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Why biodiversity matters: A review of the arguments, and counter-arguments, for the conservation of the diversity of life

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Abstract
The impact of human activities on the biosphere has accelerated rapidly during the last 200 years, and particularly so since the second half of the 20th century consequent upon an exponential rate of population growth combined with scientific and technological developments. Advances in technology continue to facilitate the exploitation of the world's organic resources and the manipulation of its physical environment. This has called for increased efforts towards the conservation of the world's biodiversity so as to reduce the rapid rate of species extinction and decline. This review paper explores the arguments and counter-arguments that have been put forward for the conservation of biological diversity. The ultimate purpose of the review is to broaden the horizon on the value of biodiversity, which will help in diminishing the narrow, humanistic valuation of biodiversity largely responsible for the current biodiversity crisis. Indeed, one of the causes of the accelerated loss of biodiversity has been the utilitarian and human-centred argument that has largely been put forward as justification for the conservation of the world's biodiversity. The major weakness with a conservation system based on economic motives is that most members of the biological community do not have immediate economic value. Therefore, justifying species preservation for utilitarian purposes predisposes many seemingly useless species to extinction. Only a moral or ethical argument for the conservation of biodiversity in which nature is conserved for its own sake, combined with sustainable use, can ensure a more effective conservation of the world's organic resources.

Keywords: biodiversity, conservation, ethical, extinction, moral, non-use value, species, use value, utilitarian

1. Introduction
Throughout the world, increasing interest is being expressed in environmental issues, largely as a result of the serious concern that is felt about the present state of both the local and global environment [1, 2]. Since the second half of the 20th century, the relationship between human beings and the natural environment has become a topic of widespread concern [3, 4]. It is now universally accepted that, according to present trends, the world must be expected to become more crowded, more polluted, less ecologically stable, and more vulnerable to natural hazards [5, 4, 6]. The present time is different from any other in history because of the rates at which humans are using resources, modifying natural systems, and increasing in their numbers [4, 7, 8]. In other words, the world is experiencing an environmental crisis.

One facet of the current global environmental crisis is the loss of biodiversity. By even the most conservative estimates, progressive degradation of ecosystem structure and function, with its associated loss of species, is occurring at an alarming rate due to a wide range of human activities [8, 9]. In spite of key gains in policy development, political participation, financial support and programme implementation throughout the world; the earth still faces an alarming downturn in its diversity of life [5, 6, 10, 9]. While extinction has always existed as a natural process, it has currently become a primarily human-sourced phenomenon especially since the second half of the 20th century due to increased human interaction with, and manipulation of biological resources [8, 11]. Habitat loss and degradation represent the leading threats to species, with the last 50-60 years witnessing major changes in the quantity and quality of tropical forests [12, 6, 13]. Deforestation rates are not decreasing in tropical forests while biodiversity hotspots appear under-protected [14]. It is estimated that one-fifth of all tropical forest cover was lost between 1960 and 1990 [15, 16, 9]. A study by the IUCN in 2000 revealed that changes in habitat affected 89% of all threatened birds, 83% of mammals and 91% of threatened plants that were assessed [9].

The IUCN Red List of Threatened Species has been documenting the threat status of flora and fauna for more than 50 years and is widely considered to be the most comprehensive dataset on the conservation status of species worldwide [17, 6]. The Red List has recorded that altogether 360 vertebrates, 373 invertebrates (of which 303 are molusks) and 110 plants are listed to having gone extinct since 1500 [18]. Given the high levels of ignorance surrounding precisely how many species there actually are, it is widely feared that far more species have disappeared, or are threatened than those recorded [18, 6], prompting some conservation biologists and other researchers to come up with even higher predicted yearly losses. For example, one researcher [19] suggested that the loss of tropical forests alone was removing between 4000 and 40000 species per year, while others [20] have estimated that over 1000 extinctions are occurring per million species per year.

The loss of biodiversity is brought about by a complex chain of causal factors, which can be grouped into proximate and

ultimate causes of loss (Figure 1) [21]. The proximate causes of loss include overexploitation of natural resources, invasion by alien species, pollution, climate change, alteration of hydrological systems and habitat alteration and loss. These processes are the ones which directly lead to biodiversity loss. On the other hand, the ultimate causes of biodiversity loss are socio-economic in nature and include market failure and policy distortions; the extremes of wealth and poverty; consumer attitudes and preferences; and human population dynamics [21].

From Figure 1, it is clear that biodiversity conservation can be achieved through action at two levels. Action at the proximate level is necessary to combat losses of biodiversity in the short-term, while action at the ultimate level seeks to prevent future losses and relieve the pressures on biodiversity in the long-term. Ultimately, the successful conservation of biodiversity relies on an in-depth and holistic understanding of the causal chain of biodiversity loss and the most effective points and types of intervention to reverse the process [21].

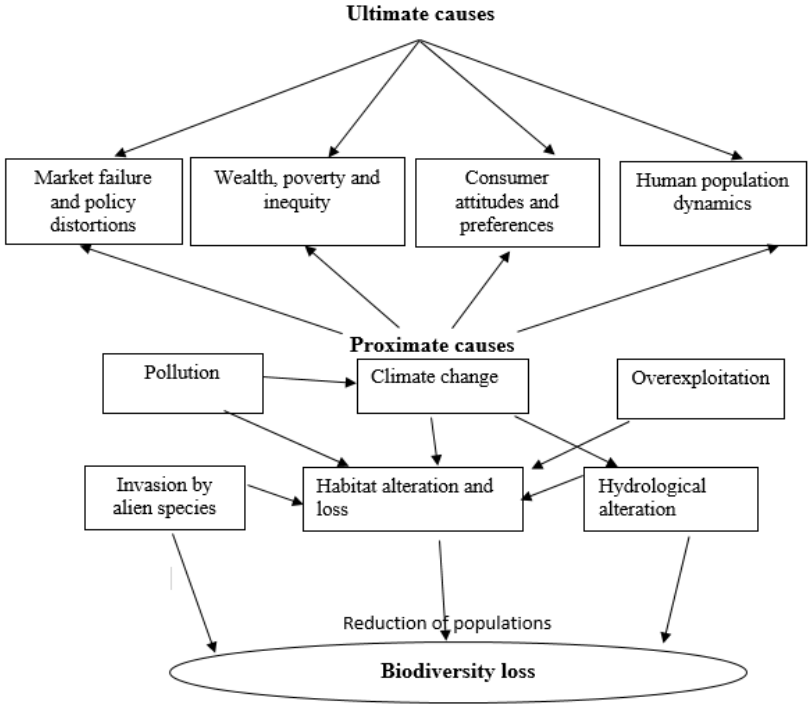

Fig 1: The proximate and ultimate causes of biodiversity loss [21]

The above discussion has shown that there is a downward trend in global biodiversity, and it has also been suggested that measures should be adopted so as to address this impending biodiversity crisis. An important question to ask, however, is: why biodiversity matters, why worry about biodiversity decline? This question is crucial to successful biodiversity conservation because it, in the first place, shapes man's attitude towards biodiversity, and will ultimately determine the nature of the response to the biodiversity crisis, and the urgency attached to such a response. In other words, the value that man attaches on biodiversity is the critical first step upon which all efforts towards effective biodiversity conservation are hinged. This review paper explores the various value justifications for saving biodiversity, including the limitations inherent in some of these value judgements. The ultimate purpose of the review exercise is to widen the value scope for biodiversity, which will help in shunning the narrow, humanistic and utilitarian justification for biodiversity conservation, which is largely to blame for the biodiversity crisis the world is currently experiencing.

2. Arguments and counter-arguments for biodiversity protection

The value of biodiversity has generally been categorised into two groups, namely, use values and non-use values. These are explored in detail below.

2.1 Use values of biodiversity: utilitarianism

Use values of biodiversity represent the practical values of elements of biodiversity to humankind [22]. These can further be sub-divided into direct and indirect values as discussed below.

2.1.1 Direct use values: the resource-based argument

Direct use values are those concerned with the enjoyment or satisfaction received directly from biodiversity [22, 23]. This kind of value is the easiest to appreciate as many people value things largely for their direct utility for humans [24, 25]. Although the direct use values are incomplete as a justification for saving biodiversity, such values are real [24] as shown below:

Food

Food is arguably the most important direct use of biodiversity [26, 27, 28, 29, 30]. This food takes forms that include vegetables, fruits, nuts, grains, meat, honey, and adjuncts to food in the form of food colourants, flavourings and preservatives [31, 32, 8]. Of the estimated 300000 species of flowering plants, about

12500 are considered to be edible to humans, although occasional use may embrace a much larger number, with around 200 plant species having been domesticated for food [31, 33]. Wild food sources still play a significant role in meeting the nutritional needs of people in many of the world's poorest nations [34, 35, 28, 33, 30, 36, 37, 38, 39, 40]. Reports have been made on the value of biodiversity as insurance against yield variability and also against total crop failure [41]. Even in the developed world where most of the foods eaten come from domesticated species, food supplies are critically dependant on wild populations, and a significant percentage continues to be foraged from the wild [42, 43].

The diversity of organisms exploited for food remains narrow when compared with their overall diversity, leaving significant potential for further exploitation [44, 26, 31, 45, 46, 47]. This gap is, however, being closed indirectly through the use of wild species and varieties to supply genes for the improvement of cultivated and domesticated species for increasing yields, tolerances, vigour, and disease and pest resistance [31, 33]. Thus, wild animal and plant species provide an enormous reservoir of genetic diversity which is the foundation of agriculture and provides for its continued support [33].

Medicine

The World Health Organisation defines human health as a state of total physical, mental and social well-being and not just the absence of disease or infirmity [48]. In addition to providing sustenance as shown above, biodiversity plays other direct and indirect roles in maintaining the health of the human population [43].

There are two main avenues through which biodiversity provide a means for mediating health risk for the poor [49]. The first has to do with the impact that biodiversity has on reducing the risk of infectious diseases, while the second has to do with biodiversity as a source of accessible medicinal regimens which are not only curative but are also preventive, thereby reducing health risks [50, 51, 49]. At the ecosystem level, biodiversity produces the appropriate balance between predators and prey, hosts, vectors and parasites which allows for appropriate controls and checks for both the spread of endemic infectious diseases as well as resistance towards invasive pathogens [49]. Other researchers [52] identify many diseases that are particularly dependent on changes in ecosystem biodiversity, with many of these diseases being particularly relevant to the poor including malaria, schistosomiasis, meningitis, cholera, dengue and lymphatic filariasis. Biodiversity not only plays the role of reducing the risk of such diseases spreading within an ecosystem and the human populations within it, but also reduces the risk of allowing invasive diseases from entering a particular system [49]. For example, it has been reported that cholera, kala-azar, and schistosomiasis have not established in the biodiverse Amazonian forest ecosystem in spite of human migration and settlements [52].

Biodiversity has proven to be an important source of traditional medicines for people in developing countries, particularly those in remote and normally more poverty-stricken areas of the developing world where access to formal health care is limited [53, 54, 49]. It is estimated that approximately 75% of the world's population depends primarily on traditional medicines gathered from wild natural products [49]. Indeed, natural products have long been recognised as an important source of therapeutically effective medicines in many parts of the world [55]. Though traditional medicines may not be as effective as scientifically tested drugs, they provide a cost-effective and accessible option in poverty stricken-communities [52, 53, 54, 49].

In addition, biodiversity has played, and continues to play, a significant role in modern medicine [56, 57, 38, 58]. For example, of 520 new drugs approved between 1983 and 1994, 39% were natural products or were derived from them [31]. Moreover, of the 20 best-selling non-protein drugs in 1999, nine were derived directly or indirectly from natural products, with combined annual sales of more than US$16 billion [31]. Nearly 3000 antibiotics have been derived from microorganisms [24]. Twenty three percent of the compounds in the 150 most commonly prescribed drugs in the USA in the 1990s came from animals while, since the mid-1980s, over 2500 medically significant chemical compounds have been found in marine species [59]. Animals are also used as models on which to test potentially useful drugs or techniques [31], though such practices may be morally questionable.

Despite advances in computer-assisted drug design, molecular biology and gene therapy, there remains a pressing need for new drugs and biological materials will continue to play a major role [56, 31, 57]. For example, one in every 125 plant species studied has produced a major drug, while for synthesised chemicals, the potential for finding major new drugs is of the order of one in 10000 compounds tested [60, 31].

Just as with food above, the proportion of species that have been investigated for potential derivation of drugs is quite small [61, 59]. For example, as of 1995, whilst about 37 500 species of plants had been studied photochemically, only about 14000 had been studied for at least one type of biological activity [38, 62]. This shows that there is still vast potential for deriving more drugs from biodiversity. The medicinal value of plants and animals, both current and future, therefore provides a powerful argument for their conservation, just as with their value as a source of food for people.

Industrial materials

Biological diversity also has immense industrial value [26, 63, 28, 64, 65, 8, 66], with a wide range of industrial materials, or templates for their production, being derived directly from biological resources [31, 67]. These include building materials, fibres, dyes, resins, gums, adhesives, rubber, oils and waxes, and perfumes [28, 67]. Many agricultural chemicals including herbicides, fungicides and insecticides are also derived from natural products, or synthesised using natural chemicals as templates [28].

Biological materials have provided the models (biomimicry) for many industrial materials and structures [31]. For example, inspiration for the dome of the Crystal Palace in London came from the Amazonian water lily *victoria amazonica*, air conditioning systems from the mounts constructed by termites, the echo-sounder from bats, and infrared sensors from the thermosensitive pit organ of the rattle snake [31, 28]. As is the case with food and medicine, the scope for exploitation of a far greater diversity of organisms for industrial materials

is vast, and for that reason, biological resources cannot be allowed to go into extinction. However, it is important to note that most of the industrial uses of biodiversity have also immensely contributed to the degradation of the earth's biological resources.

Ecotourism

Ecotourism is by definition tourism founded on biodiversity, and has developed into a massive industry [68, 69, 70, 71]. It is worth noting that "…ecotourism has consistently grown and is now widely considered the fastest growing sub-component of the world's largest industry - tourism" [72]. An estimated 157-236 million people took part in international ecotourism in 1988[73], while in 1998 about 9 million people went for whale watching alone, with expenditure on just this activity totalling US$1 billion [74, 75]. According to the UN World Tourism Organisation [76], international tourist arrivals grew by an estimated 5% in 2013 (above the long-term forecast of 3.8% per year between 2010 and 2020), reaching a record 1 087 million despite sluggish global economic growth and numerous geopolitical challenges. Furthermore, international tourism receipts generated a total of US$ 1079 billion (Euro 840 billion) in 2012 [76].

2.1.2 Indirect use values: ecosystem services

Natural ecosystems and biodiversity also provide benefits to humans that are indirect, yet essential [10]. These have been termed 'ecosystem services' and include, among others, [77, 78, 79, 25]:

- Maintaining atmospheric quality by regulating gas ratios and filtering dust and pollutants
- Regulating freshwater supplies and controlling flooding
- Generating and maintaining soils through the decomposition of organic matter and the relationship between plant roots and mycorrhizal fungi
- Disposing of wastes, including domestic sewage and wastes produced by industry and agriculture
- Cycling of nutrients
- Controlling pests and diseases, for example, through predation and parasitism on herbivorous insects
- Pollinating crops and useful wild plant species by insects, bats, hummingbirds and other pollinators

The biota annually cycles elements such as carbon, hydrogen, nitrogen, oxygen, phosphorous and sulphur and huge quantities of aerosols and particles among the atmosphere, hydrosphere and lithosphere [80, 81, 25, 10]. Such biochemical cycling modifies physical and chemical conditions, creating an environment that sustains life [80, 82, 78]. In the absence of life, earth would be a very different planet [31]. In particular, it has been estimated that the atmospheric gas composition would be radically altered, and surface temperatures and pressures drastically heightened [31, 83].

Biodiversity is crucial in regulating freshwater supplies and controlling flooding. While, in theory, water is a quintessentially renewable resource, several factors have turned freshwater into a scarce commodity [84]. Due to rapid human population growth and the increasing demands for water, pollution, and careless use, the provision of safe supplies is now a major source of concern, expense, and international and intranational tension [84, 78]. Until recently, the main focus of efforts to improve urban water sanitation and supply have been on better distribution systems, treatment plants and sewage disposal [84]. While the above are still of major importance, there is also increasing interest in the opportunities for purifying urban water through the management of natural resources [84, 63, 78, 25]. A survey carried out for World Wide Fund for Nature (WWF) and World Bank in 2003 found that about a third of the world's largest cities obtain a significant proportion of their drinking water directly from protected areas [84, 85]. On the other hand, several of the top 100 cities are experiencing problems with water supply due to degradation or pollution in watersheds [84]. It is important to note that it is usually cheaper to prevent water from becoming polluted than to clean it up afterwards [84, 63].

Poor rural communities face serious risk from natural hazards, the most common of these being floods, fires, hurricanes and storms, and landslides [49]. Lack of formal insurance mechanisms against such hazards among the poor has resulted in increased vulnerability and poverty [86, 87, 49]. It is important to note that more people are affected by natural disasters than by war [86]. For example, at least 36 million people were displaced by natural disasters in 2008, including over 20 million displaced by climate-related disasters such as floods [88]. Under such conditions, natural ecosystems can play an important role in mitigating these risks to the poor as they provide cost-effective insurance [52, 49]. For instance, the protecting of forests for the purpose of controlling flooding is increasingly becoming a major environmental service [89, 90]. Wetlands and forests can act as giant sponges to soak up moisture during rainy periods and release water slowly during dry periods [90]. Under such circumstances, the importance of biodiversity, and the need to protect it, cannot be over-emphasised. Biological pest control is also increasingly becoming popular as awareness of the detrimental effects of agrochemicals increases, and as such chemicals become unaffordable to poor rural farmers [91, 92].

The above arguments for conserving biodiversity based on utility (direct and/or indirect use) are, however, limited and incomplete. The major weakness with a conservation system wholly based on economic motives is that most members of the biological community do not have economic value [93]. Conservationists often fall into the trap of justifying species preservation for utilitarian purposes, thereby sanctioning the humanistic attitude that is responsible for the biodiversity crisis [23, 24]. The attitude implied by economic valuations of biodiversity is that the worth of a species depends on its direct utility to humans, and if a species is of no benefit to them, then it is worthless [94, 24]. This predisposes species to extinction.

At best, the utilitarian argument for biodiversity conservation is a double-edged sword [24]. Under certain circumstances, it might help gain public support for protecting species and ecosystems, while in other cases it can be used to justify the destruction or neglect of seemingly worthless life forms [24]. In both cases, it encourages disrespect for species in and of themselves [94, 23, 24]. It is also quite disturbing to note that current arguments for maintaining international biodiversity, such as those expressed in the Global Biodiversity Strategy, are thoroughly utilitarian, hanging almost entirely on presumed benefits of biodiversity to humans [93, 95, 24, 96]. The

sustainable development theme of the Global Biodiversity Strategy, and related international conservation programmes, is thus potentially dangerous for the survival of biodiversity if strict protection to sensitive areas is not part of the programme [95, 24, 97].

2.2 Non-use values of biodiversity: ethics and aesthetics

As shown earlier, resource-based arguments for the maintenance of biodiversity focus on relatively few species and therefore the fundamental justification for striving to maintain all species cannot be linked to such arguments [22, 23], but is usually based on ethics and aesthetics [98, 24]. Non-use value is that value associated with biological resources even if they are not directly or indirectly exploited, and these can be divided into at least four components: option value, bequest value, existence value and intrinsic value [31, 99].

2.2.1 Option value: future worth

It has been revealed earlier that at present, a relatively small proportion of the world's biodiversity is being actively exploited by humans. The rest may be important in terms of values which are unused or unknown currently, but could enhance the material well-being of humans in the future if they were to be discovered and exploited [22, 100, 99, 101]. There is, for example, huge, unexploited and currently unknown potential for the use of biodiversity, particularly with the possible medicinal, nutritional and industrial uses of much of the variety of life remaining unexploited [22, 45, 47]. This potential should be valued, and may be vital as the problems faced by humanity change in nature and magnitude [101]. As a result, society should be willing to pay to retain the option of having future access to this biodiversity [22, 31]. This is particularly important for resource-dependent poor rural communities. However, it is apparently clear that the inclusion of the option value among non-use values is highly questionable as it still alludes to the utility of biodiversity to humans.

2.2.2 Bequest value: intergenerational equity

Closely related to, but distinct from option value, is bequest value. This is the value of passing on a resource, in this case biodiversity, intact to future generations [31, 99]. This notion is embodied in the CBD where nations are encouraged to conserve and sustainably use biodiversity for the benefit of both present and future generations [100, 31, 99, 102]. In her famous statement, Lester Brown noted that current generations have not inherited the earth from their parents but are borrowing it from their children [103]. The bequest value is at the core of the concept of sustainable development which has been defined as development that aims to meet the needs of current generations without compromising the ability of future generations to meet their needs [104]. Thus, both intergenerational and intergenerational equity are emphasised in the above definition. The bequest value of biodiversity is important, particularly for the rural poor highly dependent on biodiversity, who should safeguard biological diversity for future generations. However, just as with the option value above, the issue of utility to humans as the basis for biodiversity conservation is still the emphasis here.

2.2.3 Existence value: 'biophilia'

All the values of biodiversity presented so far have been based, in one way or another, on marketable commodities and non-market goods and services. They assume that value is expressed solely in terms of the well-being of humanity [31]. What these values seem to ignore is the fact that biodiversity may also have value to people irrespective of the uses to which it may or may not be put that is, value may be placed simply on its existence [105, 31, 99]. According to Wilson, human beings have empathy with other bearers of life which naturally disposes them to care for biodiversity in all its varied forms, and he called this 'biophilia' [106]. The existence value of biodiversity is unassociated with actual or potential use, but reflects the satisfaction that people receive from simply knowing, for example, that there are whales in the ocean [22, 100, 101]. They are prepared to support this financially by contributing to conservation organisations to protect them even though they do not expect to visit or use the resource they are helping to conserve [22, 99]. This apparently offers a deeper and more complete argument for protecting biodiversity unlike the utilitarian resource-based arguments presented above.

2.2.4 Intrinsic value: nurturing nature for nature's sake

The direct and indirect use values, as well as the option, bequest and, to some extent, the existence non-use values of biodiversity presented above rest on human judgements of worth. It is, however, contentious whether values can exist independently of such human judgements [31]. If they can, then biodiversity may be seen to have an intrinsic value, and the existence of such a value seems to be deeply rooted in many societies, cultures and faiths [31]. For example, the Judeo-Christian rationale for natural resource conservation is that nature should be preserved for its own sake. God views man and other living resources as His creation. The Assisi Declaration by the world's religions has spelled out that their religions are for conservation of nature not because of benefits it has to man, but because it is God's creation [107]. Logically, this leads to an absolute moral responsibility to protect other species, the only known living companions of humanity in the universe [19, 31, 98].

Without moral consideration of the needs of other creatures, policies for protecting biodiversity will be built on shaky ground [99, 23, 98, 24]. Thus, there is need for a reaffirmation of the World Charter for Nature, adopted by the UN General Assembly in 1982, which stated that, "every form of life is unique, warranting respect regardless of its worth to man, and, to accord other organisms such recognition, man must be guided by a moral code of action" [24].

3. Conclusion

This review paper has explored the various value justifications that are often put forward for the conservation of biodiversity. From the review, it is clear that such value judgements are not always clear. For example, one can argue that the only true non-use values of biodiversity are existence and intrinsic values, with option and bequest values easily fitting within the indirect use values. Notwithstanding these criticisms, the above biodiversity value categorisations are quite helpful.

Their significance mainly lies in the fact that they broaden the horizon on the value of biodiversity, which helps in diminishing the narrow, selfish, anthropocentric and often deleterious valuation of the world's biological diversity largely responsible for the current biodiversity crisis. This obviously works in favour of a more effective conservation of the whole multifaceted spectrum of biodiversity, without too much regard for utility.

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