress with those as agricultural challenges. However, there were existing large regional disparities, lacking policy implication, and unequal resources allocation among farmers (Bagchi et al., 2019). Increasing labour cost and water scarcity are not the only factors threatening crop production, but weeds, lodging, blast, debases, poor kernel quality/low-quality seed and low yield rate are also responsible for it. Moreover, natural hazards like flood, drought, riverbank erosion, low price, etc are also accelerating the challenges more severe.

About 1.2 million people needs food security assistance; among this, 80% (884000 refugees are in Cox's Bazar) of refugees and also about 30% of total population of the country are vulnerable to food insecurity (World Bank, 2017). About 23.2% population live below poverty line in the country (BBS, 2016; SDG, 2018). For food security, the country still depends on the import of food grains where crop production is higher than before, implying that demand is more than production. In 2008, Bangladesh imported 11.5% of total availability and it is also predicted that until 2021, the demand of staple food will also exceed supply which indicates that demand will also remain higher than production (Begum and D'Haese, 2010).

Many developing countries are facing challenges including population growth, low management mechanisms, agricultural resources scarcity, and environmental degradation, however the government has made great effort to solve those challenges (Zhao et al., 2007). In China, agricultural contribution percentage rose to 45% in 2000 from 20% during 1953-1957 because of confirmation of more than 40,000 interventions of agricultural science and technology from 1979 to 2003 (Niu, 2004). On the other hand, India, an agriculture base economic country, has been facing challenges because of dependency on rain for crop yield, declining environmental quality of land, low adaptation of modern technology, practicing too haphazard and unscientific farming (Singh and Parihar, 2015). Singh and Parihar (2015) suggested that human resources, capital, technical resources and optimum use of natural resources are required to achieve sustainable development. Furthermore, agricultural development of Afghanistan is facing challenges with limited access to technology, weak institutional support, organization and management of research, education and extension system (Saleem and Raouf, 2011). Afghanistan is now trying to solve those obstacles through agricultural education and training (Mason et al., 2008; Saleem and Raouf, 2011).

In this paper, firstly, the agricultural condition of Bangladesh and distribution of main crops have been analysed to understand the general concept of agricultural characteristics of the country. Secondly, it emphasized the variety of distributions of main crops across the country followed by the identification of the reasons behind the variability of the production area of the main crops of Bangladesh, and finally, discusses the current challenges towards agricultural crop production and recommendation of those challenges for future food security of the country. To fill out the aim, we took three objectives first, to find out the current crop production and trends of the country; secondly, to study the issues and challenges that impact on sustainable agricultural development; and thirdly, to recommend the pathways of those challenges to achieve sustainably developed agricultural sector for future prospect of the country.

Study area

Bangladesh is situated between 88π 01´´ - 91π 41´´ E and 20π 26´´ - 23π 38´´ N, a south-Asian country, surrounded by India (west, north and eastern side), Myanmar (South-eastern side), and Bay of Bengal (Sothern side). Although it is a small country, it has distinct physiographic diversity where 12% land belong to Pleistocene land, tertiary hilly area (8%) and plain land (flood plain and deltaic land) 80% (Figure 1). More than 700 river cuts across the country and drainage system, 79% dominated by three main rivers: Ganges-Brahmaputra-Meghna (GBM) and their tributaries river and overflowed in monsoon. Being a tropical monsoon climatic country, there is fairly marked seasonal variation with frequently high rainfall difference between seasonal temperatures in hot and humid summer (March to June), hot, humid, and heavy rainy monsoon (June to November), dry winter (December to February) with low temperature.

Bangladesh has a monsoon climate with a hot, rainy summer (suitable for Aman rice, Jute) and a dry winter season suitable for Boro rice, wheat, potato, maize (Table 1). In the country, rice is the dominant crop and

Figure 1. Geographical location of Bangladesh.

and contributes 70% of calories consumed (Majumder et al., 2016), so rice management intervention has been a focus of food security activities. For the causes of climate, suitable rainfall, temperature, and soil type, Bangladesh can grow plenty of rice all over the year. Rice has wide adaptation ability under different agro-ecological niches of the country. For its distinct characteristics, it can be cultivated from slope of the hill to a very deep flooded area where water depth rises around 3 m (Nasim et al., 2017). The study area is also a disaster-prone area that almost all over the year happens in the country meanwhile different regions are affected by different disasters (Table 3).

METHODS

This research was conducted based on secondary information collected from different organizations. Both spatial and non-spatial data were collected for visualizing the distribution pattern of crop production in Bangladesh. Therefore, challenges of food security were scrutinized through related literature. Finally, based on the distribution pattern and constraint of food securities, some pathways were proposed for attaining sustainable agricultural

Table 1. Cropping season.

Criteria	*Kharif-1 (16Mar-15 Jul) or Hot Summer/ pre-kharif* **(Chaitra- Ashar)**				*Kharif-2 (16 Jul-15 Oct) or Monsoon or rainy season* **(Srabon-Asshin)**				*Rabi (16 Oct to 15 Mar) or dry winter (Kartik-Falgun)*			
Months	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Highest temperature (ºC)	31.6	33.2	32.9	31.9	31.1	31.4	31.5	31.5	29.5	26.4	25.2	27.8
Lowest temperature (ºC)	19.6	23.1	24.5	25.6	25.6	25.7	25.4	23.6	19.2	14.2	12.5	15.1
Average temperature (ºC)	25.6	28.15	28.7	28.75	28.35	28.55	28.45	27.55	24.35	20.3	18.85	21.45
Average Rainfall (mm)	52.4	130.2	277.3	459.4	523.0	420.4	318.2	160.3	42.4	9.6	9.0	25.5
Relative Humidity (%)	71	75	79	85	86	86	85	83	79	77	76	72
Prominent crops	Aus, Jute, sorghum, soybean, kachu, oilseed-sesame				Summer vegetables-lady's finger, amaranth, spinach, snake gourd, gourd, brinjal, tomato, green chili, banana, melon, papaya, pineapple, cotton etc.				Wheat, maize, Barley, Boro, Potato, Pulses, Winter vegetables, chili, onion, garlic, cumin, watermelon, groundnut, mustard etc.			

development (Figure 2).

Data collection

Data on the distribution area of three main types of rice-Aus, Aman and Boro rice were collected from the Bangladesh Bureau of Statistics (BBS) of 2016. The data of the distribution area of wheat, potato, and maize were collected from the Yearbook of Agricultural Statistics (2015) agricultural production data from FAO's country profile (Table 2). The collected data were arranged in Excel format before preparing the map of the distribution area of the main crops of Bangladesh in the year 2016 using Arc GIS. It also shows the diversity of crops and crop dominated area by proportion of cultivated area. Finally, the maps show the crop distributed area all over the country of one cropping year.

RESULTS

Four major types of food crops (paddy, wheat, maize and potato) are cultivated all over Bangladesh. The crop calendar of Bangladesh reveals that due to seasonal variety, paddy is cultivated about three times (February to April, May to July and October to November) in year (Table 2). Among them, Aus rice is cultivated from the middle of March and early April to the last of July and early in August. Aman rice is cultivated from the middle of June to the end of November or sometimes early in December to early January. Boro rice is cultivated from mid-November to April or early May. With this, wheat is transplanted in November or early December and harvested in March or early April. Potato is sown in mid-September or early November and harvested in mid-January to early March (Table 2).

Table 4 and Figure 3 explored that the productivity of Boro rice is the highest among all crops which is about 18,938 Mt per year. It also shows that about 74.85% land grows paddy. Among all, Aman rice covers about 49.12%, Boro rice covers 41.94% and Aus rice covers 8.94% land of the country. Based on production, Boro rice is higher than Aman rice. On the other hand, Aus rice productivity is the lowest among all of these crops, that is, about 2,288 Mt per year because of farmers' interest of high profit in Boro production and less yield rate of Aus rice.

Potato production per year is about 9,474 Mt and maize cultivation is 2,445,578 Mt per year.

Crop trend (Figure 3) has also been shown here to realise the productivity change by year after independence to 2016 of the country. Among all food crops, only rice and maize productivity has been increasing but wheat productivity is decreasing; on the other hand, potato productivity is increasing rapidly. In the meantime, the cash crop, Jute has lost the global market after 19th century (Figures 3, 4 and 5).

Southern and southwestern districts are more suitable for Aus rice. Aus rice is mainly cultivated all over the country except some hilly regions and production rate is higher in Barisal region than the other part of the country (Figures 4 and 6a). Aman and Boro rice are cultivated almost in all districts but Aman rice grows well in floodplain region Barisal, Bhola, Dinajpur, Naogaon, Jessore, Sirajganj, Mymensingh, Rangpur Jamalpur districts (Figures 4 and 6b).

On the other hand, Boro rice grows well in the northern region, especially in the irrigated areas such as Dinajpur, Srajganj, Tangail, Mymensingh, Sunamganj etc (Figures 4 and 6c). In Bangladesh, wheat is grown in the western region, Panchagar, Thakurgaon, Gaibandha, Rajshahi,

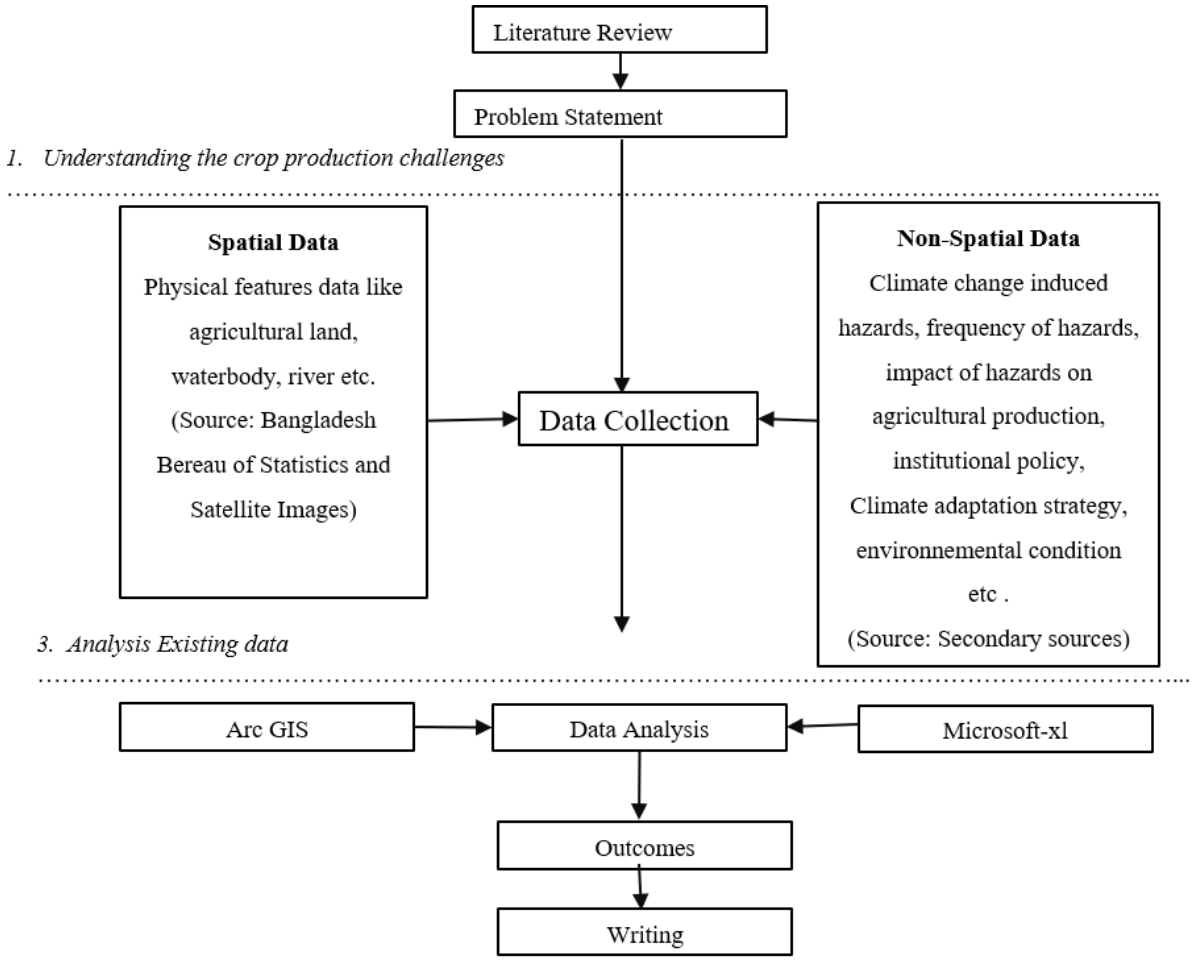


Figure 2. Flow chart of methodology.

Table 2. Data source and category.

Data type	Category		Source	Year
Spatial data	Kharif-1 (March-July)	Aus rice (Paddy), Jute	BBS,	2016
	Kharif-2 (July-October)	Aman rice (paddy)	BBS, YAS	2014, 2016
	Robi (October-March)	Potato, Wheat, Boro rice (paddy)	BBS, YAS	2014, 2016
Spatial data	Administrative Boundary		Earth explorer	2016

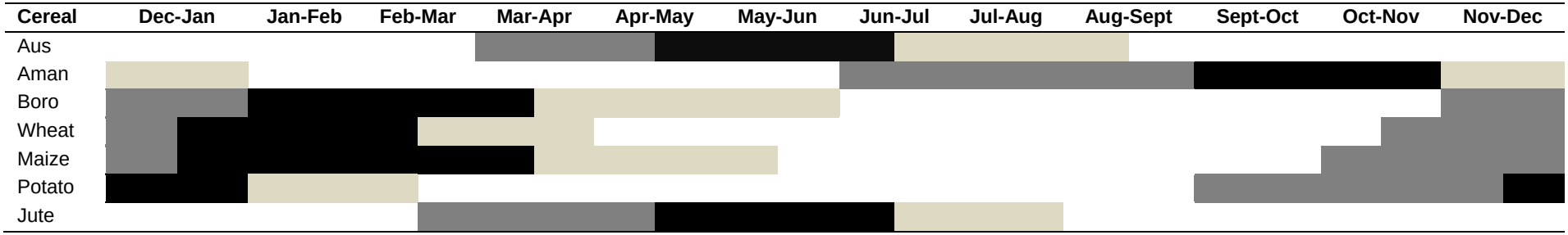
BBS= Bangladesh Bureau of Statistics, YAS=Yearbook of Agricultural Statistics.

Chapai Nabanbgaon, Pabna, Tangail, Rajbari, and Meherpur etc area (Figures 5 and 7). Potato grows in north-western region of the country especially Rangpur, Gaibandha, Rajshahi, Sirajganj, Narayanganj, and Munshiganj district of Bangladesh (Figures 5 and 8). Recently, maize also played a role in mitigating wheat demand. It grows in Faridpur, Gopalganj, Rajbari, Kustia, Manikganj, rajshahi, Meherpur, and Dinajpur districts of the country (Figures 5 and 9).

DISCUSSION

This paper examined the major challenges of agricultural production. Although the government of Bangladesh has taken so many steps for the development of the agricultural sector, there are still many present and future challenges in the sector. Due to farmer's financial problem, natural disaster, lack of promotion of new inventions, lack of proper seed and fertilizer distribution,

Table 3. Main crop calendar of Bangladesh.



Data source: BBS (2016, analysed by authors).

Table 4. Cultivated area, production, and yield rate of main crops of Bangladesh in the year of 2016.

Crop	Cultivated area (*1000. acres)	Production *1000 Mt.	Yield rate per ha kg	Percentage of land coverage (%)
Aus rice	2516	2288	909	8.94
Aman rice	13814	13484	976	49.12
Boro rice	11794	18938	1606	41.94
Wheat	1099	1348	1226	2.92
Jute	1675	7559	4512	4.46
Potato	1175	9474	2160	3.13
Maize	**827387**	**2445578**		1.20

Data source: BBS, analyzed by authors, 2016.

less availability of transportation system, unbalanced market price, lack of storage facilities, dependency on nature, land fragmentation, and traditional way of cultivation, this sector cannot develop as well.

With this, population increase, flooding, and excessive rainfall resulting to weather change make a dramatic impact on agricultural conditions. Flooding and excessive rainfall in 2008 - 2009 damaged Aman rice in Pabna whereas during 2009 - 2010 (April to May), flood and rush of water damaged 46.7% of Boro rice in Sylhet (BBS, 2011). Along with this, Manikganj and Sherpur, regions near Padma River faced severe soil and river bank erosion due to longer and high flood water level that influence change of cropping and homestead areas. From 2003 - 2012, annual rainfall increased by 809 mm in Sylhet, while the value decreased by 364 mm in Dhaka (BBS, 2011). This type of frequent drought, flood, and excessive rainfall occur as a result of changing rainfall patterns which indicates the influences of global climate change (Shapla et al., 2015).

Bangladesh has a monsoon climate with a hot, rainy summer (Aman rice) and a dry winter season (Boro rice). Aman season floods are a severe threat to the farmers in the southern coastal belt and in the northwest region (FAO, 2016). In the last fiscal year, rice was cultivated in 11.7 million hectares whereas production was

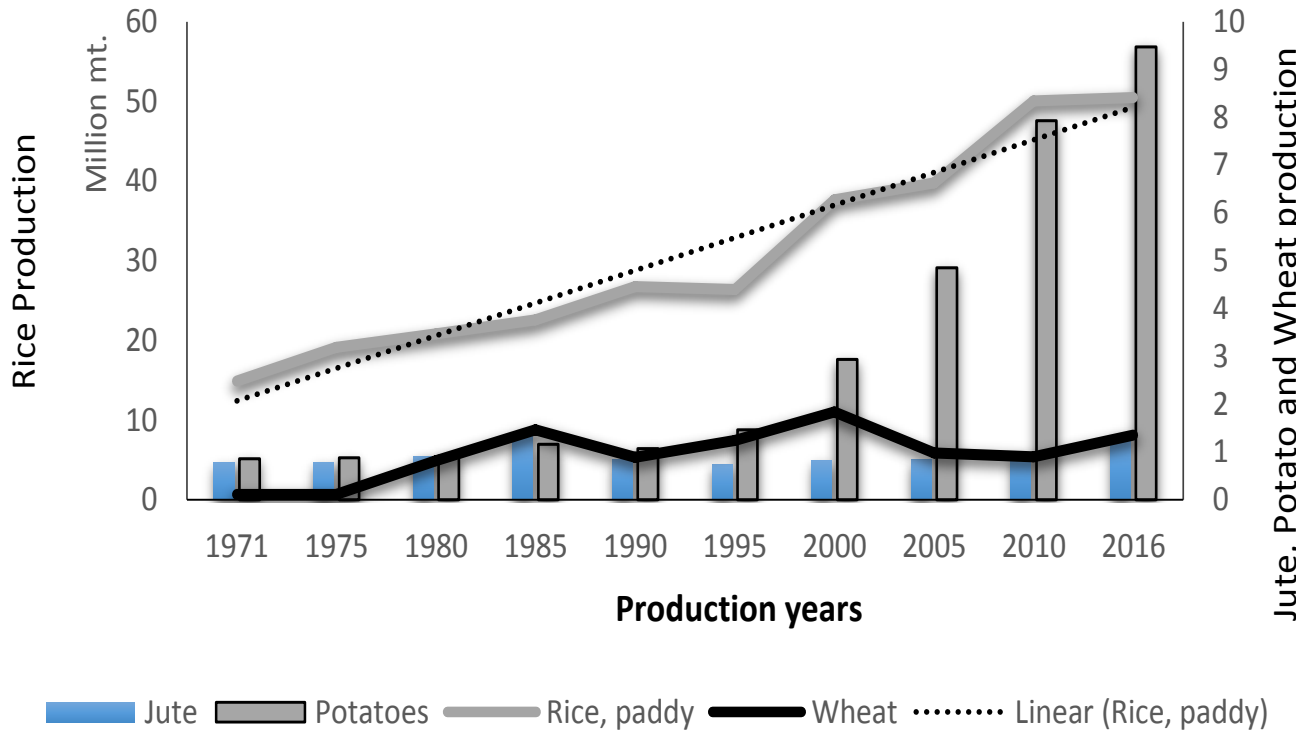


Figure 3. Trend of crop production.
Source: FAO (2018, analyzed by authors).

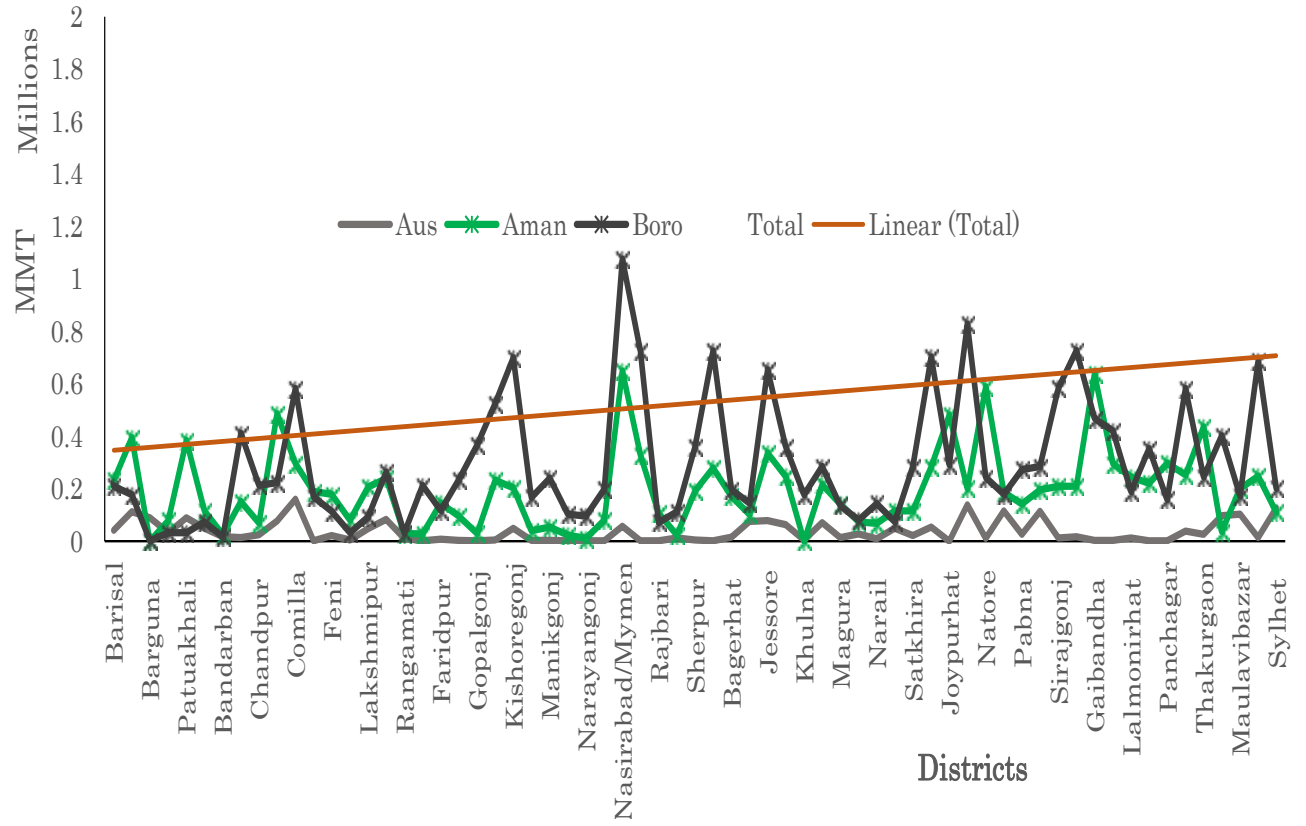


Figure 4. Rice productive area distribution.

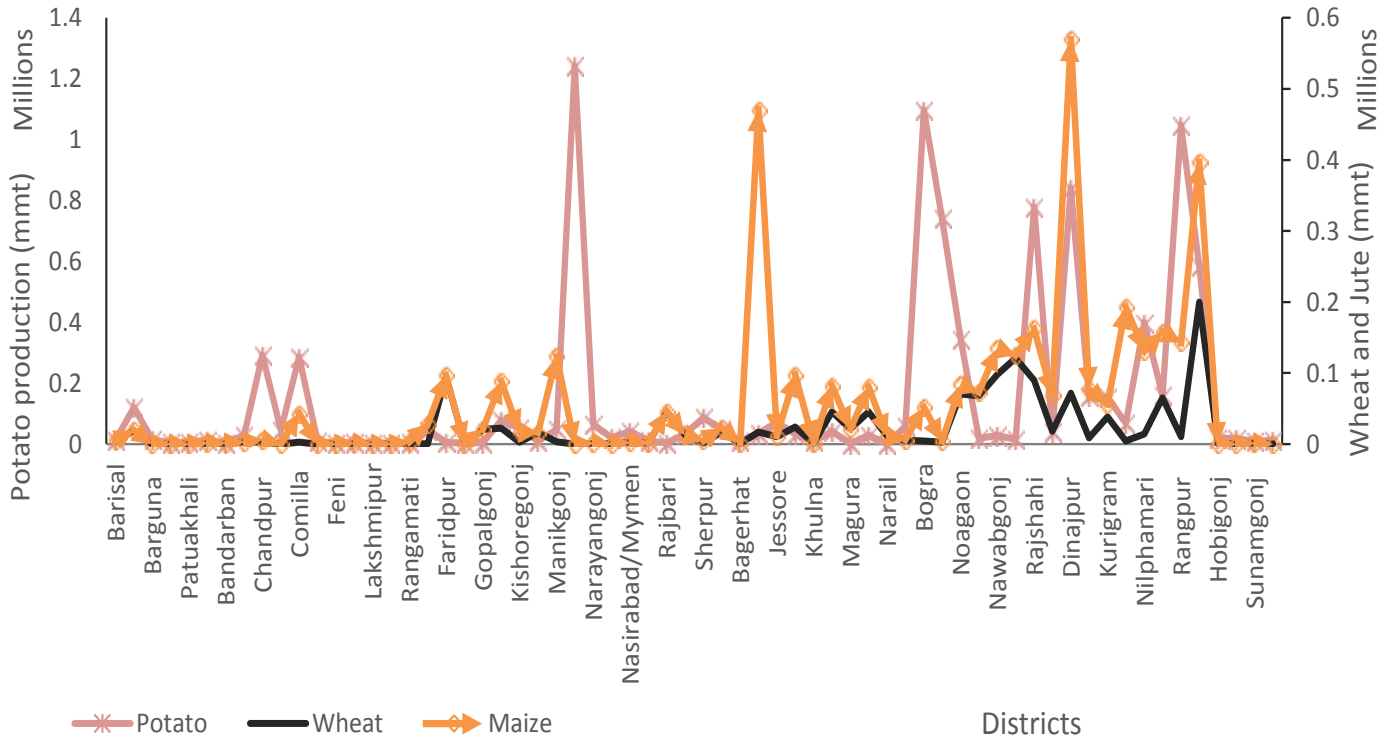


Figure 5. Other food productive area distribution for the year 2016.

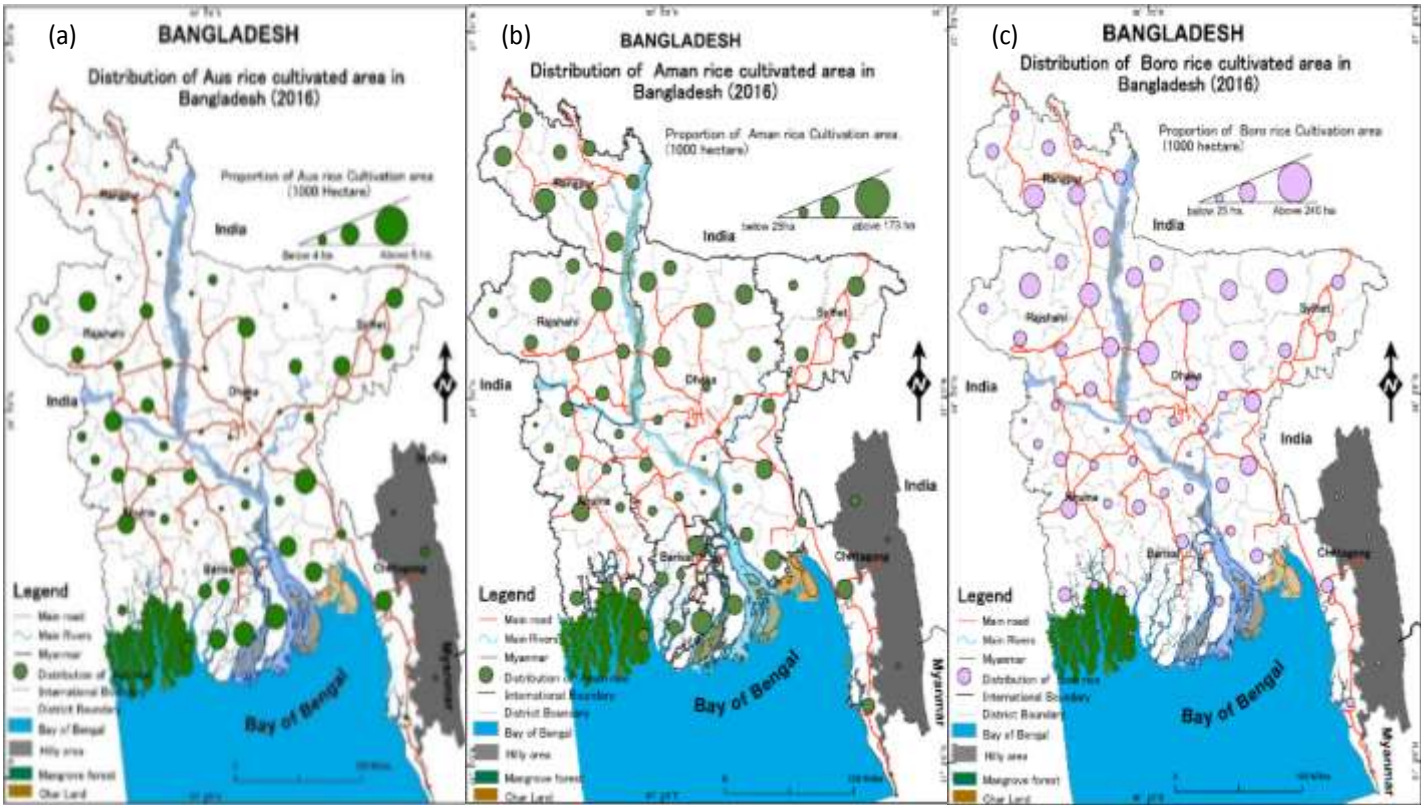


Figure 6. (a) Regional distribution of Aus, (b) Aman, and (c) Boro rice in Bangladesh in the year of 2016.

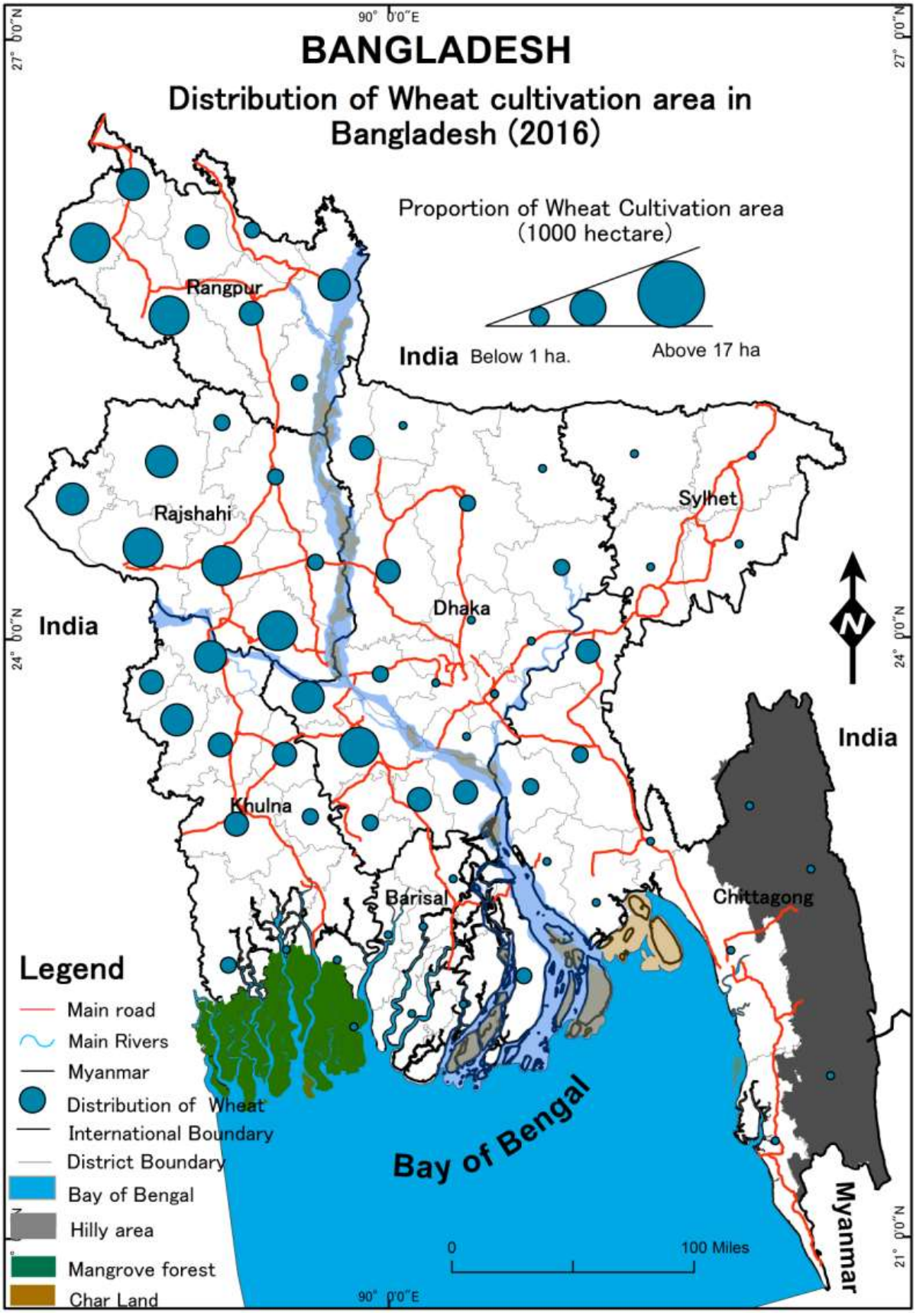


Figure 7. Regional distribution of wheat in Bangladesh in the year of 2016.

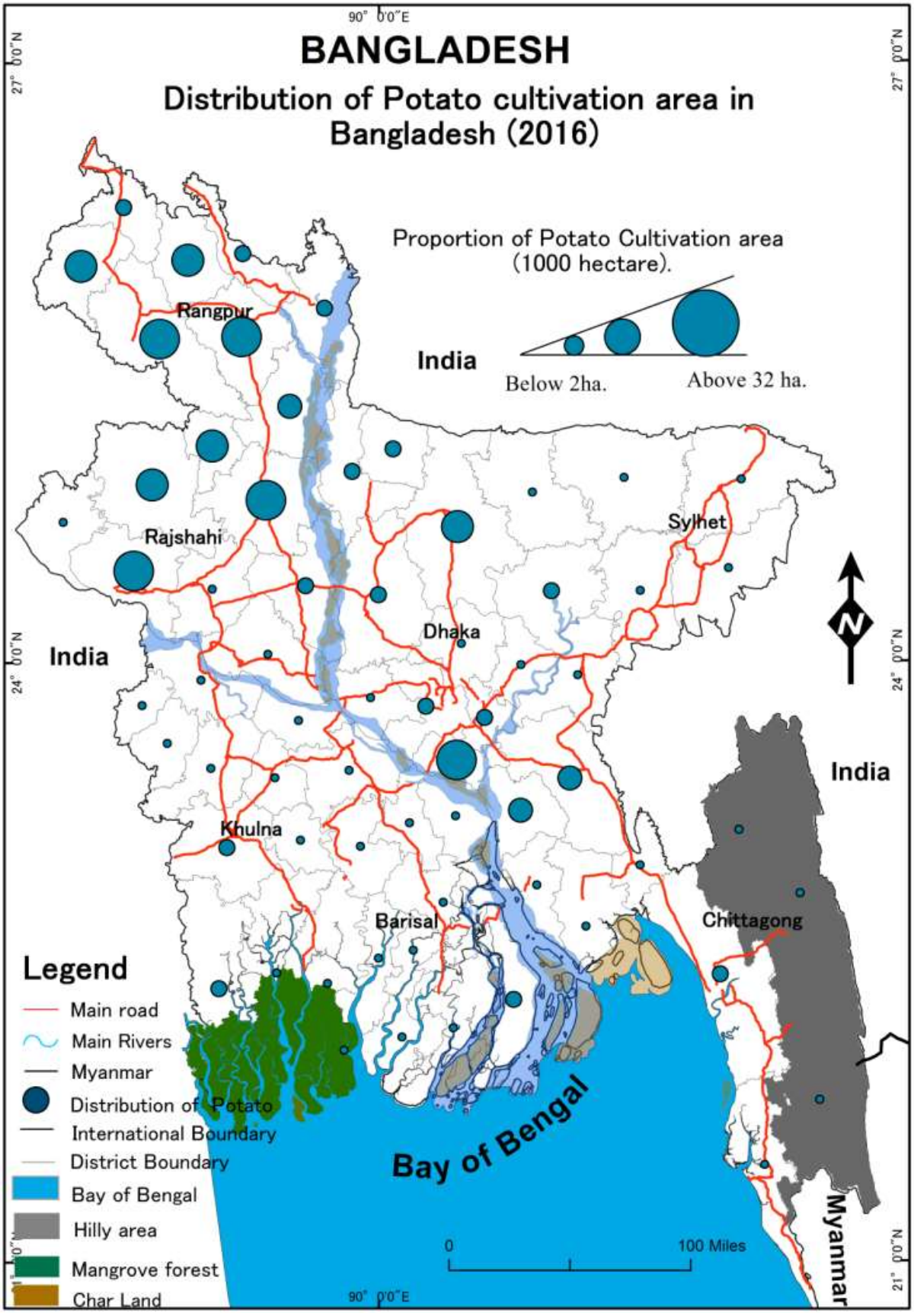


Figure 8. Distribution of potato all over the country.

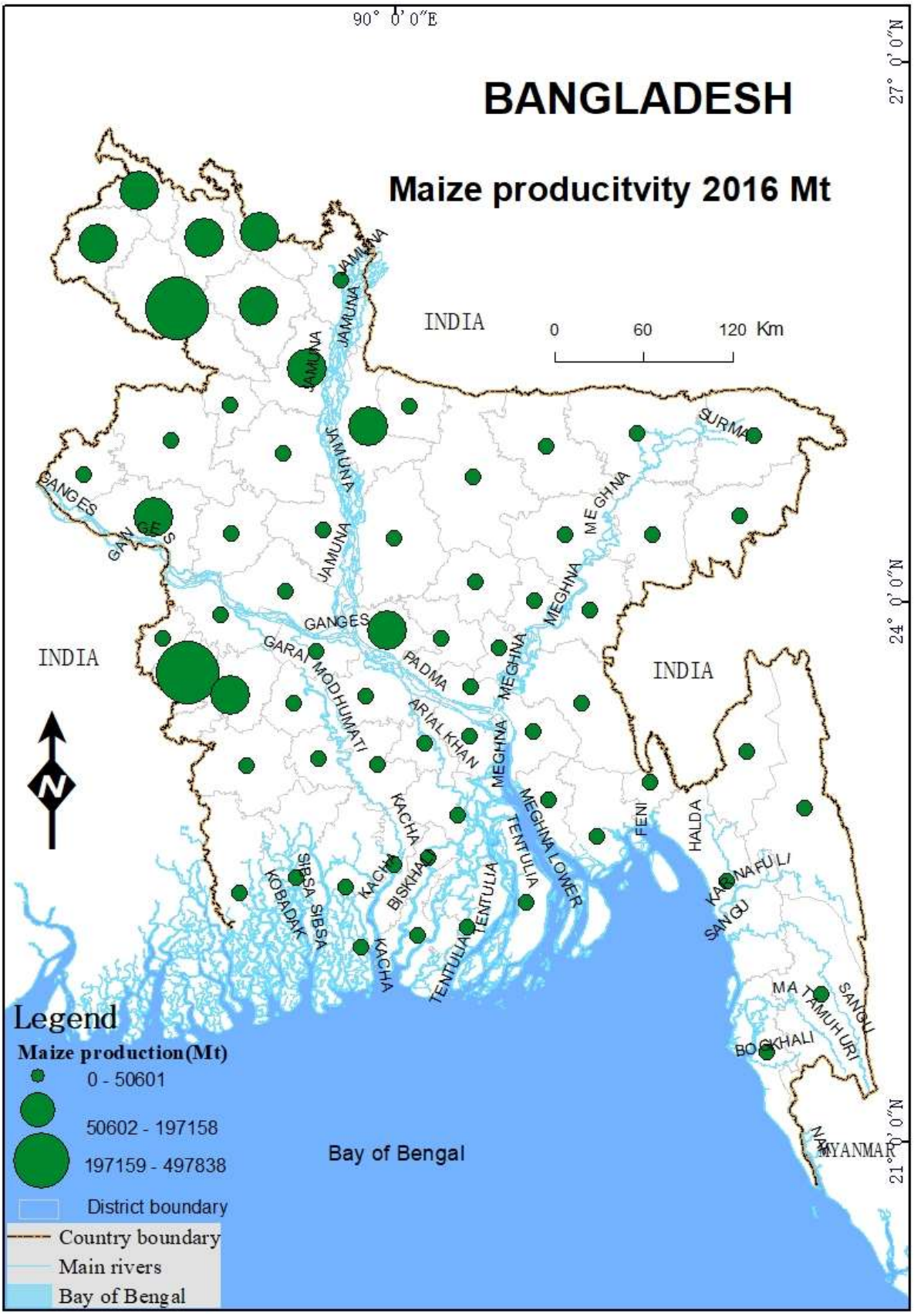


Figure 9. Regional distribution of maize cultivated area in Bangladesh in the year of 2016.

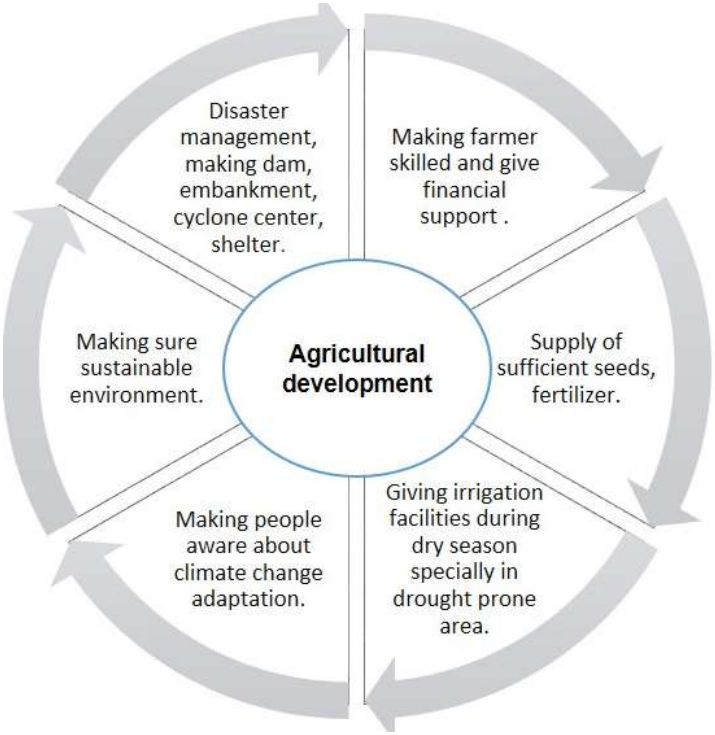


Figure 10. Requirements to make agricultural development.

34.7 million metric tons (Sindelar et al., 2016). According to Ministry of Food (MOF) in 2018, imported rice amount to 3.06 MMT. About 4% of the total cropped area is occupied by wheat and 11% of the area is cropped in Rabi season (November to February) and contribute 7% in total output of food cereals (Hossain et al., 2013). Driving of climate change to global warming has already produced a radical change in temperature routines in Bangladesh and will impact strongly on wheat production (Hossain et al., 2013). In Bangladesh, wheat is grown in the western region, Panchagar, Thakurgaon, Gaibandha, Rajshahi, Chapai Nababganj, Pabna, Tangail, Rajbari, and Meherpur areas etc (Figure 7). For 2017/2018, wheat planted area is lower at 350 million hectares and production is 1.1 MMT whereas 6.5 MMT wheat has being imported which is more than 80% of Bangladesh's wheat consumption (Sindelar et al., 2016; MOF, 2018).

Wheat yields were reduced drastically to 0.73 million tons in 2005-2006 by increased temperature, even at higher levels of CO_2. (Karim et al., 2010; BBS, 2008). In 2016, wheat was cultivated in 498,000 ha area (DAE, 2018) which is higher than 2009 but in several southwestern districts, wheat blast was observed in areas as Meherpur, Chuadanga, Jhinaidah, Pabna, Kustia, Jessore, Bhola, Barishal etc. It is estimated that 15% were affected by the wheat blast in this year. In some areas, 100% were also burned (Islam et al., 2016).

Import of wheat is increasing 1.4 million tons every year because of decreasing production to meet increasing domestic demand (Karim et al., 2010). Moreover, consumption of wheat is increasing due to industrialization, rapid urbanization and the consequent increase in the use of numerous bakery products. Cultivated land dropped to its lowest in the last three decades because farmers are switching to rice to get more profit from its high prices. In the last season, wheat cultivated land decreased by 80% (The Daily Star News, February 09, 2018; DAE, 2018). To control blast infection, wheat cultivation was discouraged in southern districts. Rainfall also forces farmers to engage in Boro rice cultivation instead of wheat cultivation.

For the causes of increasing demand and invention of new hybrid species, potato cultivation has been increasing from the last few years. We could substantially reduce pressure on rice by consuming more potatoes that can help partially to meet up the shortage of rice. Every year, million tons of potato damages for lack of proper storage facilities. It needs proper storage for fresh consumption or processing, to prevent post-harvest losses, and to guarantee adequate seed supply for the next cropping season, though off-season planting and cold storage may resolve this problem. Potato can contribute greatly to the food and nutrition security of our country, given the due attention and care.

In the early nineteenth century, Bangladesh was the highest in jute production, now second in respect of fibre production among jute growing countries. Jute alone

contributes about 1.58% to GDP and Bangladesh grow the world's best quality of jute because of the favourable soil and weather conditions (BBS, 2011). Bangladesh is the largest exporting country of raw jute accounting for 97% of the world's total and 60% of the products (FAO, 2011). Due to a fall in jute demand worldwide at the end of nineteenth century, 29 jute mills were closed, 25,000 workers were unemployed, and 18 jute mills were privatized. Adamjee Jute Mills (largest jute mill) was closed on 30th June, 2002 based on the claim that it had incurred a loss of USD 35 million (BBC News, 2002). Jute production in Bangladesh is estimated lower despite extensive planting due to crop damage with excessively heavy rainfall; premature harvesting result to shorter fibers, attack of insect, attraction towards Ready Made Garments industry of the labors, demand for food security, and farmers choice of paddy production, but the substantial fall of price and world demand was also responsible for the steady decline which had a severe impact on the livelihoods of poor jute growing farmers in the country (FAO, 2011).

Worldwide export and import of jute have declined steadily at rates of 3.5 and 2.5% over the 43 years (1961-2003) according to the FAOSTAT database analysis. Later, import of jute has increased worldwide at a rate of 2.5% p.a. from 2004 to 2013 without improvement of export of jute (Rahman, 2017). Local traders and industries of the country faced fund crisis for jute procurement in the last year which pulled down the prices in the local market as well as export price (FAO Stat, 2016). Among all challenges, two factors are most significant - one being unfavourable market price, because of price volatility, weak bargaining power, multiple intermediary levels, low quality, and government procurement policy whereas another is production inefficiency, because of limited technical knowledge, lack of irrigation facilities and low-quality seed.

Nevertheless, besides other sectors, jute sector in Bangladesh also has to recover these major pressures by determining the competitiveness of jute in the global market, examining the financial profitability at the farm level and identifying the diver of productivity and efficiency at the farm level. Figure 6 shows a diagram for agricultural development to fill out increased demand of food, to ensure nutrition for everyone, and to play an important role in the economy of the country.

Finally, while production of Aus ice is decreasing, Boro rice production is increasing, wheat and potato production is also increasing but potato production is much higher than others. Although jute production was downward before the last decade, if market management through implementation of Minimum Support Price (MSP) for the growers of jute fibre at the jute market season (September to December) can be improved, and the agricultural as well as product diversification technologies can be transferred properly, the jute sector will regain its glory and contribute to accelerating the economy of the country.

CHALLENGES OF AGRICULTURAL DEVELOPMENT

Bangladesh currently has some challenges or barriers in the agricultural sector in terms of development, e.g. climate change induced hazards like uneven rainfall pattern, long dry period, heat wave; increased soil and water salinity for sea level rise; natural hazards like flood, cyclone, hailstorm etc.; riverbank erosion; political instability etc.

Organizational structure

A meaningful and strong organizational structure is the prerequisite for sustainable agricultural development. The current agricultural policy and organizational structure cannot fully support the farmers. Bangladesh Rice Research Institute (BARRI), Bangladesh Agricultural Research Institute (BARI) and Bangladesh Agricultural Development Corporation (BADC) who is the main quality seed producer of the country, contributes only 25% seeds planted (Hossain, 2012). Department of Agricultural Extension (DAE) etc. and some NGOs (PROSHIKA, CARITAS, and UBINIG etc.) are involved in extent of sustainable agricultural practices but their activities are satisfactory.

Water stress

The retardation in crop growth caused by water stress at the seedling stage can be overcome, but at the reproductive stage, water stress can cause substantial reduction in rice yield (Shelley et al., 2016). Drought is one of the major abiotic constraints for rice and jute grown under rainfed conditions in Bangladesh. Aman rice usually suffers from water stress at the reproductive stage and reducing crop yield (Mahmood et al., 2004; Shelley et al., 2016).

Salinity

Soil and water salinity increase in the dry winter season and decrease in monsoon season in the coastal area. About 20% of the country cover coastal area, in which about 30% comprised the net cultivable area (Haque, 2006). The coastal area remains fallow during winter due to salinity. Aman is the main crop in the coastal area, and farmers mostly use traditional rice varieties, which can withstand salinity having a poor yield (Shelley et al., 2016).

Climate changes

Climate change affects agriculture most, such as irregular

pattern of temperature and rainfall. Sea level rise due to climate change is increasing soil and water salinity in the southern region and shrinking arable land (Rahman, 2017). Climate projections suggest that Bangladesh will experience significant increases in average temperature and extreme weather events (e.g., heat wave), which will threaten crop and livestock production (Mondal, 2010; IPCC, 2007). It also contributes to food insecurity and poverty of the country and represents a severe and urgent issue with the potential to reduce total agricultural crop production over the coming decades (Hoque, 2001).

Natural hazards

Every year, crops are damaged due to flood, cyclone, drought, and heat wave. Irregular and off-season heavy rainfall creates flash flood that damages Aus rice in summer, pre-monsoon and post monsoon period. Cyclone damages Jute and Aman rice with about 24% of rainfed lowland; while long dry summer damages wheat, and drought burns jute leaves (Mondal, 2010; IPCC, 2007).

From 2009 to 2014, 56% of households are affected one time, 27% of households are affected two times and the rest of them are affected three or more times by disaster (Islam, 2016). Out of 155,175 acres of land, 80.2% were croplands damaged due to disaster, 68.3% were land damaged due to river or coastal erosion, 14% of land were due to flood, 10.4% by salinity, 0.8% by drought, 3.5% by storm and 3.5% by water logging (Islam, 2016).

Not all the natural hazards happen every year all over the country; while in one year flood may not be so much destructive, next year it would be. With this, every hazard effect in some specific region of the country like flood happen in floodplain area, and waterlogging in low land area. Tidal surge happens in coastal area, land slide in hilly area etc. Among all damage of crops, 12% were damaged by flood, 5.3% by the hailstorm, 5% by drought, and 4.7% by waterlogging. From the fiscal year 2009 to 2015, if there was no damage and loss in that period, GDP could increase on average by 0.30% per year (Islam, 2016).

Riverbank erosion

Every year, agricultural land keeps decreasing due to riverbank erosion in the Ganges, Brahmaputra and Meghna floodplain. Thousands of people become landless and homeless. It also damages cattle and livestock production (Mondal, 2010).

Soil fertility

For the causes of hot and humid climate, the rate of organic matter depletion is high. Due to imbalanced use of chemical fertilizers, intensive agriculture, limited addition of crop residues, and limited practice of green-manure cropping, soil fertility is also declining in the country (Shelley et al., 2016). Soils of the area are deficient in some essential elements such as n, P, K, and S, which are limiting factors and N is the most limiting factor among which Mg, Zn, and B are also reported to be limiting in many areas (Jahiruddin and Satter, 2010).

Government policy

Political instability is one of the main barriers of agricultural development in the country. Farmers are facing an electricity crisis, fertilizer, and seed crisis, lack of irrigation facilities, unstable market price, lack of cold storage etc. where some people get the facilities and most of the farmers are deprived because of proper distribution and lack of honesty of local government officers. Farmer's right by undertaking policy reforms and strong affirmative actions can prevent farmer's rights and can remove these barriers to the improvement of the agricultural sector in rural areas of Bangladesh. Low investment in agricultural research (Karim, 1997; Bhattacharya et al., 2015).

Multiple stress

Urbanization, excessive use of chemical, dependency on nature, land fragmentation, same crop cultivation consecutively, unskilled farmer, lack of agricultural education, lack of qualitative seed (Mondal, 2005; Huda, 2004), lack of advance technologies, lack of adequate machineries, imbalanced market price, improper pest management, imbalanced use of fertilizers, uncontrolled population growth, declining of arable land and awareness are also equally responsible (Bhattacharya et al., 2015; IPCC, 2007).

Conclusion

Last but not least, the purpose of the current study was to determine the trend and challenges of crop production of Bangladesh and to give some recommendation to overcome those challenges. These findings suggested that plan should be made from community levels to international levels by bottom-up process. The following conclusions can be drawn from the present study- in community-level, government should take steps such as, making embankment, dam, river and canal drilling for removing excessive sediment, irrigation plant, sufficient supply of good quality seed, fertilizer etc.; make people aware of climate change and disaster preparedness; train the farmer about cultivation; to give financial support to farmers; to ensure stable and balanced market price everywhere; to give farmer storage facilities that they can

store their extra crops. At the national level, invent new technology, new crop species, ensure hundred percent food and nutrition to everyone, and finally, security and political commitment must be ensured to mitigate the problems.

The study has gone some way towards enhancing our understanding of challenges of increasing agricultural production and implications of those challenges and also the first study reporting an advantage in those who want to develop food security. Although the current study is based on a small data of production, the findings suggest that the most inevitable factors of food production need to be resolved for future food security of the country. The generalizability of the results is subject to certain limitations. First, lack of information of annual consumption, demand and production of all food crops. Second, the limitation of cross-sectional design. This research has thrown up many questions in need of further investigation and the challenges are investigated in future studies. The findings have a number of important implications for future practice.

Recommendations

1. Coordination with Government Organization (GOs), Non-Government Organization (NGOs), public sectors, strong network, research organizations, and private and multidiscipline organizations to extend sustainable agriculture. Construction of modern multipurpose cold storage and descent within a flexible distance from crop land. Investment should be increased in agricultural research to at least 2% of GDP as recommended by World Bank and FAO (FAO, 1996) and increased understanding institutional links between farmers and research.
2. Go and NGOs can excavate derelict ponds, canals etc. for conserving rain water for dry season. Re-excavation of canals, making dam, embankment alongside the river area that is severely flooded every year and causes massive crop damage. Uninterrupted power supply during peak irrigation time and reduction in irrigation cost or subsidy on diesel and fuel can also lessen irrigation water strain.
3. Invention of saline tolerant varieties. Tile drainage system can remove salinity, low-volume irrigation, and different salts management techniques that can minimise salts effects on crops.
4. Climate change adaptable new species of crops like saline, drought tolerant species should be invented such as salt tolerant varieties BRRI Dhan-47, 67 (Boro), BRRI Dhan-40,41 (Aman) and drought tolerant high yield varieties- BRRI Dhan-42 (Aus). Scientists and researchers should be encouraged to develop advanced technologies and inventions for coping with climate change induced hazards, simultaneously imply and disseminate as same at community level.
5. Comprehensive disaster management involves identifying disaster prone region according to climate change modelling and vulnerability and then establishing community-based adaptation programme. To develop climate change resilient cropping system by increasing applied agricultural research to invent new high yield crop varieties which will be able to survive flooding salty water for log periods, as well as keep indigenous and other varieties suited to the needs of poor farmers. Construct embankment, cyclone centre, and rehabilitate and re-reconstruct the existing infrastructures along with, planning for drainage system and water management system.

1. Constructing dam and embankment, regular river drilling, monitoring river channel, constructing permanent residence in char land for theose that have lost their land and home. Government and NGOs should emphasize on this and provide working opportunities.
2. **"**Healthy soil" is a key component in sustainability that is a very common thinking of sustainable agriculture practitioners. Encouraging farmers to choose high yield species, testing soil and following the recommended fertilizer, and use of balanced fertilizer integrating with chemical and organic manures. GOs and NGOs should motivate farmers to reduce dependency on chemical fertilizers to maintain soil fertility as well as sustainable agriculture practices. Farmers should incorporate crop residues with soil and grow short duration green manure crops to decrease depletion of organic matter (Figure 10).
3. Government should make land zoning based on current uses and potentialities, arrange sufficient credit facilities, and remove farmers- governmental communication gap, increase information access right and flexibility, train up farmers, and also protect and conserve indigenous genetic resources.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

The authors are thankful to the Bangladesh Bureau of Statistics (BBS) and Yearbook of Agricultural Statistics, Bangladesh Disaster-related Statistics, Department of Disaster Management, and Bangladesh Meteorological Department for their valuable data. Authors also appreciate Mustafizur Rahman, who always helped with arranging of data and making of maps. Finally, authors are grateful to Sharmin Shishir, the post-doctoral student of Faculty of Environmental Science of Hokkaido University for encouraging the writing of this paper.

REFERENCES

Ahmed S (2013). Food and Agriculture in Bangladesh. Encyclopedia of Food and Agricultural Ethics pp. 1-8.

Bagchi M, Rahman S, and Shunbo Y (2019). Growth in Agricultural Productivity and Its Components in Bangladeshi Regions (1987–2009): An Application of Bootstrapped Data Envelopment Analysis (DEA). Economies 7(2):37.

BBC News. 25th June (2002). http://news.bbc.co.uk/2/hi/south_asia/2065044.stm

BBS (2008). Bangladesh Census of Agriculture 2008, National Series, Volume-1. 711. Retrieved from http://www.fao.org/fileadmin/templates/ess/ess_test_folder/World_Census_Agriculture/Country_info_2010/Reports/Reports_3/BGD_ENG_REP_2008.pdf

BBS (2011). Statistical Yearbook of Bangladesh. Statistics Division, Ministry of Planning, Dhaka, Government of the People's Republic of Bangladesh.

BBS (2016). Yearbook of Agricultural Statistics-2015. (July). Retrieved from http://203.112.218.65:8008/WebTestApplication/userfiles/Image/LatestReports/AgriYearbook-2013.pdf

BBS (2017). Bangladesh Yearbook of Agricultural Statistics-2016. (May). Retrieved from http://bbs.portal.gov.bd/sites/default/files/files/bbs.portal.gov.bd/page/d6556cd1_dc6f_41f5_a766_042b69cb1687/PocketBook2016.pdf

Begum MEA, D'Haese L (2010). Supply and demand situations for major crops and food items in Bangladesh. Journal of the Bangladesh Agricultural University 8(1): 91-102.

Bhattacharya J, Mondal MK, Humphreys E, Saha NK, Rashid MH, Paul PC, Ritu SP (2015). Rice-rice-rabi cropping systems for increasing the productivity of low salinity regions of the coastal zone of Bangladesh. Revitalizing the Ganges Coastal Zone: Turning Science into Policy and Practices Conference Proceedings. Colombo, Sri Lanka: CGIAR Challenge Program on Water and Food (CPWF). 600 p.

Department of Agricultural Extension (DAE) (2018). Ministry of Planning, Government of Bangladesh. http://dae.gov.bd/site/page/ee044a3b-ef81-43ee-ba68-65f1ba3b514d/-

Food and Agricultural organization (FAO) (1996). Food, agriculture and food security: developments since the World Food Conference and prospects for the future. World Food Summit technical background document No. 1. Rome. http://www.fao.org/3/w1358e/w1358e14.htm

Food and Agricultural Organization (FAO) (2011). Current Market Situation. Joint IGG on Hard Fibres (36th Session) and IGG on Jute, Kenaf and Allied Fibres (38thSession) Salvador, Bahia, Brazil 16-18 November 2011.

Food and Agricultural Organization (FAO) (2016). Food and Agricultural Organization. http://www.fao.org/faostat/en/#country/16

Ghose B (2014). Fisheries and aquaculture in Bangladesh: Challenges and opportunities. Annals of Aquaculture and Research 1(1):1–5.

Haque SA (2006). Salinity problems and crop production in coastal regions of Bangladesh. Pakistan Journal of Botany 38(5 SPEC. ISS):1359-1365.

Hoque ME (2001). Crop diversification in Bangladesh. Crop Diversification in the Asia-Pacific Region pp. 5-23.

Hossain A, and Teixeira da Silva JA (2013). Wheat production in Bangladesh: its future in the light of global warming. AoB Plants, 5.

Hossain M (2012). Adoption and diffusion of modern rice varieties in Bangladesh and eastern India. International Rice Research Institute https://books.google.com.ng/books?hl=en&lr=&id=GMmRgZFzPqIC&oi=fnd&pg=PR1&dq=Adoption+and+diffusion+of+modern+rice+varieties+in+Bangladesh+and+eastern+India&ots=21kpo1MTyA&sig=85ZJ_OLcfai5wi_EY28HArFibBI&redir_esc=y#v=onepage&q=Adoption%20and%20diffusion%20of%20modern%20rice%20varieties%20in%20Bangladesh%20and%20eastern%20India&f=false

Huda ATMS (2004). Interagency Collaboration for Integrated Coastal Zone Management: A Bangladesh Case Study. Coastal Management 32(1):89-94.

IPCC (2007). On the destabilization of a longshore current on a plane beach: bottom shear stress, critical conditions, and onset of instability. Journal of Geophysical Research Oceans 99(C1):811-824.

Islam MT, Croll D, Gladieux P, Soanes DM, Persoons A, Bhattacharjee P, Mahboob MG (2016). Emergence of wheat blast in Bangladesh was caused by a South American lineage of Magnaporthe oryzae. BMC Biology 14(1):84.

Islam R (2016). Bangladesh Disaster-related Statistics 2015. Climate Change and Natural Disaster Perspectives, pp 1-22.

Jahiruddin M, Satter MA (2010). Agricultural research priority: Vision 2030 and beyond. Final Report. Sub-Sector: Land and Soil Resource management. Bangladesh: Bangladesh Agricultural Research Council and Bangladesh Agricultural University, 56. https://www.researchgate.net/profile/Arvind_Singh56/post/is_there_any_reports_or_review_article_on_Integrated_Soil_Fertility_Management_in_Bangladesh/attachment/59f7fc16b53d2f3ade4ba59a/AS:555379293933568@1509424150478/download/Report-soil-resource-Mgt-Final-Prof.Jahir_.pdf

Karim MA, Qauyyum MA, Samsuzzaman S, Higuchi H, Nawata E (2017). Challenges and Opportunities in Crop Production in Different Types of Char Lands of Bangladesh. Tropical Agriculture and Development 61(2):77-93.

Karim MR, Awal MA, Akter M (2010). Forecasting of wheat production in Bangladesh. Bangladesh Journal of Agricultural Research 35(1):17-28.

Karim Z (1997). Accelerating agricultural growth in Bangladesh; seminar on Agricultural research and development in Bangladesh held at Dhaka on 24-250 February 1997. BARC. https://doi.org/https://doi.org/10.1080/08920750490247526

Mahmood R, Legates DR, Meo M (2004). The role of soil water availability in potential rainfed rice productivity in Bangladesh: applications of the CERES-Rice model. Applied Geography 24(2):139-159.

Majumder S, Bala BK, Arshad FM, Haque MA, Hossain MA (2016). Food security through increasing technical efficiency and reducing postharvest losses of rice production systems in Bangladesh. Food Security 8(2):361-374.

Mason G, Mayhew K, Osborne M, Stevens P (2008). Low pay, labor market institutions, and job quality in the United Kingdom. Low-Wage Work in the United Kingdom, pp. 41-95.

Ministry of Food (MOF) (2018). Peoples Republic of Bangladesh. http://www.bangladesh.gov.bd/index.php?q=site/view/job/%E0%A6%96%E0%A6%BE%E0%A6%A6%E0%A7%8D%E0%A6%AF%20%E0%A6%AE%E0%A6%A8%E0%A7%8D%E0%A6%A4%E0%A7%8D%E0%A6%B0%E0%A6%A3%E0%A6%BE%E0%A6%B2%E0%A7%9F

Ministry of Land (2016). Ministry of Land G. of the P. R. of B. Land Zoning Report. Retrieved from https://minland.portal.gov.bd/sites/default/files/files/minland.portal.gov.bd/reports/956746d8_fedf_4955_a97b_8b1bfca2eb95/AnualReport2014-2015.pdf

Mondal MH (2005). Challenges and Opportunities of sustainable crop production in Bangladesh. Eighth Biennial Agronomy Convention. Bangladesh Society of Agronomy.

Mondal MH (2010). Crop agriculture of Bangladesh: Challenges and opportunities. Bangladesh Journal of Agricultural Research 35(2):235-245.

Nasim M, Shahidullah SM, Saha A, Muttaleb MA, Aditya TL, Ali MA, Kabir MS (2017). Distribution of Crops and Cropping Patterns in Bangladesh. Bangladesh Rice Journal 21(2):1-55.

Niu D (2004). China Agriculture Press; Beijing, China: 2004. Agricultural Science and Technology Achievements Awarded by National Government From, 2003.

Rahman MT (2017). Role of Agriculture in Bangladesh Economy: Uncovering the Problems and Challenges. International Journal of Business and Management Invention 6(7):36-46. https://doi.org/n.a.

Roy D, Dev DS, Sheheli S (2019). Food Security in Bangladesh: Insight from Available Literature. Journal of Nutrition and Food Security. https://publish.kne-publishing.com/index.php/JNFS/article/view/401

Saleem S, Raouf ME (2011). Sustainable Agricultural Development and the Challenges Facing Agricultural Education in Afghanistan. Journal of Developments in Sustainable Agriculture 6(1):45-49.

SDG (2018). Health Topics: Health Impact Assessment. The Sustainable Development Goals Report 2018, 40. https://doi.org/10.11260/kenkokyoiku.19.77

Shapla T, Park J, Hongo C, Kuze H (2015). Change detection of rice cultivation in Bangladesh based on the phenological analysis of MODIS data. Advances in Remote Sensing 4:319-329.

Shelley IJ, Takahashi NM, Kano NM, Haque MS, Inukai Y (2016). Rice

cultivation in Bangladesh: present scenario, problems, and prospects. Journal of International Cooperation for Agricultural Development 14(4):20-29.

Sindelar S, Joshua EL, Tanvir H (2016). Bangladesh Grain and Feed Annual. 19. Retrieved from https://gain.fas.usda.gov/Recent GAIN Publications/Grain and Feed Annual_Dhaka_Bangladesh_3-31-2016.pdf

Singh SK, Parihar A (2015). Challenges of Sustainable Agriculture Development in India. https://www.krishisanskriti.org/vol_image/16Dec201512125847%20%20%20%20%20%20Saroj%20Kumar%20Singh%201%20%20%20%20%20%20%20%20%20%20%20%20%20%20%20%20355-359.pdf

World Bank (2017). Atlas of Sustainable Development Goals 2017 from World Development Indicators. World Bank Publications.

Zhao J, Luo Q, Deng H, Yan Y (2007). Opportunities and challenges of sustainable agricultural development in China. Philosophical Transactions of the Royal Society B: Biological Sciences *363*(1492):893-904.