

REVIEW ARTICLE

BIODIVERSITY: OVEREXPLOITED BUT UNDERUTILIZED NATURAL RESOURCE FOR HUMAN EXISTENCE AND ECONOMIC DEVELOPMENT

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ABSTRACT

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Man arrived on the planet earth only recently i.e. about 1 million years ago! but he has been using his knowledge and technology to impact on other living organisms (the biodiversity) that have taken more than 600 million years to develop. In this review, the concept of biodiversity is considered beyond the physical/morphological manifestation of plants, animals and the microbes (i.e. species diversity), and further defined in terms of genetic, behavioral, life-history, physiological and other diversities. The paper examines the essence of biodiversity from the perspectives of food production, drug development, inexhaustible genetic resources and ecosystem services but regrets to note the unsustainable manner of its exploitation by humans. Additionally, it highlights the necessity for reducing ecological footprints (and increasing our handprints) as a way out of this environmental challenge. The paper concludes that our planet is sick, and the basis of our existence is being undermined with the onset of biological poverty. It therefore recommends that everyone of us should begin to use our "healing hands" to compensate for the damage we have done or are doing directly or indirectly to biodiversity.

KEYWORDS

Biodiversity, Forest conservation, Natural resource, Over-exploitation of resources, Sustainable development

1. INTRODUCTION

Biology is the study of living organisms, including their structure, functioning, evolution, distribution and interrelationships. The organisms, are many and varied, including the trees, the ants, the microbes and man himself, all of which have taken several millions of years to evolve and occupy the planet earth. Although, these living things taken together, are often simply called the biological diversity or biodiversity of our planet, but it is important to note that the meaning of biodiversity actually transcends the physical manifestation of these organisms. It can be broadened to include pretty much anything that has to do with the living world, and hence, it is another way of talking about "Nature" or "Environment" or "Mother Earth. As vague as its definition may seem, biodiversity is not only useful to man, he himself is part of it, and it is all that man has and requires to survive on this planet.

1.1 What is Biodiversity?

Although not a simple term to define, biodiversity has been variously defined as follows: The millions of plants, animals, and microorganisms, the genes they contain, and the intricate ecosystems they help build into the living environment. It is a collective term meaning the totality and variety of life on earth, including genetic diversity within species, the variety among species, and the range of ecosystems within which life exists and interacts [1]. It refers to the variability among living organisms from all sources including 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 [2].

From these definitions, one could easily deduce that biodiversity is complex with many components.

1.2 What are the Components of Biodiversity?

1.2.1 Species Diversity

The units that we tend to focus on are species, because they are most tangible and easiest to study. Species diversity is generally defined as the number of species and abundance of each species that live in a particular location [3]. At the species level, there are morphological, behavioral, life-history, physiological, and taxonomic aspects to diversity. Species diversity include variation in the numbers of species (= **species richness**), the relative abundance of species (= **evenness**), and variation in the distribution of species in space (= **turnover**, or **beta-diversity**). As we assess the species diversity of a particular place, or group of organisms, issues also arise as to the relative "value" of different species. Some are often regarded as more valuable than others; e.g., people tend to pay more attention to species that are large, conspicuous, and colorful than to species that are not. 'The keystone species' and 'ecosystem engineers' are particularly given more attention than the others. Species that have some human use often also get valued more highly. As such our attempts at describing patterns of biodiversity are based on information about a few particular groups (e.g. birds, mammals, butterflies, tiger beetles), which are not necessarily representative of all organisms. In the real sense of the matter, the relatively inconspicuous and little-known species also do have their values.

1.2.2 Genetic Diversity

The genetic variation that exists both within and among species forms another important component of biological diversity and is the basis for evolutionary change. Without it, future change will not occur. In some cases, genetic variation can also play a role in determining whether a population will persist or go extinct [4]. Genetic variation exists in a number of forms and can be measured in several ways. Examples include the number of polymorphic genes (i.e., genes with multiple alleles), the number of alleles each gene has, the number of heterozygous individuals in a population, etc. Genetic diversity should not be viewed as just of intrinsic value to species, but also can be important for humans too. For example, genetic variation is the basis for crop breeding. In some cases, the introduction of genes from ancestral (wild) stocks has improved the productivity of existing crops. The development of genetically modified organisms also depends on the presence of genetic diversity [5].

1.2.3 Population Structure

Diversity observed within species can also involve variation in population

structure – i.e., the presence of sub-populations within a species that differ from one another. These sub-populations may have subtle genetic differences and they may have behavioral or morphological differences, or they may act in an ecologically different manner (e.g., due to the different combinations of species that they interact with). Maintaining species throughout their ranges or population variability, is therefore important to biodiversity protection.

1.2.4 Communities

An assemblage of many species constitutes a community of organisms, and biological communities depict another type of diversity. As it were, different communities include different combinations of species and perhaps have different (emergent) properties of their own. In fact, community diversity is that which often influences the way we see the world. The “habitats” we recognize are actually different communities of organisms. So, maintaining a diverse collection of habitats involves thinking about diversity at the community level, as explained by the Species-Area Model [6,7].

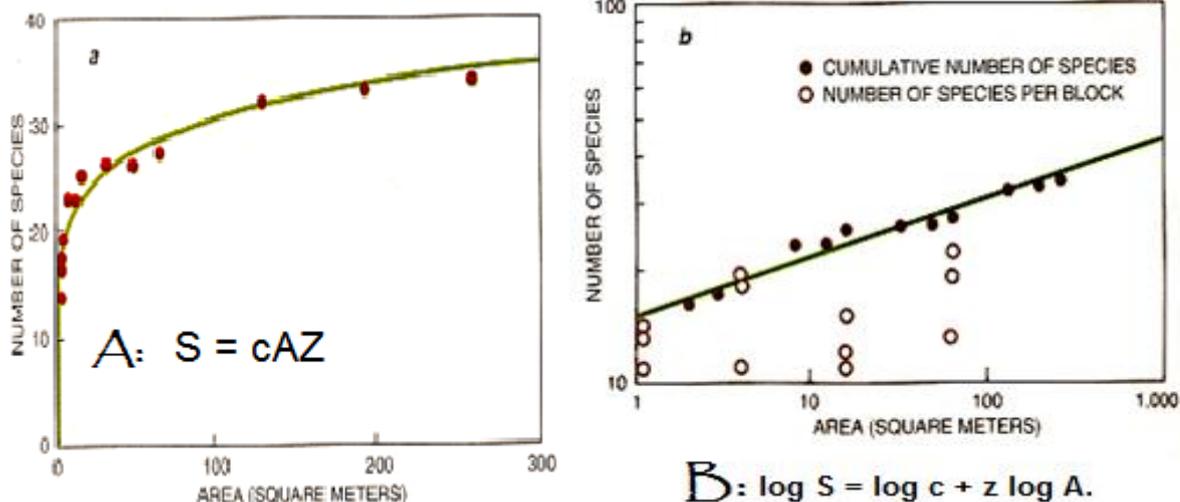


Figure 1: Species Area Curve

1.2.5 Ecological and Abiotic Processes

There is a diversity of ways in which organisms interact with each other and with their environment. In return, there is a diversity of forms in which the environment (biotic or physical) influences the organisms. These reciprocal interactions are different solutions to the problem of how to survive and reproduce. Although abiotic processes themselves are not really a part of biological diversity, they play a critical role in determining how ecosystems function and in influencing the level of diversity of different types.

1.2.6 Biological Phenomena

There is a multitude of phenomena, which ordinarily do not easily fit into one of the components of biodiversity earlier enumerated, but which nonetheless represent components of the diversity of the natural world. A biological phenomenon is the series of chemical reactions or other events that result in a transformation. These are regulated by various means like gene expression, protein modification etc. and include things like photosynthesis, respiration, metabolism, fertilization, migration, tissue transportation, transpiration and so on. Often these are considered to be a component of biodiversity.

2. HOW MANY SPECIES ARE THERE ON EARTH?

As it has been noted, the concept of biodiversity goes beyond only species diversity. However, approaching the issue from the point of view of species diversity seems to be easier than other points of view, the species being tangible and convenient to study with other aspects of diversity (morphological, behavioral, life-history, physiological, taxonomic, etc.), being readily conceived at this level. Estimates of the number of species on

earth vary from 3 million to 100 million. The UN Convention on Biological Diversity says there are some 13 million species, of which 1.75 million have been described [8]. The IUCN’s 2008 Red List of Threatened Species states that 1.8 million species have been described out of an estimated 5 million to 30 million in existence [9]. Figure 2 shows the estimated percentage composition of the described species on earth, with vertebrates (including humans) constituting only 2.7%

Table 1: Number of Described Species on Earth

	Species	Number
1	Bacteria	4,000
2	Protoctists (Algae, Protozoa)	80,000
3	Animals (Vertebrates)	52,000
4	Animals (invertebrates)	1,272,000
5	Fungi	72,000
6	Plants	270,000
	Total described species	1,750,000
	Possible total (including unknown species)	14, 000,000

Source: United Nations Convention on Biological Diversity (2003).

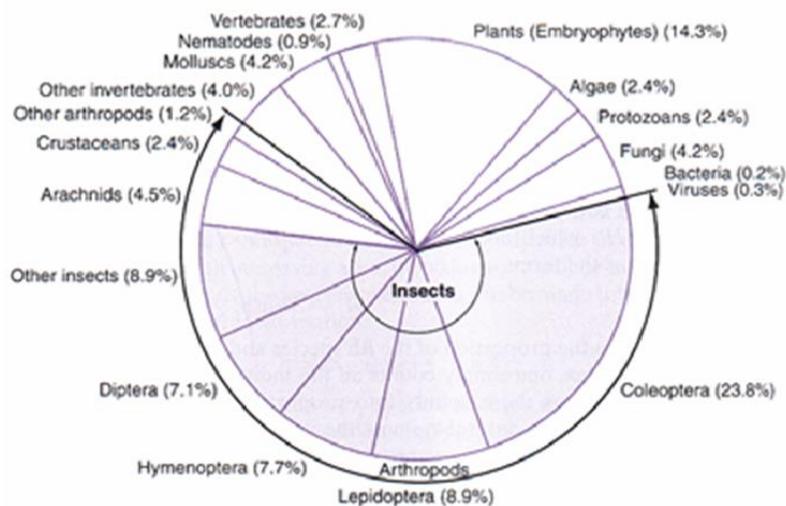


Figure 2: The Percent distribution of Known Species of living Organisms on Earth

3. WHAT IS THE ESSENCE OF BIODIVERSITY?

Biodiversity is a very important factor in determining how conducive for living the world is or will be for us [10]. It forms the basis of every aspect of our lives including food, medicine, shelter, energy generation, and clothing. Biodiversity is instrumental to the health and growth of economies, societies and individuals, through the provision of services such as the provision of food, raw materials, medicine, and water; regulating the climate; contributing to air and water quantity and quality; and mitigating natural hazards, all through the ecosystem [11]. All over the world, human beings use at least 40,000 species of plants and animals for these and other purposes on daily basis [12]. We have to protect biodiversity because of the innumerable benefits being derived directly or indirectly from it at the moment, and many more that are potentially derivable but whose technology for doing so is not yet known to us. In providing these services to humans, biodiversity can be understood as delivering natural assets and hence be seen as a "natural capital", which exists alongside manufactured, financial, social and human capital. Additionally, and perhaps most importantly, biodiversity should be protected for the sake of many benefits which may never be known to us in this generation. Much of the biological wealth so far known represents a huge resource for mankind waiting to be tapped now or in future. Such species of plant, animal or microbe may turn out to be a 'gold mine' in future, but only if it is not allowed to get lost now. As at the moment, some of the benefits derivable by man from the biological wealth around him can be summarized under the following six interrelated headings:

3.1 Biodiversity is a Valuable Natural Resource

Natural resources are valuable for their biological, economic and recreational uses as well as their natural beauty and importance to local cultures. Biodiversity falls in the category of renewable natural resources. Of the vast plant and animal resources, only very few (less than 10%) have been domesticated, the majority being in the wild [13]. Perhaps the most practicable ways to demonstrate the essence of biodiversity to man are in food production and medicine. In addition, other basic necessities of man such as housing and clothing cannot be realized but for the gift of biodiversity.

Man has been cultivating plant species for food since over 10,000 years ago and up to 2,500 species have been so cultivated. However only about 20 species provide 95% of the world's food, and of these, just four namely wheat, rice, corn and potatoes feed more people than the next 20 crops combined [14]. Of about 270,000 plant species that have been documented, hardly 10% have been investigated in a very cursory way to assess their utility, and only about 1% has been studied in detail. Much less has even been done in the case of animal species. This implies that the biological wealth so far known represents a huge resource for mankind waiting to be tapped but it may be short-sighted to sit back and rely on just the few varieties of plant species being used as food sources. Suppose a disease or pesticide-resistant insect devastated a plant species for food! then we might be tempted to turn to one of the numerous others (about 30,000 varieties) or so, of plants that have potentially edible parts. Such a

plant could be useful for food at that moment if it had not been allowed to degenerate or get lost earlier.

Biodiversity also constitutes a vast potential resource for new medicines that can be directly formulated from plants or copied from them. Ten of the world's 25 top-selling drugs in 1997 were derived from natural sources. The global market value of pharmaceuticals derived from genetic resources is estimated at US\$75 billion to US\$150 billion annually. Some 80 per cent of the world's population relies on traditional medicines and these are derived directly from natural sources. In China, for example, more than 5,000 of the estimated 30,000 identified domestic species of plants are used for medicinal purposes [15].

More than 40 per cent of all prescriptions written in the United States contain one or more drugs that originated from wild species of fungi, bacteria, plants and animals [16]. The rosy periwinkle (*Catharathus roseus*), which originated in Madagascar yields two substances that have been found useful in treating Hodgkin's disease and acute lymphocytic leukemia. Cat's claw (*Uncaria tomentosa*) has been shown to be anti-inflammatory agent that helps fortify the body's immune system. It is also known to inhibit the growth of cancer cells and is effective in treatment of arthritis. The antibiotic Penicillin is obtained from a fungus (*Penicillium*) while chloroquine is obtained from *Cinchona* bark. Imagine the plight of mankind if these and many other medicinally useful plants have disappeared before their curative properties were discovered.

Microorganisms are more diverse in their numbers, kinds, versatility and ecological niches than other forms of life. They play important roles as sources of enzymes for biocatalysis production of fermented foods and drinks, sources of drugs, nutraceuticals and bioactive compounds, generation of biofuels, mining and leaching of minerals, production of biofertilizers, production of biopesticides, single-cell proteins and probiotics, production of fine chemicals and production of biopolymers.

Other than for food and medicine, biodiversity also constitutes valuable resources in many other areas of human need such as in clothing (vegetable fibre such as cotton), provision of shelter (e.g. with timber), wealth creation (through lumbering, fuel wood gathering, charcoal making, hunting, traditional pharmacy), recreation (as in botanical/zoological gardens), religion (shrines), culture (groves) and so on.

3.2 Biological Wealth as a Valuable Genetic Resource

Repeated cultivation of a crop variety over long periods of time under human care gradually reduces its vigour and productivity. Sometimes, problems can arise due to environmental changes (abiotic e.g. climatic, and biotic e.g. pests), and such changes may require better adapted varieties in order to maintain productivity (e.g. yield, quality, etc.). Pests and diseases (like the crops), also undergo changes, so, virulent strains sometimes spring up to cause extensive damage to cultivated species. In short, all living organisms, wild or cultivated are constantly undergoing changes due to environmental pressures, and their magnitude of resistance to

these pressures varies in accordance with their genetic constitution. Desirable yield, quality, and resistance to diseases, pests and adverse climatic conditions for example are due to these genetic factors (i.e. a combination of genes), which are believed to be scattered/distributed in different strains or varieties, including the wild relatives of the cultivated species. An improved variety is therefore one, which contains a higher number of useful traits or desirable genes.

The fact is that most of the improved varieties being cultivated now are synthetic or hybrid varieties as they incorporate in them genes from a number of other varieties. This practice is an unending process. With changes in biotic or abiotic environment and quality specifications, strains once in common use are no longer acceptable. Hence, breeders in their 'hide and seek games' on genes, have been using breeding techniques, especially to pool together useful genes into the varieties cultivated so as to match them with quality requirements and the prevailing conditions of cultivation. In order to do so successfully, we should possess an assortment of traits (a large number of characteristics) or gene pool as large as possible for breeding and improvement of domesticated strains of plants and animals.

The wild relatives and old traditional varieties of domesticated plants and animals constitute a vital genetic resource for us. The genetic organization of the wild plants and animals has been evolving for millions of years. It has successfully withstood the tests and trials of a perpetually changing environment for ages. Their genetic makeup represents answer to problems which have never been imagined by a biologist. The same story is true for old varieties which have been under cultivation for hundreds of years. There are many instances when useful genes in wild species or in old traditional varieties were used to improve the strains we cultivate today. For example, genes for resistance to powdery mildew were obtained from a wild melon in India and introduced in the cultivated musk melon in California. So also, two species of wild tomato discovered in Peru have been used to produce better pigmentation and a higher solid matter content (i.e. more pulp) in cultivated tomatoes.

No one can anticipate the traits or genes which shall be needed in future to improve the cultivated varieties of the time as our environment keeps changing. Under such conditions we should have a collection of traits or gene pool as large as possible. It is only from this pool that we can synthesize the cultivars of future. Reduction in biological diversity (particularly, the wild species) shall inflict irreparable damage to future breeding and improvement activities, thereby depriving us of adequate food supply.

The versatility of microorganisms is largely due to their diverse genetic diversity that enables them to survive in all kinds of environment (where other life forms cannot be found) and to possess potent metabolic machineries that can metabolize virtually all naturally occurring compounds, including xenobiotics. Their rich genetic constituents laid the foundation for molecular biology as several enzymes such as lignases, polymerases, restriction endonucleases etc. are derived from microorganisms. Through microbes, recombinant DNA technology is made possible to create novel transgenic animals, recombinant cells and genetically modified plants.

3.3 Biological Diversity as an Instrument for Maintaining a Stable and Healthy Ecosystem

Healthy ecosystem is premised upon the diversity of life forms. This diversity brings about a system of complex interactions between various components which occur in a state of dynamic equilibrium. It is a system of checks and balance in which, to every action, there is an equal and opposite reaction so that the final outcome is nil. No matter inconspicuous a species is, or is presumed to be, it occupies a niche or performs a functional role which cannot exactly be taken up by another species. Hence if a species disappears, the niche is lost (missing niche) and stability is hampered. On the other hand, if an exotic species immigrates or is introduced into an erstwhile stable ecosystem, the equilibrium will be impacted at least for a while before stability is restored, if at all. This submission is without prejudice to 'keystone' species, which are by virtue of their interactions with others are important to the continued existence of their ecosystems. The extinction of a keystone species is predicted to cause a cascade of further extinctions.

The concept of ecosystem stability can easily be understood from the point of view of say economic value, health benefits, population distribution, transportation etc. in a typical human society (an ecological setting) in relation to adjoining biodiversity. Ecological economists study the relationship between economics and ecology. In 2004, research showed that conserving tropical forests could increase profits for coffee farmers in Costa Rica. The study showed that the closer coffee bushes are planted to patches of forest, the more and better-quality beans they produce, thanks to greater pollination by wild bees. Extra pollination provided by bees in these forest patches increased the Costa Rican coffee farm's income by 7 per cent [17].

Microorganisms play dominant role in maintaining healthy environment through biodegradation, nutrient cycling and bioremediation. They also contribute to breakdown of pollutants and are involved in several nutrient cycles.

3.4 Biodiversity as a Means of Optimum Utilization and Conservation of Abiotic Resources in an Ecosystem

An ecosystem is an integrated system of biodiversity along with abiotic components and factors interacting to yield an entity in equilibrium. While the biotic components thrive with the support of the abiotic factors such as soil and climate, the optimum utilization and conservation of abiotic resources in turn are dependent on the quantity and quality (i.e. diversity) of its biological components. In ecosystems with low biodiversity, the uptake of nutrients is not so efficient. So much of the mineral matter remains in the soil while organic material lies on the forest floor. The mineral matter is therefore prone to loss due to flow of water. The situation in the tropics effectively prevents nutrient losses. The rich biotic community is sustained largely by recycled nutrients. Mineral nutrients are made inaccessible to the flowing waters, rains and floods, which are frequent in humid tropics. Luxuriant growth of vegetation hinders rapid flow of water, binds soil particles together and prevents soil erosion. Much of nutrients which dissolve out are taken up again as water is retained for longer duration in the system. In the non-tropics on the other hand, reduction in biodiversity reduces the efficiency of this vital machinery which in turn results in rapid loss of nutrients and degradation of soils. The activities of microorganisms in nutrient cycling are key to conservation of abiotic resources such as the minerals and atmospheric gaseous composition in an ecosystem.

3.5 Protection of Biodiversity, a Must Due to Increasing Wave of Disappearance of Species (i.e. Extinction)

A species is classified as extinct if a single individual member cannot be found despite exhaustive surveys over a long period of time. According to the IUCN (2017), there are different categories of threat to biodiversity listed in order of increasing severity as Data Deficient (DD), Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN), Critically Endangered (CR), Extinct in the Wild (EW), and Extinct (EX). To be classified as threatened, a species must have been evaluated based on some quantitative criteria related to extinction risk such as population size, rate of population decline, area of geographical distribution and degree to which its population has been fragmented (Tables 2 and 3). Meanwhile, the five major threats to biodiversity include climate change, deforestation and habitat loss, overexploitation of resources, occurrence of invasive species and pollution, all of which can arise due to anthropogenic influences. The essence of biodiversity to humans is realizable only if concerted and conscious efforts are geared towards its conservation.

Population structure and genetic constitution of microorganisms are also adversely impacted through various activities of man that promote mutation, loss of genetic elements and lateral gene transfer. The risk of wide dissemination of antibiotic-resistant genes among microbes contributes to failure in healthcare systems.

3.6 Biodiversity in Scientific Research, Innovation and Technological Breakthroughs

Abundance and frequency of vocalizing frogs as well as their visual encounters and trapping have been used as indicators of successes recorded in ecosystem restoration [18]. Several species of plants and animals are used as indicator organisms (bio-indicators) for pollution in

aquatic and terrestrial ecosystems. Through studies on microorganisms, we are now into recombinant DNA technology which has resulted in creation of novel plants and animals. Microbes are also potent tools to

study a number of biological phenomena, and they have continued to serve as model organisms in several investigations.

Table 2: Species of Plants and Animals that are Extinct or Extinct in the Wild

	Extinct	Extinct in the Wild	Total
Vertebrates			
Mammals	76	2	78
Birds	133	4	137
Reptiles	20	1	21
Amphibians	37	2	39
Fishes	90	13	103
Sub-total	36	22	378
Invertebrates			
Insects	60	1	61
Crustaceans	7	1	8
Molluscs	295	14	309
Others	1	0	1
Sub-total	363	16	379
Plants			
Mosses	2	0	2
Ferns	3	0	3
Gymnosperms	0	4	4
Dicots	77	22	99
Monocots	2	2	4
Sub-total	84	28	112
Grand-total	803	66	869

Source: IUCN Red list of threatened species, 2009

4. NATURE OF MAN IN THE COSMOS

Humans, with our 6 billion population on earth constitute just one of the 1.7 million species described, but we have been using our knowledge and technology to alter our environment, including the biodiversity, for better

or for worse. In conducting our life, we must never let ourselves ignore the natural order of things. We still preserve the illusion of being privileged among living beings and of escaping the common law. The sense of being free gives us a deceptive confidence. We believe that our situation is vastly superior to that of bacteria, trees or animals. It is however important for us to have a clear idea of our true place in nature.

Table 3: Rate of Extinction in Recent Years

	No of Species Described	No of Species Evaluated, 2010	% (of No described) threatened, 2010
Vertebrates			
Mammals	5490	5490	21
Birds	9998	9998	12
Reptiles	9084	1672	5
Amphibians	6433	6284	29
Fishes	31,300	4,446	5
Sub-total	62305	27890	10
Invertebrates			
Insects	1,000,000	2,888	0.06
Molluscs	850,000	2,305	1
Crustaceans	47,000	1,735	1
Others	173,250	755	30
Sub-total	1,305,250	7,881	34

Source: IUCN Red list of threatened species, 2009

The Biblical account aptly describes the situation prior to our existence here on earth, detailing the progression from chaos (disorder) to cosmos (orderliness), which culminated in the existence of the first human being. Cosmos refers to the world or universe, occurring as an orderly, harmonious system, where natural laws apply, and are to be obeyed. Since this beginning, many philosophers have tried to explain the nature of man and his purpose here. They were led to know that human body is an autonomous unit made up of tissues, blood and consciousness, the three elements being distinct but inseparable from each other. These three elements are equally inseparable, though distinct from the physical, chemical and psychological milieu in which we are immersed (i.e. our environment). Unfortunately, with the wealth of their knowledge, humans often make the mistake of observing natural phenomena as if they themselves stand outside nature. Whatever we do or say, we can never break the bonds which bind us to the earth from which we sprang. The will of man to alter the structure (or order) of the universe will always be impotent. Since we are part of nature (just a little fragment for that matter), we must conform to her laws as advised by Epictetus (55-135AD), "We must be that which it is in our very essence to be".

4.1 Man's Impact on Earth and Ultimately on Biodiversity

Man arrived this planet earth only recently (about 1 million years ago!), and his existence depends on health and wellbeing of other forms in the biosphere. Regrettably enough, man has chosen to become an agent of his own destruction. Due mainly to human activities and influence, we are losing the accumulated heritage of millions of years (i.e. biodiversity) at a fast rate (Table 2) Human beings have an enormous impact on the natural environment, and ultimately on each other (through the way we choose to house, clothe, shelter, and meet the needs for vital resources such as food, energy, and water). It is disheartening to note that some of the worst problems of humanity have either been brought about or aggravated by science and technology: application of an array of our scientific discoveries and inventions, generation of hazardous chemicals e.g. man-made radioactive substances, misuse of biotechnology e.g. instruments of biological warfare, genetic engineering etc, origination of the nuclear dilemma e.g. nuclear bomb, hydrogen bomb, etc. [19]. Strictly speaking, this is not development; it is destruction, and we scientists should be responsible for the foreseeable consequences of our research – good or bad [20].

Those who care shall observe that due mainly to astronomical increase in human population coupled with unsustainable lifestyles, the following

undesirable changes have occurred or are taking place around us: stock of many vital resources are diminishing rapidly, biodiversity is declining rapidly, deserts are expanding, soils are degenerating at a fast rate, wildlife habitats are disappearing, toxic poisons circulate from air, water, and soil to food and are bio-accumulated up the food chain, accumulation of greenhouse gases threatens to change climatic systems, there are increasing armed conflicts between nations, and poverty, hunger, starvation and diseases are the order of the day in many nations.

From all indications, our planet is sick, the basis of our existence is being undermined, with the onset of biological poverty, and everyone seems to be looking the other way! That we shall continue to benefit from science and technology is undisputable, but as we err by using these tools to create disorder, our universe shall continue to promptly call us to order, sometimes in the most calamitous manner. There is therefore the necessity to stop and appraise the state of the cosmos, our global environment, and begin to do the needful. Energy from the sun is much more than required by us now and by the generations yet unborn. In fact, only 1 to 2% of the photosynthetically active radiation that strikes the earth is converted by vegetation cover into carbohydrates; while much is wasted [21]. It is our fault not to have acquired adequate technology to tap this resource to the maximum. We should stop polluting the environment now.

5. INTERCONNECTEDNESS OF THE LIVING WORLD AND THE CONCEPT OF MISSING NICHE

In a healthy ecosystem, there is a system of complex interactions between various components which occur in a state of dynamic equilibrium. As such in an ecosystem, everything is related to everything else. This system of checks and balance is of a fundamental importance in an ecosystem which is maintained in a functional state by the activity of a large number and types of organisms. In a complicated ecosystem with several trophic levels each of which is composed of several species, elimination of a single species or few species may not create any problems. This is because there are many other species or alternatives which can take over and keep the system in a functional state. In a simple system however, loss of a single or few species could be catastrophic because of the lack of alternatives (i.e. missing niches). Thus, diversity truly imparts stability in an ecosystem.

We shall continue to realize that creatures thought of as useless or undesirable, actually do play crucial roles in a natural ecosystem. For instance, predators driven to extinction no longer control rodents which damage our crops; earthworms and termites killed by pesticides do not aerate our soils anymore; and mangroves, destroyed to supply firewood have stopped protecting our coast line from erosion. Frogs eat mosquitoes, serve as bio-indicator, food for birds, fish and monkeys, and their larvae

filter drinking water [22]. In Pakistan as well as in India, diminishing frog population has been associated with increased rate of pest damage to crops and recurrence of malaria fever. The foregoing points, to the fact that we cannot dismiss any life-form in this complex biosphere as useless. Each species occupies a unique niche; it has its own importance. Disappearance of any of the component species in an ecosystem shows itself up in the form of altered structure and/or function in the ecosystem which may not be apparent for the time being, but it is bound to have serious long-range consequences.

5.1 Which Way Out?

Have you ever wondered how much "nature" your lifestyle requires? Or how much of the potential vital resources of the earth disappears owing to your habit or way of life. The Footprint and the Handprint are two complementary concepts that help people like you and me to find their own best way to lead a more sustainable lifestyle that would contribute towards a sustainable society and planet. Ecological Footprint is a measure of human pressure on earth's resources or a measure of the sustainability of our lifestyles [23]. Handprint is a measure of what we can do individually, and together, to restore the balance between consumption and the planet's carrying capacity. Whereas Footprint measures our impact on the planet and its resources, Handprint will help quantify what we do to tread lightly on the earth. Handprint measures the positive impacts we can make, simply by changing the way we do things at home, and at work e.g. reducing our consumption of energy and resources and being more considerate about the pollution and waste we generate. A country, a company or a private individual can analyze how much pressure it applies on the environment and use this to compute its ecological/environmental footprint.

Ecological footprint is defined/calculated as the land area (in hectares) that would be needed to meet the consumption of a person/an organization/a population and to absorb all their waste (Figure 2). Different formulas and online tools (footprint calculators) are in use today, e.g. <https://www.footprintcalculator.org/>; <https://footprint.wwf.org.uk/>; and <https://www.carbonfootprint.com/calculator>. The ultimate goal is to calculate the number of earths that human society would need, given that everyone followed a certain lifestyle. In doing this, ecological footprint tracks the use of six categories of productive surface areas of the earth namely, cropland, grazing land, fishing ground, built-up land, forest area and carbon demand on land. These demands include space for food growing, fiber production, timber regeneration, absorption of carbon dioxide emissions from fossil fuel burning, and accommodating built infrastructure. Hence, the principal components of Footprints include Food, Housing, Carbon, and Goods and Services Footprints [24].

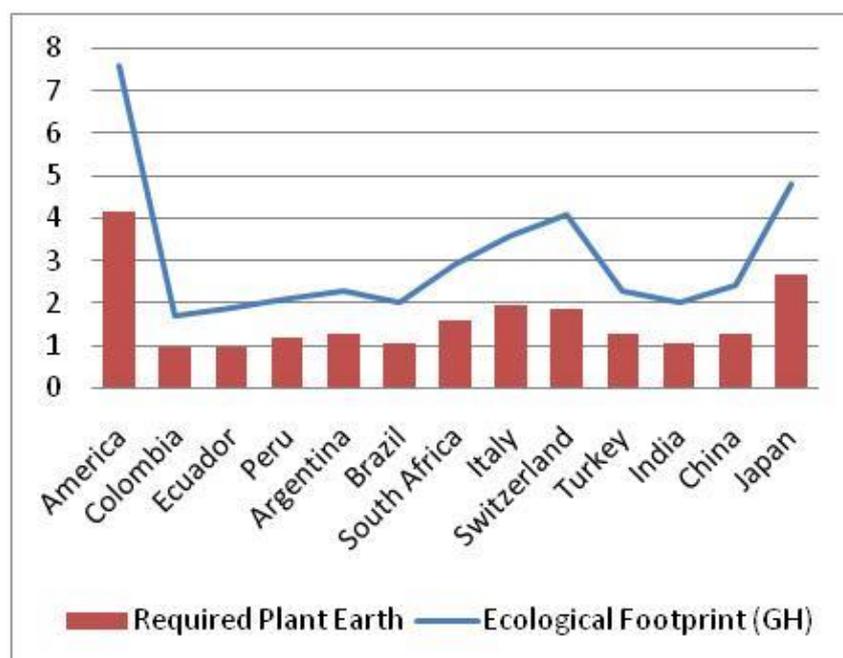


Figure 2: Ecological footprint and required plant earth in different countries

In order to appreciate the significance of information on ecological footprints in bridging science, policy and economics, the Global Footprint Network introduces the concept of biocapacity. Biocapacity is measured by calculating the amount of biologically productive land and sea areas available to provide the resources a population consumes and to absorb its wastes, given current technology and management practices. In order to make biocapacity comparable across space and time, areas are adjusted proportionally to their biological productivity (expressed in Global Hectares). The results from this analysis give an indication of a country's ecological impact. A country is said to have an **ecological reserve** if its Footprint is smaller than its biocapacity; otherwise it is operating with an **ecological deficit** (referred to as **ecological creditors**, and **ecological debtors** respectively).

By definition, ecological handprint is a symbol of, measure for, and commitment to positive action on the planet earth. Rather than sitting around blaming the developed world for their higher carbon emissions, we must change to a more eco-friendly, sustainable lifestyle and do our part to create a cleaner, greener and friendly world. The campaign is to reduce Footprints and increase Handprints (Inverse relationship). We can all use our "healing hands" to compensate for the damage we are doing to

our environment. Want to make a difference?, then consider the following actions: Plant trees, save trees; cut down on car use, hop on a bicycle if possible to reduce emissions; buy food from local markets, and buy in season, every exotic food bought has its contribution of carbon footprint; use resources efficiently (electricity, paper, etc.); say no to plastic bags; buy wisely (environmental friendliness) and go for actual needs; as all commodities carry with them an embedded amount of bio productive land and sea area necessary to produce them and sequester the associated waste. International trade flows can thus be seen as flows of embedded ecological footprint.

Transition to "Green Economy" is now necessary and so important to us than ever before. UNEP (2011) defines a green economy as "one that results in improved human well-being and social equity, even as it significantly reduces environmental risks and ecological scarcities [25]. In its simplest expression, a green economy can be thought of as one which is low in carbon, resource efficient and socially inclusive". Critically, the green economy concept is more than merely "greening" economic sectors, it is a means of achieving the sustainable development imperatives such as improving the wellbeing of man, increasing social equity, reducing environmental hazards and reducing ecological scarcities (Figure 3).

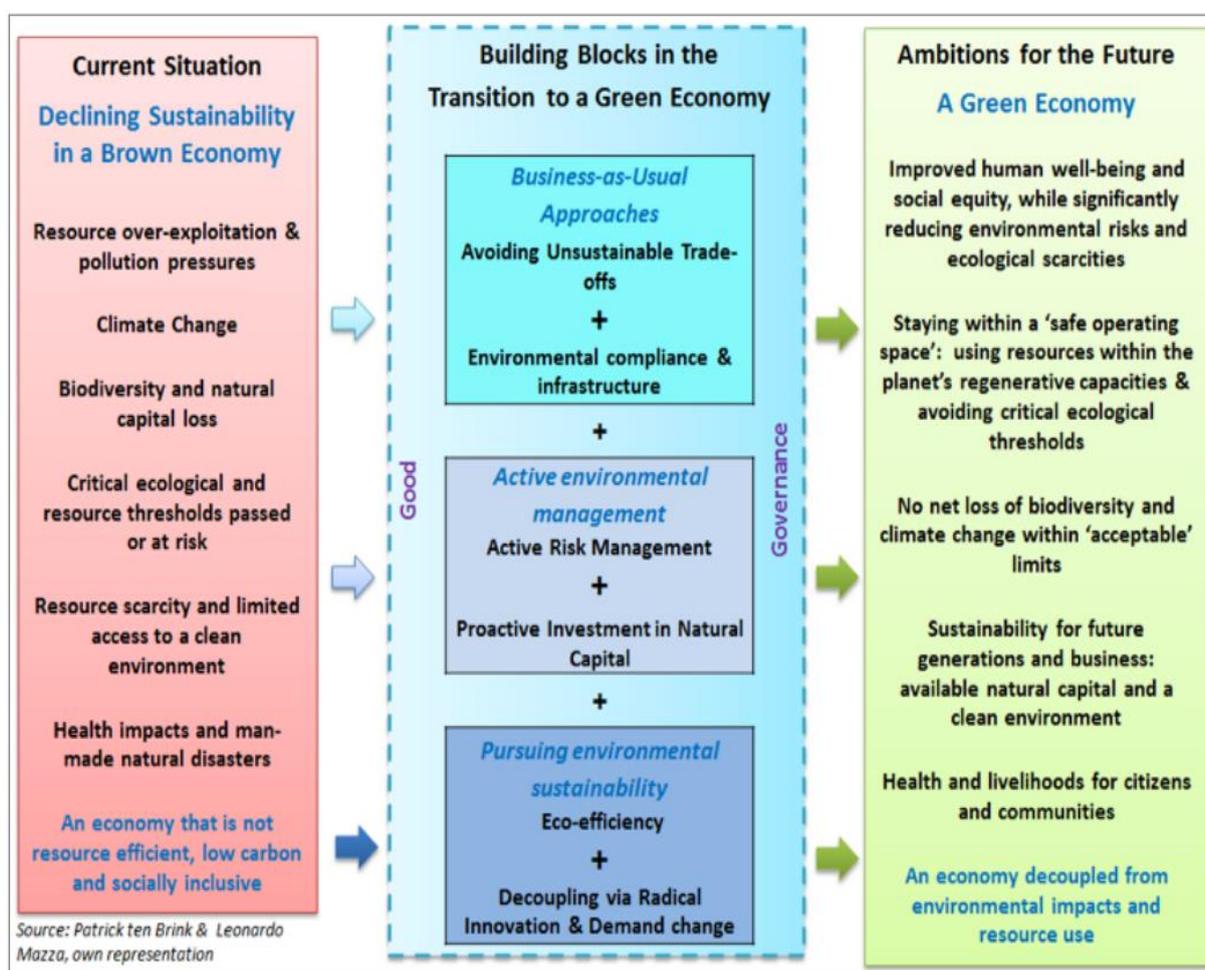


Figure 3: The key components and instruments to enable ease of transition to a green economy [26].

Human and societal health depends on biodiversity. Where natural capital is degraded and lost, there is a risk that communities are malnourished, and humans suffer. In contrast, the efforts to restore, conserve and sustainably utilize natural capital can improve human well-being, support livelihood and increase socio-economic and intergenerational equity [27]. In South Africa as an example, interventions by the government to restore and improve wetlands have not only provided much needed employment opportunities but have also increased the capacity of the wetlands to provide essential services to the poor, including crop and reed production, water for domestic purposes, grazing for livestock, etc. [28].

6. HOW MUCH OF BIODIVERSITY HAS BEEN SUSTAINABLY TAPPED?

Much has been said on the biological wealth on earth and its present and potential benefits for our existence. The question now is "has man taken enough advantage of this rich resource and in a sustainable manner?" The answer is No. As valuable as this natural resource is, much still remains unknown about biodiversity. Less than 1% of those microorganisms that are found in ambient environments are culturable and can be truly accounted for through conventional methods of isolation and identification. The extremophiles that are found in extreme environments are poorly studied altogether.

Well above 99% of the wealth of plants and animal origin still remains untapped by man. Of the 270,000 species of plants so far described for example, only about 20 are known to provide us with food. This is a far cry

from what ought to be. Additionally, the number of species so far documented in the development of new medicines is negligible compared to the number described. Even with our knowledge of genetic engineering spanning through about twenty years in 2014, only 26 plant species have been genetically modified and approved for commercial release [29]. On biodiversity conservation too, the net result of human activities has not been encouraging, and everyone should ask himself "how big is my ecological handprint?".

The summary of the situation is that biodiversity remains largely underutilized in terms of diversification, and its exploitation so far has been unsustainable [30]. True, biodiversity is vast, but regrettably enough; the biologists are reducing in number by the day. It is not clear what the future holds about this development in Nigeria as only few parents/guardians want their wards to take up a career in biological sciences when seeking admission into the Universities for the fear that they would later become 'ordinary biology teachers' [32].

7. CONCLUSION

The existence of all the organisms as well as the non-living components in the world depends solely on the awareness and kindness of man. His actions or inaction have heavily impacted on the climatic systems, which has taken its toll on biodiversity. Climate change is real; the effects are currently being felt all around us. Desserts are closing up on us. Our atmosphere has been heated up. Greenhouse gases are all around us. Hazardous ultraviolet radiations are penetrating deep into our living tissues. Flooding is rampant. Our soils and coast lines are being eroded. Biodiversity is disappearing fast. Our life support system is under threat. Sustainable development is what we desire on this planet earth to ensure our continued existence as humans. This is development that meets the needs of the present without compromising the ability of future generations to meet their own needs; development that harmonizes economic gains and ecological necessities. Our experiences in the 21st century have ushered in a better understanding of sustainable development beyond a simple, one-sentence definition. The Rio Declaration on Environment and Development fleshes out the definition to generate specific actionable plans in form of 27 principles of sustainability, which are hereby summarized into five as follows:

1. Nations have the sovereign right to exploit their own resources, but without causing environmental damage beyond their borders and noting that development today must not undermine the development and environment needs of present and future generations.
2. Nations shall respect peoples' entitlement to a healthy and productive life in harmony with nature and develop international laws to provide compensation for damage that activities under their control cause to areas beyond their borders.
3. Nations shall use the precautionary approach to protect the environment; and where there are threats of serious or irreversible damage, scientific uncertainty shall not be used to postpone cost-effective measures to prevent environmental degradation.
4. Nations shall enact effective environmental laws and develop national law regarding liability for the victims of pollution and other environmental damage, the polluter being held responsible, in principle, to bear the cost of pollution and where they have authority, nations shall assess the environmental impact of proposed activities that are likely to have a significant adverse impact.
5. Nations shall hold that sustainable development requires better scientific understanding of the problems and also, the knowledge of indigenous people with full participation of women and youth, and hence Nations should recognize and support the identity, culture and interests of indigenous people and share knowledge and innovative technologies within and with neighbors to achieve the goal of sustainability.

8. RECOMMENDATIONS

The Nigerian people should make their democratically elected governments at various tiers to imbibe the political will towards

implementing the Rio Declaration on Environment and Development to which Nigeria was a signatory. The ruling class, through appropriate legislation, should see to domestication and enforcement of these principles. The Nigerian University system should consider professionalization, re-branding and re-packaging of academic programmes in Biological sciences as a means of encouraging up-coming generations to participate in this rescue mission. Everyone should also accept and perceive biodiversity as an integral component of our life support system that must not be allowed to suffer. Lastly, in compliance with Mahatma Gandhi's warning that "the earth provides enough to satisfy every man's need, but not every man's greed", all of us should begin to use our "healing hands" to compensate for the damage we have done or are doing directly or indirectly to biodiversity.

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