# Understanding Biodiversity, for human & societal wellbeing[1]


***Ramanatha Rao V[2]***


## Synopsis/Abstract


The Earth's ecosystem is made up of both living and non-living components, and their interactions. Plants, animals, and all other living beings interacting with each other (in each area) make up the living component, while the non-living component includes the weather, earth, sun, soil, climate, and atmosphere. The structural components of an ecosystem are the vegetation, water, soil, atmosphere, and biota (plant and animal life of a region, habitat, or period) and their interactions within and across the ecosystem(s). Ecosystem services are the benefits that humans obtain from ecosystems; for example, food and water, medicines, etc., which sustain the conditions for life on Earth. The living component of the ecosystem constitutes its biodiversity, comprising all forms and variety of life on Earth across all the different levels of biological organization.

One can safely assert that without biodiversity, there is no future for humanity, at least as we know it. Human wellbeing includes food, nutrition, and health, along with many other creature comforts. For almost all these necessities, humans are dependent on nature in general, and biodiversity in particular. Take for example, food and medicines: All our food and nearly two-thirds of the drugs approved by the U.S. Food and Drug Administration between 1981 and 2014 derive in one way or another from natural products; other developing countries like India, which have strong/long tradition of plant-based remedies, are even more dependent on biodiversity for their medical needs. It has been estimated that about 40 per cent of prescription medicines come from plant extracts or synthesized plant compounds. For a list of plant-based medicines, go to https://www.thoughtco.com/drugs-and-medicine-made-from-plants-608413 (accessed on 24/09/2019). Along with indigenous communities, forest dwellers and farmers are our best hope to preserve biodiversity, environmental health, and food security (Sthapit et al. 2019).

One major contribution that the social sciences can make about the uncertain human future is to help us explore alternative futures; for example, what would the world be like with depleted biodiversity, or with higher global temperatures than average. In that effort, the social sciences could include, but not be limited to, anthropology, archaeology, communication studies, economics, history, musicology, human geography, jurisprudence, linguistics, political science, psychology, public health, and sociology. However, often biodiversity (and other gifts of nature) get short-changed since only economics is used while valuing it. This leads to a great undervaluation of the importance of biodiversity to human wellbeing as well as future survival. Something as basic as biodiversity need not be measured solely in terms of dollars and rupees. It is vitally important that this attitude of indifference should change to active concern so that humanity will be able to sustain the existing biodiversity into the future; neglecting to take such an integrated perspective is inviting our own downfall.

The importance of biodiversity, especially of the readily useful agricultural biodiversity, and its use for the sustained future of humans, requires wider understanding by the general public; it needs to be routinely turned into actions like diversity of foods and other everyday uses. There is a need for greater understanding by the society as a whole about (i) why we should be concerned about biodiversity conservation, (ii) how the conservation and use of biodiversity at different levels is essential for our survival, and (iii) how such efforts can be balanced with contemporary developmental efforts.


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[2]Former Senior Scientist, Bioversity International and Co-Founder, GRSV Consulting Services,
Bengaluru – 560068, Karnataka, India; vramanatharao@gmail.com



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This paper summarizes concepts of the ecosystem, its functions, and services, and focuses on biodiversity, explores its value for humans, and describes the role it plays in the wellbeing of human societies. It also emphasizes the need for conservation efforts.

## Introduction

Biological diversity or biodiversity refers to the amount of diversity within and between living beings and ecosystems in each location at a time. Generally, tropical regions of the earth are richer in biological diversity than temperate regions, deserts, etc. It estimated that there are up to about 100 million species on the earth, of which humans know only about 1.6 million species (Table 1); however, these estimates tend to vary significantly from author to author. All these estimates confirm one fact: there are many species of living beings about which we know very little. Several of these species are known to be threatened, and IUCN (2019) estimate puts the number such threatened species at 41,415. It is also recognized that several species are already extinct and such extinctions are still happening.

Ecosystem services are the benefits that humans obtain from ecosystems of which biological diversity is a component; for example, food and water, medicines, etc., sustain the conditions for all life on Earth. Hence, the health of biological diversity and resources is essential for the wellbeing of human beings as well as that of wild beings. Sustainable use and conservation of biodiversity become essential for both environmental health and human wellbeing.

Table 1. Estimated number of species on earth (source – Mora et al. 2011)

| **Species** | **Earth (Number of species)** | | | **Ocean (Number of species)** | | |
|---|---|---|---|---|---|---|
| **Animalia** | 953,434 | 7,770,000 | 958,000 | 171,082 | 2,150,000 | 145,000 |
| **Chromista** | 13,033 | 27,500 | 30,500 | 4,859 | 7,400 | 9,640 |
| **Fungi** | 43,271 | 611,000 | 297,000 | 1,097 | 5,320 | 11,100 |
| **Plantae** | 215,644 | 298,000 | 8,200 | 8,600 | 16,600 | 9,130 |
| **Protozoa** | 8,118 | 36,400 | 6,690 | 8,118 | 36,400 | 6,690 |
| **Total** | 1,233,500 | 8,740,000 | 1,300,000 | 193,756 | 2,210,000 | 182,000 |
| **Archaea** | 502 | 455 | 160 | 1 | 1 | 0 |
| **Bacteria** | 10,358 | 9,680 | 3,470 | 652 | 1,320 | 436 |
| **Total** | 10,860 | 10,100 | 3,630 | 653 | 1,320 | 436 |
| **Grand Total** | 1,244,360 | 8,750,000 | 1,300,000 | 194,409 | 2,210,000 | 182,000 |

*Note: Predictions for prokaryotes represent a lower bound because they do not consider undescribed higher taxa. For protozoa, the ocean database was substantially more complete than the database for the entire Earth. So, the authors used only the total number of species in this taxon. All predictions were rounded off to three digits.*

### Ecosystem Functions and Services

During the last few decades, there have been numerous discussions and writings about ecosystem functions, especially in the context of environmental health and biodiversity conservation and its sustainable use. Despite diverse perceptions, there is hardly any disagreement that the ecosystem, its functions and services, and biodiversity are important elements in transforming the hunter-gatherer stage of humans to the early domestication of plants and animals, to the current modern-day agriculture, and the need for preserving and using all the three in a sustainable manner is well recognized (Ramanatha Rao 2018a). Ecosystem function consists of the biological, geochemical, and physical processes and components that take place or occur within an ecosystem, e.g. vegetation, water, soil, atmosphere, and biota, and how they interact with each other within an ecosystem and across ecosystems. Ecosystem services are the benefits people obtain from ecosystems, for example, food and water, disease control, etc. The living component of the ecosystem is the biodiversity, comprising the variety of life on Earth across all the different levels of biological organization. On a smaller scale, biodiversity can be used to describe the variation in the genetic makeup of a species; on a larger scale, it can be used to describe the variety of ecosystem types. Scientists, social activists, and the political masters are now recognizing the degradation of ecosystem services and functions and loss of biodiversity that has happened over the years, and that efforts are needed to make them sustainable for future generations (Gleissman 2014).

Ecosystem functions refer to the structural components of an ecosystem and how they interact with each other in different combinations, within and across ecosystems. Much literature can be found on various types of ecosystem functions and services in the literature (e.g., Daily 1997, Tallis et al. 2007, Wratten et al. 2013, Kareiva et al. 2011). Ecosystem functions are called ecological processes, usually classified into 4 classes:

*1. Provisioning Functions* relate to the provision of life-supporting natural resources, including raw materials, water, shade and shelter, nutrients and medicines, and genetic resources.
*2. Regulating functions* relate to maintenance of essential ecological processes and life support systems, including regulation of oxygen levels in the atmosphere, water for life to flourish, pollination to promote seed production, soil retention, nutrient regulation, waste decomposition, biological control, etc.
*3. Supporting functions* relate to providing habitat (living spaces) for plant and animal species at local and regional scales; for example, soil formation and nutrient cycling.
*4. Cultural Functions* relate to providing life fulfilment opportunities and logical development, such as landscape opportunities, cultural heritage, and recreation and tourism.

Each ecosystem function can contribute to more than one ecosystem service, and it can take more than one ecosystem function to provide any of the ecosystem services. Organisms build up ecosystems that in turn create a biosphere, consisting of a variety of ecosystems that interact with each other and exchange services like our body does to function effectively (Ruhl et al. 2013).

Nature provides ecosystem services on its own. Society at large benefits from several such benefits, which are most often provided free of cost and humans (and other living beings) enjoy the natural functions of the ecosystem (Kareiva et al. 2014). A few examples of ecosystem services are the following:

• Leaf, fruit, and seeds, etc., produced by photosynthetic processes as food,
• Oxygen provided by removing carbon dioxide in the air, via growing plants and trees,
• Provision of timber by trees for house construction, etc.,
• Provision of clean water and fish for human consumption,
• Beneficial insects, such as pollinators, honeybees, parasites, etc., and
• Healthy soils for food production.

In general, ecosystem services are life-supporting nature and are for the survival of humans, animals, and other living organisms. At the same time, human activities have been impacting significantly on ecosystem services and, in some instances, may cause their abuse. For instance, the natural processes of seed distribution are interrupted due to overexploitation and harvesting of too many trees or too many fruits, compromising the life-sustaining function of oxygen supply and carbon sequestration. Hence, understanding the nature of ecosystem services and how these are sustained helps all of us to be alert and to play a part in protecting the ecosystems (Naeem et al. 1999; Ramanatha Rao 2018a).

The science of ecology that deals with various aspects of biodiversity functions and services is relatively new, going back to the 1800s. However, we can see that the roots of ecology lie at the basis of various religions and cultures, for example, 'Sanatana Dharma or Hinduism that pays much attention to environment and environmental ethics and to e understanding the role and value of nature to human society (Kermani 2017). In more recent times, a variety of ethical considerations and approaches to human relationships to biodiversity are described in a report by the United Nations Educational, Scientific and Cultural Organization (UNESCO 2011). Despite the range of ideas that have been included by the authors of the report, most argue that human beings should modify their behaviour to slow the rate of biodiversity loss. Earlier we have seen that ecosystem functions are classified into 4 categories, and now we explore further how the biodiversity component of the ecosystem fits into the scheme of things and helps to maintain ecosystems healthy enough for human societies to survive and prosper (more details can be found in Ramanatha Rao 2018b).

## Biodiversity

Biodiversity or biological diversity is the variety of plant and animal life (including microorganisms) in a habitat (or in the world). It is based on a hierarchy/ rank of variation/diversity of plants and animals in the given location and is a 'live' component of the ecosystem. In simple language, it refers to the amount of diversity within and between species and ecosystems in each location at a time. Thus, it is the sum of all the variability among living organisms from all sources, including those on earth, air, and water. Generally, tropical regions (for example, India) are rich in biological diversity and temperate regions, deserts, etc., are less so. As noted in the Introduction above, several species are known to be threatened, or already extinct, due to various natural and human-induced causes. Hence, the conservation of biological diversity and resources is essential for a healthy society and the continuation of humanity (Ramanatha Rao 2018a).

It is generally agreed that the value of biodiversity goes far beyond anything we can describe using economic valuation indices. Ecologists and economists, with or without the involvement of governments, have been struggling with these questions for decades with little success. Establishing the value of biodiversity to economies is important, in part because it will help policymakers in all countries to appreciate that there's a cost to losing nature. But at the same time, an economic assessment must consider the perspectives of the humanities, of developing countries and of members of indigenous communities. Due attention needs to be given to multifunctionality and context specificity (e.g. the value of a variety or product— for a rich, as opposed to poor farmer— a livelihood asset) of a biodiversity entity, which makes the process complex. Some level of obsession with some policymakers for the nature being socially useful to be valued is ethically incorrect. Various tools and conceptual frameworks that have been developed based on the need of commodification of nature, for example, the methods promoted by the United Nations System of Environmental-Economic Accounting in valuation of nature(SEEA 2014) valuation of nature and shows its inadequacy in arriving at a non-commoditised conception of “socially useful nature” (Prasad 2019). Cost-benefit calculations tend to rule out the normative moral arguments for an equitable sharing of future carbon space (and biodiversity) that do not converge with the material interests of states (Jaiswal and Jayaraman 2019), which is again unethical.

It may be possible to develop a system of valuation that is strictly based on attributed values and market price, but it is possible that such systems and values arrived at would vary enormously with space and time and will, in the end, have little value. In addition, a narrow perspective bears the risk that people's attitudes and perceptions will transition towards a mere economic perspective on nature, which could arguably jeopardize long-term biodiversity protection aims (Kaphengst et al. 2014)

Biodiversity is the basis for numerous ecosystem services, for example, air quality, climate, pollination, water purification, and soil formation. The material benefits it offers humankind are also tremendous in terms of its functions in maintaining equilibrium in any given ecosystem, in addition to providing food, fibre, medicines, and other day-to-day needs of humans. Thus, the conservation and optimal use of the available biodiversity becomes imperative. Biodiversity is the foundation of our existence on earth, as it provides us with many benefits. In addition to its utilitarian values, it is also important to conserve biodiversity to satisfy our own curiosity and aesthetic appreciation. Biodiversity is the life support system of not only humans but also of other living beings— for air to breathe, food to eat, and water to drink.

Despite its value and importance, biodiversity is being lost at an alarming rate due to such factors as population growth, deforestation, and habitat loss, overexploitation, invasive species, pollution, and climate change. Among many of these anthropogenic actions, four have been highlighted as main drivers by many authors: (i) land-use change, habitat loss, and fragmentation; (ii) global climate change; (iii) invasive alien species; and (iv) natural resource overexploitation (e.g. over-hunting, over-fishing) (Alkemade et al. 2009). At the same time, it is also known that biodiversity loss is a major driver of ecosystem change (Hooper et al. 2012). It is interesting to note that somewhat similar actions by humans have varied effects on the environment and biodiversity. For example, solar-powered irrigation systems offer a cost-effective and sustainable energy solution to off-grid farmers and thus help in increasing food production and sustaining livelihoods. At the same time, they have been shown to result in serious groundwater depletion (as the power is available almost always) due to overexploitation (Closasa and Rap 2017). If unchecked, the long-term effects could increase the aridity of the area and reduce the flow of water in rivers and streams (de Graaf et al. 2019), with consequent effects on surrounding vegetation and animals. Land-use changes can affect the environment and biodiversity; for example, change of land from agriculture to solar parks may reduce biodiversity, but can help in the sustainability of power production and reduction in carbon dioxide, etc. In addition, well planned and carefully laid out solar farms can be beneficial to wildlife and pollinators (Midgley 2019).

**Effects of Loss of Biodiversity on Ecosystem**

Changes in biodiversity (or the loss of it) cause concern not only for ethical and aesthetic reasons but also due to their capacity to alter the ecosystem properties and the goods and services they provide to humanity. The scientific community has come to a broad consensus on many aspects of the relationship between biodiversity and ecosystem functioning, and some examples are given below (including those found in literature):

1. Species' functional characteristics strongly influence ecosystem properties.
2. Alteration of biota in ecosystems via species invasions and extinctions caused by human activities has altered ecosystem goods and services in many well-documented cases, many of which are irreversible.
3. The effects of species loss or changes in composition and the mechanisms by which the effects manifest can differ among ecosystem properties, ecosystem types, and pathways of potential community change.
4. Some ecosystem properties are initially insensitive to species loss because of multiple species having similar roles or such species have an insignificant role.
5. More species are needed to ensure a stable supply of ecosystem goods and services as spatial and temporal variability increases.

According to Hopper et al. (2012), more research is needed in the following areas:

- Relationships among taxonomic diversity, functional diversity, and community structure,
- A deeper understanding of multiple trophic levels,
- Long-term experiments to assess temporal stability, and assessment of response to and recovery from a variety of disturbances.
- Because biodiversity both responds to and influences ecosystem properties, understanding the feedbacks involved is necessary.
- More work on these lines is needed to understand the intricacies of influence and relationships in the marine ecosystems.

These conclusions do establish that biodiversity loss decreases ecosystem functioning at the local scales at which species interact, but it is not clear as to how biodiversity loss affects ecosystem functioning at a larger scale, which is very relevant to biodiversity conservation and policy (Isbell et al. 2018). Isbell et al. (2018) conclude that species loss can reduce ecosystem functioning both locally and by eliminating species that would otherwise enhance ecosystem functioning across temporally fluctuating and spatially heterogeneous environments.

Governments around the world recognized this at the Earth summit in Brazil in 1992 and established the Convention on Biological Diversity (CBD 1992) to protect and conserve biodiversity. But the situation has become more and severe. The continued loss of biodiversity is not only an environmental issue as the largest driver of biodiversity loss on land in recent decades has been land-use change, primarily the conversion of pristine native habitats into agricultural systems to feed the world, while oceans are over-fished. The climate crisis and the loss of biodiversity are issues that affect each other. Loss of biodiversity can adversely affect climate: deforestation increases the atmospheric abundance of carbon dioxide, for example, which is a greenhouse gas. It has been well recognized that human land use threatens global biodiversity and compromises multiple ecosystem functions critical to food production. Whether crop yield-related ecosystem services can be maintained by a few dominant species or rely on high richness remains unclear. Recently a global synthesize study carried out by Dianese and colleagues indicate that maintaining the biodiversity of ecosystem service providers is therefore vital to sustaining the flow of key agroecosystem benefits to society (Dainese et al. 2019).

Most attention, which is very limited by any measure, on biodiversity tends to focus on saving large charismatic animals, rather than informing the public of the importance of biodiversity to human societies and wellbeing. Business as usual and scenarios that focus on economic growth and regional competition will lead to continued loss of biodiversity. Sustainable consumption practices can slow, but not eliminate, future loss of biodiversity, in part because warming will continue in all scenarios (Watson 2019).

**Biodiversity and Economic Development**

Almost in all countries, plans for economic development overlook ecosystems and biodiversity; it has been asserted many times that development and conservation are mutually exclusive. However, increasingly, leaders in academia and finance, and experts in sustainable development and the private sector agree that nature is a key engine of economic prosperity. There are now efforts to search for ways and means, as well as tools and technologies, to balance these two. For example, Gretchen Daily and Lisa Mandle of Stanford's Natural Capital Project are looking for tools for improving the well-being of people and nature at the same time. This involves implementing approaches that reduce poverty and increase access to education, health care, and infrastructure, while investing in the natural assets on which our livelihoods, health, and economies depend—our natural capital (Cafasso 2019). The question of whether conservation and human development can go hand in hand is being researched by many institutions. Preliminary results of such studies indicate that conserving nature while providing water, food, and energy for a growing human population is possible, this would require fast action (Tallis and Polasky 2019). An increase in population is leading to a scramble for resources, as well as the development of new technologies and socio-economic and political structures to help organize a rapidly expanding society (Sood 2019), causing severe environmental damage and biodiversity loss. There thus an urgent need for us to alter how we perceive ourselves, each other, and the environment. We need to promote radical transformations in the method and scale of efforts, and in the global political economy; there is no time to waste.

**Agricultural biodiversity**

Although there is no formal definition of agricultural biodiversity, generally we use what is agreed by the parties to the CBD (Convention on Biological Diversity 2005). It includes all components of biological diversity of relevance to food and agriculture (or economically useful to humans) and all components of biological diversity that constitute the agricultural ecosystems, also named agro-ecosystems, i.e., the variety and variability of animals, plants, and micro-organisms at the genetic, species, and ecosystem levels. Thus, agrobiodiversity includes all those living beings which are necessary to sustain key functions of the agroecosystem, its structure, and processes; in other words, all those elements that sustain and nurture human societies. Agricultural biodiversity is a vital component of human wellbeing, as the services it provides include all the agricultural products needed by us in everyday life—for food, feed, fodder, fibre, health, habitation, etc. Hence, it is needless to highlight the importance of agricultural biodiversity in our lives, and it becomes imperative that we should be concerned about its status.

Some of the existing measures of biodiversity conservation, including agricultural biodiversity, include the following: biosphere/forest preservers, zoological/botanic gardens, national parks, genebanks and adoption of breeding techniques, tissue culture techniques, social forestry to minimize stress on the exploitation of forest resources (Ramanatha Rao and Hodgkin 2002; Rawat and Agarwal 2015). One end of the biodiversity conservation spectrum is that the plant genetic resources are irreplaceable, and it is essential that we should be concerned with their conservation, at the species level, gene pool level, or at the ecosystem level. Genetic diversity is a natural defence mechanism against the genetic vulnerability, which has been built into the genetic structure of traditional cultivars or landraces. Countries that still have a significant amount of genetic diversity and species diversity have a responsibility unto themselves as well as to the world at large to conserve it and make it available to for use (NRC 1972 Brown 1983; Ramanatha Rao 2012).

### Value of Biodiversity

Policymakers and the general public in many countries have responded to concerns over declining levels of biodiversity in general and agricultural biodiversity specifically. Such efforts nationally and internationally have led to the introduction of a range of policy measures at the national level and conventions (or agreements) at the international level. The individual components of biodiversity—genes, species, and ecosystems—provide society with a wide array of goods and services (McNeely et al. 1990; Reid and Miller 1989). The value to human society could emanate from either the biodiversity in domesticated systems or the biodiversity in wild landscapes. The variety of services provided by biodiversity from both those systems to humankind, as described earlier, are often take for granted. Try to imagine what life would be without one or more of these services. For example, services such as maintenance of gaseous composition in the atmosphere, pollination, formation of soil, nutrient cycling, climate control by forests and oceanic systems have been valued at 16 to 54 trillion ($10^{12}$) US dollars per year. There are a host of other services, and how does one put a value on colourful butterflies hovering above?

Let us look at Biological diversity in the context of social sciences, which helps to explore alternative futures; for example, what would the world be like with depleted biodiversity, or with higher global temperatures than average. In any such effort, the social sciences could include, but not be limited to, anthropology, archaeology, communication studies, economics, history, musicology, human geography, jurisprudence, linguistics, political science, psychology, public health, and sociology. One could link biodiversity (and other gifts of nature) with most of these if not all branches of social sciences. Nevertheless, biodiversity gets short-changed, since only economics is used while valuing it. This leads to a great undervaluation of the importance of biodiversity to human wellbeing as well as future survival. Something as basic as biodiversity need not be measured solely in terms of dollars and rupees. As noted earlier, there is a need for humans to change their apathetic attitude toward positive one for us to sustain the existing biodiversity into the future; neglecting to take such an integrated perspective is inviting our own downfall. Considering the enormous and vital role that biodiversity plays in human lives prioritizing valorisation of, and questioning the costs of conservation measures to be taken, may help in convincing doubting policymakers, but it is surely not an essential task. Estimating the costs for measures that promote conservation is relatively easy; however, it is much more difficult to estimate the benefits. Econometrics alone cannot help guide the design of biodiversity policy by eliciting public perceptions and preferences on different attributes of biodiversity. In addition, it can be complicated by the generally low level of awareness and understanding of what biodiversity means on the part of the public. Since many of the estimates will be/are based on highly theoretical concepts, assumptions, and perceptions, it is important to treat them as guidelines and not as standards (Rajeswari and Dey 2016).

I belong to the group that questions the need for the valuation of such life-sustaining natural resources purely in economic terms, which runs the risk of undervaluing the immense social and cultural benefits provided by agricultural biodiversity (Ramanatha Rao 2012). For me, measuring everything in terms of economic returns/economic viability and the obsession with, for example, gross domestic product (GDP) only reflects human greed. At the same time, binge spending is not advocated as well. Whatever we do to conserve biodiversity should be based on a full understating of its use for the current and future wellbeing of human society and planet earth.

## Conservation and Use

The main driving force for the conservation of biodiversity is its value for the present and future of the humans and other beings of the earth. Thus, either now or in the future, all conservation efforts that we make and the methods and approaches that we use should ultimately focus on promoting the use of conserved resources, be it from the protected areas, biosphere reserves, genebanks, experimental fields, farmers' fields. or plantations. Since the 1970s, global as well as national efforts on conservation and use of biodiversity have made significant progress. Some national governments are considering making Biodiversity Net Gain (BNG) mandatory. BNG is both an approach and an outcome. It involves not only avoiding or mitigating harm to natural areas but also seeking to improve them through the creation or enhancement of habitats over and above what is there already. This will require a baseline assessment of existing habitats on a given site and evidence to demonstrate that a net gain has been achieved (BBOP 2018). At COP-14 of CBD, the "Sharm El-Sheikh to Kunming Action Agenda for Nature and People" was launched. It explicitly asks countries to do as follows: (1). Raise public awareness about the urgent need to halt biodiversity loss and to restore biodiversity health; (2). Inspire and help implement nature-based solutions to meet key global challenges; and (3). Catalyse cooperative initiatives across sectors and stakeholders in support of the global biodiversity goals (CBD 2019)

Agricultural biodiversity is of direct concern to humans as it plays a role in almost all spheres of human activity, starting with food and nutrition. Both at the national level and at the global level, agriculture continues to face five major challenges: ensuring food and nutrition security; livelihood security; achieving sustainable production and productivity of food and commodity crops; combating diminishing non-renewable resources, including land and water; and meeting the demands placed by global changes such as migration, urbanization, and climate change and their impact on agriculture and the environment. A well-coordinated work on making agricultural biodiversity easily accessible and refocusing on integrating traditional knowledge with modern knowledge and methods can help us to continue to make progress in using agricultural biodiversity in facing those challenges. It will also require supporting on the ground action and conservation by communities. Community restoration groups, seed savers, backyard trappers, coastal and marine protection advocates, and forest protection movements can bring a paradigm shift on biodiversity management (Sthapit et al. 2016). There are over 300 million indigenous people in the world and most of them are directly dependent on the natural resources for their livelihoods. Hence it is a strategic imperative that indigenous peoples are involved in the maintenance and conservation of the world's biodiversity (Toledo 2001). Relatively greater number of researchers now believe that indigenous knowledge can help solve the biodiversity crisis and that people who live off the land depend on keeping ecosystems intact, and scientists are tapping into their unique expertise (Rundle 2019)

Some essential features that our efforts to conserve biodiversity should include are as follows (Shanker et al. 2005; Sthapit et al. 2019):

- generate knowledge on biodiversity in all its three states, i.e., genetic diversity, species diversity, and ecosystem diversity and ways and means to manage these;
- understand the context and develop the team;
- provide the soundest scientific information to policymakers and enhance public awareness;
- promote stakeholder participation from the planning stage and emphasize multidisciplinary, multi-institutional, and multisectoral collaboration;
- develop management systems and process documentation systems that emphasize decentralization, fairness, and equity in the use of resources by civil society and promotion of public and private sector collaboration;
- disseminate information for conservation and sustainable use of biodiversity; and
- develop and implement focused training programmes to foster a new generation of researches and leaders to meet current challenges in biodiversity conservation and environmental protection.

## Biodiversity and Climate Crisis

Climate change is the most pressing concern faced by humanity.  Ecosystems and the biodiversity and services they support are intrinsically dependent on climate. There have been many speculations about impacts of climate change on biodiversity, ecosystems, and ecosystem services (Staudinger et al. 2012), all of which have a direct bearing on humankind. Many studies report that biodiversity and ecosystems are significantly stressed. Climate change is causing many species to shift their geographical ranges, distributions, and phonologies at faster rates than previously thought (Peterson et al. 2019) and such changes alter ecosystem structure and functioning. There is growing evidence that populations of certain species are declining and of localized extinction that can be directly attributed to climate change (Razgoura et al. 2019). Overall, it is predicted that there could be a net loss of global biodiversity and major shifts in the provision of ecosystem services. For example, the range and abundance of economically important marine fish are already changing, and some fisheries may become more valuable if the fishing community can adapt.

In spite of numerous publications, documentaries, and workshops and meeting proceedings, climate change remains an abstract and uncertain concept to most people. Ironically, the story of climate change is, in fact, a deeply human one—we caused it, we will suffer from it and we alone can take action to avoid its worst consequences and prepare for the rest (Markowitz and Corner 2019).  In many peoples' minds, it is still primarily an "environmental" issue. It has been reported that that human activity is driving one million plant and animal species to extinction (IPBES 2019). From an extreme point of view, it is probably not just any human action; it is the choices of a tiny minority of wealthy and powerful people (Noor 2019). There is the urgent need to move the issue of climate change, and the resulting loss of biodiversity, from a scientific reality to social, economic, and political reality. This needs to become a people's movement. A group of UN experts has warned that the erosion of nature, the extinction of species, and the loss of biological diversity at unprecedented rates severely threatens human rights for present and future generations (UN 2019).

The world is already witnessing changes in precipitation regimes and extreme events that can cause ecosystem transitions, changes in transport of nutrients and pollutants (including pesticides) downstream ecosystems, impacting the capacity of nature to adapt to changes (Arnell 2019). Longer growing seasons and warmer winters are enhancing pest outbreaks, leading to tree mortality and more intense and extensive fires. One can find many more examples in literature. Climate adaptation has experienced a dramatic increase in attention recently, and more emphasis is being placed on biodiversity conservation and natural resource management. However, more multidisciplinary, multi-institutional, and multisectoral (3M Approach) research and management approaches are essential in areas such as monitoring, experimentation, and a capacity to evaluate and modify management actions. The 3M Approach is essential as ecosystem functions and the value of biodiversity (for example, energy, agriculture, transportation, etc.) are interrelated and interdependent, and they cannot be tackled in isolation. Risk-based framing (Gentle and Marasen 2012; Shukla et al. 2019) and stakeholder-driven scenario planning (Thomas et al. 2019) are necessary to improve our ability to manage the crisis resulting from climate change.

There are many who argue that regenerating the planet through biodiversity-based ecological processes has become a survival imperative for the human species and all beings. Such a transition can only happen only when a shift from fossil fuels and dead carbon to living processes based on growing and recycling living carbon, renewed and grown as biodiversity, occurs (Shiva 2019, Lal et al. 2012). At the same time, there is a large group of researchers and intellectuals who are cautiously optimistic. Most understand that they can't afford as a global society to ignore nearly universal scientific observation of anomalous climate trends and degraded nature patterns, and we also cannot tone down the severity, scale, and systemic nature of the current biosphere reality (Cunningham 2019). However, we cannot just wish for a positive future but need a strategy that includes a conscious reduction in our wants and desires. Even scraggy wild areas are now shown to contribute significantly to the survival of species (Di Marco et al. 2019).

**Biodiversity and Social Sciences**

Social sciences can contribute to the human ability to tackle our uncertain future by helping us to explore alternative futures; for example, what would the world be like with depleted biodiversity, or with higher global temperatures than average. They can help us to explore biological (genetic diversity, species diversity, ecosystem diversity, landscapes and seascapes), and cultural diversity (diversity of languages, livelihoods, values, knowledge systems, social and political systems, beliefs, spirituality and worldviews), as well as their interactions and evolution. Both those components are facing unprecedented change and, in some cases, erosion, which need to be studied and used to identify alternative scenarios.

UNESCO seeks to develop innovative approaches (UNESCO 2019), as follows:

1. to promote understanding of the linkages between biodiversity and cultural diversity;

2. to raise awareness of the essential role of cultural diversity in sustaining and creating biological diversity;
3. to support the meaningful inclusion of local and indigenous knowledge in biodiversity conservation and management;
4. to mobilize cultural diversity to counter biodiversity loss; and
5. to address ethical dimensions of biodiversity

The IPBES expects the role of social sciences in its work could be three-fold (Vadrot 2018):

1. Identification and understanding of social and human-related drivers of biodiversity loss.
2. Understanding of politics and policies for biodiversity conservation and use—concerns the political frameworks and the range of instruments specifically established to tackle the loss of biodiversity at different policy levels and scales.
3. How to enhance the uptake of scientific knowledge in nature conservation policy and improve "science-policy interfaces" for biodiversity and to describe the means by which they could contribute to tackling the perceived lack of scientific advice and consensus in international biodiversity.

Society shapes our relationships with the living world, and ethics can help us to better understand and, as appropriate, re-orient these relationships. Some of the ethical questions related to biodiversity include the role of humans in its conservation, sustainable use, and benefit-sharing.

**Concluding Remarks**

The ecosystem, its functions and services are highly interrelated, and the ecosystem impacts the biodiversity that it contains and, in turn, is influenced by that biodiversity. Research to date shows that the ecosystems that are home to several species are generally more productive, efficient. and healthy, compared to those with fewer species. Ecosystem functions, services, and biodiversity are interrelated and interdependent. Nevertheless, there are some serious gaps in information, for example, how biodiversity affects the wide variety of ecological functions and how this leads to improved services. This would require more studies and a deeper understanding of ecosystems and biodiversity. Global conventions and national laws and regulations go only thus far. There is the need to combine usable traditional knowledge with modern knowledge and come out with workable solutions. Of course, serious gaps are there and new ways to fund the efforts are to be explored and implemented (Droste et al. 2019).

In this paper/lecture, the importance of biodiversity for human survival and wellbeing has been described in some detail and has touched on what society could do in conserving it efficiently and using it sustainably this important natural resource. It has been suggested that we need to be responsible so that we do not live on the inheritance of future generations. To do so, there is a need for us to be aware of the significance of ecosystem functions and the importance of biodiversity, so that we, individually or collectively as a society, can contribute to its conservation, and in arresting environmental degradation. Governments, the private sector, and civil society must work together to address the human-induced climate change and biodiversity loss. As individuals, we can make it a habit to promote biodiversity, by being more aware of its importance, by increasing the diversity of our daily diet, by buying biodiverse products, and by participating in environmental and biodiversity-related activities that are carried out at the community level. As Watson (2019) says, incremental changes will not suffice. Stronger will (at individual, societal, and political levels) is needed, and maybe we should stop pretending that we care about the environment and biodiversity and focus more on preserving human societies, which would require a functioning environment and flourishing biodiversity.

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