Chapter
02

Climate Change and Ecosystem Services: Issues and Approaches

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Introduction

Biodiversity is defined by the Convention on Biological Diversity (CBD) as the variability among living organisms from all sources including, among others, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems (CBD, 2016). Biological diversity includes species diversity, genetic diversity and ecosystem diversity. Species diversity is the diversity of all the species on earth from single celled bacteria and protists to all the species of the multicellular kingdom. Diversity in species shows the variation of species due to evolutionary and ecological adaptations of the species to the entire geographical range. Genetic diversity is the variation within species due to geographical separation and intraspecific variation within the population. As defined an ecosystem is a dynamic complex of plant, animal, and microorganism communities and the nonliving environment interrelating as a functional unit. Ecosystem diversity is the variation of different biological communities and their interaction with the biotic and abiotic environment. Biological components are crucial in proper ecosystem functioning which provides essential ecosystem services to human beings.

Climate change and Ecosystem services

Marine and coastal ecosystems are the most vulnerable to the impacts of climate change which is occurring at a faster rate than ever in the human history. There are lots of pieces of evidences from the nature that climate change drastically affecting biodiversity. Especially the changes in the species distribution pattern, increased extinction rates of species, changes in the reproductive timings, development of new phonological traits and rate of the growing season in

plants. Among these, the increased rate of species extinction due to the human activities resulted in biodiversity loss and ultimately affected the supply of the ecosystem services to human well-beings. Many species showed changes in their distribution pattern in space and time. They have either expanded their distribution pattern towards poleward in latitude and upward in elevation. The restricted distribution pattern changed the population structure of species which already showing signs of decline due to the other non-climatic factors. Several fish species showed changes in the phenology such as breeding, spawning and migration due to climate change.

To address the biodiversity related issues, *i.e.* climate change, the over exploitation of living resources, damage due to dredging, reclamation wetlands, pollution, sea erosion, siltation, anthropogenic destruction of ecosystem, loss of biodiversity a thorough knowledge about the goods and services from the different marine ecosystems of is a prerequisite. It is well established that there is no readymade solution to the serious biodiversity issues mentioned here. But, some of the International Agreements and treaties are good examples of the contemporary approaches to discover the answers to the fundamental issues through an exhaustive research and development of biodiversity. There is no single solution to the very complex issues mentioned above. But some of the approaches like, Convention on Biological Diversity (CBD), Ecosystem-Based Management (EBM), Millennium Ecosystem Assessment (MA), The Economics of Ecosystems and Biodiversity (TEEB), Intergovernmental Panel on Climate Change (IPCC) and Global Biodiversity Indicators (GBI) were discussed in the context of the issues and solutions to biodiversity crisis. For a better understanding of the impact of climate change on species and ecosystem, a thorough knowledge of four ecosystem services such as provisioning services, regulating services, supporting services and cultural and aesthetic services is a must. That knowledge will improve the existing climate resilient models and helps in reducing the uncertainties of prediction.

I. Ecosystem services from Marine and Coastal Ecosystems

Marine ecosystems provide a wide variety of services to nature, which is essential for the well-being of the human population. The ecosystem services are classified into four *i.e.* provisioning services, regulating services, supporting services and cultural and aesthetic services. Provisioning services include the products gained from the environment in the form of food, natural crops, firewood, medicines, genes and ornamental resources, energy capitals, and product from bio prospecting. Regulating services comprise the coastline

equilibrium, flood prevention, storm shelter, climate regulation, hydrological services, nutrient regulation, carbon sequestration, deposition of contaminated waters and waste disposal. Supporting services are mainly the habitat provision, nutrient cycling, migration, seed dispersion, primary productivity and soil formation. Cultural and aesthetic services include the culture, tourism and recreation (Joshi and Vinodh, 2015).

1. Provisioning services

Food provisioning in the form of fish landings and aquaculture products is one of the most important services obtained from the marine and coastal ecosystems. Mangroves are essential in supporting to fisheries owing to their function as fish nurseries and refuges. Mangroves help to increase fish production in the inshore waters near to it. Coral reefs also provide services like protection of breeders and larvae for the better survival and recruitment success of the resources (Joshi and Vinod, 2015). They form an important source of fisheries products for coastal populations and export markets. The coral reefs of the Gulf of Mannar, Andaman & Nicobar Islands, Lakshadweep Islands and Gulf of Kutch contribute substantially to the total marine finfish production of India. Other ecosystems like rocky intertidal, near shore mudflats, seagrass beds, mud bank areas, seamounts, brackish water, lagoons, estuaries, marshy areas and beaches also helps in the production of fish as food in one way or another.

The total marine fish landings from India were estimated at 3.95 million tonnes during 2017. Fisheries sector plays an important role in the Indian Economy, contributing about 1% to the national GDP. The sector provides livelihood to about 4 million fisher folk population along the coastal line of 8129 Km. The value of total marine fish landings at retail level was estimated at Rs. 78,408 crores during 2017. Since 1950 the marine fish production in India has gradually increased from mere 5.8 lakh tonnes (1950) to 3.59 million tonnes (2014) showing six-fold increase. Several of the marine and coastal ecosystems offer coastal populations with construction materials and building materials from the mining of marine ecosystems. Mangroves provide coastal and Island community with construction materials for boat building. Of the 33,059 total fish species from the world, India contributes of about 2492 marine fishes owing to 7.4% of the total marine fish resources. Of the total fish diversity known from India, the marine fishes constitute 76 percent, comprising of 2492 species belonging to 941 orders 240 families. Among the fish diversity-rich areas in the marine waters of India, the Andaman and Nicobar archipelago shows the highest number of species, 1431, followed by the east coast of India with 1121 species and the west

coast with 1071. As many as 91 species of endemic marine fishes are known to occur in the coastal waters of India (Joshi et al, 2017).

Among the products exported, shrimp product formed the major share about 3.0 lakh tonnes which form about 64% of the total value realized. Increased export demand often leads to expansion of mariculture practices. Coastal areas provide the foundation for the marketers which produce fisheries products from prawn, crab and fish. The factors affecting the marine fish production are the overexploitation, species extinctions and use of destructive methods of the fishing. The magnitude of marine fish stocks that are over exploited and declining are increasing over the last 30 years. It is reported that 133 extinctions of regional and global marine species occurred over the last 30 years. The major cause of the extinction was overexploitation (55%) and rest of habitat loss and other reasons (IUCN, 2018). Out of the 28 groups of finfishes studied by CMFRI, 20 were found to be under the abundant category, five under less abundant group and one each under declining, depleted and collapsed category. Elasmobranchs, threadfins, ribbonfishes, mullets and flatfishes are the five resource groups falling under less abundant category. Big-jawed jumper falls under declining category, flying fishes under depleted category and unicorn cod is the one that falls under collapsed category (Sathianandan *et al.,* 2011). Bio prospecting is the valuation of biodiversity for novel biological assets of social and economic value. It yielded several products from species in marine and coastal ecosystems. Coral reefs are important reservoirs of natural bioactive products many of which exhibit structural features not found in the terrestrial natural products. The pharmaceutical industry has discovered several potentially useful substances among sponges, jellyfish and Mollusca. CMFRI has developed nutraceuticals like Green Mussel Extract (GMe), Green Algal Extract (GAe) and Cadalmin Ade (Cadalmin extract) from marine mussel and seaweed.

Marine ecosystems: The topographical structures environment of the continental shelf and a dispersal array of fish and shellfish diversity in the coastal region as well as in the Exclusive Economic Zone (EEZ) differ from area to area along the Indian coast. Previous studies on the physical, chemical and biological oceanography of the seas around India have revealed that coastal waters (0-50 m) are fairly more productive (Devaraj *et al.,* 1998). Diversity in the species composite, typical of tropical seawaters and co-existence of dissimilar fish and shellfish species in the similar ground are significant features of Indian Marine Biodiversity. Historical readings on the biology and fishery features of the vital groups revealed that, most of the species supporting the fishery are short

lived with a normal life span up to 3-5 years, but the fishery being mostly supported by below a year olds and one-year-old. They are greatly prolific and spawn over lengthier periods typically with fractional spawning and display varied annual difference in recruitment. Several matters in the captive fisheries segment harmfully affect the marine biodiversity of the country, specifically in the fish as ecosystem good for human survivals. The difficulties like limitations of growth and production in the inshore trawling grounds, less cost-effectiveness and financial returns due to lesser cost of fishing operations, management difficulties in the framework of common property multi-user, multiple-choice nature of fisheries (Devaraj, 1996).

The above concerns brought about by the uncontrolled fishing effort put into the fishery without any respect to the stock-production-recruitment relationship. In addition, these the ecological problems mounded by cumulative pollution of coastal waters by release of crude sewages and pollutants by agro manufacturing centers working in the coastal zone. It has been witnessed that the sediment in certain waters comprises unusual levels of Copper, Zinc and Lead. The mercury content in some of the marine animals in certain places has been found to be higher than the normal, which may modify the genetic makeup of a species. The fly ash deposits from thermal plants in certain places are on the increase and it changes the bottom topography of the affected area and probabilities of species reduction and replacement.

The Bay of Bengal is much deeper than the Arabian Sea and more numbers of cyclonic storm's progress over the Bay of Bengal than the Arabian Sea. Periodic mean surface temperature over the Arabian Sea is highly variable from one season to another season, as compared to the Bay of Bengal. The lowest sea surface temperature in the Bay of Bengal was about 25 to 28^{o}C throughout the winter period, but in other spells, it remains at 28.5 to 29^{o}C. The Bay of Bengal is the one of the world's largest submarine fans which included large volumes of sediments discharged by the Ganges and Brahma Putra Rivers. The Bengal basin can be divided into Mahanadi – Godavari and Cauvery off shore basins and areas such as Vishakhapatnam – Chilka lake shelf and Madras-Pondicherry shelf. Central Bengal Bay has got an average depth of about 3400 m and numerous turbidity channels are present with a width of 5 to 27 km. South Bay of Bengal is characterized by the presence of a large number of sea mounts and coral Islands. They not only deliver food

and protection, but also for the breeding grounds for a large number of organisms. The Bay of Bengal shows moderate primary production in all the seasons as compared to the Arabian Sea (Devaraj, 1996).

Mangrove ecosystems: A large number of Islands along the Indian coastline in the Gulf of Mannar, Gulf of Kutch, Lakshadweep and Andaman group and the massive mangrove networks along the coast of Goa, Karnataka, Kerala, Tamilnadu, Andhra Pradesh and West Bengal constitute rich marine biodiversity supporting a diversity of species of corals, sponges, ornamental fishes, crustaceans, mollusks and plants. Indiscriminate fishing, mining, dredging, deforestation, industrialization, and other anthropogenic activities are the main pressures instigating significant damage to these environments and consequently to the associated flora.

Coastal Ecosystems: Distinguishing features of the Indian Ocean are the upwelling, southwest monsoon, northeast monsoon, mud-bank along the southwest coast and high coastal production. Upwelling happens in the area between Kanyakumari and Karwar during the beginning of southwest monsoon. It starts in the southern area first and then spreads northwards with the development of southwest monsoon. Southwest monsoon season is the period when mud-banks have formed in some places along the southwest coast of India particularly the Kerala coast. Mud banks of the Alleppey – region is formed by the subterranean mud and the Vembanad lake system provides the mud for this. The mud-banks between Parapanangadi and Tanur are the aggregation of coastal mud. The mud-banks at Chellanam, Narakkal, Valappad, Elathur, Quilandy, Muzhuppilangadi, Kottikulam, Adakathubali, Kumbala, Uppsala and Ullal are formed by the sediments and organic debris discharged from river and estuaries. Mud-banks at Vypeen are formed from dredging operation (Rao *et al.*, 1992). The optimum hydrographic condition in the southwest monsoon mouths, the salinity of water falls from 35‰ to 30-31‰ the temperature decreases from 31-32°C in 23-25°C and abundance of nutrients like phosphate, nitrate and silicate become abundant due to pulling and river discharges makes maximum phytoplankton production which is higher than some of the fertile seas of the world.

Coral reef Ecosystems: India is blessed with vast sections of coral reefs in the Gulf of Mannar and Palk Bay, Gulf of Kutch, South-west coast and along the Andaman & Nicobar and Lakshadweep islands. Coral reefs are the most biologically productive and diverse of all other natural ecosystems. Reefs are

equal to tropical rain forest for their rich biological diversity. Coral reefs have enormous amounts of calcium carbonate which forms the raw material for numerous lime waste, cement and calcium carbide industries. They are also used as building blocks in many parts of India. The finfish fauna of coral reefs is very rich and diverse. Moreover, they are raw materials for industries such as cement, lime and calcium carbide. A total of 225 species of corals is known from the Indian seas (Pillai, 1996). The coral reefs of India face numerous pressures from both natural and anthropogenic origin. Indiscriminate use of corals for many purposes, over exploitation of reefs associated fauna, dredging, reclamation, are important anthropogenic factors for the damage of corals in India. Pollution, sea erosion, siltation, constructive activities in brackish water lagoons also added to this man made cause of destruction of reefs. Global warming, coral bleaching, cyclones, white band diseases, pest attacks by *Acanthaster planci* are some of the natural cause affect mortality of corals.

Estuarine ecosystems: The total brackish water assets of India as projected by the Government of India were 1.44 million ha. Orissa, Gujarat, Kerala and West Bengal have vast brackish water assets. West Bengal is gifted with the rich brackish water zone, estimated to be 405,000 ha with Hooghly-Matlah estuary accounting for the 8,029 km^2 and part of Sunderbans to be 2,340 km^2. Orissa has an over-all brackish water resources of 417,537 ha. Estuaries, lakes and backwater account for 247,850 ha, 79,000 ha and 8,100 ha correspondingly. The Mahanadi estuary lies in the Cuttack and Puri districts of Orissa and drains into the Bay of Bengal. The major fauna includes *Tenualosa ilisha, Nematalosa nasus*, *Sardinella* sp., *Ilisha* sp., *Mugil cephalus, Planiliza parsia and* other perches. Estuaries face difficulties of absence of realistic planning and coordinated among the diverse stakeholders in the implementation of management option, lack of critical knowledge on the environmental principles as well as sustainable management of assets, and low level of knowledge in the biodiversity worth of goods and services providing by estuary.

Lagoon Ecosystem: A lagoon is a low water body along the low lying coast, parted from the ocean by a barrier and also linked to the sea by creeks or estuary at one or two places. Of the total of 17 major lagoons occur along the coast of India the main lagoons are Chilka Lake, Gulf of Mannar, Muthupet, Muthukkadu, Nizampatanam, Pennar, Pulikat Lake, Vembanad Lake, Ashtamudi Lake, Ettikulum, Paravur Lake, Murukkanpuzha, Talapdy, Veli Lake, Lagoons of Bombay, and Lakshadweep atolls (Alok Saxena, 2012). The lagoon ecosystems are the most susceptible ecosystems due to numerous anthropogenic actions

which threaten flora and fauna of the system. Pressures consist of pollution from industries, discarding of urban sewage, recreational boating, navigation, the growth of urban and rural settlements, reclamation, over exploitation of fish stocks, intensive aquaculture practices and effluents from different sources.

The Chilka lagoon is the principal brackish water lagoon on the east coast of India and is chosen as a Ramsar site since 1981. The area during the summer and rainy season has been estimated to be 906 and 1,105 km^2 respectively. The brackish water of Andhra Pradesh is about 2.0 lakh ha and mangrove swamp of 27,500 ha which supports about 268 species of fishes which includes *Nematalosa nasus, Mystus gulio, Planiliza macrolepis, Tenualosa ilisha* and *Gerres setifer*. Pulicat Lake is a very important brackish water lake of Nellore district of Andhra Pradesh and the rest of Tamil Nadu region with an overall area 77,000 ha. The fishery comprises of *Nematalosa nasus, Planiliza macrolepis, Sillago sihama, Chanos* etc. The Godavari estuarine system has an area of 330 km^2 drains to Bay of Bengal on the east coast in the state of Andhra Pradesh. The major fisheries are formed by *Gerres filamentosus, Caranx* sp., *Sillago sihama, Platycephalus* sp., *Lates calcarifer* and *Mugil cephalus* (Joshi *et al*, 2017).

2. Regulating services

Regulating services are the benefits people obtained from the regulation of ecosystem processes, including air quality maintenance, erosion control, regulation of human diseases and water purification. The mangroves, sea grass, coral reefs, rocky intertidal, mudflats, and deltas play key role in shoreline stabilization, protection from storms, tidal waves and soil loss, dispensation of pollutants and stabilizing land in the event sea level surge. Estuaries are main buffer regions as it is a conversion zone between freshwater environments and are subject to marine effects such as tides, waves and incursion of saline water, fresh water and sediment. This influx of both marine and fresh water carries lots of nutrients in both water and sediment makes them most productive habitats in the world. India has rich estuarine and other brackish water assets along the east and west coasts formed by the rivers. Mangroves give fortification to the coastline from natural calamities like Hurricane, flood and Tsunami. Mangroves have great ability to absorb heavy metals and other toxic substances, coral reefs buffer land from storms and prevent beach loss. Estuaries, lagoons, marshes, brackish water areas play a crucial role in preserving the hydrological balance and cleaning water of pollutants. Marine ecosystems play important roles in climate regulation. CO_2 is constantly exchanged between the atmosphere and

ocean; it dissolves in surface waters and is then transported to the deep ocean. Marine plants fix CO_2 during photosynthesis in the ocean and return it via respiration.

3. Supporting Services

Many species use coastal areas like estuaries, mangroves, sea grass beds as nurseries. Estuaries are used as the major as nursery areas for finfishes and other species and they form one of the strongest linkages between coastal, marine and freshwater ecosystems and the ecosystem services they provide. The success of the prawn fishery mainly depends on the migration of prawns through the estuary. Mangroves provide nursery for many species as well as give links to sea grass beds with associated coral reefs. Mangroves are good breeding and nursery grounds for a variety of prawns and fishes. It offers nutrition for many organisms through recycling of plant and animal remnants. Decline in the area of mangroves can interrupt these linkages and cause biodiversity loss which results in lower productivity from the reef and sea grass beds.

4. Cultural and Aesthetic Services

Cultural services comprise of tourism and recreation, visual and spiritual services, traditional knowledge and education and research amenities. Mangrove ecosystem delivers services like, opportunities for boating, hunting, bird watching, wildlife observation, education excursions for specimen gathering and photography. Apart from these activities, in many species are dependent on mangroves and estuaries for their survival.

II. Approaches to Link Climate change and biodiversity

The mainstream theories have set new avenues for the research and progress in the Life sciences. Biodiversity researchers per say adapted several new approaches during the recent years to find solutions to biodiversity loss and conservation. The simple tool for the sustainable growth has an inclination to oversee the scientific uncertainties in an unrealistic routine. The recent tactics and instruments like the Convention on Biological Diversity (CBD), Ecosystem-based management, Millennium Ecosystem Assessment, The Economics of Ecosystems and Biodiversity (TEEB), Intergovernmental Panel on Climate Change (IPCC) developed for the sustainable development and conservation of biodiversity can be considered as a neorealsitic approach.

1. Convention on Biological Diversity (CBD)

The Convention on Biological Diversity (CBD) come into power on 29th December 1993 has 3 main goals: The conservation of biological diversity; the

sustainable use of the components of biological diversity; the rational and equitable distribution of the benefits arising out of the exploitation of genetic resources. The Convention on Biological Diversity was stimulated by the world community's mounting obligation to sustainable growth. It characterizes a dramatic step onward in the conservation of biological diversity, the sustainable use of its constituents, and the reasonable and rightful allotment of benefits arising from the practice of genetic assets.

2. Ecosystem Based Management (EBM)

Ecosystem-based management is an agenda for evolving effective management plans created with an accepted set of guiding principles. An ecosystem-based management plan should: highlight the health of the whole ecosystem ahead of the alarms of special benefits; be focused on a specific place, with frontiers that are logically defined; an account of the customs in which things or activities in that place affect each other; consider the way the things or actions in this place can impact or be influenced by things or activities on land, in the air, or in diverse portions of the ocean; and assimilate the concerns of the environment, humanity, the economy and our organizations (UNEP, 2018).

3. Millennium Ecosystem Assessment (MA)

The Millennium Ecosystem Assessment assessed the apprehensions of ecosystem alteration in social well- being from 2001 to 2005 and it involved the effort of more than 1360 specialists worldwide. The previous 50 years, humans have altered ecosystems more quickly and widely than in any similar period of time in human history, mainly to meet fast growing demands for essential items like food, fresh water, timber, fiber and fuel. This has caused in a considerable and chiefly irreparable damage in the diversity of life on Earth. Millennium Ecosystem Assessment provided a valued logical evaluation of the condition and trends in the world's environment and the services they provide, as well as the logical basis for action to protect and use them sustainably. The task of backing the degradation of ecosystem while gathering increasing hassles for amenities can be moderately met in some situations measured by the MA, but will include important variations in strategies, organizations and performs that remain not presently below mode. Numerous choices occur to preserve or improve precise ecosystem services in means that lessen undesirable trade-offs or that deliver helpful collaborations with other ecosystem services (MA, 2018).

4. The Economics of Ecosystems and Biodiversity (TEEB)

The Economics of Ecosystems and Biodiversity (TEEB) is an international initiative concentrated on "making nature's values visible". Its major objective is

towards mainstream the values of biodiversity and ecosystem services into policy making at all levels (TEEB, 2018). To attain this objective by succeeding an organized method of valuation that helps policy makers to distinguish the wide array of paybacks provided by ecosystems and biodiversity, establish their value in economic terms and, wherever suitable, capture those values in policy making. In March 2007, environment ministers from the G8+5 countries meeting in Germany planned to initiate the procedure of evaluating the global economic value of biological diversity, the overheads of the loss of biodiversity and the catastrophe to take protective measures against the prices of effective conservation (TEEB, 2018).

5. Intergovernmental Panel on Climate Change (IPCC)

The Intergovernmental Panel on Climate Change (IPCC) is the foremost global body for the assessment of climate change. It was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988 to deliver the world with a vibrant technical view on the present state of knowledge on climate change and its possible ecological and socioeconomic bearings (IPCC, 2018). It analyses and evaluates the most recent scientific, technical and socioeconomic information produced globally pertinent to the understanding of climate change. Thousands of scientists from all over the world contribute to the effort of the IPCC on a voluntary basis. Appraisal is a vital part of the IPCC procedure, to safeguard an objective and whole assessment of presenting data. IPCC targets to replicate a variety of opinions and knowledge. The Secretariat organizes all the IPCC work and communicates with Governments (IPCC, 2018).

III. Global Biodiversity Indices (GBI)

Global Biodiversity Indicators are statistical measures of biodiversity which benefit experts, managers and legislators realize the condition of biodiversity and the factors that disturb it. These indicators allow managers and legislators to see if their resolutions are protecting biodiversity or leading to its degradation and loss. Without this information it is not imaginable to distinguish if the activities being taken are working and should continue or if different methods need to be tried. Some of the important GBIs currently in use include; Living planet Index(LPI), Wild Bird Index (WBI), Red List Index (RLI), Marine Trophic Index (MTI), Forest extent, Ecological Footprint, Number and distribution of Invasive Alien Species (IAS), Proportion of fish stocks that are fully exploited, over-exploited or depleted, Extent of Protected Areas (PAs) (CBD, 2016).

Climate change and Sustainable utilization of Marine Resources

The various approaches mentioned above are recent origin and needs to be tested for the effectiveness for an array of different species regimes occupies in a wide range of habitats of concerned ecosystems. The fact that the rate of degradation of ecosystem and the rate of extinction of species during the past decade from the biosphere is faster than it occurs during the period of nineteen centuries. Hence, immediate steps needed to be taken to reduce or to sustain a balance between the extinction rates of species from the biosphere. But at the human population shows unprecedented growth over the years which necessitates the use of more and more natural resources. In order to meet the growing needs increasing and sustainable use of resources, equitable distribution of benefits arising from the ecosystem and to preserve it for the future generation is to use it. The ecosystem goods and services provided by the fauna and flora and the interrelationship between the biodiversity and ecological processes are the fundamental issues in the sustainability and the equilibrium of the ecosystem. Several of the marine resources like seaweeds, sponges, gorgonids, corals, sea horses and others are being exploited for the extraction of pharmaceuticals, active substances which are recognized to cure numerous diseases. While there are reports of over utilization of certain of these assets, there are also reports of ecological degradation due to anthropogenic influences. Certain delicate and sensitive marine ecosystems will not exist in the future, if suitable care is not taken to protect the system. In order to attain better returns while protecting the environment, an appropriate policy needs to be framed to exploit the assets on sustainable levels, to extract the drugs indigenously, mostly for domestic use and for limited export. It is realized that there is an inclination for severe exploitation of exportable commodities, but the country cannot lose sight of the need to protect biodiversity and meet national requirements in its offer to increase foreign exchange earnings.

It is well known that the resilience of ecosystems can be improved and the jeopardy of damage to human and natural biotas reduced through the implementation of biodiversity-based adaptive and mitigating strategies. Mitigation is designated as a human involvement to reduce greenhouse gas sources or augment carbon sequestration, while adapting to climate change denotes to modifications in natural or human systems in response to climatic change, which controls damage or exploits beneficial opportunities. Some of the examples of actions that encourage mitigation or adaptation to climate change are preserving and, restoring natural ecosystems, protecting and enhancing ecosystem services, managing habitats for endangered species, creating national

parks, refuges, protected areas, and buffer zones, establishing networks of marine protected areas in order to account probable fluctuations in climate.

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