Impact of Climate Change on Biodiversity: A Challenge to Agro-ecosystems in South Asia

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Abstract

Agro-ecosystems of South Asia are characterized by high diversity at both the species and genetic levels and are highly vulnerable to climate change. In addition to human-induced pressure, climate change has exerted severe pressure on the globally significant biodiversity in many countries, especially in the South Asian region. It is imperative to manage the biodiversity in agro-ecosystems in a sustainable way and to use it systematically to cope with environmental challenges such as climate change. Agricultural biodiversity (agrobiodiversity) provides many benefits within production systems, contributing directly to production and productivity, ecosystem function, and human well-being. The sustainable use of genetic resources for food and agriculture in the wake of climate change will be the foundation for many of the strategies required to ensure long-term food security in the South Asian region. Maintaining this diversity of crop plants and farm animals and their wild relatives will not only protect the agriculture system from total failure, but it could also be used by breeders to develop new crop varieties and farm animal breeds to cope with climate change.

Keywords: agro-ecosystems, biodiversity, climate change, food security, South Asia

1. Introduction

Climate change poses a formidable challenge via widespread impacts on human and natural systems. Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850 (IPCC, 2014). Over the period 1880–2012, the average of the combined land and ocean surface temperature at the global scale has shown a warming of 0.85 ˚C (0.65 to 1.06 ˚C). According to the World Meteorological Organization (2014), 14 of the 15 hottest years were reported since 2000 and each successive decade since 1980 has been warmer than the previous one. The decade 2001–2010 was recorded as the warmest decade ever, and 2014 was the hottest year on record.

The human influence on the climate system has been clearly highlighted by recent studies (IPCC, 2014). The recent anthropogenic emission of greenhouse gases, which is the main factor

determining global warming, has been the highest in the history. A report by the Asian Development Bank (Ahmed and Suphachalasai, 2014) stated that South Asia, where nearly 33% of the population of 1.5 billion is still living in poverty, faces a major challenge due to climate risks resulting in significant economic, social, and environmental damage, thus compromising their growth potential and poverty reduction efforts. The mean sea level increased by 0.19 m during the last century and is projected to rise even faster during the 21st century (IPCC, 2014). Seasonal melting of major ice sheets and glaciers has accelerated during the recent past, and significant areas of snow cover have permanently disappeared. These changes in global climate could lead to negative physical and socio-economic outcomes around the globe. Sustainable Development Goal (SDG)-13 of the United Nations, under the 2030 Agenda for Sustainable Development (United Nations, 2015), regards "climate action" and highlights the need to combat climate change and its impacts during the 2015–2030 period.

The Convention on Biological Diversity (CBD) defines biodiversity as "the variability among living organisms from all sources including, *inter alia,* 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, 2015). Biodiversity is determined by many factors, including mean climate conditions and climate variability, as well as disturbance regimes caused by changes of tectonic, climatic, biological, anthropogenic, and other origin. It is now generally accepted that global biodiversity will be significantly affected by climate change, although its precise impacts are still unclear. Food production depends on biodiversity and the services provided by ecosystems, as different crop varieties and animal breeds are founded in the rich genetic pools of species. Biodiversity is also the basis for soil fertility, pollination, pest control, and all aspects important for producing the world's food.

At the global scale, governments have already made a number of commitments to protect biodiversity. A key achievement was the adoption of the United Nations' Strategic Plan for Biodiversity 2011–2020 and the Aichi Biodiversity Targets (CBD, 2010). The strategic plan set out its vision as follows: "By 2050, biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people." The plan highlights the importance of conserving biodiversity to ensure ecosystem health, services, and resilience. The importance of the strategic plan and its Aichi targets was reaffirmed by governments at Rio+20, and the United Nations General Assembly has encouraged Parties to consider it in the elaboration of the post-2015 United Nations development agenda. The SDG-15 regarding "life on land" (United Nations, 2015) aims to "protect, restore and promote sustainable use of terrestrial ecosystems, sustainably managed forests, combat desertification, halt and reverse land degradation and halt biodiversity loss."

Agriculture and food systems are at the center of debates around post-2015 development goals and targets. Hunger and food insecurity remain as the major challenges and development priorities at the global scale. The situation has been made worse by climate change, price volatility and over-consumption in wealthy countries (Sustainable Development Knowledge Platform, 2015). Current food systems are capable of producing adequate food for all. However, the existing practices place major stress on environmental assets including soils, water, fisheries,

and biodiversity. Although the technical solutions available to meet these challenges are well advanced, their implementation and adoption have not succeeded due to failure in understanding and appreciating the political and economic systems, as well as the social barriers to these changes.

This paper deals mainly with the agricultural biodiversity (agrobiodiversity) in Asia, South Asia, and Sri Lanka. We particularly highlight the impact of climate change on the precious genetic resources in agro-ecosystems in the selected regions.

2. Biodiversity in Asia, South Asia, and Sri Lanka

Asia occupies only 8.6% of the world's land area but is home to over 60% of the global population. South Asia covers about 4.4 million km^2, which is 10% of the Asian continent. Overall, South Asia accounts for about 34% of Asia's population (or over 16.5% of the world's population). The population in Asia and South Asia is growing quickly, and many of the countries are considered poor.

The countries of Asia have great biodiversity importance and richness, ranking with South America as the richest place on Earth for variety of living forms; hence these regions contain some of the most important biodiversity hotspots in the world. Specifically, for an area to be considered a biodiversity hotspot it must: (i) contain at least 1500 species of vascular plants as endemics (species found nowhere else on Earth) and (ii) have lost at least 70% of its original habitat (Conservation International, 2012). Of the world's 34 recognized biodiversity hotspots, eight are in Asia (Fig. 1) (Mittermeier et al., 2004). These hotspots cover the entire region of the Association for South East Asian Nations and the Western Ghats of India, Sri Lanka, southwestern China, and the eastern Himalayan countries of Nepal, Bhutan, and India. The Hengduan Mountain area of China is the richest temperate ecosystem in the world.

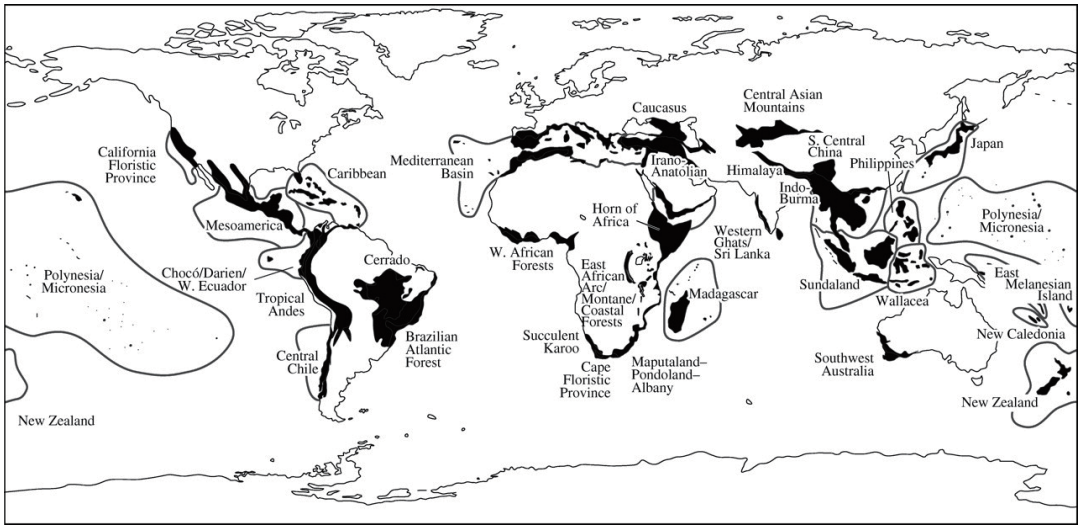

Fig. 1 Biodiversity hotspots (adopted from Mittermeier et al., 2004)

Biodiversity in Sri Lanka is considered to be the richest per unit area in the Asian region with regard to mammals, reptiles, amphibians, fishes, and flowering plants, surpassing several mega-diversity countries such as Malaysia, Indonesia, and India. Sri Lanka's exceptionally high biodiversity is due to the broad range of ecosystems it carries and the diverse species those ecosystems harbor (Ministry of Environment and Renewable Energy, 2014). The rates of endemism of both flora and fauna species are very high. For instance, around 28% of Sri Lanka's 3154 species of indigenous angiosperms are endemic to the country (Weerakoon, 2012), and among the faunal species, the highest endemism is seen among freshwater crabs (98%), amphibians (86%), land snails (81%), reptiles (59%), freshwater fishes (55%), and spiders (51%) (Table 1). The global importance of Sri Lanka's biodiversity is highlighted by the fact that it has four forests recognized as Natural World Heritage Sites and four Biosphere Reserves within UNESCO's World Network based on their exceptional biodiversity value due to high endemism. Furthermore, six RAMSAR Convention sites identified in Sri Lanka show the importance of the country's wetland ecosystems.

Humans mobilize approximately 40% of the total primary production on land per annum,

Table 1 Species richness of selected faunal and floral groups of Sri Lanka

Taxonomic group	Number of species	Number of endemic species
Angiosperms	3154	894
Gymnosperms	2	0
Pteridophytes	336	49
Soft corals	35	0
Hard corals	208	0
Spiders	501	256
Centipedes	19	0
Marine crustaceans	742	0
Freshwater crabs	51	50
Dragonflies	118	47
Ants	194	33
Bees	130	0
Butterflies	245	26
Leafhoppers	257	0
Dung beetles	103	0
Bivalves	287	0
Gastropods (marine)	469	0
Land snails	253	205
Echinoderms	190	0
Marine fishes	1377	0
Freshwater fishes	91	50
Amphibians	111	95
Reptiles	211	125
Resident birds	240	27 + 6 (proposed)
Mammals	125	21

Source: Weerakoon (2012)

exerting a heavy pressure on biodiversity. Estimates show that more than 40% of the world's economy and 80% of the needs of the world's poor are derived from biodiversity (MacKinnon, 2015). This alone emphasizes the huge dependency on biodiversity and the need for its wise management. On the other hand, biodiversity of the Asian region is increasingly threatened by the demand generated by rapid economic development. With pressures on biodiversity escalating, it is not surprising that one-third of all the threatened species are found in Asia (International Union for Conservation of Nature, 2009). Table 2 shows the status of plant and animal species in Asia's biodiversity hotspots.

3. Benefits and Value of Biodiversity in Asia and South Asia

The benefits derived from biodiversity can be grouped into four categories: (i) direct harvesting, including plants or animals for food, fodder, medicine, fiber, dyes, fuel, construction materials, and other uses; (ii) social values, including aesthetic, cultural, recreational, education, and research benefits; (iii) ecosystem services such as climate regulation, flood and drought control, consistent water supply, nutrient recycling, natural pest control, pollution cleansing, and

Table 2 Status of plant and animal species in Asia's biodiversity hotspots

Land area and species	Indo-Burma	East Melanesian Islands	Himalaya	Southwest China Mountains	Philippines	Sundaland	Western Ghats and Sri Lanka	Wallacea
Area (km^2)	2,373,057	99,304	741,706	262,446	297,179	1,501,063	189,611	338,494
Plants								
Species (no.)	13,500	8000	10,000	12,000	9253	25,000	5916	10,000
Endemic (no.)	7000	3000	3160	3500	6091	15,000	3049	1500
Endemism (%)	52	38	32	29	66	60	52	15
Birds								
Species (no.)	1266	360	977	611	535	769	458	647
Endemic (no.)	64	149	15	2	186	142	35	262
Endemism (%)	5	41	2		35	18	8	41
Mammals								
Species (no.)	433	86	300	237	167	380	140	222
Endemic (no.)	73	39	12	5	102	172	18	127
Endemism (%)	17	45	4	2	61	45	13	57
Amphibians								
Species (no.)	286	42	105	90	89	244	178	48
Endemic (no.)	154	38	42	8	76	196	130	33
Endemism (%)	54	91	40	9	85	80	73	69
Reptiles								
Species (no.)	522	117	176	92	237	452	267	222
Endemic (no.)	204	54	48	15	160	243	174	99
Endemism (%)	39	46	27	16	68	54	65	45
Freshwater fishes								
Species (no.)	1262	52	269	92	281	950	191	250
Endemic (no.)	553	33	33	23	67	350	139	50
Endemism (%)	44	12	12	25	24	37	73	20
Extinct species	1	6	-	-	2	4	20	3

Source: Conservation International (2012)

soil generation; and (iv) development potential, through domestication, development and improvement of genetic resources, and biotechnology. The total value of these products and services is enormous, and as a whole it contributes substantially to the economy. For example, in 2009, Asia provided wood products valued at US$28.4 billion, representing 27.4% of the world's total, and non-timber forest products, such as rattan and bamboo, valued at US$7 billion, representing 37.8% of the world's total (FAO, 2010b). The value of biodiversity for China alone has been estimated at US$257–421 billion per annum (Council for International Cooperation on Environment and Development. 1996), which totals to US$5000 billion (State Environmental Protection Agency, 1998). Asia also has the most productive freshwater fisheries in the world, which make a significant contribution to the national economies, improve food security as a source of protein, and provide a livelihood for the rural poor (Baran et al., 2008). According to the FAO (2010b), Asia contributes 66.4% of global inland fisheries production. The marine ecosystems in Asia provide significant economic goods and services that contribute to the livelihoods, food security, and safety of millions of people (World Resource Institute. 2011).

Components of biodiversity provide fresh water for domestic and industrial uses and underpin the socio-economically vital areas of agriculture and livestock production, fisheries, forestry, tourism, traditional medicine, and several important manufacturing industries. For example, Sri Lanka's biodiversity provides a wide range of ecosystem services, which include providing fresh water, ameliorating the climate, reducing soil erosion, regulating surface runoff, and providing biological resources for subsistence use as well as domestic and export-oriented markets. Biodiversity of the coastal and marine ecosystems of Sri Lanka provides over 65% of the animal protein requirement of the country. Thus, many components of biodiversity are vital to meet the consumptive and economic needs of the society.

4. Biodiversity in Agro-ecosystems

Agriculture is the largest global user of biodiversity. Selection and value addition to wild biodiversity have occurred for more than 10,000 years of agrobiodiversity management. Agrobiodiversity contributes significantly to reduce malnutrition, alleviate poverty, and combat challenges from climate change. This diversity has been in decline over the years and is now in danger of disappearing. Agro-ecosystems and agrobiodiversity help to sustain livelihood security at the local, national, and global levels by providing a range of goods and services including food, fodder, climate change mitigation, biodiversity conservation, and water quality options. Farmers and farming communities play an important role in the preservation and conservation of these resources and ecosystems. However, the role of agriculture in the provision of ecosystem services depends on the incentives available to the ecosystem. At present, incentives are designed to pay for the goods rather than the services provided by agricultural ecosystems.

Agrobiodiversity remains the main raw material for agro-ecosystems to cope with climate change because it contains the reservoir of traits for both plant and animal breeders and farmers to select resilient, climate-ready germplasm and produce new cultivars or breeds. The traditional farming systems in Sri Lanka are the results of centuries-long evolution of production systems to

suit local conditions. Agrobiodiversity in any form can only be effectively maintained and adapted with the human management systems that created it, including indigenous knowledge systems and technologies, specific forms of social organization, customary or formal law, and other cultural practices (Marambe et al., 2012).

Sri Lanka has a high diversity of traditional varieties of rice, vegetables, and cash crops that are clearly resistant to diseases and insect pests and are well suited for the various soil and climatic conditions on the island. The nation also has many wild relatives of rice and other crops in farmers' holdings, forests, and wetlands, amounting to 410 species (Fonseka and Fonseka, 2010). Of these, 289 species are indigenous and 77 are endemic to the island. This diverse gene pool can be used in crop breeding programs to enhance crop production and food security for the nation. The development of the livestock sector in Sri Lanka is based on cross-breeding or grading up of local stocks of cattle, goat, swine, and poultry with imported high-yielding breeds. The main target of this effort is to preserve the characteristics of local poultry and livestock as much as possible while improving the productivity. Local livestock breeds are more resistant to disease and parasites than imported breeds, are well adapted to local conditions, and have low nutritional requirements.

5. Loss of Biodiversity and the Underlying Drivers

Biologically diverse ecosystems, apart from providing basic ecosystem services like climatic stabilization and carbon sinks, are also a vital resource for technological development in agriculture, pharmaceuticals, and value addition. The loss of biodiversity reduces an ecosystem's ability to adapt to change and is an issue of profound concern for its own sake. Biodiversity also underpins the functioning of ecosystems that provide a wide range of services to human societies. Its continued loss, therefore, has major implications for current and future human well-being. This is of concern to nations in South Asia such as Sri Lanka, where the country's exceptionally rich biodiversity is central to its national identity and is required to maintain the numerous ecosystem services essential for the 21 million people living there at present and future generations.

Habitat destruction, such as habitat conversion, degradation, and fragmentation, is linked to biodiversity decline in the South Asian region. In spite of the implementation of conservation and reforestation projects, the rates of deforestation and forest degradation are still high in the region. The relatively recent widespread deforestation and the associated fragmentation of natural habitats are expected to accelerate biodiversity decline in the coming years. In broad terms, habitat destruction processes are driven by a combination of proximate and underlying factors. Proximate factors of biodiversity loss are those human activities that directly affect habitats, such as agricultural expansion, biofuel production, wood extraction, infrastructure development, and biomass burning. They operate mainly at the local scale. In addition, the underlying drivers include population growth, poverty, urbanization, policy failures, institutional failures, trade, and globalization, as well as climate change and variability. In contrast to proximate factors, the underlying drivers of biodiversity decline can operate at scales ranging

from the national to the global. Other processes that contribute to biodiversity loss in the region include biodiversity overexploitation and the introduction of invasive species.

Over the period 2002–2009, nearly 2500 species in Asia and the Pacific were recorded in the Red List of the International Union for Conservation of Nature as "critically endangered", "endangered," or "vulnerable" (UNEP, 2010). Thirteen of the 34 biodiversity hotspots designated by Conservation International are also in this area (East Melanesian Islands, Himalayas, Indo-Burma, Japan, mountains of southwestern China, New Caledonia, New Zealand, Philippines, Polynesia-Micronesia, southwestern Australia, Sundaland, Wallacea, and Western Ghats and Sri Lanka). Compared to the global average, mammals have suffered the steepest increase in risk of extinction in South and Southeast Asia.

6. Climate Change and Biodiversity Loss in Asia and South Asia

The potential impacts of climate change are of considerable concern worldwide and have been given due consideration by both the CBD and the United Nations Framework Convention on Climate Change. The findings of the Intergovernmental Panel on Climate Change (IPCC) and the attention given to this subject by the Conference of Parties to the CBD suggest that, although there are potentially serious threats to biodiversity, it is possible to adapt to climate change while conserving biodiversity. Climate change is likely to be an additional threat to agricultural biodiversity, increasing genetic erosion of landraces or ecotypes and threatening wild species, including crop wild relatives. The IPCC has reported that, globally, up to 30% of species are at increasing risk of extinction, whereas approximately 15 to 40% of ecosystems are being affected by climate change. Changes in temperature and precipitation mostly affect the key components of biodiversity such as the individual organisms, populations, species distribution, and ecosystem compositions and functions.

Scientists have estimated that rice production in Asia could decline by 4% due to altered timing and magnitude of rainfall leading to drought or flood injury to rice crops (Swaminathan, 2009). Thomas et al. (2004) estimated that 15–37% of wild plant biodiversity would be threatened with extinction by 2050 due to climate change. Jarvis et al. (2008) predicted that up to 61% of *Arachis* species, 12% of potato (*Solanum*) species, and 8% of *Vigna* species could become extinct within 50 years. Hence, analogue crop areas for many future climates should be promising locations to focus on collection and conservation of crop genetic resources (Lenne and Wood, 2011). The FAO has predicted that climate change could cause up to 10% reduction in staples such as rice and more than 10% reduction in millet and maize production (FAO, 2010a). Localized extreme events and sudden pest and disease outbreaks are already resulting in greater unpredictability of production from season to season and year to year, and require rapid and adaptable management responses. Grain harvests in China may also drop by 37% by 2050 due to weather extremes, whereas extreme drought (i.e., doubling in severity and frequency) in northeastern China could result in 12% crop losses (or 13.8 million t) by 2030.

Climate change will cause heat stress and reduce feed intake of farm animals, thus influencing both growth and reproduction. High-output breeds, on which more than 90% of world's livestock

and poultry production depends, are more susceptible to heat stress (IPCC, 2014). The areas and incidence of diseases and parasites will be increased, causing greater exposure of farm animals. In addition, the expected adverse effects on crop yields and quality will seriously affect animal diet composition. Changes in community composition of microorganisms and crop pests and diseases will create additional problems. The impact of climate change on freshwater ecosystems will modify the habitat characteristics and alter the distribution and abundance of species now found in those environments. These threats exacerbate the ongoing threat to river systems in Asia due to existing dams and plans for construction of more dams in the future. Sea level rise is another consequence of global warming that will influence freshwater ecosystems and species. As saltwater intrudes upon freshwater areas, only salt-tolerant species will be able to adapt to these changes. Climate change can alter flowering/fruiting and flushing in forest species and crops, and disrupt the breeding and reproduction of wild fauna and livestock (FAO, 2010a; Ministry of Environment and Renewable Energy, 2014). The inordinate spread of invasive species (Marambe, 2008; Marambe et al. 2009; 2014; Silva, 2009) inevitably leads to an increase in the number of threatened indigenous species and species extinctions. Changes in rainfall regimes due to climate change could lead to pronounced water scarcity, droughts, and floods that will disrupt cropping cycles and cause socio-economic upheavals among farming communities, affect human well-being, and impede national development (Ministry of Environment and Renewable Energy, 2014).

In the context of South Asia, climate change will have a major impact on the biological resources of the region, including agricultural biodiversity and availability of water. A 2 ˚C temperature rise and 7% increase in precipitation has been estimated to cause a 3% loss in net farm revenues (Jerath et al., 2009). This can seriously undermine the economy of the South Asian region. Grain harvests in South Asia have also been predicted to drop by 30% by 2050 due to weather extremes (Lenne and Wood, 2011). In Bangladesh, for example, reductions in production could be as high as 17–28% for rice and 31–68% for wheat (Karim et al., 1999) due to increased temperature. Reduction of monthly rainfall by 100 mm could reduce productivity of tea by 30–80 kg per hectare (Wijeratne et al, 2007). Extended dry spells and excessive cloudiness during the wet season can reduce coconut yield, with annual losses of US$32–73 million. However, during a high rainfall year, the economy could gain by US$42–87 million due to high coconut yields. Future projections on coconut yield suggest that production after 2040 may not be sufficient to cater to local consumption (Eriyagama et al., 2010). It has also been suggested that climate change will have a significant impact on smallholder profitability. Reductions in precipitation during key agricultural months in Sri Lanka can be devastating for farmers. At the aggregate level, a change in net revenues of between –23% and +22% can be expected, depending on the climate change scenario. These effects will vary considerably across geographic areas from losses of 67% to gains that more than double current net revenues.

Fisheries production is one of the many ecosystem services that disappear when a reef is affected. When water is too warm, corals expel the algae (zooxanthellae) living in their tissues, causing the coral to turn completely white (NOAA). In the central Indian Ocean, such bleaching has been shown to have direct impacts on 90% of the traditional artisanal fishing communities

(Cesar, 2004). Initial studies estimate that dead, crumbling reefs could lose 50% of their fisheries value. In 1998, coral bleaching was estimated to cost as much as US$8 billion in the Indian Ocean in terms of fisheries, tourism loss, and reduced coastal protection (Cesar, 2004).

7. Synthesis

Climate change could alter natural systems connected to the water cycle, ecosystems, and biodiversity of a country or a region, leading to the decline of many ecosystem services that are indispensable for the welfare of human populations. As a phenomenon with impacts looming at the global, regional, national and local levels, climate change calls for multiple actions at all levels. Agro-ecosystems are characterized by high diversity at both species and genetic levels, suggesting that they have a relatively good potential to adapt to climate change. High crop genetic diversity is especially useful for adapting to climate change, which is already being felt in the agricultural sector. Over-reliance on a handful of crops and livestock place global food security at a higher risk, especially in the context of climate change. It is imperative to manage agrobiodiversity in a sustainable way and to use it systematically to cope with environmental challenges. Collecting samples of endangered species to be preserved in gene banks will be the primary step, but also protecting the habitats where they thrive is essential to ensure the in situ evolutionary processes of wild species contributing to agrobiodiversity.

Minimal efforts are in place with respect to mainstreaming of agricultural activities toward conservation of agrobiodiversity and eliminating rural poverty. There is a need to provide traditional varieties of both plants and livestock to promote biodiversity conservation and to strengthen community-level crop and livestock improvement programs (e.g., participatory plant and livestock breeding) toward establishing community seed banks and farms. A lack of responsible institutions with coordinated action, together with necessary funds and staff, makes it difficult to mainstream these activities.

The wealth of traditional knowledge that exists in South Asia, especially in Sri Lanka, was hardly recognized or harnessed in the past for development (e.g., agriculture) or biodiversity conservation. It is now increasingly recognized that the traditional wisdom and the lifestyles of people with minimal demands on natural resources must play a vital role to ensure sustainable development while conserving nature. This aspect is of particular importance in the areas of agriculture, control of pests/parasites and plant/animal diseases, and curative purposes for humans and livestock, especially to face the exigencies of climate change.

Habitat modifications due to changing rainfall patterns and temperature threaten the range, distribution, and diversity of terrestrial species. High temperature and prolonged drought may increase the risk of forest fire, which will also threaten species and habitats. Rising temperatures affect flowering and seasonality and have particularly dramatic effects at high latitudes and elevations. Thus, climate change will have a disproportionate impact on alpine and high-elevation areas, including significant effects in the Himalayas and the Tibetan plateau, the sources of much of Asia's freshwater supply. Food is very much a product of biodiversity, and biodiversity can play a major role in the development of crop and animal agriculture in the

future. The rich genetic diversity that exists within indigenous crops and livestock species offer a great potential for genetic improvement. Traditional varieties of crops that are acclimatized to various climatic conditions, wild relatives of crops, and indigenous livestock breeds offer potential to address challenges that may arise for agriculture in the future. Conserving agrobiodiversity and the systems in which these species occur, as well as conserving traditional knowledge associated with agriculture and livestock rearing, are increasingly important for developing the agriculture sector in the face of climate change.

The consequences of biodiversity loss of this magnitude are profound. Most significant is the destruction of species and ecosystems that are vital for the functioning of global life support systems. Others are loss of wild relatives of crop plants and domesticated animals that serve as gene banks when economically valuable breeds have to combat disease or adapt to climate change. Many species with potential medicinal or economic value may also become extinct before they are discovered. Developing countries, which are the main repositories of global biodiversity, do not have the financial and technical resources to manage and conserve their indigenous biological resources, which exacerbates biodiversity loss. Developed countries contribute to biodiversity loss by providing lucrative markets for timber from tropical forests, ornamental fish, and other endangered species. While the ultimate prerogative for conservation and management of a country's biodiversity lies with its national government, the global implications of continued biodiversity loss have resulted in increased international cooperation to strengthen national efforts. International efforts comprise bilateral and multilateral financial assistance for biodiversity conservation, international treaties, and conventions such as the Convention on International Trade in Endangered Species, the Convention on Wetlands of International Importance (RAMSAR Convention), and, most significantly, the CBD. The links between biodiversity and climate change run both ways: biodiversity is threatened by climate change, but the proper management of biodiversity can reduce the impacts of climate change. There is ample evidence that climate change has already affected biodiversity and will continue to do so. The Millennium Ecosystem Assessment ranks climate change among the main direct drivers affecting ecosystems and their biodiversity.

The genetic diversity of the plants and animals in the South Asian region provides a range of options that would be extremely valuable for climate change adaptation. Hence, one of the most important ways of coping with the impact of climate change on food security is to maintain a diversity of crop plants and farm animals and their wild relatives. This will not only protect the agriculture system from total failure in extreme climate events, but also help in the development of new crop varieties and farm animal breeds to cope with the challenges of changing climate.

Being cognizant of the detrimental impact of climate change on ecosystems services, biodiversity and agrobiodiversity, and food security, Asian countries have taken many initiatives to deal with climate change impacts with a strong level of policy support. For example, the Government of Sri Lanka has established the Climate Change Secretariat (CCS) under the Ministry of Mahaweli Development and Environment, which is also the national designated entity for the United Nations Framework Convention for Climate Change, to spearhead activities in the national initiative. The CCS has made two major achievements, namely, the development

of the National Climate Change Adaptation Strategy for Sri Lanka 2011–2016 and adoption of the National Climate Change Policy formulated in 2012. The National Climate Change Adaptation Plan is currently nearing completion. All these documents have given due recognition of the need to safeguard the country's precious biological resources under a changing and variable climate.

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