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Research Paper

Climate Change and Food Security: A review of current and future perspective of China and Bangladesh

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Abstract

This review has mainly focused on China and Bangladesh, as taken in some parts of comparison due to climate changes (CC) affected the country. The study implicated a range of socioeconomic and agro-economic literature that was developed subsequent two different development trail linked with the Intergovernmental Panel on Climate Change (IPCC) pessimistic and optimistic scenarios. The food security index (FSI) has proven to be a powerful and reliable quantitative cause-effect analysis tool. Analysis of the literature results compared with other factors such as agricultural land area, population growth and GDP growth, showed that CC has only a modest positive impact on food security. Overall, socio-economic development pathways have a major impact on future food security trends in China and Bangladesh. Furthermore, emphasis on environmental sustainability, the impartial expansion path associated with the pessimistic emissions scenario, has proven to be far better in ensuring food safety than the other optimistic path. In regression analyzed literature, it was found that yield growth rate was a much better indicator in food security analysis than crop yield per season. Therefore, the yield enhancements on a yearly basis are highly consequence in ensuring food security for the countries with a big sized and densely populated region like China and Bangladesh. The comparatively lower FSI, values recommended that per capita food consumption in China is on a stable growth while Bangladesh would face deficiencies. Therefore, there is a need to focus more on food safety and balanced nutrition, taking into account climatic conditions. The review information derived from the study is similarly suitable for formulating climate change and agricultural relevant planning and policies.

Keywords

Climate Change, Food Security, Impact and Challenges, General Framework, China, Bangladesh

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1. INTRODUCTION

The variability of climatic factors and its changes, impacts, and vulnerabilities are thriving distress around the world. Global temperature and rainfall changes induced climate are already marked in any regions of the world (Rahman et al., 2009; Hossain et al., 2019). Climate change (CC) is the change within climatic factors such as rainfall, temperature, humidity, sunlight, and wind speed over a long period, typically 30-50 years (Hossain et al., 2019). Global climate change, as well as the essential changes inside the condition of the climate of any region, may be known by change within the mean related as of the unpredictability of its properties that may persist for an extended amount overwhelmingly decades or longer (Change, 2014). The temperature change would be a fact and has been accepted globally as proof of life subsistence on Earth. Therefore, the condition entails a matter of positive statements that could regularly be subjected to natural changes or dynamism.

Meanwhile, the global land surface temperature found increased by 0.5^{o}C to 0.8^{o}C in the last hundred years, while most severe increases temperatures occurred by the previous three decades (Hansen et al., 2006). However, the increase in the rate of global temperature and associated changes in rainfall has already exaggerated on the regional ecosystems, biodiversity distributions, and human sustainability on Earth(Kotir, 2010). Overall in multiple impacts through CC on Earth, the agricultural sector is always considered highly significant in risk and vulnerable as CC influences agricultural land, cultivation process, and food production (Godfray et al., 2011).

The influences of CC such as temperature, precipitation, humidity, cloudiness, and sunshine on vegetation index, agriculture, and food production have already evident (Islam and Ma, 2018). Due to changing climatic conditions, food production has been reduced, which is a significant concern in the coming years [Hossain et al. (2019), Yuji et al. (2009)]. The CC and its impact on crop yield are now increasing attention worldwide (Rahman et al., 2009). According to IPCC (IPCC, 2007), the influence of CC significantly shrinking the agriculture production, especially crop yields vary considerably when the temperature is higher and lower level. Moreover, the amount and variability of rainfall considered one as the vital climatic factors in crop cultivation and production [Rahman et al. (2009), Karim et al. (1999)]. Every crop passes a critical phase of needs water and sufficient temperature in survives, growing up, and optimum production.

Furthermore, excessive rainfall might cause flooding in low lying floodplain regions and as well as waterlogging conditions, which also lead to loss or reduce crop production (11). Therefore, crop production would influence by climatic phenomena as of increasing temperatures, changing amount and variability of rainfall, humidity, and grew CO_2 in the atmosphere. However, the total amount of production may also be influenced by biological elements as of the duration of cropping growth, crop calendar, and cycle periods. The observed genetic changes over the 20th century in Northern Hemisphere identified the longer crop growth life cycle in response to crops to the global warming situation (Steltzer and Post, 2009). Moreover, the recent global warming from the 1980s, in global cultivation of maize and wheat, has responded negatively in growth and production, while other crop production (e.g., rice) response signals still been imprecise (Lobell et al., 2008). Schmidhuber and Tubiello (Schmidhuber and Tubiello, 2007) suggested that global food production need to increase at least by 70 % more within 2050 for the expected 9 billion people to feed. However, this food security goal would be an essential challenge under existing CC. It is particularly difficult for China and also for Bangladesh, as one is the world's third-largest area with the highest population and another characterized by small areas with the most densely populated, respectively.

China is a first and rapidly industrial growing developing country and the highest emission of CO_2 gas and also the most risk and vulnerable countries due to CC (Turral et al., 2011). Although many kinds of research in China have focused on the effect of CC on food security [Steltzer and Post (2009), Lin et al. (2005), Piao et al. (2010)], however, some systematic researches which directly associated CC on food security still have to lack, particularly at the overall national scale. Generally, food security estimation regards not the only production of food but also several parameters including food consumption and added complexity as well as multiple socioeconomic and agro-economic data, different factors, and model simulations (Schmidhuber and Tubiello, 2007; Tubiello et al., 2007).

On the other hand, over 250 years in Bangladesh, forest degradation, burning of fossil fuels and per capita cropland over atmospherically deliberated of CO_2 and different greenhouse gases have risen considerably (IPCC, 2007). The climatic phenomena of Bangladesh are changing every year more unpredictably as well as land use and land cover simultaneously (Islam et al., 2019). CC has gain attention over the world because it changes as the top significant challenge over the century (Rahman et al., 2009; Hossain et al., 2019). The definition of CC is genuinely usual in the preceding, which means every single one changes within the climatic elements by human activities or as well as natural variations (Walsh et al., 2014). The Earth is encircled by the layer of gases, which act like the glass wall and the top limit of green-house (Sikder and Xiaoying, 2014). The questionable greenhouse blanket is essential to keep up life on Earth. This layer lets the sunray infiltrate and as well stop excessive of the warmth in absconding and maintenance the Earth enough heat as well as permit growth and production. However, we drawback that happens naturally into the layer at the atmosphere and getting thicker as resulting as of increased productions of greenhouse gases, which overall lead to the fast warming of the world's climate (Mainuddin et al., 2011). Therefore, this critical review aimed to analyze the food security scenarios, impact, and challenges in the CC perspective of China and Bangladesh. Concurrently, it has highlighted China's action to tackle the CC and food security issue, research framework to combat these challenges.

2. EXPERIMENTAL SECTION

2.1 Materials and Methods

This study try to find out the influence of CC resting on food security across China and Bangladesh associated with climatic variables, existing resources, planning, and policies. The literature related to carbon budget, CO_2 emissions, temperature, precipitation, evapotranspiration, GDP, population growth, agricultural land, existing cultivation, food production, etc. of existing published scenarios, planning, and policies were studied critically after 2000 to present periods. The study involved a range of socioeconomic development and agro-economic scenarios at the national level of both countries that were developed following agricultural land, cultivation, and production pathways associated with the IPCC pessimistic and optimistic series of CC scenarios. Systematic literature was sourced from different renowned databases like Scopus, science direct, Pubmed and Web of Science using keywords such as "Climate change," "food security," "Socioeconomic and Agronomic Scenarios" and "Climate change scenarios." Furthermore, secondary data was obtained from Bangladesh Ministry of Environment, forest and climate change, climate change cell, Ministry of Food and Disaster Management, Bangladesh Agricultural Research Council (BARC), Bangladesh Meteorological Department, China Ministry of Ecology and Environment, National Development and Reform Commission of China, Intergovernmental Panel on Climate Change (IPCC), World Bank-Climate series, books, magazines, and newspaper. In searching the content, more than 200 literatures was found directly and indirectly related to the topic content, while 50 of them finally selected as well as have a specific and particular relation with CC and food security. However, the chosen results were critically analyzed crossed and matching with existing data sources of UN, World Bank, IPCC, and both countries' national portal. The datasets were used in the study for China and Bangladesh national level GDP, population, CO_2 emissions, temperature, rainfall, potential evapotranspiration, suitability and existing, pessimistic and optimistic production scenarios in different ranges annually.

3. RESULTS AND DISCUSSION

3.1 Impact and challenges of climate change and food security

3.1.1 Impact and challenges perspectives of China

The emerging economic growth reached China to the second-largest economic entity in the world, next to the United States (23). Throughout the past three decades, the range of economic growth in the country is unprecedented in modern human history (Ninno et al., 2005). Meanwhile, this fastest economic growth is forwarding the environment of China beneath increasing stresses afterward (Zheng et al., 2015). The environmental strain in rapid economic growth required a shifting paradigm in socioeconomic development (23). The land-use policy, which was initiated after the 1970s, must be restructured and opened by rapid economic growth stimulated over the following decades. Otherwise, these may exert unparalleled influences on ecosystems, sustainability, and overall environments. Since the 1990s, the central government has already been launched many national sustainability and restoration projects to create degraded ecosystems, as described in some literature. Some of the notable initiatives include controlling the rate of increase in pollution and high energy use, and enforcing strict regulations on farmland protection and resilience of natural ecosystems. Mitigating and tolerating regional and global CC by reducing CO_2 emissions is one of the most challenging issues (26). Currently, China is one of the most significant annual CO_2 emissions countries in the world as temperature and rainfall changed with the dramatic expansion of GDP (Figure 1). Meanwhile,

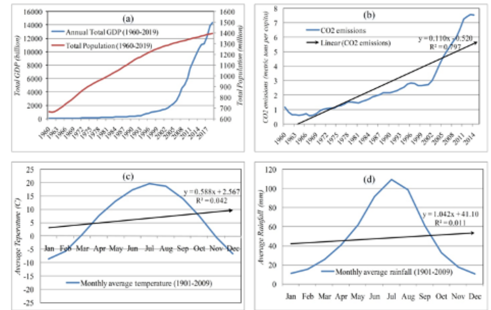

Figure 1. Growth of China's (a) Total annual national GDP and total population from 1960 to 2019, (b) Annual CO2 emissions from 1960 to 2014, (c) Annual average monthly temperature (1901-2009), and (d) Annual average monthly rainfall (1901-2009) (Data source: The World Bank, 2020)

the country also placed in the spotlight by efforts to manage global carbon (C) emissions as well by spatially designed CC policies. Therefore, in order to mitigate CC not only at the regional level but also at the global level, it is important to deepen the understanding of the carbon balance (C), improve it and the dynamics in China.

However, Tao et al. (2015) identified that about 27.6% of the total global CO_2 emissions by China overall from fossil fuel burning in 2013. Therefore, in the key to achieve global emissions-reducing targets, China needs proper and robust policies of CC as well as CO_2 emission reduction. The country's emissions, however, closely related to the growth rate of population, infrastructure and economic growth. As with 1.39 billion people, China is the top populous country in the world as of more prominent as that of the United States and the European Union by 4.3 and 2.7 times, respectively (Guo et al., 2010). Fang et al. (2012) evaluated that in the past 30 years, China's total GDP, however, expanded of an average annual rate by 10.1% and as well ranked as second largest in the world. After that, the environment can be detrimental by fast economic development through the processes of land use and land cover change, massive consumption of resources, and pollution. For example, Wang et al. Wang et al. (2010) identified in northern China, the land conversion to cultivation and agriculture resulted in a drastic turn down of the groundwater table as well as associated overall water shortage.

Moreover, the use of chemical fertilizers and pesticides in China has accounted for about 36%, and 25%, respectively, of the world total, uses (Lal, 2004). Along with some lacking of strong environmental regulation, the rapid economic development of China resulted in hard and extensive water, air, and soil pollution. While, (Piao et al., 2009) evaluated, about 19% of the country's land area in the risk of soil erosion affects as well as changing, one-fourth of the nation's cities are affecting by acid rain every year, most of the

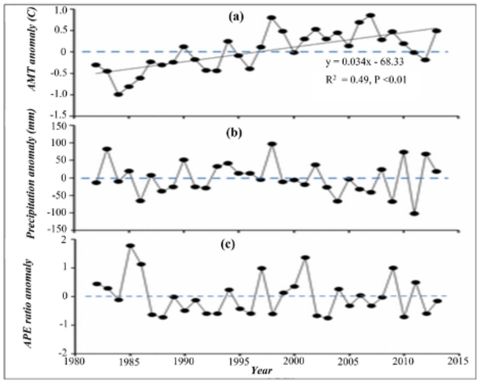

Figure 2. Annual anomalies of major climatic elements in China using climatic records during 1980–2015; (a) annual mean temperature (A.M.T.); (b) Precipitation (A.P.); and (c) annual potential evapotranspiration (APE) (Data source: National Development and Reform Commission 2015)

lakes (approximately 75%) are polluted, and 15–20% of the species found endangered situation. Therefore, literature related to CC mostly recommended that carbon dioxide emission reduction hence not only important for achieving global emission-reduction targets, as well also significant for the country's self environmental protection and ecosystem sustainability.

Moreover, it is essential to note that globally China feeds about 20% of the world population by only 7% of the total land area (Wen, 2009). Intensive cultivation over large regions of China has remarkedly impacted the regional vegetation cover and accumulation of soil organic matter in the future (Hu et al., 2015). Recently, afforestation and reforestation have increased vegetation cover and created a significant C sink across the country (Wu et al., 2017; Tang et al., 2018a). These socioeconomic and physiographic criteria have significantly influenced ecosystem patterns, processing, and functioning as well as increased the interactions between ecological systems. In these special climatic features, there have diverse ecosystem types have evolved. China has a long agricultural history, with a vast area of various cultivated lands (Wen, 2009). Besides, the monsoon climatic behavior of the countrycharacterized it highly sensitive to global CC. More than 10C mean annual temperature (air temperature) has in the past three decades over China, which is higher than that of global temperature average (Figure 2). However, the annual precipitation has not remarkably changed as a whole as well as increasing slightly, while regional as well as seasonal patterns have changed apparently across the country (37). Overall, China's agriculture, cultivation, food production, as well as ecosystem functions and structure profoundly influenced by CC.

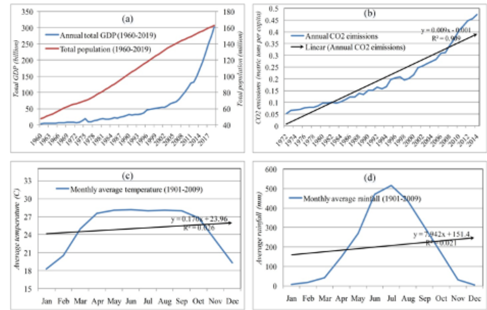

Figure 3. Evolution of Bangladesh in the (a) Total annual national GDP and total population from 1960 to 2019; (b) Annual CO2 emissions from 1972 to 2014; (c) Monthly average temperature (1901-2009); and (d) Monthly average rainfall (1901-2009) (Data source: The World Bank, 2020)

3.1.2 Impact and challenges perspectives of Bangladesh

Bangladesh is one of the most vulnerable and disaster prone countries in the world in response to CC and rising sea-level [Hossain et al. (2016), Salehin et al. (2020)]. High densities of the population are here always hindering the development as well as annual total GDP growth. According to the datasets of the World Bank (26), Figure 3 described the total annual GDP, population, CO_2 emissions, monthly average temperature, and rainfall of Bangladesh. The total yearly GDP steadily increasing while sharp increased after 2008 and as well as simultaneously the population is increasing. The emissions of CO_2 in the country overall not so alarming while growing steadily. Between 1901 and 2009, the monthly average temperature and rainfall are also increasing that overall positively impacted food production in the middle and lower floodplain regions. Contritely the overall CC negatively impacted the upper floodplains, tidal floodplains, and coastal plain region of Bangladesh.

In Bangladesh, there are several environmental problems as well as natural and human-induced issues, continuously hindering human habitation, livelihoods and overall development in the country (Islam et al., 2019, 2014). Salinity is such an environmental problem which is expected to exacerbate by sea-level rise as well as CC impact in the future Ghosh et al. (2020); Ganguli et al. (2018). The higher levels of salinity intrusion have undesirable impacts on agriculture, cultivation and aquaculture, in domestic and industrial water use, and overall production and development Islam et al. (2019); Ganguli et al. (2018). The present temporal and spatial variability of salinity is likely to deteriorate further as a result of the external factors of change (Islam and Ma, 2018; Walsh et al., 2014). However, Bangladesh has held as the 4th largest (currently 3^{rd} largest) rice producing country in the world, which comprises 11.10 million hectors of the total area of rice production Hossain et al. (2016). In total, about 80% of the whole cultivable land has been using for rice cultivation (Figure 4) (BBS, 2002). This principal field agriculture is already under stress due to the enormous

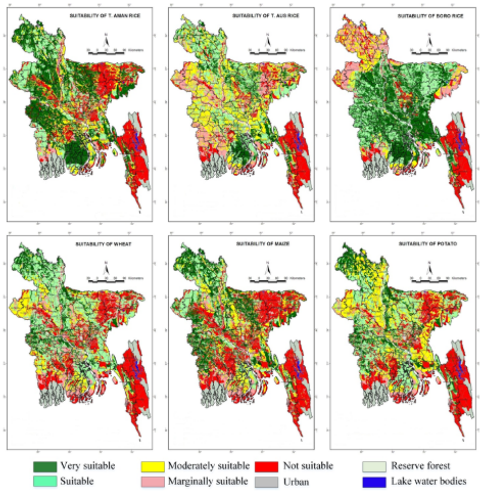

Figure 4. Spatial distribution of major crops suitability in Bangladesh (Data source: Bangladesh Agricultural Research Council)

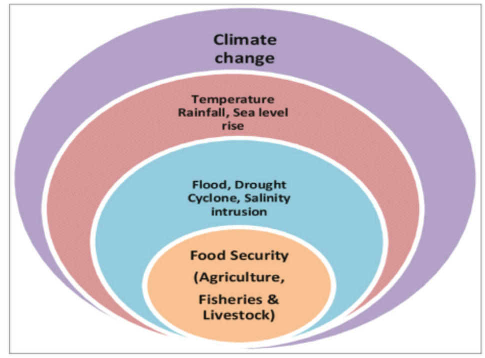

Figure 5. Challenges of climate change on food security in Bangladesh (Source: BARC and DMB, Bangladesh)

demands of food, insufficient cultivable land, and deficiency of water resources (Mistri et al., 2015).

However, Bangladesh recently and as well in continuously facing severe challenges in the production of food to feed a overpopulation across the inadequate and shrinking cultivable land under the impact of CC. Ahmed and AlamAhmed and Alam (1999) reported that Global warming and related changes in climatic phenomena like temperature and rainfall are becoming evident on a global scale, as well as in Bangladesh. Meanwhile, as a hazard-prone country, seasonal, tidal and flash floods as well as droughts, cyclones, and riverbank erosions being influenced more frequently in Bangladesh than ever before, which are day by day aggravated due to CC and variability as well (Salehin et al., 2020; Ganguli et al., 2018; Hossain et al., 2015). The overall impacts and conditions are in inter-connecter by a vicious cycle (Figure 5). Uncertainty and uneven spatial distribution temperature and rainfall were creating flooding in one hand while longer dry spells are evoking droughts another side (Al-Masud et al., 2014).

Climatic factors such as temperature, precipitation, solar radiation, and humidity are closely related to agriculture, farming, and production. Bangladesh has been in front of higher temperatures since the last three decades (Sarker et al., 2012). Meanwhile, IPCC (2007) forecasted that Bangladesh would experience rising annual mean temperatures over 1^{o}C by 2030, 1.4^{o}C by 2050, and as well 2.4^{o}C by 2100. The principal reason for this increasing temperature is CO_2 emissions and other heat-trapping greenhouse gases, which are mostly producing by human activities (Rahman, 2009). The most significant sources of additional CO_2 is adding from burning coal and fossil fuels Ayers (2010). Netz et al. (2007) forecasted that the current rate as of around 9 billion metric tons of C emissions every year that would be increased to approximately 12 billion tons until 2040. After that, carbon emissions would gradually again decline to 5 billion tons per year by year 2100. However, there are still many assumptions have been made from a wide range of climate model simulations. For example, the scenario assumes that humans will be able to make more sustainable development decisions around the world if they use a broader range of technologies to produce energy more efficiently (Walsh et al., 2014). Food security is defined as everyone's access to sufficient and safe food at all times to maintainan active and healthy life. Bangladesh is primarily a densely populated agrarian country, where food security is a crucial issue. Since the past decades, in associated scientific innovation as well as the application of several measures, total national production and per capitaavailability of food grains have increased in the country. Still, now, thecountry depends on the import of grain foods (Ayers, 2010). Therefore, most of these studies have demonstrated that agriculturalactivities across developing countries are extremely vulnerable due to CC.

3.2 Food security assessment in China and Bangladesh

The World Food Summit 1996 defines, food security as the conditions in which all people have access to adequate, safe and nutritious food for physical, social and economic access that meets their dietary needs and also the inclination to be active and a healthy life. Since then, numerous measures have been taken to standardize the general situation within global food security (or insecurity) and regional inconsistencies, including the FAO indicators of malnutrition (Piao et al., 2009). China, in overall, approximately earned means food self-sufficiency and even also has grain self-sufficiency (Wu et al., 2017). In order to maintain food security at the national level of the country overall, China's National Development and Reform Commission recently adopted a strategic goal as to the level of 95% grain self-sufficiency. Overall the country's population is too high to rely on the world food market for its food supply. Therefore, rapid as of fair delivery of huge quantities of imported food would be a significant challenge, especially for the country like China, while food is meticulous good. However, self-sufficiency at the national level of the country has political and economic importance at the national and international levels (Zheng et al., 2015).

Agricultural, cultivation, and production in Bangladesh have dramatically influenced through seasonal characteristics, which generally shaped by the variables like variation of temperatures, amount rainfall, sunshine duration, humidity, etc. Crop production in the country are often controlled and reshaped by a different type of natural hazards such as seasonal, tidal and flash floods, waterlogging, tropical cyclones, uneven droughts, soil, and water salinity intrusion, and storm surges (26). Hossain et al. (2008) predicted by using the Geophysical Fluid Dynamics Laboratory (GFDL) model that approximately 17% of rice production and 61% wheat production may decline under 4^{o}C mean air temperature change overall for Bangladesh. In several crop production estimation and prediction, the most affected there would be on wheat production as well as cultivation followed by rice production (Aus variety). While, Hossain et al. (2016) predicted using the Canadian Climate Change Model (CCCM) as also resulted in a significant downward in food-grain production. Moreover, an extreme increase in temperatures by CC would also affect fish breeding, livestock, and farming. Extreme temperatures for animals caused uneasiness highly, decreased feed intake, and modify nutrient metabolism and as well as the leading loss of energy (Hossain et al., 2008). The mutual effects of nutrient metabolism and uneasiness reduce animal's productivity that overall financial losses for farming activity. Therefore, the extreme temperatures, uneven rainfall distribution and frequent high intensity of natural disasters may impact and challenges for agriculture, cultivation and production and as well as suffering for livestock that ultimate food security of the country like Bangladesh (FAO, 1996).

3.2.1 Yield simulation and modeling approach in food security

Ye et al. (2012), Lobell and Field (2007) and Lin et al. (2005) were individually simulated the yields for cultivation and production of rice, wheat, and maize in per grid cell of cultivated land through the CERES-Rice, Wheat and Maize model, respectively, under the CO_2 fertilization effects. However, in many other literatures worldwide used the CERES dynamic process-based mechanistic models for crop production and growth stimulation. It simulates daily phenological development and growth in response to climatic phenomena and soil as well as environmental factors with relation to crops, cultivating conditions, Nitrogen fertilization, irrigation processes, etc. combined called management factors Ye et al. (2012). Across the world, from the temperate region to the tropical region, especially for China and Bangladesh, this model is appropriate and validated in a wide variety of production estimation (Jones et al., 2003). Moreover, Ye et al. (2012) and Portmann et al. (2010) assessed the spatial distribution of cultivable land based on the MIRCA2000 dataset. Ye et al. (2012) were simulated three times on the flooded and the rain-fed croplands as of 1981–2000 for calibration periods, 1961–1990 for reference periods and 2011–2040 was performed for the projection period. Therefore, Xu et al. (2006) designed climate data with reference and projection periods for China and can be derived and extended to provide PRECIS or Providing Regional Climates for Impact Studies. Moreover, Hu et al. (2015) simulated daily weather data during 1961–1990 periods in CO_2 concentration at $\tilde{3}30$ ppm using the PRECIS baseline scenario, while they were also generated two separate CC scenarios for 2011–2040. Lin et al. (2005) prepared IPCC SRES scenarios based on two situations as the first category was a heterogeneous world of high population growth, slow economic development, and strong regional cultural identities. The second situation generates a heterogeneous society that emphasizes diversified technological change, low population growth, and local solutions to problems of economic, social, and environmental sustainability.

3.2.2 Scenario Building for food security assessment

Major socio-economic development and agro-economic scenarios preparation by predicted total population, urbanization rate, projected cropland, crop intensity variations, and technological innovation by new varieties and managerial applications were designed in some literature across the national level of China in food security assessment and analysis (Table 1).

Walsh et al. (2014) evaluated that the urban population growth rate of China is increasing by 1% per year over the historical trend and the country's national development strategy observed from 1978 to 2009. China's National Development Reform Commission identified the country each year has been lost cropland and cultivable land at a rate of 1.45 million ha since the year 2000. Lu et al. (2018) suggested that the future prediction of the arable land area needs to be evaluated in correlation with the loss of land with the urbanization rate through a linear regression model. Fang et al. (2018) described the intensity of cropping in terms of the multi-cropping index (MCI) that was calculated by the ratio of the total sown area with the existing cropland area. In China, the cropping intensity or MCI have evaluated, which is increasing steadily by the rate of 0.9% per year over the last two decades

Moreover, Tang et al. (2018b) identified the national multi-cropping index (MCI) average was only 130% in 2009, while double-cropping or even triple cropping over southern China is a widespread practice. The National Office of Agricultural Regional Planning (NOARP)62 researched the national level of China and evaluated that the country has the ability the average multi-cropping index (MCI) to reach 170% with existing facilities and also has the potentiality of 190% by some theoretical and technological innovation.

Table 1. Scenarios building for food security assessment in China

Year	Population (million)	Urbanization (%)	Cropland (M. ha.)	Multi-cropping index (%)	Variety (% year-1)	Management (% year-1)
Baseline						
2009	1,334	46.3	121.7	130	-	-
Pessimistic Series						
2020	1,505	58.2	118	134	0.4	0.35
2030	1,577	62.9	115	139	0.4	0.35
2040	1,590	65.8	113.3	144	0.25	0.2
2050	1,560	68.6	111.6	150	0.25	0.2
Optimistic Series						
2020	1,455	64.6	116	137	0.8	0.7
2030	1,469	72.6	111	148	0.8	0.7
2040	1,451	77.6	108	158	0.5	0.4
2050	1,417	82.6	105	169	0.5	0.4

3.2.3 Major adaptation procedures to food security

Adaptation generally defined as the processes of avoiding unanticipated losses as well as the unrestrained methods to become accustomed up to shifting its circumstances (Zheng et al., 2015). There have multiple ways and sorts of adaptation in CC and food security. Following the influences of unexpected effects, the adaption type would be different, as well as their applications. Although structural and non-structural adaptations are standard features in practice, structural measures recognized the fundamental criteria to lessen the influence of CC and not, for the most part, applicable (Rahman, 2009). However, in ensuring food security from the adverse effects of environmental changes as well as future generations to sustenance, combined adaptation must need to expand. Therefore, Mirza (2010) suggested doing this job success by developing and building up adequate floodgate door, polder, torrent, dam, and deluge water gathering, etc. in the beachfront zone. However, non-structural measures adjustment generally considered as the subtle adjustment.

Moreover, Mirza (2010) described the livelihood migration to less danger zone from a high threat region is as the non-basic adjustment as well as manner deemed, and that is added problem rather than a solution. The expectant adjustment is to say that eventually, sooner or later, before encountering the outcomes, additional groups can receive the exercises by unfavorable impacts of this environmental change. However, Hossain Hossain et al. (2016) evaluated a similar type of adaptation is the common practice in Bangladesh in the absence of proper and in time financing from the Government and creating more vulnerable rather than solutions. It is mostly seen at the low lying floodplain, riverbank eroded, and coastal plain and tidal plain region of Bangladesh. Besides, the post calamity amendment also infers the receptive adjustment. Therefore, Zheng et al. (2015) suggested identifying the affected and vulnerable areas firstly by expert identifiers and then need proper steps to ensure the sustenance from the adverse impacts.

3.3 Actions on tackling climate change and food security issues

Most of the literature in the national level study of China and Bangladesh ensured that both the country's Government and related department/divisions are well recognized about the importance of sustainable economic growth considering environmental protection, about the mitigation of carbon dioxide (CO_2) gas emissions and preservation of resources. The Government of China already developed many policies and legislation to impede the trend in ecological conservation. However, the People's Republic of China announced at the 2009 Copenhagen Accord Conference that 40–45% of its carbon dioxide (CO_2) emission reduce intension by 2020 (Zheng et al., 2015). Moreover, at the COP2 in Paris 2015, the country also announced its voluntary emission-reduction targets by 2030 (23). Therefore, initiatives and efforts to reach the previous level, the main problem is there, the emissions per unit of GDP, may decrease by 60–65% from the 2005 levels. However, the share in non-fossil fuels in the primary energy consumption would be increased by 20%. Also, forest reserve volume needs to increase by 4.5 billion m^3, equivalent to 31.6% of C stock concerning the levels of 2005 26. Walsh et al. (2014) concluded if achieved the above target of emission reduction, China would have far-reaching effects on future climate-change policies, industries, businesses and also might be contributed significantly in mitigation of regional as well as global CC. It's genuinely appreciated that the country already started to implement plans for the slowdown of climate change and to protect the environment. The national and regional governments have already invested highly and carried out a large number of national ecological restoration projects, as well as programs for the protection of natural forests, a program to combat desertification around Beijing and Tianjin and conversion of Sloping Land Conversion Program.

The overall climatic conditions and land of Bangladesh are very much appropriate for harvesting an extensive range of tropical and temperate crop production. Historically, the country is famous for well cultivating many verities of rice, jute, wheat, sugarcane, maize, potato, oilseeds, pulses, vegetables, spices, and many fruits. Due to the large population size, only potatoes and cereals production can fulfill the overall country's demand. Although the country is the 3^{rd} ranking of rice production in the world, it has some deficiencies other crop productions, including rice. Therefore, the considerable currency is spent every year for import in oilseeds, pulses, spices, and sugar to meet internal demand [64]. By increasing the production of some specific crops in a suitable and cost efficient manner could reduce the deficiencies. Therefore, the country needs to select, identify, and delineate suitable cultivable land for growing exacting crops and harvest maximum potential land.

However, the country, both China and Bangladesh, has closed much energy-demanding across national level for reducing CC and taken many initiatives in increasing crop and agricultural production. Also, there are still some deficiencies in inefficient factories and companies. The Chinese government recently adopted a unified development strategy to reduce air pollution in the Pan-Beijing region (Fang et al., 2018). The implementation of these policies and practices hopefully responds to both countries in their environmental protection, ecological sustainability, and overall public health.

3.4 General framework and major findings of this special feature

The Government of China is funding many national climate change-related research programs at the national level as well as regional. Remarkably, the Chinese Academy of Sciences has implemented five years Strategic Priority Project in Carbon Budget by around 35 million US dollars (Fang et al., 2018). During the last 5 years, there were about 350 researchers already participated in that project (Liu, 2013). Using of particular research designs as of protocols in the investigation of soils, vegetation cover, and habitats, there were about 17,090 research schemes sampled in croplands, grasslands, forests, and shrublands all over the country. However, the compiled and combined results report is believed to be the world's largest field campaign after the International Biological Program. On the other hand, the Government of Bangladesh has initiated different measures, policies, and projects for preparing a general framework in agricultural cultivable land management. The Land Resources Information System of Bangladesh Agricultural Research Council has developed spatial land suitability assessment datasets based on agro-edaphic and agro-climatic data. The evaluation will help identify and delineate the suitable land for growing plants such as varieties of rice (aus, aman and boro), wheat, corn, potatoes, sugar cane, oilseeds, jute, mustard, etc. The evaluation report of the suitability of the soil was carried out based on 11 agro-edaphic factors such as soil permeability, soil depth, soil moisture, nutrient status, soil reaction (pH), soil salinity, soil consistency, drainage, flood depth, flood risk, and land slope (Hussain et al., 2012). Thus, the assessment also considered agro-climatic factors that influence cropping growth about crop phenology and photosynthesis, were as extreme temperature and thermal zone, length of Kharif growing period, and pre-Kharif transition period. Therefore, land suitability of crop cultivations has been evaluated individually based on each land and its climatic factors as of limitations considering the crop requirements Hussain et al. (2012). The total procedure was done by the expert decision of National Agricultural Research Scientists (NARS) and many other experts having field experience on the cultivation of crops. The agro-edaphic and agro-climatic suitability maps of the main crops were created one after the other. However, agro-edaphic and agro-climatic fitness cards were overlaid to determine the final fitness cards for different crops. General maps and datasets for suitability assessment were based on that introduced in 1979 and 1985 by Brammer and 2005 by (Hussain et al., 2012).

3.4.1 Theoretical frameworks

Most literature have concluded that theoretical frameworks for food safety systems are complex and often have unintended and detrimental effects in ensuring food security under changes in the global environment. Therefore, to ensure the food security researches under distinct CC need the modeling, technological and extension frameworks. However, in modeling framework, Godfray et al. (2011) suggested as for different understanding needs to research simultaneously as well as economists, land reform planners, social and agricultural scientists together in modeling can perfectly overlay the food system. Furthermore, Alston et al. (2009) evaluated the biophysical and economic models based on the combination of food prices and parameters to guarantee priority, which will satisfy the needs of agro-environmental and socioeconomic decision-making. Challinor et al. (2009) and Gosling et al. (2011) suggested the multi-model ensemble simulation of crop yield under CC is essential to manage and to quantify the uncertainties associated with the accumulated outcomes. Geospatial and temporal distribution used in these models could provide a promising platform for food security analysis under CC Rötter et al. (2011). Many studies proved that technological innovation framework could eventually reform food production. Zeng et al. (2019), however, evaluated that per year 32 million tons of global food productions have linearly increased in the past few decades by breeding and agro-economic improvements.

Meanwhile, large-scale ecological changes are creating significant and continuous pressure on this linear trend. Therefore, globally spatial and seasonal breeding of climate tolerable, as well as droughts and temperate tolerable [Challinor et al. (2010), Long (2012)] crop varieties, are in urgent need that would be more efficient in utilizing water Molden and Sakthivadivel (1999) and nitrogen fertilizers (Jin, 2012). However, in the extension framework, the conservatory service is needed to be invented and modernize to build the relevant skills, including food producers. At the same time, more new economic incentives must be introduced so that farmers can adopt new technologies and methods. Extension services have always been considered the key to the quick and efficient implementation of new technologies. Piao et al. (2010) suggested the revitalization of extension services as well as small producer systems in China's food production to ensure the successful adoption of invented technologies.

3.5 Research frameworks

Both countries have extensive and practical research on CC feasibility on agriculture, cultivation, and production as well. Tang et al. (2018b) presented the first study on large-scale patterns of carbon (C), nitrogen (N), and phosphorus (P) stoichiometry at the community level forests, grasslands, and shrublands on a plant leaf, shoot, and root. The studyevaluated that vegetation gross primary productivity (GPP) is closely associated with leaf N and P. The research for all three ecosystems were documented with expansion and distribution of leaf N and P. Therefore, an average mean of 250 gC G.P.P./gN.yr and 3,158 gC G.P.P./gP.yr productivity for nitrogen (N) and phosphorus (P)were identified respectively over the country. However, leaf N and P productivity increased with both temperature and precipitation, suggesting that CC could enhance GPP, even without added N and P (Tang et al., 2018a). Based on field measurements from forests, grasslands, and shrublands across the national level of China, Fang et al. (2018) evaluated theinfluences of climate, soils, anthropogenic impacts, and ecosystem traits on soil organic carbon (SOC) stock. They prepared the framework that high temperature and rainfall were directly associated with reduced SOC, in forests and shrublands while in not grasslands. However, anticipated high amounts of rainfallwere associated with high species richness and also underground biomass that, overall, in turn, enhanced SOC stock in the ecosystems. It proves that SOC is directly influenced by the offsetting of temperature and rainfall. The authors suggested for increasing plant diversity and productivity by proper ecosystem management, which could increase soil carbon sequestration.

Furthermore, During 2001-2010 in comparing areas of six major ecological restoration projects with un-restored reference areas in China, Lu et al. (2018) identified the changes in ecosystem C stocks. However, the authors assessed thatthe restoration projects induced 56% of the C sequestration in the application fieldwith an annual sink of 74 Tg C/yr. It accounts for about 50–70% of China's yearly total sink in major terrestrial ecosystems and 9.4% of China's C emissions from fossil-fuel combustion. Moreover, using the field data collected from 58 counties across China, Zhang et al. (2017) assessed the impact of crop residue management on cultivated soil C sequestration. The authors have noted that over the last 30 years, from 1980 to 2011, cultivated soils are the key C sink, with an average net increase of 140 kg C ha^{-1} yr^{-1}% in the topsoil (0–20 cm) This SOC increase was primarily due to increasing organic inputs driven by economics and policy, which contrasts with crop soils in European countries, where insufficient organic C inputs were a primary cause of the SOC decrease 23. Bothof these studies provide the first ground-based evidence that ecological conservation practices and improved crop residue management significantly increasedcarbon sequestration in managed ecosystems. The interactions between ecological and climatic systems at the level of the ecosystem, Liu (2013) found that experimental and observed climate warming decreased soil moisture, but did not cause a systematic change in net primary production. However, the species composition of shallow-rooted sedges shifted towards deep-rooted grasses. Thus, the obtained result suggested thatchanges in species composition and functional characteristics contribute to increased productivity, whichmakes this alpine CCsusceptible to climate change than ever expected. Thus, theresearch frameworks have provided fundamental datasets to test theories on climate change, human activities, and ecosystem feedbacks on food productions as well as a baseline testing ofevaluation ofsimulations and future projections.

4. CONCLUSIONS

Based on the past, present, and future analysis and simulated results on the overall impacts of CC on food security, this review critically evaluated the comprehensive and multivariant food security index of China and Bangladesh. In CC and food security issues, both countries are alike on the highly vulnerable and risky situation in several manners, although their capacities and size difference in many aspects. Therefore, the perspectives of conditions, impacts, and challenges were mostly discussed comparatively and comprehensively, while measures individually that both countries could share. However, the conceptual consequences of CC were mainly on food productions and diversitiesof food security of these two countries. This review analysis describes per capita relative food surplus and food safety, which is recognized as a simple, yet powerful, and dimensional tool for quantitative cause-effect food security analysis. Most of the researches were concluded that CC, as well as environmental changes, have some positive effects on food production rather than cultivable land and population growth. Existing socioeconomic development pathways would more exert future food productions and food securities of China and Bangladesh. As large and diverse areas of cultivable land, China might survive by its high capital investment, while Bangladesh would suffer a lot. Therefore, to ensure food security in China and Bangladesh, more attention needs to be paid to extended research projects, policies, and food security with proper implementation and balanced nutrition issues.

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