Chapter 2
Loss of Agro-Biodiversity and Productivity Due to Climate Change in Continent Asia: A Review

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Abstract The population of the world is growing day by day, and according to the estimation by the year 2050 the population will exceed nine billion. The food demand will increase and agricultural activities need modification to satisfy the hunger and nutrition requirements of this up-surging population. The demand for productive agricultural land will be increased. The environmentally sustainable system needs to be introduced to maintain the level of production and the quality of food. The increasing greenhouse gases are the cause of climate change, due to industrialization. The agricultural activities are particularly affected by the environmental issues, including climatic alterations, increasing scarcity of water resource. The movement of populations from rural to urban areas will increase the burden on resources. That is the reason the agricultural practices needed to be renewed by undertaking the ecological, economic, and social aspects of agriculture sector. Moreover, the food and nutrition requirements in the increasing population of developing and resource-scarce countries, especially in Asia and Africa is a challenge. These countries are already poor and resource scarce, and the phenomenon of climate change is adding further challenges for the agriculture practice of small-scale farmers. This review presents the science-based evidence of climate change effect on crops. So the sustainable modifications in agricultural activities should be made by keeping in view these effects. The concept of sustainable practices is distributed in four categories such as agrarian farming, health and nutrition valve, sustainability of ecosystems, and prosperity of the populations and associated factors. The formulation and implementation of policies along with initiatives to mitigate and adapt to the climatic variations. The strategy of agro-biodiversity can be effective to overcome these problems associated with increasing population and climate change. The agro-biodiversity can reduce the challenges of global food security.

Keywords Agro-biodiversity · Climate change · Crop production · Livestock · Food scarcity

2.1 Introduction

2.1.1 Agro-Biodiversity: Trends and Varieties

Variability and changeability of wildlife, vegetation, and microbial species are used directly or tortuously for the production of food in agricultural activities, comprising harvesting of edible and other crops, livestock, forestry, and fisheries. The agro-biodiversity encompasses the variety of innate assets (diversities, strains) and the type of species used in the production of food for humans, animal fodder, medicines, and other resources. The species, which are not used for directly as food purposes but they play a vital role in the growth of other species such as microbial species, arthropods, and predator species. These non-harvested species are part of environment and significant for the diversity of agro-ecosystem (FAO 1999a, b). Agro-biodiversity is associated with agricultural biodiversity and the hereditary resource for the food and agronomy, it contains the following:

- Agro-biodiversity includes harvestable crops that are used for foodstuff and other purposes like breeding of livestock, and for all species of fishes. The wild species within the agricultural land, rangeland and forest species, aquatic biodiversity, goods from trees and plants, species hunted for food purposes.
- The species which help in the growth and production of harvestable species are non-harvested species. It includes pollinators, micro-biota, insects, honey bees, butterflies, etc. All species which are present in environment and which support the production of biodiversity are part of agro-biodiversity (FAO 2004).

2.1.2 Productivity of Crops

2.1.2.1 100 Years of Agricultural Change: Trends and Figures Related to Agro-Biodiversity

The threat posed by locally varied food production systems may include skilled men and women farmers, culture and local knowledge regarding older systems. As a result, extensive decline in agro-diversity was taking place. Therefore, other wild and native species disappear along the harvested crops and species (Rizwan et al. 2017a, b). Today, most of the world population is getting food only from 5 animal and 12 plant species; this may constitute 75% of total world food requirement. About 2.5–3 million species are used for food purposes, while humans use approximately 200 species for different purposes. More than 60% of Recommended Daily Intake (RDI) for calories and protein is obtained only from three sources, i.e., rice, maize, and wheat. Approximately 35% food necessities of humans are dependent on animals. About 12% of the world's inhabitants are dependent on animal species for different products. In order to increase the yield, farmers use GMO plants and seeds which is ultimately the reason for 75% extinction of original genetic species since 1990. Therefore, about 30% livestock species are becoming extinct. Many crop varieties and animals are lost from fields. The 17 main fish species of the world produced more than their sustainable limits to fulfill the food requirements. The genetic diversity of agro-biodiversity is affected due to loss of forests and wetlands and pollution of water bodies (FAO 1999b). The acceleration of decline in agro-biodiversity throughout the twentieth century can be due to expanding population and exploitation of resources to fulfill the need of population.

2.1.2.2 The Decrease in Cultivated Land and Green Revolution Agriculture

The rigorous production of livestock, aquaculture, and industrial fisheries, use of genetically modified organisms, and varieties and breeding of animals are the major reasons for the decline of agro-biodiversity. Moreover, limited number of domestic animal breeds and aquatic species have reared due to demand, and the prevalence of monocultures with cultivation of few crop varieties compact the agro-diversity in the ecology (Farid et al. 2020).

2.1.2.3 Food System and Marketing Globalization

The agro-biodiversity is declined due to perception and preferences of producers and customers, and this competition is increasing day by day. The policies are being developed for industries to secure patents for the cultivation of widespread and fewer varieties of GM products. This system will eventually create more competition in the global market, more uniform and reduced diversity of species.

2.1.2.4 Reduced Incorporation of Livestock in Arable Production

The livestock feed is limited and it has no diversity, similarly fisheries is nurtured to conserve and develop aquatic biodiversity. The major reason for the genetic eradication of agro-diversity is the replacement of local varieties by exotic or improved varieties and species, as reported by almost all countries. Recurrently, genetic eradication takes place when old varieties in fields are substituted by newer varieties. The previous gene varieties are not found in modern varieties due to the use of commercial varieties. Nowadays, genetic erosion is a serious problem in many countries according to FAO (1996).

2.1.3 Varieties of Crops and Their Production

2.1.3.1 South Asia

The diversity of South Asian region with regard to flora and fauna, climate, agroecology, and ethnicity is evident. The number of cultivated plant species at Hindustani (Indian subcontinent) Diversity Centre reaches up to 166 (Zeven and de Wet 1982). They possess extensive variability among wild plants. More than 300 species of such wild relatives of crops have reported in India alone (Arora and Nayar 1984). The conversion of sustenance production system to commercial agriculture is responsible for the change in agricultural landscape in this area (Farid et al. 2019). Crops produced by old-style farming are mainly used for domestic feeding and sold in market if produced in surplus. The cultivation of traditional cash crops like jute, sugarcane, and tobacco, etc. has reduced with the passage of time; most of the farmers now turn to commercial production and edible crops including rice, wheat, fruits, and vegetables because they are the best to generate income. The availability and traditional choices on numerous kinds of cereals is the reason for diverse food consumption pattern. In India, about 1.1 billion inhabitants are dependent on agrarian sector. India still has numerous native genetic diversities including trees of bamboo and rattan (Rana and Handel 1992). The hotspot of native species in India is Western Ghats, Deccan Plateau, Central India, North-Western Himalayas, and North-Eastern hilly region. Nepal is also an agrarian country, 80% population is dependent upon agricultural sector, and 90% agriculture is performed by sowing seeds (Joshi 2000).

2.1.3.2 Southeast Asia

Southeast Asia is a center containing seven biodiversity hotspots, including Indonesia, Philippines, and Malaysia known for their vast diversity. Traditional, wild and few landraces are the backbone of agriculture in this region. Cambodia's agriculture includes only typical varieties of rice, maize, sesame, and vegetables holding 80% of area. Biodiversity reduces massively due to carelessness of human intervention like urbanization, industrialization, and exploitation of resources that leads to deterioration of stability in agriculture and agro-biodiversity in countries like Laos that also affects plantations of maize, cassava, tea, teak, and rubber leading to deforestation. Vietnam leads in rice production holding 80% of area fulfilling 90% of food requirement cementing its second position. Maize, sweet potato, cassava, legumes, soybean, fruits, and vegetables are tried for alternate crops of rice through facilitation of government of Thailand in terms of income and subsidies.

2.1.3.3 East Asia

In East Asia, mostly rice, wheat, corn, soybeans, sorghum, barley, millet, peanuts, pulses, sugar beets, potatoes, cotton, oilseeds, forages, root crops, vegetables, and fruits are grown. East Asia is the center for crop diversity in the world. About 300 edible crops are grown in this area, and they are famous in the globe including soybean, rice, wheat, citrus, oat, barley, buckwheat, Chinese cabbage, and tea. East Asia is also famous for production of rice over 7000 years. East Asia is rich in eco-geographical diversities and ancient agronomy practices. Approximately 200 hundred crops of 600 species are grown in china. Extensive and intensive farming practices for food requirements and economic development are the reason for biodiversity damage. About 70% of plants are imported for cultivation purposes, which can damage native species. The variability of wheat seeds in china decreased about 90% from 1949 to 1970. Fifteen million hectares of land in china are used to grow hybrid rice. Similarly, it is reported in Japan that genetic diversity has declined.

2.2 Impact of Climate Change on Crops

Asian agriculture culture is accountable for two-third of agricultural Gross Domestic Product (GDP) globally. There have been many researches explaining the effect of climate change on crop productivity in particular places in Asia, but no research has so far studied crops through the whole continent (Mendelsohn 2014). The vast continent of Asia is distributed into regions of South and Southeast Asia (Pakistan, Viet Nam, India, Indonesia, Myanmar, Cambodia, Bangladesh, Thailand, Malaysia, and Philippines) and East Asia (China, North and South Korea, Japan, and Taiwan).

Agriculture in Southeast and South Asia is extremely susceptible to weather-related hazards, mainly storm surges, tropical cyclones, droughts, and floods that harm life, crop production, and property. In January 1991, the Philippine weather bureau “Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA)” reported that after the beginning of an ENSO-related drought, maize and rice crops faced a loss of 753 million dollars (Escafio and Buendia 1994). Seasonal monsoons are the foremost climate feature. The surface waters of Indonesia and Malaysia are the main part of the ENSO procedures. Changes in these leading climate features have significant effects on agriculture in this region. Climate change also increases sea level, causing flooding of low coastline areas which maintain great populations and widespread agricultural production (for instance, Bangladesh). A drop in production of rice due to the effects of climate and rise in sea level, along with quickly growing population, would impede food security.

Because of climatic variations, the biotic stress is enhanced in both plants and animals. Due to climate change, precursors associated with growth and development of plants is also altered. Due to environmental changes, pollination of plants is affected, more disease-causing agents can arise, and they can become more resistant. Various components of the global food system is threatened due to the changes in climate patterns. Extreme weather events can disrupt the entire global food system (Brown et al. 2013).

There is clear proof for an estimated rise in global temperature and changes in precipitation patterns in the course of the twentieth century. The most forthcoming variations in current era is the rise in the temperature of globe because of amplified level of GHGs including CO_2, CH_4, O_3, N_2O, and CFCs. Due to the increasing amounts of these greenhouse gases, there are projections about climate change showing warning about future variations in climate and indirect or direct impact on agricultural sector (Farid et al. 2018a). The amount of CO_2 rise in atmosphere and the projected changes in climate because of global warming are expected to disturb the agrarian yield in the future because of fluctuations in transpiration factor and plant development rate (Mendelsohn 2014).

The growth of crops is distributed in two long-term seasons. The summer or kharif crop-growing season (June to September) overlaps with South-West monsoon. The main kharif crops include soybean, maize, rice, cotton, sugarcane, bajra, jute, etc. Depending on the period of crops, kharif crops can be reaped during the winter (December to February) or autumn (October to November) months. The South-West monsoon is dangerous for the kharif crop that accounts for approximately 51% of grain yield and around 65% of oilseed crops. The internal monsoon precipitation inconsistency in India is the reason for massive flood and droughts causing a decrease in the Indian food crops yield and economy. Sowing and growth of the winter (rabi) crop begins after the rains in summer and remains over the coming spring or primary summer. Precipitation at the end of the monsoon season offers soil moisture and frequent water availability for irrigation of rabi crop (October to November). The summer rainy season as a result is in charge for both crop productions in India. The main rabi crops include gram, potato, onion, mustard, barley, wheat, etc. (Farid et al. 2018b).

In various tropical and sub-tropical areas, possible yields are predicted to decline due to maximum anticipated rises in heat. The effects of increased carbon dioxide must be measured in the framework of alterations in the air temperature, mainly nighttime temperature. Because of the rise in carbon dioxide and numerous trace fumes and fluctuations in humidity accessibility and its effect on vegetation v/s reproduction, requirement of more farming means (for instance, fertilizers) and the distribution and persistence of pest, therefore evolve a new balance between pests and crops. Ultimately, there will be significant change on land use because of ice melting, temporal and spatial precipitation changes, accessibility of irrigation, occurrence, and concentration of inter- and intra-seasonal floods and droughts, soil organic matter conversions, soil erosion, alteration in pest profiles, deterioration of arable areas due to expansion of sea, and accessibility of energy. In Asia, the overall 8% decline was measured due to climatic variations including the wheat crop (12%), maize (7%), sorghum (3%), and millet (9%). According to projections, this situation will be more severe by 2050.

2.2.1 *Factors Involved in Decreasing Crop Productivity*

Approximately 50% of crop production is endorsed to the impact of climatic influences. The following are some atmospheric variables that effect the crop production.

1. Temperature
2. Precipitation
3. Atmospheric gases (CO_2, CH_4, O_3, CFCs, and N_2O)
4. Solar radiation
5. Atmospheric humidity
6. Wind velocity

2.2.1.1 Temperature Variations

There is a major increase in the number of warm days approximately in all areas of the region. Warm nights have increased in rate nearly in each part of the region which is noteworthy. Cold nights and cool days have decreased in rate approximately all over the region. The increase in the quantity of warm days and nights and the decrease in the quantity of cool nights and days are realistically undeviating throughout the years (1961–1998) which have a major impact on the production of crops in the continent Asia. The number of warm nights and hot days has risen by the ratio of around 2–3 while the number of cold nights and cool days has declined nearly half of the total.

2.2.1.2 Water Deficiency

By 2030 only 60% of water demand will reach by existing resource at the current rate while 40% of population will be without access to water it needs. In the region of South Asia, water is needed for 1.6 billion people. The urbanization is creating pressure on water demand while in the rural areas the ground water is withdrawn for domestice purposes thus causing the depletion and deficiency of ground water table. The number of farmers complaining that their agriculture production is decreasing only by water deficiency that causes great loss to farmer every year in Pakistan and India. In India, 22 out of 32 cities daily face water crisis. In Nepal, people wait for hours and struggle for miles to obtain drinking water. The problem of water in South Asian region is scarcity amid abundance. Transboundary rivers that include Ganges, Indus, and Brahmaputra have great history. The rivers are now under pressure due to industrial sector, development of cities, increase in population, and environmental pollution (Surie 2015). Water contamination affects the Yellow River in China and the River Ganga in India by the domestic issues. Sino-Indian conflict regarding the fresh water is also rising. Due to water crises in Asia, water diversion projects are initiated such as China's South-to-North Water Diversion Project. Indians are drinking contaminated water containing harmful chemicals present in water, and half of the million population has water-borne diseases. Water crises in Asia are intensifying and sustainable water supply is decreased, which is giving rise to water wars. The construction of dams and diversion of water are the reasons for conflicts in Asian countries (Challaney 2017).

2.2.1.3 Rising CO_2

The concentration of CO_2 in atmosphere is rising day by day either because of anthropogenic activities or natural phenomenon that is becoming a reason for climatic variability. According to a report of Intergovernmental Panel on Climate Change (IPCC) 2007, the amount of carbon dioxide in the air has raised almost 22% since 1960. Enhanced economic and other anthropogenic activities are eliminating the globally available natural resources for sinking of carbon dioxide due to which CO_2 in the atmosphere is rising by the average of 1.3–3.3% annually as observed from 1990s to onwards 2006 (Canadell et al. 2007). The heat waves leaving the earth's surface are absorbed by the increased concentration of atmospheric CO_2 as a result of which earth's temperature increases and long-term changes in climatic condition occur. Rise of carbon dioxide concentration in the atmosphere and hence climatic variability has prominent impacts on human health and environment (Patz and Kovats 2002).

A significant change in the response of plants has been observed because of increased atmospheric carbon dioxide. The whole plant mechanism is affected due to increased CO_2 in the air because atmospheric CO_2 is the exclusive source of carbon availability to plants for the process of photosynthesis. Plants need a sufficient amount of carbon to carry out the process of photosynthesis. Increased concentration of CO_2 in the atmosphere is serving efficiently in this regard because around 95% of plants are not able to grow efficiently due to unavailability of sufficient supply of carbon. However, the plant growth with the supply of carbon is dependent on temperature (Long 1991). Because of the supply of sufficient carbon to the plants, atmospheric carbon dioxide increases, hence resulting in increased temperature which can potentially affect plant growth (Ziska et al. 2008).

2.2.1.4 Emission Trends

Plants face biotic and abiotic stress conditions because of variability in climatic conditions. They face stress factors such as high temperature and high light due to variation in the surroundings and results in the release of different volatile organic compounds (VOCs). When the temperature varies in the surrounding (in long-term climate change), plants undergo biotic and abiotic stress and they not only release carbon, oxygen, and water vapors but also a massive concentration of VOCs in the atmosphere (Habiba et al. 2015; Ehsan et al. 2014). These emissions include different derivatives of fatty acids, amino acids, and their derived metabolites, terpenes, phenylpropanoids, etc. The emissions of such volatile organic compounds are normally coupled with a series of biotic and abiotic stress in plants. The release of such compounds from plants is dependent on different factors such as plants type or species, phase of development of plant, and surrounding conditions such as climate, emission trends in the atmosphere, etc. The prevailing environmental conditions widely influence biotic and abiotic stress factors in plants, and emissions of volatile compounds from plants are also dependent on environmental parameters. For example, an increase in the release of volatile substances, such as (Duhl et al. 2008) a range of terpene compounds and some isoprene (Sharkey and Yeh 2001) and monoterpenes (Loreto et al. 1996), has been observed in herbaceous and woody plant species (Schuh et al. 1997) because of climatic variability (Holopainen and Gershenzon 2010).

2.2.2 Most Affected Crops

The emission of greenhouse gases is enhanced due to rapid increase in anthropogenic activities and development interest. The rapid increase in emission increases the temperature of the earth, and agriculture is the most vulnerable sector affected by these emission trends. This increase in temperature day by day affects the yield of crops and enhances pests and weeds growth (Nelson et al. 2009). Not only the crop yield is reduced because of climate change but also survival of some wild plant species such as potato, peanuts, and cowpea is vulnerable due to altering climatic conditions (Jarvis et al. 2008). In recent years, different crops are taken under observation and tested for seeing the impacts of global heat stress on agricultural crops due to varying climatic conditions (Farid et al. 2017a). Different species of maize, soya bean, rice and wheat are taken for applying statistical models and testing land use types to simulate the changing trends in crops growth, yield and nutrient value due to climate change (Teixeira et al. 2013). And the results have shown that agricultural production is affected worldwide due to global warming, and global warming poses threat to food security globally (Fischer et al. 2005; Schmidhuber and Tubiello 2007; Ainsworth and Ort 2010).

2.3 Impact of Climate Change on Livestock

Livestock is important for global food requirements. In developing Asia, total protein from livestock was 68.9 g/capita in 2002 (Steinfeld et al. 2006a, b). Climate change impacts on livestock in Asia are in a number of ways and mostly neglected. Many factors influence and alter livestock very speedily in emerging nations, especially in Asia and Africa. The manufacture of livestock products will raise constantly in the coming years around the globe due to population and urbanization expansion (Delgado et al. 1999; Thornton et al. 2009). The significant impacts of alterations in livestock would be harmful for lives of poor people and of those who depend on livestock. The changes in this system are inclined by alteration in natural variants in resources and also by changes in demand (Thornton et al. 2009). Major variations have been detected in many other continents due to climate change, particularly global warming, and substantial impacts on physical and biological structure have been witnessed (Rosenzweig et al. 2008). Livestock depend on agricultural practice. Regular weather determines plant development, growth rate, water requirement, and yield so even a small deviation in climate can be harmful for plants (Keeling et al. 1995). In south East Asia, the production of livestock is high alongwith their access to ocean enhanced their imports to rest of the world. Thus, climate change has direct and indirect impacts on livestock and can affect the imports to the world (Steinfeld et al. 2006a, b).

2.3.1 Direct Impacts of Climate Change on Livestock

2.3.1.1 Feeds Quality and Quantity

In South Asia, the quality and quantity of feed of livestock is at risk in consequences of climatic variations. In Asia, climatic variation is causing reduction in meat quality and calories content is reducing, which is harmful for the growth of children (Nelson et al. 2009). The food insecurity is rising due to high carbon in soil and atmosphere in Central and South Asia and china and requires carbon sequestration. The reduction in soil organic carbon reduces the yield of these regions (Lal 2004). Water availability is expected to reduce in Brahmaputra and Indus Basin and will raise the issue of food security approximately for 60 million people due to low crop and livestock production (Immerzeel et al. 2010).

2.3.1.2 Heat Stress

According to Sirohi and Michaelowa (2007), due to heat stress animal breeding, fertility, and low intake of food can be affected as thermal comfort temperature is 5–15 °C. In developing countries, intensification and temperate breeding could be more vulnerable for livestock (Parsons et al. 2001; Mader and Davis 2004; King et al. 2006).

2.3.1.3 Water Availability

Water demand for livestock is rising with an increase in atmospheric temperature. Major contributors to world livestock production, i.e., China, Brazil, India, and Pakistan are under the severe danger of shift in atmospheric temperature (Farid et al. 2017b). An increase in temperature will significantly affect livestock in Asia (Rust and Rust 2013; Rosegrant et al. 2010). Climate change also leads to various infections and vector-borne diseases in crops and livestock (Medlock and Leach 2015; Nardone et al. 2010).

2.3.1.4 Diseases and Infections

Harvell et al. (2002) and Baylis and Githeko (2006) describe about vector and non-vector diseases of livestock in developing countries. As a result of ozone layer depletion, mammalian cellular immunity can be inhibited and genetic variations in animals and disease outbreak can occur. Climatic variations can increase the number of brown-ear ticks, *Rhipicephalus appendiculatus,* the main cause for East Coast Fever, a sickness that disturbs feeding of livestock. The development of disease depends on many factors such as species and age. (Thornton et al. 2009; Tabachnick 2010; Irado et al. 2010).

2.3.1.5 Biodiversity

Loss of biodiversity due to various factors has been observed in developing countries such as feline species population decreased by 7–10% (FAO 2007). In India, rice production is at risk due to climate change (Ehrenfeld 2005). Studies have shown that a 2.5 °C increase in temperature will lead to loss of biodiversity. Especially 20–30% endemic plant species would be more vulnerable. All species cannot adapt to changing environment and climate change; this would damage biodiversity in the coming years on a large scale (Pereira et al. 2010; Bellard et al. 2012). As a result of rising population and food demand, changes in agricultural systems will occur. New technologies introduced for enhanced economy to save labor cost and more production, intensifications of agriculture practices, and livestock production can be affected due to climate change (Baltenweck et al. 2003; Steinfeld et al. 2006a, b).

2.3.2 Indirect Impacts of Climate Change

The direct influence of climate change will affect the health of humans ultimately. Transmission and outbreak of diseases, mortality, and morbidity rate can enhance due to favorable conditions in developing countries under climate change conditions. More vulnerable are poor people due to low economy. Due to the spread of diseases such as AIDs\HIV, labor issues can arise which also have impacts on economy (Thornton et al. 2009; Patz et al. 2005).

2.4 Impact of Climate Change on Fisheries

In marine ecosystem, composition, distribution, and richness of species vary leading to rising ocean temperatures (Perry et al. 2005; Pörtner and Peck 2010). In result of temperature variations on various stages of ecosystem, physical alterations at molecular, cellular and at entire ecosystem level will depend on species-specific reactions. Climate change, CO_2, acidification, nutrients, oxygen level, and temperature are main factors of biological changes (Portner 2001, 2002; Pörtner and Peck 2010). The increase in temperature creates a cloud of extra deviations, such as increase in sea level, amplified ocean stratification, reduced sea-ice degree, and changes in arrays of ocean movement, rain, and freshwater contribution (Keeling et al. 2010). All fish are exothermic and cannot regulate their temperature through physiological changes and their body temperature is identical to environment (Moyle and Cech 2004). Poles and tropical ecosystems are more vulnerable. Coral reefs are also at risk as they are sensitive to temperature. Climate change will cause fluctuations in whole marine and terrestrial ecosystem and will also affect services (Doney et al. 2011). South Asia is severely affected by climate change and the increase in food insecurity is due to population rise, natural resource degradation, heat waves, and change in rainfall pattern across Himalaya. Fisheries are affected in abundance due to climate change, and poverty and hunger are on the rise in this region (Sivakumar and Stefanski 2010). Northeast Asia is the biggest hotspot of fish production, consumption, and trade in the world. Industrialization leads to GHG emissions and warming in this region. Mostly small fishes are yield, i.e., pelagic fish which is very sensitive to climatic variations. Production of fisheries biomass is affected by climate change thus leading to economic and social issues in Asia (Kim 2010; Barange et al. 2014; Ficke et al. 2007). According to Jackson and Mandrak (2002), global warming will lead to introduction of warmth water species in Asia which will affect native species of marine ecosystem (Ficke et al. 2007). So there is need for better management of fisheries in Asia at various levels for better ecosystem, economy, and service (Pomeroy et al. 2001).

2.5 Economic Loss Due to Climate Change

Climate change has adverse effects on global food production by affecting the quality and quantity of food. Agriculture, livestock, and fish sector are greatly affected by the changing in weather for the last few years. It also reduces our capacity to maintain an adequate supply of food for all living organisms (Sen 1982). It is very difficult to estimate net impact of these environmental changes on agriculture sector and food production which creates the issue of food security. It is not only determined by the climate factor but also by the ability of people to afford, access, and use food (Battisti and Naylor 2009).

2.5.1 Fluctuation in Prices of Staple Foods

Climatic variations will be the reason for great economic pressure on food availability and its prices. According to International Model for Policy Analysis of Agricultural Commodities and Trade by International Food Policy Research Institute, the cost of the three mostly used edible crops in the world, i.e., wheat, maize, and rice will be increased by 31–106% by 2050. Most important factors that define the exact values of these crops within the range are mitigation, income growth, and population growth (Nelson et al. 2010). Mostly analysis in numerous countries shows higher prices of food that enhance food insecurity and poverty in both urban and rural areas (Ivanic and Martin 2008). People that are net consumers are also affected by inflation of prices. The benefits of greater income may help out some smallholder farmers to adjust with the expensive food but landless laborers working on these farms will face this more badly (Singh et al. 1986). Higher prices also reduce nutrient intake and increase malnourishment rate among people. Magnitude of effect will vary depending upon the income status and wealth across the country. In low-income countries, review on price elasticities reveals that price increase is also linked to the national economy. The impact of expensive food and higher rates of crops increases food insecurity which depends on the structure of economy and the capability of agrarians to adapt to unstable economic and ecological conditions (Morton 2007).

2.5.2 GDP and Economic Growth

Gross domestic product (GDP) is also affected by fluctuation in food prices (Schmidhuber and Tubiello 2007). It is very difficult to project growth trajectories, even by excluding the environmental variables. A recent research work on the association between temperature and macroeconomic productivity within countries reveals that labor productivity, labor supply, and crop production are largely affected due to extreme heat. The author finds that lower earning issues and temperature-related issues will rise by 75% in the developed nations by 2100. Due to the increase in the intensity of climate change and low economic growth scenario, almost 43% of all countries will be at risk and also be poorer by the end of this century than they are now (Burke et al. 2015). This will clearly show that there is a chance of increasing economic losses due to unmitigated climate change situation, which also greatly weakened the purchasing power of consumers to obtain basic facilities of life in the developing world. Even, if we are successful in improving the crop yield and increasing the production of food worldwide, resource-scarce countries are still struggling for access to food on the global market because there is a huge difference between where food is produced and where food is needed. An increase in food production in developed countries will not improve the drought and low attitude agriculture situation of poorer countries. These threats will increase with the demographic reality that a large part of world's anticipated population of almost 2.5–3.0 billion will be expected to occur in cities in the coming decades for the developing countries.

2.6 Effects on Food Security and Nutrition

Climate change has adverse effects on food production, crops yield, and food insecurity. The demand dynamics of market and supply of food are not only the factors that create food scarcity in an area (Hodges et al. 2011). Utilization of food and resources, cooking nutritious and safe food, protecting food stocks against pests and spoilage allowed to retain the nutrients in food for consuption. (Parfitt et al. 2010). Safe growth, healthy food, and then protection are very difficult in those situations where safe water and sanitation system are absent, and crops will face harsh climate issues like increased rainfall and prolonged drought (Rose 2015). This will also lead to increased exposure of parasites, mycotoxins, viruses, and pathogenic bacteria that destroys the harvested crops too. These infectious crops cause diarrheal diseases in children which have intense influence on child development and its nutritional status (Ngure et al. 2014). An environmental survey of 171 countries in the context of health represents their whole nation from 70 countries from all over the world between 1986 and 2007 reveals that the level of growth restricting in children under 5 years is highly associated with access to poor sanitation and water quality (Fink et al. 2011).

2.6.1 Fluctuation in Prices

Trends like levels of income, prices, production, and disease will define the future predictions of food accessibility and consumption in the upcoming time. Prices will also fluctuate greatly by the increase of temporal and spatial variability in a food production pattern due to climate change. The projections and final estimation of the future food scarcity rate in the world are very difficult when we are considering all the determinants for that, with respect to food access and volatility. But all the economic and biophysical models reveal that upcoming world will experience more fluctuations in food pricing due to harsh climatic conditions (Lobell et al. 2009).

2.6.2 Nutrient Quality of Food

Environmental changes also have a serious impact on the production and nutritional value of crops. Climate change reduces the nutrients from vegetables and legumes, also reduces the yield of crops day by day. Water scarcity and the increase in temperature have a large impact on the nutrient quality of food. Greater concentration of carbon dioxide affects the process of photosynthesis in plants which allows plant to transform sunlight into food. It also has influence on the nutrient content of sea food and food chain. It changes the nutritional composition of phytoplankton communities by reducing long-chain polyunsaturated fatty acid content (Bermudez et al. 2015). Thermal pollution also limits the uptake of iron and minerals and alters the micronutrient composition in fishes (Chavez et al. 2011). Like plants, carbon dioxide combined with climate changes leads to substantial uncertainties regarding the availability of food and nutrition (Myers et al. 2017).

In Asia, most of the countries are developing and agriculture is their most important sector of economy. GHG emissions and atmospheric concentrations will continue to increase for some decades; therefore, mitigation measures are not sufficient to control food scarcity issues. Climate functions and predicted changes in temperature will also disturb the food production and agro-ecological conditions. Thus, farmers need to adjust their practices and modify their technologies to meet the food requirement of future generations. Adapting to new climate scenarios is not feasible all the time because weather forecasts are not always trustable (Caldeira et al. 2004). Sometimes better seed varieties will not endure weather conditions and cause more food scarcity. To better prepare the vulnerable regions, scientists and economists have to make models according to the high-risk regions and crops present there, and also socioeconomic impacts that affect those models and their prediction, along with all uncertainties (Rosegrant et al. 2010).

2.7 Future Projections of Climate Change

The state of climate in future can be derived from different models which are projecting statistical analysis of weather and climatic patterns. According to the second report of assessment of IPCC, the warmer span of season increased the colder one, and hence there is occurrence of prolonged summers and short winters as well as variability in precipitation rate, etc. According to different reports and assessments, there is a complexity in different weather and climatic patterns just like heat stress in warm areas and variable rainfall pattern as well as variability of cooling days, etc. (Meehl et al. 2000). The data from different projection reports suggested that East Asia will face warmer climatic patterns in the twenty-first century, and the area of continent will experience high precipitation and temperature rate then oceanic area according to different spatial indications. It is projected that regular temperature changes for East Asia for the 30-year periods of 2020s, 2050s, and 2080s simulated 1.2, 2.5, and 4.1 °C increase, and precipitation changes are 0.4, 2.2, and 5.0% increase, respectively (Min et al. 2004). Climatic changes in stream flow sinks directly impact supply of freshwater, irrigation, etc. according to different assessments; the glaciation in the future is complex in the extent of water availability and majorly in Central Asia (Sorg et al. 2012). The study reveals that water for food security situation will intricate and might get daunting if no action is taken. The agricultural sector globally and in Asia has pressure on needs due to increasing population; it also increases the use of water and land resources. The greenhouse gas emissions from agricultural sector have a diverse negative impact (Hanjra and Qureshi 2010; Bellard et al. 2012). The carbon level in atmosphere is variably altering and atmospheric chemistry is crucially changing. The warming in continent Asia is not equally distributed overall, and agricultural sector is majorly affected sector along with various corresponding factors. The losses due to climate change in Asia are more in terms of crop yield and cause a severe issue of food security (Rosegrant et al. 2010). Since 1980, crop productivity is reduced in Southeast Asia. Immediate response is required to cope with these climatic variations, and agricultural production needs to be increased.

2.8 Conclusion

Our planet is facing climatic alterations and problems like water shortage, change in rainfall pattern, high temperature issues, and drought conditions. All major staple crops of the Asian continent such as rice, cereals, vegetables, grains, and spices are climatically sensitive. Due to rising temperature and changing of rainfall pattern, water scarcity increases which result in low productivity of crops and ultimately food shortage. Developing countries are facing food insecurity, crucial hindrance to their economic and social development. The decrease in crop yield is the cause of fluctuation in food prices, and it will be the reason for high food prices in the future and food security. The nutrition valve of crops is reduced. Agro-biodiversity provides income and food to farmers in this area. Native genetic diversity is declining in the continent. Due to climate change, GM species are mostly used nowadays, which is the reason for the decline in biodiversity. The species which can adapt adverse ecological conditions need to be introduced. The actions are need to be taken for the conservation of agro-biodiversity on international level. Asian Productivity Organization (APO) is working for Green Revolution and working to store genetics of agro-biodiversity. To increase the production, more climate-resistive species are being introduced which can provide more yield and more nutritional valve by genetic resources. But more research and policy need to be developed and implemented in this production of new species.

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