



Major Environmental Issues and Problems of South Asia, Particularly Bangladesh

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G. N. Tanjina Hasnat, Md. Alamgir Kabir, and Md. Akhter Hossain

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G. N. T. Hasnat (✉)

Department of Land Administration, Faculty of Land Management and Administration, Patuakhali Science and Technology University, Dumki, Patuakhali, Bangladesh
e-mail: gnthasnat@gmail.com

M. A. Kabir

Department of Agroforestry, Patuakhali Science and Technology University,
Dumki, Patuakhali, Bangladesh
e-mail: alamgirmk@gmail.com

M. A. Hossain

Institute of Forestry and Environmental Sciences Chittagong University, University of Chittagong,
Chittagong, Bangladesh
e-mail: akhter.hossain@cu.ac.bd

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Abstract

South Asia covers diversified climatic zones and experiences an array of climate change impacts. Human pressures together with changing hydrology and land resources have distinct impact on the production of food grain and resilience of ecosystems. The most threatened areas are grasslands and mountain forest ecosystems of the Himalayas and ecosystems of the Sundarbans. Forests of South Asia having most biologically diverse ecosystems on the planet are destroyed due to rapid deforestation and urbanization. Moreover, the South Asia partake the worst air pollution in the world, and it is maximum in India. *Thar* Desert is extending at a rate of 100 ha per year which may cause damage to approximately 13,000 ha of cultivated lands and pastures in India and Pakistan. Availability of freshwater is highly seasonal in this region, and water supplies become more threatened by higher temperatures, changes in river regimes, and greater incidence of coastal flooding. This article discusses major environmental issues faced by the South Asian people particularly Bangladesh and the resultant problems encountered by majority of people. Major environmental issues discussed here are climate change, geophysical setting, ecosystem changes, overgrazing, import of hazardous wastes, deforestation, desertification, pollution, population pressure, collapse and pollution of land resources, water resources and lack of potable water, biodiversity loss, food security risks, depletion of energy resources, and degradation of river and marine resources. Different problems created by mentioned environmental issues like biodiversity loss, impacts to the marine environment, atmospheric pollution, deficient urban structure, water scarcity and degradation, soil erosion and land degradation, natural disaster, pests, and diseases have been depicted in this chapter. Some recommendations have also been provided on the basis of major environmental issues identified and resultant problems.

Keywords

Afghanistan · Agrochemicals · Arsenic · Bangladesh · Bhutan · Biodiversity · Brickfield · Climate change · Cyclone · Deforestation · Desertification · Disease · Drought · Ecosystem · Exotic · Flash flood · Forest fire · Glacial melt · Global warming · Greenhouse gas · India · Industrialization · Invasion · Land degradation · Landslide · Lightning · Livelihood · Nepal · Pakistan · Pollution · Population pressure · Salinity · Sea level rise · Sedimentation · Shrimp cultivation · Soil erosion · Sri Lanka · Sundarbans · Urbanization · Vulnerability · Waste · Water scarcity

Introduction

South Asia is the large unique landmass representing the southern region of the Asian continent. The South Asia comprises of eight countries – Bangladesh, India, Nepal, Pakistan, Bhutan, Maldives, Sri Lanka, and Afghanistan (Sivakumar and Stefanski 2010). The total area of South Asia covers almost 5.1 million km² (1.9 million mi²), and this is 11.51% of the Asian continent. The land mass of this region gives a ground for near 1.749 billion people that covers about one fourth of the world's population (SACEP 2016). South Asia is not only the most populated region in the world but also densely populated (South Asia Regional Overview 2008).

The physiography of South Asia region ranges from the northern mountains to southern plateaus. The landforms distributed from the world's highest magnificent Himalayas with nearly two dozen peaks rising to 24,000 ft or above of Bhutan and Nepal to the lowest, the Bay of Bengal, the Indian Ocean, and the Arabian Sea beaches. The physical landscape of this region is also demonstrated with the fertile delta of Bangladesh, peninsula of India, and jewel-like islands of Sri Lanka and Maldives in the Indian Ocean.

The South Asia is ecologically more valuable area in the world because of its diversified natural resources and ecosystems. The total forest area of South Asia covers 2.73% of world's forests and provides a shelter for approximately 15.5% flora and 12% fauna of the world. The floral diversity comprises 39,875 species of flowering plants, 66 conifers and cycads, and 764 ferns. Faunal diversity is wide-ranging with 933 species of mammals, 4494 birds, 923 reptiles, 332 amphibians, and 342 freshwater fishes. Only the Hindu Kush Himalayan belt was embracing a home to a number of 25,000 major plant species that covers 10% of the world's total flora. In addition, India contains extensive savannah and forest habitats that provide spaces for many endemic species having international importance. Sri Lanka is also one of the most biologically diversified countries in the world. South Asia is the home of around 14% of the world's mangrove habitat. Moreover highest percentage of threatened wetlands are in here, 82 of which are in Bangladesh.

The climate types of South Asia are quite difficult to understand and describe. About half of the climatic zones that exist on the earth can be found in South Asia. Though the climatic condition is quite different and varies considerably from area to area as of tropical monsoon in the south to temperate in the north, several distinct zones appeared here quite clearly. The total area is broadly separated into six main climate zones. The *highland zone* has the coldest climate. This area covers the Himalayas and other northern mountains. Snow exists here in all the year-round. Another one is the *humid subtropical zone*, much warmer than the highland zone. This zone includes the lower elevations and encompasses the deluxe slopes and valleys of Nepal, Bhutan, and northern India and the Indo-Gangetic Plain.

The *semiarid zone* is a region of high temperatures and light rainfall. This type of region is generally found at the western end of the Plain and in parts of the Deccan Plateau. The other zone is the *desert zone*, and it covers much of the lower Indus Valley in the borderlands of Western India and Southern Pakistan. The *Thar Desert* is

located in this region and is the driest part of this area with an average 10 in. annual rainfall. The *tropical wet zone* is found along the western and eastern coasts of India and in Bangladesh. Temperatures are comparatively high, and rainfall is heavy in this zone and has recorded a world's record of 366 in. in a month. The sixth one is *tropical wet and dry zone*. In Sri Lanka the southern part has a tropical wet climate, while the northern part reveals a *tropical wet and dry* climatic zone.

The variety in climatic conditions of South Asia mainly is influenced by three bases – the altitude, vicinity to the seacoast, and the seasonal impact of the monsoons. Literary monsoon means seasonal winds that bring alternating periods of wet and dry weather. During summer season winds blow from the sea and bring moisture, called wet monsoon period. But, in the winter season winds blow out from the center of the region toward the sea and bear much less moisture. This period is dry monsoon period. The climate of South Asia is influenced by the monsoon patterns. The southern parts are near to the seacoast, so it's mostly hot in summer and receive rain during monsoon periods. The northern belt of Indo-Gangetic Plains gets both the seasonal warm air from the seacoast and the cold air of Himalayas. The mountainous north is colder and receives snowfall at higher altitudes of Himalayan ranges.

Although monsoons are crucial for South Asia, it causes severe suffering for millions of people, especially in the lowlands of Bangladesh and India. Monsoons are highly unpredictable, and recent years abnormal monsoon patterns generate more frequent and intensive natural disasters as well as climate change.

Major Environmental Issues and Problems of South Asian Countries

Having diversified climatic zones along with its physical landscape, the region experiences a huge range of climate change impacts, for example – glacial melt, sea level rise, soil erosion, saline water intrusion, etc. The key environmental issues in broad aspect which are a great threat to the sustainable development of South Asia are discussed below.

Climate Change

Climate change is the mother of all climatic hazards and extreme weather events, such as heat waves, heavy rainfall and droughts, etc. (WHO 2015). Climate change is drastic variations and shifts of weather conditions (moisture, cloudiness, precipitation) from warm and moist climate to cool climate due to external or in internal factors over different time scales (Singh 2009).

The main cause of climate change in South Asia is the increase in concentration of greenhouse gases (GHGs). The concentration of one of the major GHGs, carbon dioxide (CO₂), has been constantly increased in South Asia due to rapid industrialization and other anthropogenic activities. India and Pakistan are the major

contributors of CO₂ emissions in this region, while, in terms of per capita emissions, Maldives is the highest contributor. This changing climate is manifested in the form of global warming, changing rainfall patterns, melting of glaciers, sea level rise, and increase in the frequency and intensity of cyclones or floods. Since 1950s, the number of cold days and nights decreased, while number of warm days and nights increased (IPCC 2014). The geophysical and demographic conditions make the region more vulnerable to climate change. Impacts of climate change are visible now in water resources, agriculture, forests, and ecosystems. It is affecting the well-being of billions of people in the South Asian region.

Climatic Events

The most dangerous climatic event of South Asia is cyclone. Cyclones are most destructive in low-lying coastal region especially in Bangladesh and India. High waves slough large coastal parts and cause severe damages and kill thousands of people. In 1970, a cyclone killed more than 300,000 lives in Bangladesh (BBS 2017). The frequency and intensity of droughts also increased in South Asia (Webster et al. 1998; PAGASA 2001; Lal 2003). Consecutive droughts in 1999 and 2000 in Pakistan and India steered to a sharp decline in water tables and crop failures. Longer duration of heat waves was observed in South Asia region, especially in India (De and Mukhopadhyay 1998). Moreover, the increased frequency of intensive rainfall events along with some anthropogenic issues causes severe landslides, floods, and mudflows (Khan et al. 2000; Shrestha et al. 2000; Mirza 2002).

Globally, South Asian countries are most vulnerable in terms of floods (UNDP 2004). Since 1984–2017, Bangladesh has experienced seven severe floods and more devastating was in 2007 that affected 10,655,145 people (BBS 2017). In 2005 Mumbai faced more hazardous floods that led to a loss of over 1000 lives, and a total loss was more than US\$250 million (IPCC 2007). In Pakistan, due to floods almost 2000 people died in 2010 and leaving behind 20 million homeless people with a loss of \$10 billion. Only in Sri Lanka, from 2005 to 2014, the total number of people affected by floods were 4,626,078. Bhutan was affected by three major floods in 2009, 2011, and 2013. Landslide is another common event in South Asia. Bhutan suffered by annual occurrence of landslides (NEC 2008), and in Bangladesh it killed 152 people only in 2017.

Geophysical Setting

The South Asia covers only 4.8% of the world's land surface area but provides home for above 24% of the world's population and growing at an alarming rate of 1.8% annually (Kakakhel 2012). This demographic coverage of South Asia gives a shelter for 39.49% of total Asia's population.

The South Asia is surrounded by three water bodies – the Bay of Bengal, the Indian Ocean, and the Arabian Sea. Moreover, it has highly varied climate zones

from snowy highlands to sun-scorched deserts. The region is the quary of various topographies, for example, glaciers, rainforests, mountains, plateaus, beaches, valleys, deserts, savanna, and grasslands.

Climatic condition of South Asia ranges from arctic temperatures that found in the high mountains to a temperate in the foothills and on the Indo-Gangetic Plain to tropical environments on the Deccan Plateau. Diversified geophysical settings with varieties of climatic condition make the region more prone to different types of environmental issues.

Glacier Melt and Sea Level Rise

There are three main seas in South Asia and are vulnerable to sea level rise. Sea level rise is a gradual process and aggravated with global warming. The ice mass of the Himalayas is melting rapidly than the global average rate and creates great threat to this region. Sea level rise emerged in the Bay of Bengal in 1947, and the rising rate is 1.4 mm and 3.9 mm per year in the southeast and south-central part nearest to the sea of Bangladesh (MoEF 2012). More than 100 million hectares of arable lands of Bangladesh are affected due to sea level rise. It is predicted that sea level will rise 45 cm by 2050 and will affect 10–15% of the land area and near about 35 million people. Sea level rise first appeared in Indian Ocean in 1960s (CDKN 2014) and may rise up to 15–38 cm by 2050. Coast land of Sri Lanka is less than 1 m above sea level. Average elevation of the Maldives' is 1.5 m above sea level and its highest point is less than 2 m. About 47% of all dwellings of the country are located at high risk of sea level rise within 100 m of the coastline, and these are the home of 42% of total population (Das 2010). The total islands are affected by saline water intrusion, and a rising tide may submerge the islands easily. The major problems of sea level rise are saline water intrusion, threatening drinking water supply, agricultural land degradation, and aquaculture damage.

Land Degradation

Land degradation due to water and wind erosion is a common phenomenon in South Asia. South Asia has nearly 90 million ha irrigated land that is seriously affected by water erosion. Irrigated cropland of Bangladesh, India, and Pakistan is severely affected by salinity-induced water erosion. Afghanistan, India, and Pakistan are suffering by another type of erosion, wind erosion due to desertification (UNEP 1997a).

Water Scarcity

Many parts of South Asia are suffering from water scarcity. Parts of Afghanistan, India, and Pakistan are distressed of water shortage due to desertification. Some parts of India, Bangladesh, and Sri Lanka are facing the problem of lowering of

groundwater table. Maldives is facing depletion of freshwater due to salinity intrusion. Moreover water pollution (UNEP 1997b) from industrial wastes, agricultural runoff, commercial pesticide, and arsenic contamination decreases usable water availability.

Ecosystems and Biodiversity Loss

Within South Asian countries, highest rate of deforestation is found in Pakistan. Deforestation leads to habitat and species loss that tends to ecosystems and biodiversity depletion. Mangrove forests in Bangladesh, India, and Sri Lanka (UNEP 1997b) are also under pressure for shrimp cultivation and salt production.

Pollution

With increasing urbanization and demographic pressure, pollution is becoming a vital concern in South Asia. Increased industrial activities, vehicles, and brick kilns increase regional pollution over time, and GHG emission has risen in South Asia by approximately 3.3% annually since 1990 (Khwaja et al. 2012). India is the highest air-polluting country in this region followed by Pakistan (Khwaja and Khan 2005). In Bangladesh air is polluted mainly by vehicular emissions, industrial emission, and brick kilns. In Bhutan, forest fire is the main source for air pollution. In Nepal air quality is deteriorating with high levels of dangerous pollutants (Khwaja et al. 2012). In Sri Lanka key source of air pollution are motor vehicles, burning of domestic and industrial wastages, firewood, etc. (Senarath 2003).

Import of Hazardous Wastes in South Asia

Disposal of industrial waste in environment increases the pollution level in land, air, and water. The international waste traders always searched for welcoming dumping grounds in third worlds as waste importer. And South Asia is more recent discovery by them. Different types of waste such as plastic waste, metal waste, tin waste, iron waste, lead waste, etc. are imported in South Asia consciously or unconsciously. For example, in late 1991, four US corporations secretly mixed 1000 t of hazardous waste containing high levels of lead and cadmium into a shipment of fertilizer which was imported by Bangladesh, and one third of that toxic fertilizer was applied on farms (Leonard 1993). In 1992, the South Asian countries imported only 15% of the US plastic waste. But in 1993, Bangladesh, India, and Pakistan imported 53% of total US plastic waste deliberately (Leonard 1993). These various nondegradable, slow degradable chemical and hazardous wastes cause environmental degradation and health hazards too. Banning the international waste trade may be a solution to protect the importer countries. But, developing environmentally sustainable production processes for every country will be the better solution.

Country Basis Environmental Issues, Causes, Vulnerable Areas, and Overall Impacts

Afghanistan

Afghanistan is a landlocked country of South Asia with 652,000 km² land area. It is a mountainous and very arid country of South Asia. Agriculture is the primary source of livelihood. Continuous drought and extensive degradation of its natural and biophysical resources are stunting its future development and making it more vulnerable to climate changes (Table 1).

Bhutan

Bhutan is also a landlocked country in South Asia. It is located at the eastern end of the Himalayas. The country is bordered by China to the north and by India to the south, east, and west. It contains most abundant forest and water resources. The country is considered as a sanctuary for biodiversity and a model for environmental stability. But, now a days, climate change creates many threats to Bhutan. This country is more susceptible to flash floods and landslides due to accelerated glacier melt (Table 2).

India

In consideration of area, India is the largest country of South Asia and the seventh largest country in the world. The vastness of the country provides diverse

Table 1 Environmental issues, causes, vulnerable areas, and overall impacts in Afghanistan

Key environmental issues	Main causes	Vulnerable areas	Impacts
Soil degradation; deforestation; loss of biodiversity; overgrazing; desertification; soil erosion; air pollution; water pollution; food security risks; natural disasters such as earthquakes and droughts	Population growth; increased demand for agricultural lands, fuelwoods, housing materials, etc.	Agriculture; water resources; ecosystems; natural calamities; human health; and social development	Water scarcity; high temperature; reduced precipitation; increased evapotranspiration; vulnerability of agriculture, wetlands and ecosystems to desertification; food insecurity; duration and frequency of drought; flash flooding from glacial melt; increasing risk from malaria; malnutrition and migration

geographical settings and varied climatic regimes from humid to arid that makes the land more vulnerable to the diverse environmental problems (Table 3).

Maldives

Maldives, situated in the Indian Ocean, is an island nation of South Asia which consists of coral reefs and hundreds of smaller islands. It is the smallest South Asian country both in population and area. The coral reefs are the seventh largest in the world and rich in biodiversity and aesthetic value. The country is exposed to the risks of extreme climatic events, sea level rise, and saline intrusion (Table 4).

Table 2 Environmental issues, causes, vulnerable areas, and overall impacts in Bhutan

Key environmental issues	Main causes	Vulnerable areas	Impacts
Soil erosion; air pollution; water pollution; scarcity of drinking water; deforestation; solid waste disposal; climate change; and glacial melt	Rapid urbanization	Agriculture; ecosystems and biodiversity; water resources; human health; and natural calamities	Agricultural yield reduction; forest area degradation; biodiversity and habitat loss; floods; vector-borne and waterborne diseases

Table 3 Environmental issues, causes, vulnerable areas, and overall impacts in India

Key environmental issues	Main causes	Vulnerable areas	Impacts
Deforestation; soil erosion and land degradation; desertification; overgrazing; loss of biodiversity; air pollution; surface water pollution; arsenic contamination in groundwater; forest and agricultural land-use change; demographic pressure; climate change; natural disasters such as floods, cyclones and landslides; sea level rise; glacial melt; salinity intrusion	Urbanization; industrial effluents; emissions from vehicles and brick kilns; unmanaged ecotourism; agrochemicals; fossil fuel burning	Agriculture; water resources; coastal, terrestrial, and marine ecosystems; human health; urban area	Sea level rise; increase of sea temperature; frequent and intensive floods, cyclones and droughts; glacial melting; increased temperature; changes in precipitation patterns; floods; saline intrusion; heat waves; water- and airborne diseases; decreased agricultural production; biodiversity loss; and impacts on urban infrastructure, drainage, sanitation, etc.

Table 4 Environmental issues, causes, vulnerable areas, and overall impacts in Maldives

Key environmental issues	Main causes	Vulnerable areas	Impacts
Climate change; sea level rise; saline water intrusion; coastal erosion; groundwater depletion; marine biodiversity loss; air and water pollution; waste generation; coral reef bleaching	Demographic pressure; marine-based tourism; sea level rise	Coral reefs; coastal and marine ecosystems; water resources; disasters and hazards; tourism; public health; social development	Ecosystem damages, loss of coral reefs; salinity intrusion in groundwater; increased intensity and frequency of climatic hazards such as cyclones, flooding, and inundation of islands; diseases; disturbance in tourism; and migration

Table 5 Environmental issues, causes, vulnerable areas, and overall impacts in Nepal

Key environmental issues	Main causes	Vulnerable areas	Impacts
Deforestation; soil erosion and degradation; water pollution; air pollution; loss of biodiversity; waste generation and disposal; climate change; ice cap melting; natural disasters	Rapid urbanization; emissions from motor vehicles and industries; increased demands for timber; population growth; lands conversion	Agriculture; water resources; terrestrial ecosystems and biodiversity; human health	Increased intensity of glacier lake outburst floods due to rapid glacial melt; intensified scarcity of water; outbreaks of diseases; agricultural production loss; glacial melt dependent ecosystems and biodiversity loss

Nepal

Nepal is one of the three landlocked countries in South Asia. It is located at the foot of world's highest mountains the Himalayas and bordered by China to the north and India to the south, east, and the west. Its topography ranges from very high altitudes of the Himalayan Mountain to the Gangetic Plains. Agriculture is the main livelihood option. This country is vulnerable to the climatic events too (Table 5).

Pakistan

Pakistan, the second largest country of South Asia, comprises dry or cold climatic regimes. It is bordered by India to the east, Afghanistan to the west, Iran to the southwest, and China in the far northeast. Alike climatic zones, geography also varies across the country. Near 60% of the total watershed area of the Indus basin lies within Pakistan's territory. Main climatic changes found in these areas are glacial melt, sea level rise, and drought (Table 6).

Table 6 Environmental issues, causes, vulnerable areas, and overall impacts in Pakistan

Key environmental issues	Main causes	Vulnerable areas	Impacts
Water pollution; seasonal scarcity of freshwater in natural resources; soil erosion; coastal habitat loss; degradation in marine ecosystems; natural disasters, deforestation; desertification; biodiversity loss; climate change; air and water pollution	Urbanization; industrialization; wastes disposal; population pressure; unplanned ecotourism; mangroves depletion for aquaculture; overfishing; increased demands for timber and fuelwoods; hunting and poaching; excessive use of agrochemicals	Agriculture; coastal zones; marine and terrestrial ecosystems; water resources; land resources; climatic events; health and social development	Increased intensity and frequency of drought; coastal erosion and salinity intrusion from sea level rise; increased natural disasters; changes of sea and atmospheric temperatures; several flooding and future drying of water resources due to glacial melt; reduced soil productivity and fertility, reduced crop production; food and water insecurity; land-use changes; increased intensity of drought and desertification; longer exposure to water logging; outbreak of heat-related and vector-borne diseases; malnutrition; migration; and conflict

Sri Lanka

Sri Lanka is also an island country in South Asia and bordered by India and Maldives. The country is rich with mountainous and coastal biodiversity. Weather condition of the country is hot and humid. Part of the country experiences long-term dry spells, and extensive areas suffer from water deficit. The country is in tremendous risk by predicted changes in climatic condition in terms of temperature, frequency and duration of drought, intensity of rainfall and storm surges, and sea level rise (Table 7).

Bangladesh

Bangladesh, the largest delta on earth, is situated in South Asia. It is located between 20°34' and 26°38' north latitude and 88°01' and 92°41' east longitude (BBS 2017). It

Table 7 Environmental issues, causes, vulnerable areas, and overall impacts in Nepal

Key environmental issues	Main causes	Vulnerable areas	Impacts
Deforestation; loss of biodiversity; coastal degradation; land degradation; soil erosion; waste generation; pollution by municipal and domestic waste; limited access to potable water; waterborne diseases; air and water pollution; climate change	Human pressure; increased demand for timber; unplanned marine-based tourism; poaching; sea level rise; industrial and municipal waste disposal	Agriculture; coastal and marine ecosystems; water resources; fisheries; public health; natural disasters	Reduced crop production due to high temperature and sea level rise; damages to settlements, industries, and livelihoods in coastal areas; ecosystem degradation and biodiversity loss in coastal and marine ecosystems; saline water intrusion into the freshwater and groundwater; increased incidence of vector-borne diseases; imbalanced climatic events; threats to ocean; threats to food security, fishery, and livelihoods; and coral reef bleaching

is bordered by India on the west, north, and east, by Myanmar on the southeast, and by the Bay of Bengal on the south (Fig. 1). The area of the country is 147,570 km². Most of the country is low-lying comprising mainly the delta of the Ganges and Brahmaputra rivers. A total of 80% of the country is floodplain (Agrawala et al. 2003). Mean elevations range from less than 1 m on tidal floodplains, 1–3 m on the main river and estuarine floodplains, and up to 6 m in the Sylhet basin in the northeast (Rashid 1991). Only in the extreme northwest, elevations are greater than 30 m above the mean sea level. The northeast and southeast portions of the country are hilly, with some tertiary hills over 1000 m above mean sea level (Huq and Asaduzzaman 1999).

The climatic condition of Bangladesh is tropical monsoon. It has a hot and rainy summer and a dry winter. January is the coolest month with an average temperature of 26 °C, and April is the warmest with temperatures ranging from 27 °C (east) to 40 °C (west). The climate is one of the wettest in the world. In the rainy season, most places receive above 1525 mm rainfall annually, and hilly areas receive about 5080 mm. Maximum rainfalls occur from June to September all through the monsoon and least from November to February during the winter season (Banglapedia 2014).

The environment of the country is under severe pressure due to changing climate and destructive anthropogenic activities. Environmental degradation is directly and



Fig. 1 Map of Bangladesh

indirectly affecting human health, ecosystems, and economic growth of the country. Demographic pressure, poverty, lack of proper awareness on environmental issues, and lack of implementation and monitoring of environmental rules are the main causes for existing environmental condition of Bangladesh (GEDPCB 2015).

As environment is a vast area and each part is linked with others. Changes in any part or issue are responsible for changing the other parts. The major environmental issues and problems in Bangladesh are climate change, natural calamities (lightning, cyclone, flood, flash flood, drought, earthquake, riverbank erosion, sedimentation), geospatial setting, environmental pollutions (air pollution, water pollution, soil pollution, and noise pollution), ecosystem changes, deforestation, forest fire,

desertification, salinity intrusion, waste disposal, salt/shrimp cultivation, brickfield, exotic species, etc.

Climate Change

Among all countries of South Asia, Bangladesh is the most vulnerable one to climate change (Huq 2001; Rahman and Alam 2003; UNDP 2007) because of its unfavorable geographic location, flat- and low-lying topography, high population density, high levels of poverty, livelihoods reliance on climate-sensitive sectors like agriculture and fisheries, and inefficient institutional aspects (Climate Change Cell 2006). Change of climatic condition affects adversely in every sectors directly or indirectly. But the most disparaging effects of climate change are sea level rise, higher temperatures, unexpected monsoon precipitation, increased flooding both in terms of extend and frequency, frequent cyclonic hazards, drought, salinity intrusion, and increasing temperature (Huq and Ayers 2008). Impacts of climate change are extremely detrimental to the national economy, environment, and national development (Reid and Sims 2007).

Human health is severely affected by weather and climate. Climate change induces health problems, such as cardiovascular and respiratory diseases, infectious diseases, malnutrition, and even deaths. On the other side, it is declining water and food securities and undermining infrastructures, health systems, and social protection systems (WHO 2015).

Global Warming

The world's temperature is increasing day by day, and it is predicted by the specialists that due to climate change the global temperature will rise between 1.80 °C and 4.0 °C by the year 2100, although it could possibly be 6.4 °C (Alley et al. 2007). In case of direct effects of temperature, Bangladesh experiences the most rapid rates of warming, degradation of land, diseases in human, and demolition in local livelihoods and biodiversity. As well as, in case of indirect effects, hotter weather increases the number of deaths and illness due to heat, particularly in older people and urban poor (Depledge and Lamb 2005).

A research was conducted in Bangladesh from 1983 to 2009 and found a relationship between mortality rate and temperature (Alam et al. 2012). From 1961 to 1990, the rate of heat-related deaths in elderly persons (65+ years) was 4 deaths per 100,000 annually. It is increasing rapidly after 1990, and the devastating death occurs during the 8-day heat wave in 2008 (WHO 2015). During those 8 days, more than 3800 people died from the excess heat. Two thirds of those were 65 or older which indicates that the elderly are especially more vulnerable to heat waves (Gawthrop 2017). In 1990 the warm spell was 60 days. But a projection by WHO (2015) revealed that under this environmental condition, the warm spell will be almost 300 days by 2100, and death rate will increase at 30 per 100,000 people by 2080. Only a systematic reduction of global warming could limit warm spell days to 120 on average and heat-related mortality at 7 per 100,000 people.

The increasing temperature directly effects on food production sector. Crop yields directly depend on climatic conditions (temperature, rainfall, etc.), and higher

temperature leads to large declines in cereal production (Stern 2006). A long-term increase of temperature in water will increase the concentration CO_2 that make the harbor of fishes more acidic. Some fishes and aquatic fauna are intolerable to acidic water and may become extinct with time (Pender 2008).

Geophysical Setting

Bangladesh covers a land area of 130,170 km^2 containing 162 million people, and the population density is 1251.8 people per km^2 . Bangladesh covers diverse geophysical features – floodplains (80%), terraces (8%), and hills (12%) (BBS 2017). Moreover, the evergreen, deciduous, and mangrove forest depicts diversified physiography (Ahmed and Vijnan 1997). Furthermore the seasonal monsoon climate of the country is rich with high rainfall, high humidity, and high and low temperatures (BBS 2016). These varied geophysical settings expose the country to rapid environmental changes and natural hazards.

Demographic Pressure

Bangladesh is one of the most densely populated country in the world (Huq et al. 1998). Population pressure is an obstacle for Bangladesh to achieve major two broad goals – socio-economic development and reduction of poverty. Population density of Bangladesh was 196 per km^2 in 1901 (Huq et al. 1998) increased to 1251.8 per km^2 in 2016. Now the average annual growing rate is 2.08%, and if the population increases in such a rate, then the “carrying capacity level” of the country will be collapsed.

Population pressure is the main culprit for environmental changes (Bremner et al. 2010) and also the vital factor for rapid land-use and cover change (Vanclay 1993; Wibowo and Byron 1999) and deforestation (Amelung and Diehl 1992; Mather and Needle 2000). Rising of population leads to excessive demands for housing and consumption of goods and services. For meeting the additional need of house and foods, existing agricultural lands are converted into building construction, and marginal lands like forest lands are brought under cultivation (Fig. 2). Encroaching and deforestation causes soil erosion, loss of soil fertility, siltation, flooding in river basins, changes in microclimate, habitat loss, loss of genetic diversity, ecosystem loss, and damages of environmental balance. Moreover, low-lying areas are also invaded for more housing and cultivation of more food grains; thus habitats of fish are encroached. Similarly, shrinkage of pasture land affects livestock resources. Thus growing people over exploit the natural resources of the country (Huq et al. 1998) and induce ecological hazards.

Unplanned Urbanization and Industrialization

Urbanization is closely linked with industrialization (Rahman 2012). Moreover, urbanization, migration, and development are also interlinked (Kawsar 2012). But, in Bangladesh rapid urbanization is the greatest challenge of twenty-first century because of unplanned and uncontrolled urban growth (Khan 2016). Total land of urban area covers 10,600 km^2 which is only 7% of the total land but contains 34% of the total population (LGED 2017).



Fig. 2 Forest lands are converted into agricultural land

The country was predominantly agrarian and rural. In 1951 only 4% of the population lived in urban area. Urban population increased moderately to about 8% by 1971. But it grew rapidly after independence at 19% by 1991. Saha (1989) reported that increased industrialization in Bangladesh increases urbanization in that period. In 2005, about 26% of the total population was found in urban area while 28% by 2011 and 34% by the end of 2016. If this growth rates exist, then the country's urban population will reach at 79 million or 42% of the total population by 2035 (LGED 2017).

Growing urbanization creates numerous problems and challenges for the growing people including poor housing and transport; inadequate drinking water; lack of drainage and sewerage; high percent of people living in slums; inadequate urban basic services especially water, electricity, sanitation, and gas; dumping of huge wastages on open land and in rivers; increasing industrial pollutions; social and political conflict over land resources; and high level of vulnerability to natural disasters (LGED 2017). Unplanned urbanization not only depletes the country's natural resources but also degrades the environment.

Unplanned Construction of Brick fields

Brick burning contributes to climate changes and global warming by absorption of greenhouse gases in the atmosphere in higher quantities (IUSS 2002). Brick kilns produce long-term and short-term impacts on the environment. Deforestation,

reducing agricultural yields, damaging arable lands, air pollution, etc. are the short-term effects, while climate change, global warming, impacts on human health, ozone layer depletion, etc. are the long-term effects (Pokhrel and Lee 2011). Collection of soil from agricultural land, mountains, and hillocks for manufacturing bricks (GEDPCB 2015) removes topsoil, and it takes 25–30 years for those lands to regain fertility. Brickfields near the rivers or other water resources cause great impacts on fish production, aquatic plant survival, and aquatic ecosystems (Jerin et al. 2017).

In Bangladesh there are approximately 10,000 brick kilns (Fig. 3). According to the Bangladesh Brick Manufacturing Association, for growing Dhaka City, it needs to manufacture 3.5–4 billion bricks per year. According to the estimation of Department of Environment, about 430 metric tons of fuelwood are required for manufacturing one million bricks. Fuelwoods used in brick kilns are approximately 25% of total fuel used in Bangladesh annually (Islam 2001). Bangladesh Forest Research Institute (BFRI) estimated that, on average, 8000 ha of reserve forests are deforested annually where brick manufacturing plants play a vital role in this destruction. Moreover, the chimneys used by the manufacturers are totally environment unfriendly and spread unsafely the poisonous vapors, dust, carbon dioxide, carbon monoxide, sulfur dioxide, fluorine, and lead into the lower atmosphere. Brick kilns are the main source of fine particulate pollution in Bangladesh and produce nearly 40% of total emissions. The Bangladesh Country Environmental Analysis reports that emissions of particulate matters from this kiln cluster are responsible for 750 premature deaths annually (Sarker 2012). In



Fig. 3 Unplanned brick field construction on the bank of Buriganga River

general different types of diseases like skin disease, eye irritation, and respiratory problems are recorded around the brick manufacturing kilns.

Sea Level Rise and Salinity Intrusion

Vast coastal area, high population density, and high poverty rate and reliance on natural resources tend Bangladesh to be one of the most vulnerable countries to extreme weather events. Almost 25% of the total population live in coastal areas and under threat of storms, sea level rise, and tropical cyclones. At present, saline intrusion into the agricultural lands, drinking water (Fig. 4), and livelihoods reaches at 100 km upland from the Bay of Bengal (Khan et al. 2011). Sea level rise is a long-term process, and if continued, an annual average of 7.2 million people will be affected between 2070 and 2100. If there is proper protection like construction and raising of dikes, the effect could be limited to about 14,100 people only (WHO 2015).

If the sea level rise up to 1 m, Bangladesh could lose 15% of its land area and around 30 million people could become refugees. It will effect on agriculture, industry, infrastructure, livelihoods, marine resources, forestry, biodiversity, fisheries, human health, and other utility services by flooding and salinity intrusion (Denissen 2012). IPCC predicted that due to sea level rise, 17% land area, 30% food production, and 20 million people will directly be suffering by 2050.



Fig. 4 Indigenous water collection technique at high saline period

Natural Calamities in Bangladesh

Currently Bangladesh is ranked worldily as one of the most disaster-prone countries. Almost 97% of the total land area are at risk of multiple hazards including tropical cyclones, floods, droughts, and riverbank and coastal erosion (Alam 2016). The natural disasters that Bangladesh experiences frequently are described in the following paragraphs.

Flood and Flash Flood

Among all disasters, flood is more hazardous in Bangladesh. Floods in Bangladesh are more frequent and cause a pronounced national economic damage. Bangladesh is a low-lying country with 54 trans-boundary rivers (Alam and Siddiqi 2007) that carry huge floodwater during the monsoon. Almost 80% of the total area of the country is prone to flooding. Catastrophic floods occurred on average of every 10–20 years – 1974, 1987, 1988, 1998, and 2004. Direct impacts occurred on agriculture, fisheries, drainage, infrastructures, industry, trade, commerce, utility services, as well as urban and rural lives (Denissen 2012).

Flash floods occur mostly in the northeast and southeast regions of Bangladesh caused by heavy rainfall in bordering hilly regions (Fig. 5). During flash floods the violent inflow from the hills run offs and washes away infrastructures, crops, and lives. Because of the steeper gradients in hilly areas, flash floods have less travel time and short-lived but more violent, sometimes causes landslides. Flash floods



Fig. 5 Flash flood overflows the stream in the Chittagong Hill Tracts (CHTs)

sometimes also occur in the northwestern region of Bangladesh due to heavy, localized rainfall (Alam and Siddiqi 2007).

Cyclone

Bangladesh experiences significantly frequent tropical cyclones each year (Salek 1998; Paul 2009; Haque et al. 2012). At present 8.3 million people are living in cyclone-prone area, and Tanner et al. (2007) anticipated that it will be nearly 20.3 million by 2050. South and south-eastern parts of the country are more exposed to and hit by tropical cyclones during last few years (Figs. 6 and 7). In Bangladesh, women are especially vulnerable to cyclone. During the most devastating cyclone in 1991, the death rate in case of women was almost five times higher than the men (Denissen 2012).

Riverbank Erosion

In Bangladesh per capita cultivated land is only 12.5 decimals, and around 52% of rural population are functionally landless. Moreover, every year roughly 1% of farm land is being converted to nonagricultural uses (Quasem 2011). In such condition, any loss of land by riverbank erosion is shocking (Rana and Nessa 2017). Rivers are dynamic in nature and riverbank erosion is a natural process (Fig. 8). Channel changes due to bank erosion in one side and accretion of land in another side are the natural process. But sometimes it occurred due to anthropogenic activities like sand mining, infrastructure building on the riverbank, artificial cutoffs, construction



Fig. 6 A single patch of Sidr (disastrous cyclone of 2007) affected Sundarbans after 4 years of attack



Fig. 7 Damages by Sidr in the core zone of the Sundarbans

of reservoirs, land-use alterations, etc. (Li et al. 2007; Uddin et al. 2011). River bank erosion causes socio-economic losses rather than killing. Loss of houses and agricultural land forces people for migration. Due to riverbank erosion in Bangladesh, almost 129,853 people were displaced yearly (Mollah and Ferdaush 2015).

Lightning

Lightning is an emerging environmental issue throughout the world including Bangladesh. About 24,000 deaths and 240,000 injuries occur globally per year due to lightning (Holle 2008). Lightning injury is globally considered as leading cause of weather-related death after tornadoes, flash floods, and hurricanes (Biswas et al. 2016). Bangladesh government also added lightning strikes to the country's disasters list (Islam 2016). Bangladesh is more prone to this type of disaster. Most lightning deaths usually occur during the warm months of March to July and severe in month of May (Tasin and Roy 2016).

According to the report of Dewan et al. (2017), since 1990 to mid-2016, a total of 5468 casualties occurred in Bangladesh comprised of 3086 fatalities and 2382 injuries. Previously, the fatality and injury rate were 0.92 and 0.71 (correspondingly) per million people per year and become double in 2010 (1.6 and 1.4 per million people per year, respectively). According to the Bangladesh Meteorological Department, 1476 people have died from lightning in Bangladesh since 2010. The rural portions are 93% more vulnerable than urban and male are more susceptible than women. The more lightning-prone areas in Bangladesh are field (43%), house (22%) (Holle 2009), water body (14%), and road (12%). Frequency and intensity of



Fig. 8 River bank erosion in the countryside of Bangladesh

lightning is linked with climate change, as climate change causes global warming, leads to more evaporation, and causes more clouds that are more potential for lightning storms.

Drought, Desertification, and Water Scarcity

Drought and desertification are other alarming environmental issues and greatest challenges for Bangladesh (Ali 2007). North and northwestern regions of the country are suffering from drought (Pender 2008) because of extreme temperature (Denissen 2012) and water deficiency (Stern 2008) (Fig. 9). Deforestation leads to desertification in Bangladesh by reducing groundwater level that leads to soil dry, fragile, and easily erodible. Desertification already started at the central Barind area in the northwest part of the country. Besides deforestation, low soil fertility also causes aridity that leads to land degradation and ultimately desertification. About 6.0 million ha (43% of total area) of Bangladesh was affected by various forms and degrees of degradation (Ali 2007; Islam et al. 2010).

Desertification originated great economic losses and human sufferings than any other environmental issues in Bangladesh. Since 1960–1991 drought occurred in Bangladesh 19 times and affected about 47% area and 53% population of the country (Fig. 10). Between 1969–1970 and 1983–1984, the relative effects of drought were more damaging than flood on rice production (Ali 2007; Islam et al. 2010). Drought and desertification affect directly on food production, biodiversity, water resources, fisheries, socio-culture, economy, and human health. Moreover, mortality rate of infant is twice in dry zones than the non-dry zones.



Fig. 9 Drying up of stream causes water scarcity

Pollution

Environmental pollution has become a major global concern in recent years as well as in Bangladesh. Bangladesh is now facing a serious problem of air pollution, water pollution, soil pollution, and noise pollution. Each and every of these types of pollution has detrimental effects on environment, human health, biodiversity, and quality of life. Major cities of Bangladesh – Dhaka, Chittagong, Khulna, Sylhet, Rajshahi, Barisal, Gazipur, and Narayanganj – are more prone to the pollutions.

Air pollution: Air pollution is one kind of anthropogenic generous environmental pollution. It is associated with around 7 million premature death and 45 million new cases of chronic bronchitis globally each year (UNEP 2001). In Bangladesh, air pollution has recently been receiving priority among all environmental issues. According to World Health Organization (WHO) latest report, Bangladesh has ranked fourth among 91 countries with worst urban air quality. There are two main sources for air pollution in Bangladesh – industries and vehicles. Industries and vehicles specially two-stroke engines produce enormous quantities of harmful gases that pollute air (Shams 2017). Another major source of air pollution is brick field that burn fossil fuels and produce a large portion of air pollution.



Fig. 10 Drinking water collection during drought period

Indoor pollution by burning of biomass for cooking causes great threats to women and children health. In Bangladesh, household air pollution is responsible for 61% of total child deaths due to acute lower respiratory infections (Hales et al. 2014).

Particulate pollutants with the sizes of 10 μm diameter (Pandve 2008) or smaller are more detrimental than gaseous pollutants. Particles can penetrate and lodge deep inside the lungs and may cause cardiovascular and respiratory diseases and even cancer in the lung or urinary tract or bladder in human body. It is assumed that around 20–80% decrease in air pollution level in Bangladesh could save approximately 1200–3500 lives annually (GEDPCB 2015).

Water pollution: Water pollution is the second most devastating pollution in Bangladesh. The main sources of water in Bangladesh are rainwater, surface water, and groundwater (Ahmed 2015). Rainwater pollution includes acid rain that directly linked with air pollution. The intensity of acid rain is low in Bangladesh, sometimes found in Dhaka City. Surface water generally polluted by industrial wastes (Islam et al. 2015), solid wastes, and sewage disposal. Mostly contributing industries for water pollution are pulp and paper, pharmaceuticals, metal processing, food industry, fertilizer, pesticides, dyeing and painting, textile, tannery, etc. Out of 230 main rivers of Bangladesh, more than 200 rivers directly or indirectly receive a large quantity of untreated industrial wastes and effluents (Islam 2011). Everyday approximately 700 tanneries of Dhaka city are discharging about 16,000 m^3 of toxic wastes (Alam 2009). About 4000–4500 t of solid wastes are generated daily (Rahman et al. 1999), and most of that are discharging in low-lying areas or into river water (Figs. 11 and 12). This contamination transports to human bodies through food chain (Chakraborty et al. 2013).



Fig. 11 Water pollution in Buriganga River due to dumping of solid wastages

About 97% people of Bangladesh are using groundwater as the main source of drinking water that has been threatened by arsenic contamination (Smith et al. 1998). Seventy-five million people are at risk, and 24 million are potentially exposed to arsenic contamination (Safiuddin and Karim 2001). Arsenic contamination of groundwater in Bangladesh is considered the world's largest case of water pollution (Safiuddin and Karim 2001; Ahmed 2015). Groundwater is also polluted by infiltration of industrial wastes disposed on the ground or in surface water bodies, intrusion of saline water, and extensive use of agrochemicals. Leaking sewers/septic tanks/pit latrines also causes groundwater pollution.

Soil pollution: Soil is the main part of terrestrial ecosystems (Shahabuddin et al. 2010). After water, soil is the second most useful natural substance in Bangladesh (Latif et al. 2008). This part is contaminated by pollutants arising from domestic, municipal, industrial, mining, agricultural wastes, and agrochemicals (Kalantari et al. 2006; Osman 2014). These hazardous elements increase the optimum level of soil chemical substances and thus induce soil pollution (Kabata-Pendias and Pendias 2001).

Most common chemicals such as petroleum hydrocarbons, heavy metals (chromium, lead, copper, arsenic, etc.), pesticides, and solvents (Davis and Cornwell 1998) pollute ground soil generally in 4 ways – (1) discharging of industrial wastes, (2) seepage from landfills and sewages, (3) close contact with contaminated water, and (4) excessive and nonregulated use of agrochemicals. Underground soil is



Fig. 12 Water pollution in the city areas due to careless throwing of wastages in the drainage systems

contaminated by leaching, infiltration, and percolation of pollutants (Kanta et al. 2014) along with above mentioned four ways.

Industrial wastes deteriorate soil-water-plant system (Islam et al. 2006; Shamsad et al. 2009), produce pollutant gases, increase soil salinity, and mix with food chain. Soil pollution causes ecosystem loss and ecological imbalance; decreases soil fertility, crop yield, and soil nutrient; and increases soil erosion, water logging and inundation, pollutant in water, and public health problems.

Noise pollution: According to the World Health Organization (WHO), noise is considered as the third hazardous environmental pollutant in Bangladesh following air and water pollution (Muhit and Chowdhury 2013). Noise pollution produces from traffic, airports, ports, railroads, industries, construction works, loudspeakers, and in broader sense from urbanization (Dewan et al. 2012). Effects of noise pollution include hearing loss in human, nervous disorder, hypertension, headache, indigestion, peptic ulcer, degradation in lifestyle even death, and wildlife disturbances (Kadiyali 1997; Tanvir and Rahman 2011). Ahmed (1998) reported about 5–7% patients of Bangabandhu Sheikh Mujibur Rahman Medical University (BSMMU), Dhaka, admitted themselves due to permanent deafness from noise pollution (OECD 1995). Noise pollution also creates birth defects and changes in immune system (Passchier-Vermeer and Passchier 2000). It also increases workplace accident rates, stimulating aggression, and antisocial behavior (Kryter 1994).

According to World Health Organization (WHO), 60 decibel (dB) sound can make a man deaf temporarily, and 100 dB sound can cause complete deafness. According to the Department of Environment (DOE), in peaceful areas the perfect sound condition for Bangladesh is 45 dB for the daytime and 35 dB for the night, while in case of residential areas, 50 dB sound is considerable for the daytime and 40 dB for night. At present noise level in Dhaka City of Bangladesh is measured between 60 and 100 decibel (Alam 2009). Daily variation of noise level in decibel at different locations of Dhaka City is represented in Table 8.

If this condition continues, then 50% people of Dhaka City will lose 30 decibel of hearing power by the year 2017 (Alam 2009).

Ecosystem Changes and Biodiversity Depletion

Bangladesh is a tropical country (Khan et al. 2007) and harbor of rich biological diversity (Hossain 2001). It was assessed that altogether about 5700 species of angiosperms (excluding gymnosperms) and 1500 species of fauna have been available in the country (Hossain 2001), but recently the population of some of the species have declined to about a half.

Bangladesh has got a wide diversity of ecosystems. The vast ecosystem was found in the world's largest mangrove forests in Bangladesh. It has an area of about 601,700 ha and covers 4.13% of the country and 38.12% of the state forest land. A total of 334 species of trees, shrubs, and epiphytes and 269 species of wild animals have been identified here. The most significant is the famous Royal Bengal Tiger. But the ecosystem is changing and biodiversity is declining day by day due to climate change impacts and human activities, and the Sundarbans are likely to suffer the most.

Growing people depend on forests and aquatic ecosystems for livelihoods and pose a serious threat to biodiversity and ecosystems through illegal cutting, encroachment, poaching, and land grabbing (Kibria and Haroon 2017). Since 1880 to till now, 14 animal species have been extinct in Bangladesh (BFD 2017). According to IUCN Bangladesh Red Data Book (2000), there are 266 species of inland fishes, 442 marine fishes, 22 amphibians, 109 inland reptiles, 17 marine

Table 8 Noise pollution in decibel at different places in Dhaka City

Time interval	Location						
	Gulshan	Gulshan	Science lab	Saydabad	Farmgate	Dhanmondi	Uttara
	Commercial	Residential	Mixed	Commercial	Commercial	Residential	Residential
7–11 am	80.08	76.16	76.24	83.27	80.07	75.87	76.25
11 am–3 pm	79.34	74.83	75.19	83.89	78.86	74.38	74.81
3–7 pm	81.13	76.11	77.23	84.37	81.96	75.21	76.81
7 pm–1 am	78.52	74.31	75.32	82.08	80.28	76.30	73.36

Source: Alam (2009)

reptiles, 388 resident birds, 240 migratory birds, 110 inland mammals, as well as 3 species of marine mammals in Bangladesh; out of which 54 species of inland fishes, 8 amphibians, 58 reptiles, 41 resident birds, and 40 mammals are threatened throughout the country. Among the marine and migratory species of animals, four fishes, five reptiles, six birds, and three mammals are threatened. When an ecosystem loses a species, then total ecosystem and environmental balance collapsed.

Introduction of Exotic Species

Biological invasion has become a burning environmental issue globally as it dominant over native ecosystems (Seabloom et al. 2006) and changes climate over time (D'Antonio and Vitousek 1992). To meet the basic needs of growing population, alien species were introduced deliberately in Bangladesh. Some flora was introduced due to their economic value (*Tectona grandis*) and rapid growth (*Acacia auriculiformis*). Mono-crop plantation of *Tectona grandis* initiated at Kaptai, Chittagong in 1871 by clear felling the natural forests creates a great environmental hazard. Teak plantation lacks undergrowth and is more subject to intense surface soil erosion (Miah et al. 2014). Similarly, to meet food nutrition value, some fauna were introduced too. A few of introduced flora and fauna became invasive later and cause great threats to the environment.

The first widely introduced alien species in Bangladesh is water hyacinth (*Eichhornia crassipes*) (Fig. 13) brought from Brazil during the British period for



Fig. 13 Invasion by water hyacinth in Kopotakkho River

its ornamental value. With time it became invasive in nature and vigorously spreads throughout all wetlands (Pallewatta et al. 2003). Introduction of acacia and eucalyptus into Bangladesh from Australia during the 1980s created great controversial problems. These two genera are proven to be adversaries to the endemic flora and found as environmentally unfriendly species to Bangladesh (Ameen 1999). Moreover out of all fish species that brought from abroad, 15 became more invasive. The most disastrous ones are *Clarias gariepinus* (African magur), *Pangasius giganticus* (giant pangas), and *Oreochromis niloticus* (nilotica). These were introduced from Thailand between 1953 and 1990 (Rahman 1997).

Deforestation

Deforestation induces climate change and global warming and thus initiates other environmental issues. Though forest area of Bangladesh is 17.62% of total land, actual canopy coverage is only 6% (Fig. 14). Only deforestation is the culprit for this forest condition. About 50% forests of the country have been destroyed by deforestation during last 20 years (Hossain et al. 2014; Rasel 2014; Chakma 2015). Indiscriminate felling of trees for industrial purposes in the greater parts of Dhaka, Mymensingh, and Rajshahi and for shifting cultivation in Chittagong Hill Tracts resulted an alarming depletion of natural forests.

Population explosion is the prominent cause for deforestation faced by Bangladesh. Country's forests have been depleted since the early twentieth century



Fig. 14 Barren hills in Teknaf due to deforestation

due to increasing demand of land for agriculture, homes, and industries for over population. In the 1980s, deforestation rate was 8000 ha per year, and now with growing population, it is 37,700 ha per year. Deforestation causes soil erosion, reduced rainfall, ecosystems and biodiversity damage, and species extinction and prompts climate change.

Forest Fire

Large and irregular forest fires create intensive environmental impacts (Holmes et al. 2007). Forests of Bangladesh are tropical moist deciduous, so natural forest fire is a sporadic event here. But intentional man-made forest fire occurred several times in Bangladesh (Fig. 15) basically in the Sundarbans. In last 14 years, there have been 19 fire incidents occurred in the Sundarbans. This intentional fire usually is created just before the monsoon in order to clear the lower land of forest to collect rainy water for fishing.

Shrimp Cultivation and Salt Production

An enormous expansion of commercial shrimp cultivation and salt production recently appeared as another major environmental issues. Shrimp cultivation and salt production in the existing agricultural land (Fig. 16) or by encroaching forest lands near the coastal zone affects soil and ecosystems terrifically since it needs holding saline water for a long period of the year. Dikes of the shrimp



Fig. 15 Intentional forest fire in hill of Chittagong Hill Tracts



Fig. 16 Salt cultivation in agricultural lands of Teknaf

enclosures hinder the free flow of tide water which causes acute salinity mostly during the month of April and reduce soil fertility rapidly. As a consequence, the land becomes unproductive for further crop production. The severe concentration of salinity in the soil increases vegetation mortality rate and damages forests.

Chakaria Sundarbans in Cox's Bazar, Bangladesh, is an evidence of how unplanned shrimp culture can destruct a natural forest rapidly. Historical records of deforestation for shrimp cultivation represent that in 1972, the Chakaria Sundarbans occupied an area of 19,000 ha. By 1981, this forest area shrink to near 9000 ha. In 1985, it was further reduced to only 4000 ha and again squeezed to half by 1991 (Rasel 2014).

Sedimentation or Siltation

World's largest delta, in Bangladesh, was affected by regular flood, riverbank erosion, and sedimentation (Grosjean et al. 1995). The Ganges-Brahmaputra-Meghna (GBM) delta is one of the most dynamic tide-dominated deltas in the world (Haque and Rahman 2016). The GBM system carries the world's highest annual sediment load at one billion tons (Milliman and Syvitski 1992) (Fig. 17). Seasonal overbank flooding during monsoon discharges 95% of total sediments (Goodbred 2003) and has created a 16 km thick fluvio-deltaic sediment layer in the Bengal Basin since the Paleogene (Allison 1998).

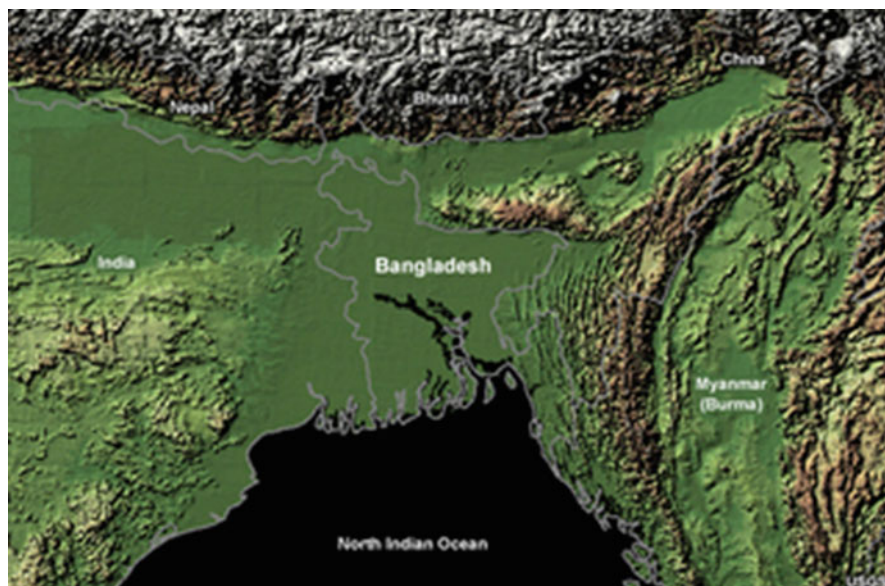


Fig. 17 Exposure of GBM delta to sedimentation (Source: <http://www.goesr.gov>)

All rivers of Bangladesh carry and deposit 2 billion tons of sediments per year in the delta (ISPAN 1993; Rana 1993). The major effects of sedimentation are rising up river basins and sea levels. Many rivers already lose their depth and disappeared permanently due to sedimentation. Sea level of Bangladesh was 120 m lower 18,000 BP (Grosjean et al. 1995), and it is predicted that global sea levels could rise more than 3 ft by 2100 (IPCC 2014). If the lower level of sea and rivers lifted up, then flood intensity and salinity intrusion will increase more.

Excessive and Nonregulated Use of Agrochemicals

Bangladesh is mainly an agrarian-based country. To meet the demand for growing population, farmers had to adopt a lot of strategies in different times. The most adverse ones were use of chemical fertilizers, insecticides, herbicides, and pesticides. Maximum farmers and dealers are illiterate and untrained. They apply agrochemicals massively for getting rapid and huge amount of crops from their small amount of land (Chakrabarty et al. 2014). Without examining the soil type, excessive and indiscriminate use of agrochemicals may augment natural permissible level of some radioactive elements in soil. Without direct attachment, this kind of radioactivity could contaminate human body and other animals (Rajendran 2003) by entering food chain and creates slow poisoning. Moreover it causes a great threat to the soil and water ecosystems. Irrational use of agrochemicals impacts on human health, environment, surface water, groundwater, soil and soil fertility, air, non targeted vegetation, and organisms (Aktar et al. 2009).

In Bangladesh, use of agrochemicals started in 1960 but it became more severe since 1980. It is well established that insecticides cause acute and chronic toxicity on human beings. According to the World Health Organization, pesticide poisoning kills 25 million people globally every year (Mohammad 2012). Contaminated and excessive use of agrochemicals expedites different types of diseases in Bangladesh. Heart disease, kidney complicacy, hypertension, eye irritation, acidity, diabetes, liver cancer, etc. are the most common ones.

Conclusion and Recommendations

Urbanization, industrialization, and burning of fossil fuel along with many other factors are responsible for raising the CO₂ level in the atmosphere and producing other greenhouse gases in many ways (Khwaja et al. 2012). Raised CO₂ and other greenhouse gases are the major contributor to the global climate change and resultant effects (IUSS 2002). To combat with climate change, site appropriate mitigation and adaptation measure can be taken. For reducing greenhouse gases emission to safer level, renewable energy sources like solar energy can be used in industries, vehicles, brickkilns, and for cooking. Non-degraded forests and nonpolluted soil and water can consume huge amount of CO₂ from the atmosphere. Human pressure is the rooted problem for rapid urbanization and industrialization, increased number of vehicles and fossil fuel burning, pressurized land-use changes, and rapid climatic changes with its adverse impacts (Bremner et al. 2010; Vanclay 1993; Wibowo and Byron 1999). Developing the existing population into human capital along with measures for controlling the future population size to desired level by reducing growth rate could be proper solutions for mitigating all adverse environmental issues.

Cross-References

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