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Biodiversity organization, threats and conservation methods

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ABSTRACT

Biodiversity plays a great role in human existence and in healthy function of natural systems although it is on the way of depletion dominantly due to anthropogenic activities. This requires giving attention to the conservation of biodiversity at different organization levels of biodiversity by using either in *in situ* or *ex-situ* conservation approach or both methods in combination based on the conservation objectives. Hence, the objectives this paper was to review biodiversity conservation at different levels with considering threats and conservation approaches available for biodiversity management. Recently biodiversity is being lost at an alarming rate due to natural and more importantly by anthropogenic factors. The most threats to biodiversity are agricultural expansion, overexploitation, urbanization, industrialization, pollution, fire incidence, exotic species and global climate change, which are all driven by human population growth. To achieve the goal of sustainable biodiversity conservation, there is also a need to understand what to conserve, where to conserve, how to conserve and also it needs to prioritize species, populations and ecosystems for conservation actions. Moreover, promotion of indigenous resource management practices, involvement of local people in conservation planning and management, involvement of all relevant stakeholders and provision of adequate human, financial and physical resources for conservation efforts are important measures that should be taken into account to ensure the conservation, management and sustainable use of biodiversity. In order to ensure the maintenance of biodiversity, there is a need to take urgent actions to protect biodiversity from different threats, by employing complementary *in situ* and *ex-situ* conservation methods. Furthermore, scholars, policymakers, local communities, academic institutions, conservation organizations, practitioners and all other relevant stakeholders should be work closely in conservation and management of biodiversity to improve human wellbeing.
Keywords: Biodiversity, Conservation, Diversity, Loss, Species

INTRODUCTION

Background

Biodiversity conservation refers to the management of human use of biodiversity in order to get the greatest sustainable benefit to present and future generations. Thus, conservation of biodiversity embraces the protection, maintenance, sustainable utilization, restoration, and enhancement of biodiversity (Kasso M, et al. 2013).

Biodiversity affects us in almost every walk of our life. Since, Biodiversity provides us with food in the form of cereals, grains, fruits, vegetables, meat, milk and eggs (Roos E, et al. 2016). On the other hand biodiversity is essential for sustainable development and human well-being. It underpins the provision of food and water; it mitigates and provides resilience to climate change; it supports human health, and provides jobs in various activities such as; agriculture, fisheries, forestry and many other sectors (Opoku A, 2019). Apart from the edible things, we get an assortment of materials like gum, resin, rubber, fibers, colors and, hide, perfumes, pesticides, wax, lubricants, timber, paper which make our lives easier (Roth I, et al. 2013). Many medicines and drugs are either direct plant products, derived from plant products or synthetically produced compounds which mimic the actions of plant produced chemicals. Additionally, coal, petroleum and natural gas, all are products of biodiversity (Meyer HP, 2016).

Biodiversity is not only providing us with such materials (provisioning services), it also serves a lot of other regulatory functions like regulation of natural cycles (carbon cycle, water cycle, nitrogen cycle etc.), water purification, disease regulation (Vidal AG, et al. 2013). It also has protective functions such as protection of soil from erosion, protection against floods and tsunamis by reducing their impact. Biodiversity also has an aesthetic as well as social and cultural value to us (Silva R, et al. 2017).

Nevertheless, biodiversity is on the way of depletion dominantly due to anthropogenic activities such as; human development and encroachment to the natural and wild habitat which leads to the extinction of biodiversity due to the exhaustive agriculture and conversion of forestland's, mining for energy demands, transportation development and unregulated recreation (Himshikha, et al. 2022). This loss has negative consequences on the delivery of ecosystem services and further on human wellbeing, since it erodes the capability of the earth's ecosystems to provide the goods and services that generate economic, agricultural, public health, scientific, cultural, and spiritual benefits (Assessment ME, 2005). Even more, the poor people are affected the most by biodiversity loss as they directly depend on biodiversity to meet their daily needs for subsistence life (Singh V, et al. 2021). Therefore, this requires more attention and urgent action from different stakeholders, to conserve and protect biodiversity which should be the primary response, since; biodiversity plays a great role in human existence and in healthy function of natural systems.

For sustainable biodiversity conservation first of all we should have to think about four things; why to conserve, what to conserve, how to conserve and where to conserve, then after we can carry out the conservation activity with the necessary management methods on the necessary place based on the conservation objective (Ramya AR, et al. 2015). In the conservation of biological resources considering about the various organizations of biological diversity (genes, species, ecosystem and functional diversity) is very crucial since, because, biodiversity conservation could not be succeeded at single level (Nunes PA, et al. 2001).

Even though, there are different methods of biodiversity conservation, but, generally it could be conserved with two major approaches; either *in situ* or *ex-situ* conservation. Both of the conservation efforts, (*in-situ* and *ex-situ*) involves the establishment and management of protected areas and relevant research institutes or academic institutions, which establish and manage botanical or zoological gardens, tissue culture, and gene banks.

The concept of *ex-situ* conservation is fundamentally different from that of *in situ* conservation; however, both are important complementary methods for conservation of biological resources at all levels of biodiversity organization (Hawkes JG, et al. 2012). Therefore, this review paper was designed to review biodiversity conservation at different levels with considering threats and conservation approaches available for biodiversity management.

Objectives

General objectives: The general objective of this paper was to review biodiversity conservation at different levels with considering threats and conservation approaches available for biodiversity management

Specific objectives; the specific objectives of this paper was to review:

- Biodiversity conservation at different levels.
- Biodiversity conservation approaches.
- Threats or losses of biodiversity.

LITERATURE REVIEW

Levels of Biodiversity (Organization's)

Biodiversity has different levels of organization (biological organization) including genes, populations, species, communities, ecosystems, landscapes, regions (Poiani KA, et al. 2000). Since, a life are dynamic and involves multi-scale ecological patterns and processes. Although each scale is important, the interdependence of scales needs to be understood and assessed in order to conserve biodiversity (Cumming GS, et al. 2015). Even though there are various levels of biodiversity, however for this paper I have focused on the three very important levels of biodiversity (genetic diversity, species diversity and ecological diversity).

Genetic Diversity

Before starting to conserve biodiversity, we should have to consider about the importance and problem of genetic variation in conservation. Genetic difference refers to the variation of genes within the species stores as immense amount of genetic information (Sivanandam S, et al. 2008). Genetic variation is seen among the individuals within a species. For instance, in cattle there are many varieties with respect to colour, milk yield, and size or disease resistance. This genetic variability contained in the genetic material facilitates adaptations in an organism and constitutes the genetic diversity of a species (Burger PA, et al. 2019). The more the genetic variability, the more a species is likely to adapt and survive natural selection and other environmental pressures. Lesser the genetic variability, more are the chances of a species to be vulnerable to threats like fungal, parasitic and insect infestations and diseases (Costello MJ, et al. 2017).

According to Hughes et al., a key source of biodiversity is genetic diversity which is the magnitude of genetic

variability within a population or the genetic makeup of the variation of organisms and species on Earth (Alberti M, et al. 2017). Genetic diversity is the variation of genes among species and populations as well as within those populations that separate distinct breeds or races from one another. Some species have as many as 400,000 genes, e.g., human beings have ~25,000 genes, while rice has >56,000. In dynamic ecosystems, genetic variability is crucial for population survival and often rises with environmental variability since alterations in environmental variables affect genetic diversity within populations (Bickham JW, et al. 2000). Even species with significant capacity for gene flow are affected by environmental influences in their dynamics. Failure to retain genetic variability restricts the ability of a population to adapt to a changing environmental condition, making it vulnerable to the likelihood of extinction.

Species Diversity

Species diversity is referring to the various species found within a region. It is variability found within a species or between different species of a community and can be measured by species richness (number of species per unit area) and evenness or equitability (evenness in the number of individuals of a species). In the case of species richness, higher species diversity represents greater species diversity while, evenness of species represents higher species diversity. Here, species richness refers to the total number of individuals within each species, while, species composition refers to the total number of different species within a community and species diversity is the combination of the species composition as well as the species richness.

Species diversity has two primary components, *i.e.,* species richness (the number of species in a community) and species composition (the identity of the species present in a community) which has a major influence on ecosystem functioning and stability. Typically, it is the patterns of species richness over various geographical extents (local, regional, continental, and global) or over various time periods (seasons, years, centuries, to millennia). Species play essential roles in ecosystems and species diversity is essential for economic, biological, social, and cultural reasons, therefore local and global species losses could threaten the stability of the ecosystem. The community and ecosystem processes became more stable as species diversity improved.

A stable community should not show too much variation in productivity from year to year; it must be either resistant or resilient to occasional disturbances (natural or man-made), and it must also be resistant to invasions by alien species. We don't know how these attributes are linked to species richness in a community, but Tilman was found that plots with more species showed less year to year variation in total biomass. He also showed that in his experiments, increased diversity contributed to higher productivity.

In a healthy ecosystem, diverse and balanced number of species exists to maintain the balance of an ecosystem. In an ecosystem, all the species depend on each other directly or indirectly. So to make a more efficient, productive and sustainable ecosystem, it is important to maintain high species diversity. Here healthy ecosystem is ecosystem that is sustainable and it has the ability to maintain its structure (organization) and function (vigor) over time in the face of external stress (resilience).

According to Jucker et al., more diverse ecosystem tends to be more productive e.g. the ecosystem with a great variety of producer species will produce large biomass to support a greater variety of consumer species.

- Greater species richness and productivity makes an ecosystem more sustainable and stable.
- More diverse the ecosystem, greater is the ability to withstand environmental stresses like drought or invasive infestations.
- Species richness makes an ecosystem able to respond to any catastrophe.
- In species rich communities, each species can use a different portion of resources available as per their requirement e.g. plants with smaller roots can absorb water and minerals from shallow soil and plants with deeper roots can tap deeper soil.
- Rich diversity is important for the survival of mankind.
- Healthy biodiversity has innumerable benefits like nutrients storage and recycling, soil formation and protection from erosion, absorption of harmful gases, climate stability.
- Humans get lots of product from nature like fruits, cereals, meat, wood, fibre, raisin, dyes, medicine, antibiotics, etc.
- Amazon forest is estimated to produce 20% of total oxygen in the earth's atmosphere through photosynthesis.
- Pollinators, symbiotic relationships, decomposers, each species perform a unique role, which is irreplaceable.
- Diversity in large numbers help in large scale interaction among organisms such as in the food web.
- In the nitrogen cycle, bacteria, plants have a crucial relationship, earthworms contribute to soil fertility.
- Apart from these, there are other benefits such as recreation and tourism, education and research.

Each species plays an important role in an ecosystem. The role that a species plays in its ecosystem is known as its "ecological niche", and species can be broadly divided into generalist and specialist species.

- **Generalist species:** They have broad niches. These can live in many places and can eat a variety of foods. They can thrive in rapidly changing environmental

conditions e.g. cockroaches, rats, mice, flies, white tailed deer, raccoons, humans, etc.

- **Specialist species:** They have a narrow niche, found in only one type of habitat and feed on a few types of food. They are more prone to disturbances in the environmental condition and cannot tolerate the change and environmental stress. In the tropical rain forests where environmental conditions are fairly constant, specialist species hold an advantage as they have fewer competitors for the resources.
- **Native species:** Species that normally live and thrive in a particular ecosystem.
- **Introduced species (invasive or alien species):** Species that migrate deliberately or accidentally to an ecosystem. They can spread rapidly if they find a favorable niche. Invasive species compete with other species for food and habitat. If the indigenous species are unable to compete, they are forced to leave or die.
- **Indicator species:** These serve as biological smoke alarms. An indicator species is an organism whose presence, absence or abundance reflects a specific environmental condition. Indicator species can signal a change in the biological condition of a particular ecosystem, and thus may be used as a proxy to diagnose the health of an ecosystem. These species provide early warnings of damage to an ecosystem e.g. birds are an excellent biological indicator of their habitat loss and fragmentation and use of chemical pesticides. Butterflies are also a good indicator species as their association with various plant species makes them vulnerable to their habitat loss and fragmentation.
- **Keystone species:** They play an important role in maintaining species diversity and integrity of an ecosystem. They have a high impact on the types and abundance of species in an ecosystem. These species play several critical roles in helping certain species (e.g. role in pollination like bees, butterflies) to sustain as well as check the overpopulation of other species to become overly dominant (e.g. top predators like a lion, shark, wolf, etc.) e.g. if predatory starfish was removed from an ecosystem, it resulted in different species of mussels to outcompete other species and reducing species diversity.
- **Umbrella species:** Species selected for making conservation related decisions, typically because protecting these species indirectly protects the many other species that make up the ecological community of its habitat.

Ecosystem Diversity

Diversity of ecosystem is refers to the variations in the biological communities in which the species live or the number of ecosystems present in a region constitutes its ecosystem diversity. Earth harbor's a wide variety of ecosystems which can be divided into terrestrial and aquatic. Aquatic ecosystems can be further be categorized into marine, freshwater and wetlands. Whereas, various types of terrestrial ecosystems are forest, grassland, desert, wetland, and tundra. Larger ecological systems are composed of biomes, which are fundamental units categorized on the base of vegetation and climatic parameters. Ecosystems like grasslands, rainforests, deserts and other ecosystems including aquatic ecosystems can be found a region, and make it ecosystem diverse. Diverse ecosystems are able to withstand environmental stress, which leads to increased productivity.

Hence, the ecosystem level conservation offers a powerful strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. The ecosystem approach is based on the application of appropriate scientific methodologies focused on levels of biological organization, which encompass the essential structure, processes, functions and interactions among organisms and their environment. It also recognizes that humans, with their cultural diversity, are an integral component of many ecosystems.

The Millennium Development Goals (MDG) and especially the Millennium Ecosystem Assessment (MEA) was established a functional link between biodiversity, health and human well-being. This link is expressed through the notion of "ecosystem services". The degradation of ecosystem functioning and associated losses of biodiversity has negative impacts on the quality of ecosystem services, thus affecting the safety, health and welfare of populations. The notion of ecosystem services emerged from the ecosystem approach, which is also defined by the Convention on Biological Diversity (CBD).

Nature provides us with natural resources, raw materials and benefits such as insect pollination, soil formation, and improvement of our health and well-being. Most of us appreciate these benefits, or ecosystem services, and we can map their contributions to our economy. People are also part of ecosystems. Following an ecosystem approach means understanding these connections, and taking account of ecosystem services in how we manage land, freshwater and sea.

The ecosystem approach conservation is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. Thus, the application of the ecosystem approach will help to reach a balance of the three objectives of the convention on biological diversity: Conservation; sustainable use; and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources.

Moreover, an ecosystem approach is based on the application of appropriate scientific methodologies focused on levels of biological organization, which encompass the essential structure, processes, functions

and interactions among organisms and their environment. It recognizes that humans with their cultural diversity are an integral component of many ecosystems.

It is obvious that ecosystem services are the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on earth". While any change in biodiversity can influence the contribution of ecosystem services to human well-being, biodiversity conservation is crucial for human development and reduction of poverty. This was the links established between the degradation of ecosystems and fight against poverty and its consequences, such as the state of health and well-being of populations.

Biodiversity Conservation Approaches

There are several methods for conservation of biodiversity; however, the popular conservation methods can be broadly divided into two approaches; *in-situ* and *ex-situ* conservation methods. *In-situ* (on-site) conservation is the conservation of genetic resources within the natural ecosystem in which they occur, while ex-situ (off-site) conservation is the conservation of genetic resources outside their natural ecosystem in which they occur. *In-situ* and *ex-situ* conservation are mutually reinforcing and complementary approaches. In order to ensure the conservation of the widest possible range of biodiversity and minimize the risk of genetic erosion, the various conservation methods should be combined in an integrated approach (that is, integrated biodiversity conservation). Indeed, there is no universal method that can cover all conservation purposes.

The development of complementary conservation strategies in which different conservation approaches and methods are being combined helps to achieve the most stable and cost-effective conservation effort for a given gene pool under locally prevailing conditions. Here it is important to note that both in-situ and *ex-situ* conservation have merits and demerits.

Due to the complexity of biodiversity, rapid loss of biodiversity, and increased realization of the importance of undertaking cost-effective programs, developing realistic and viable strategies and setting priorities for effective conservation and management of genetic resources will always be necessary.

There is a need for identification of action priorities both in geographical space and biological importance. Definitely, the choice of suitable conservation methods depends on the objectives of the predicted genetic conservation and the ecological requirements of the species in question. Conservation is a dynamic process, and requires continuous evaluation based on emerging issues and newly acquired research findings.

***In-situ* Conservation**

Biodiversity rich regions are protected as biosphere reserves, national parks and sanctuaries *i.e.* called *in-situ* conservation. *In-situ* ('on site', 'in place') conservation is a set of conservation techniques involving the designation, management and monitoring of biodiversity in the same area where it is encountered. *In-situ* management approaches can either be targeted at populations of selected species (species centered approaches), or whole ecosystems (ecosystem based approaches).

Both approaches follow the same purpose: To enable biodiversity to maintain itself within the context of the ecosystem in which it has been found, *i.e.*, to enable a species population to self-replicate and maintain its potential for continued evolution. This requires conservation of the components of the natural system (populations, species, communities and biophysical systems) as well as the ecological and evolutionary processes occurring within that system. Conservation measures are aimed at the surroundings where a target species developed its distinctive properties. This could be a natural habitat, or an environment which is heavily modified by human activity. For instance, agricultural or domestic species may have evolved characteristic traits in human dominated environments. The conservation of agricultural biodiversity therefore requires the conservation of agro-ecosystems by farmers, commonly using traditional farming practices.

In-situ conservation maintains species in dynamic relationships with the habitat and allows gene flow and geographical distribution. Ecosystems, species and populations are dynamic; they are variable in space and time. Moreover, in-situ conservation allows evolutionary and ecological processes to take place and promotes genetic variability and adaptability of species to changing environmental conditions. Therefore, the conservation of biodiversity is best achieved in natural ecosystems.

Furthermore, the *in-situ* conservation approach allows the conservation of a large amount of genetic diversity, species diversity and ecosystem diversity in a very extensive and cost-effective manner. The costs, risks and research needs of *in-situ* conservation are generally low. However, *in-situ* conservation is not feasible in areas with high environmental and human pressures. The reconciliation of the conservation activities with immediate and basic human needs, for example, for agricultural land, is often difficult. Species or populations conserved *in-situ* may be susceptible to calamities or deliberate damages (for example, fire) depending on the level of disturbance. Hence, *in-situ* conservation is not feasible for threatened species due to escalating human pressure. Moreover, *in-situ* conservation may be impaired by lack of direct influence due to ownership. *In-situ* conservation methods in general includes the different protected area systems, and

on-farm conservation in which cultivated plants and domesticated animals are conserved in the agro ecosystems where they have been developed and utilized.

Protected Areas

Protected areas are the cornerstone of *in-situ* conservation, as outlined in article 8 of the CBD. Since, protected area network may contribute to conservation targets through the maintenance of target species and their habitats, as well as the conservation of natural or semi-natural ecosystems. The socioeconomic and political context around a threatened habitat may prevent the establishment or success of a protected area, and the development of alternative *in-situ* conservation management approaches may show more useful in these situations.

Overall *in-situ* initiatives beyond protected areas may include; habitat restoration, recovery or rehabilitation, strategies for the sustainable use and management of biological resources, recovery programs for nationally or sub-nationally threatened or endangered wild species, on-farm agricultural biodiversity conservation which is targeted at traditional crop varieties and crop wild relatives, genetic reserve conservation, *i.e.*, monitoring of genetic diversity in natural wild populations within a delineated area (known as genetic sanctuaries or gene management zones), control of threats to biodiversity such as invasive alien species, living modified organisms or over exploitation, preservation and maintenance of traditional knowledge and practices; and implementation of the regulatory, legislation, management or other frameworks needed to deliver the protection of species or habitats.

Historically, *in-situ* conservation was the preferred biodiversity conservation approach over *ex-situ* conservation. Since, *in-situ* measures are perceived as more holistic in their approach and allow the conservation processes or habitats which can't be protected through *ex-situ* measures (e.g. soil microbial processes, evolutionary processes, and specific ecosystems such as coral reefs or species with highly specialized needs).

Protected areas are geographically delineated areas that are designated or regulated and managed to achieve specific conservation objectives. Any protected areas should have sufficient size that can allow the maintenance of a given ecosystem or species. In addition, there is a need to have protected area systems that are representative of major landforms and ecosystems. Because, protected areas play a great role in the conservation of biodiversity. They have environmental, social, economic, scientific, educational and aesthetic values and there are different forms of protected areas based on the management objectives.

The sustainability of *in-situ* conservation in protected areas depends on the long term protection and effectiveness of management systems. It is necessary to provide adequate human and financial resources in order to ensure the effectiveness of protected areas for maintaining biodiversity. In addition, the development and management of protected areas needs the participation of the local people in making decisions and undertaking conservation measures.

On the other hand, the conservation of biodiversity in protected areas requires the generation of appropriate incentives from international, regional and national agencies for resource users both in and around the protected areas. It is important to provide incentives of various forms (for example, tax breaks, subsidies) for the local people in order to ensure the sustainability of protected areas. There is a need to have appropriate mechanisms for sharing benefits that are generated from the conservation and sustainable use of biodiversity within protected areas. For instance, in Cameroon and Zimbabwe, the involvement of local people in conservation activities and sharing of benefits derived from the protected areas have been found most effective.

However, in many African countries, protected areas have failed to meet their conservation objectives mainly because of the exclusion of local people from participation and lack of appropriate mechanisms to provide incentives. In many developing countries with rich tropical biodiversity, government agencies responsible for the management of protected areas lack the necessary technical capacity to stem biodiversity loss effectively. Managers of protected areas often have limited access to the vast and dynamic body of knowledge and tools in conservation science. Therefore, there is an urgent and critical need to transfer the advances in conservation science to individuals and institutions in biodiversity rich countries.

On-farm Conservation

On-farm conservation is the conservation of crops and their wild relatives, livestock, and the agro ecosystems in which they occur. Agro ecosystems include home gardens, crop fields, agroforestry systems, fallow fields and grazing lands. Agricultural biodiversity, or agro biodiversity, is the component of biodiversity that contributes to food and agricultural production. Thus on-farm *in-situ* conservation is important for maintenance of agro biodiversity.

Indigenous resource management systems and agricultural practices play an important role in the maintenance and diversification of domesticated plants and animals. Low input agricultural systems are important sources and custodians of agro biodiversity. Farmers and pastoralists maintain a tremendous diversity of crop and livestock varieties around the world on their farmland. Thus, indigenous knowledge, skills and practices of farmers play an important role in the conservation and management of agricultural

biodiversity. They are better options for building the scientific basis of *in-situ* conservation of agro biodiversity on-farm. For instance, the farmers' indigenous knowledge and practices in germplasm selection, storage and exchange are major elements in the conservation of agricultural biodiversity through community gene banks.

The expansion of large scale/modern agricultural systems, in which relatively a few improved varieties have replaced many farmers' varieties, has caused erosion of agricultural biodiversity. Therefore, there is a need for basing the rural development strategy on traditional farming systems, knowledge and agro-ecological techniques in order to ensure the maintenance and continual use of the diverse genetic resources associated with traditional agricultural systems. Farmer based on-farm conservation of agro-biodiversity has been found a more successful approach.

Opportunities and Risks of *In-situ* Conservation

In-situ maintenance of biodiversity through the establishment of conservation and multiple use areas offers distinct advantages over off-site methods in terms of coverage, viability of the resource, and the economic sustainability of the methods.

- **Coverage:** *In-situ* approach can cover a wide area and would allow a significant number of indigenous species and systems to be protected, thus taking care of the unknowns until such time as methods are found for their investigation and utilization.
- **Viability:** As a result of *in-situ* conservation, natural selection and community evolution continue and new communities, systems, and genetic material are produced.
- **Economic sustainability:** When an area is set aside as an *in-situ* conservation approach, a country can maintain specific examples of biodiversity stores up future economic benefits. When the need develops and this diversity is thoroughly examined, commercially valuable genetic and biochemical materials may be found.

***Ex-situ* Conservation**

It is the process of protecting an endangered species of plant or animal by removing part of the population from a threatened habitat and placing it in a new location, which may be a wild area or within the care of humans.

Ex-situ conservation literally means, "off-site conservation". While *ex-situ* conservation comprises some of the oldest and best known conservation methods, it also involves newer, sometimes controversial laboratory methods. *Ex-situ* conservation, using sample populations is done through establishment of gene banks, which include genetic resources centers, zoos and botanical gardens.

If *in-situ* conservation is not feasible due to various reasons, threatened species can only be conserved with ex-situ conservation. Moreover, *ex-situ* conservation serves as a source of material for research and ecosystem restoration. Nevertheless, *ex-situ* conservation interrupts evolutionary and ecological processes and limits genetic variability and adaptability of species to changing environmental conditions. Moreover, the costs, risks and research needs of *ex-situ* conservation are significantly higher than that of *in-situ* conservation.

Botanical Gardens

Botanical gardens are institutions holding documented collections of living plants for the purposes of scientific research, conservation, display and education. So, botanical gardens have played a vital role in the conservation of the world's plant diversity. Many of the world's threatened plant species are represented in their living collections or seed banks which collectively provide an insurance policy supporting the maintenance of global biodiversity. In fact, botanical gardens have a strong focus on wild species which are endangered in their natural site.

In more recent years, some botanical gardens started to accept new responsibilities and were designed to be broadly based botanical resource centers. They have been and still are ideal institutions for managing wild species gene banks with the aim of preserving rare and threatened plants and making the material available for research. According to Zegeye botanical gardens are involved in the conservation of plants of importance for food and agriculture, as well as those used for many other economic purposes. Additionally, botanical gardens are involved in habitat management and restoration, plant reintroduction, control of invasive species and environmental education.

Moreover, botanic gardens are living laboratories and they undertake and promote scientific research on plants in particular and biological diversity in general. The research areas include botany, taxonomy, ecology, horticulture, plant breeding, evolutionary biology, conservation biology, population genetics, molecular biology, biotechnology, invasive species biology and control, climate change and environmental education. Many botanic gardens maintain extensive collections and undertake research on useful plants of actual or potential value for agriculture, healthcare, horticulture, forestry, habitat management and restoration, amenity and many other purposes. However, most botanic gardens do not have sufficient human, financial and physical resources to be able to achieve much effective conservation and research into biodiversity. Even though, botanic gardens play important roles in the assessment and conservation of biodiversity.

Captive Breeding

It is also known as captive propagation, is the process of keeping plants or animals in controlled environments, such as wildlife reserves, zoos, botanic gardens, and other conservation facilities. It is sometimes employed to help species that are being threatened by the effects of human activities such as climate change, habitat loss, fragmentation, overhunting or fishing, pollution, predation, disease, and parasitism.

Habitat protection alone is not sufficient if the expressed goal of the world conservation strategy and the maintenance of biotic diversity are not achieved. Establishment of self-sustaining captive populations and other supportive intervention will be needed to avoid the loss of many species, especially those at high risk in greatly reduced, highly fragmented, and disturbed habitats. Captive breeding programs need to be established before species are reduced to critically low numbers, and thereafter need to be coordinated internationally according to sound biological principles, with a view to the maintaining or re-establishment of viable populations in the wild.

Many endangered species are being breed in zoos, to improve populations and reintroduce them into the wild. This introduction should be compatible with the wild ecosystem and should not be with potential harm with the wild flora and fauna. Otherwise, this is worthless if there is not adequate habitat left in the wild. In general, captive breeding approach becomes necessary;

- When populations in the wild have declined to such low levels that they may not be self-sustaining,
- Where threats to populations and/or their habitats are so severe that extinction is deemed likely.
- Where captive individuals and their off spring can be protected from natural enemies or other factors causing high mortality, so that numbers can be built up either to augment source populations or to found new populations by translocation or other controlled release.

However, undertaking, captive breeding can also cause several problems;

- Potential for disease transmission from captive animals to both humans and wild species.
- Potential for loss of genetic integrity amongst populations of wild species should they breed with escaped captive animals, which are often non-indigenous or hybridized.
- Questionable caring treatment of the animals in captivity.
- Reduced incentive to conserve wild populations and their habitats.

Field Gene Banks

Field gene bank is one of the techniques in the strategy for plant genetic conservation. It is an *ex-situ* method where genetic variation is maintained away from its original location and samples of a species, subspecies or variety are transferred and conserved as living collections.

Field gene banks are important for conservation of plant species that do not produce seeds and propagate vegetative or produce the so-called recalcitrant seeds (seeds which cannot be stored at low temperature). According to Borokini the conservation of germplasm in field gene banks involves the collecting of material and planting it in the orchard, or field, in another location. Field gene banks have been used for perennial plants including species that produces recalcitrant seeds, species that produces little or no seeds, species that are preferably stored as duplicating material and species that have a long life cycle to generate breeding and/or planting material. Usually these difficult to conserve species can be maintained as living collections in field gene banks. On the other hand, conservation in field gene banks requires sound information on the ecological requirements of the species in question. It needs area of sufficient size and site conditions similar to that of the original population but with a lower environmental pressure.

Gene Banks

It is an *ex-situ* method where genetic variation is maintained away from its original location and samples of a species, subspecies or variety are transferred and conserved as living collections. Field gene bank is the most common method of conserving genetic resources with recalcitrant seeds and vegetatively propagated plants.

Gene banks are important for the conservation of or genetic material. Germ plasms that can be stored in gene banks include seeds, pollen, spores, semen (sperms), eggs, embryos, cells and tissues. More recently, DNA sequences are also being kept in specialized banks. Based on their storage behavior, seeds are categorized into three groups–orthodox, intermediate and recalcitrant. Orthodox seeds are seeds which can withstand conventional storage conditions (5% moisture content and -20°C) without viability loss, while recalcitrant seeds are seeds which cannot be stored below 20% moisture content and 0°C. Generally, recalcitrant seeds do not show dormancy because they are in continuous growth, that is, there is no resting period. While, orthodox seeds are generally used for long-term storage of plant germplasm (about 90% of plant species).

Opportunities of *Ex-situ* Conservation

The conservation of biodiversity can be achieved through an integrated approach balancing *in-situ* and *ex-situ*

conservation strategies. The maintenance of viable and self-sustainable populations of wild species in their natural state represents the ultimate goal, but habitat destruction is inevitable and endangered species need to be preserved before they become extinct, by transforming the threatened species to new location (off-site).

Ex-situ conservation provide the opportunity to study the biology of, and understand the threats to, endangered species in order to eventually consider successful species recovery programs, which would include restoration and reintroduction. It also has the advantage of preserving plant material and making it available for research purposes, without damaging the natural populations. *Ex-situ* conservation is therefore complementary to *in-situ* conservation and can act as an "insurance policy" when species are threatened in their natural habitats.

According to Fetene et al., ex-situ conservation, facilities provide excellent opportunities for researchers to study plants, animals, and microorganisms in controlled conditions, and to improve collection, storage and regeneration techniques, can also be used for germplasm evaluation, as centers for documentation and information systems and for providing information on genetic resources on a commercial basis, moreover, captive breeding of wild animals can be used to restore endangered species populations and it is important to increase populations as quickly as possible and reintroduce the animals back to their original habitat to minimize genetic erosion ultimately plants can also be re-introduced to their natural areas of occurrence.

However, *ex-situ* conservation approach has also its own drawbacks unless the re-introductions are performed in such a way that other indigenous species are not harmed or adversely affected. Similarly, care must be taken while collecting material/animals for *ex-situ* conservation not to endanger other native species and genetic resources. The regulation and management of such transactions requires accurate information to determine the impact of collection on populations and ecosystems.

REULTS AND DISCUSSION

Threats or Losses of Biodiversity

Loss of biodiversity is the decrease in the number and variety of living things on the earth. It can affect genes, species, ecosystems, and the planet as a whole. The major causes of biodiversity can be natural or human factors, such as climate change, habitat loss and fragmentation, pollution, and over-exploitation of resources. Finally, it can lead to ecological imbalance and extinction of species.

Causes of Biodiversity Losses

The accelerated rates of species extinctions that the world is facing now are largely due to human activities. Some of these are;

Habitat loss and fragmentation: This is the most important cause to driving the species of animals and plants to extinction. The most dramatic examples of habitat loss come from tropical rain forests. Once covering more than 14% of the earth's land surface, these rain forests now cover no more than 6%. For example, the Amazon rain forest (it is so huge that it is called the 'lungs of the planet') harboring probably millions of species is being cut and cleared for cultivating soya beans or for conversion to grasslands for raising beef cattle.

Besides to the total loss, the degradation of many habitats by pollution also threatens the survival of many species. When large habitats are broken up into small fragments due to various human activities, mammals and birds requiring large territories and certain animals with migratory habits are badly affected, leading to population declines. The habitat destruction is the massive destruction of the natural habitat of the species that it becomes incapable of upholding the native ecosystems and the species. This ultimately results in species extinction *i.e.,* biodiversity loss. The cutting of the forests for preparing the fields for agricultural use, filling the wetlands and converting land uses for creating residential or commercial sites, harvest of the fossil fuels, etc. are all examples of habitat destruction. The destruction, degradation and fragmentation of habitat are the three predominant categories of habitat loss.

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Development of agricultural practices, reduced resources such as food, water, air quality, mining, pollution, logging, catastrophic fishing activities, urbanization and the interruption of processes related to ecosystem are the predominant elements of degradation of habitat. The habitat degradation affects both the species dwelling in the habitat and the humans both. The erosion, depletion of nutrients and desertification causes the further loss of the degraded land.

Habitat fragmentation is another huge issue arisen due to human developmental activities. Human beings for the purpose of development and to meet the never ending needs to expand even at the cost of extinction of their own species converts large wild areas into smaller fragments of land. These split-up areas break down the habitats of the animal and plant species, isolate animal communities, compressing genetic diversity.

Over exploitation: Humans have always depended on nature for food and shelter, but when 'need' turns to 'excess, it leads to over-exploitation of natural resources. Many species extinctions in the last 500 were due to overexploitation of the resources by humans. Presently many marine fish populations around the world are over harvested, endangering the continued existence of some commercially important species.

Introduction of invasive alien species: The introduction of invasive species is the tremendous threat to biodiversity crisis. The species, which is not native to the ecosystem, arrives or is introduced mostly *via* humans in the new ecosystem and start to pullulate the native species. When alien species are introduced unintentionally or deliberately for whatever purpose, some of them turn invasive, and cause decline or extinction of indigenous species. For example, the Nile perch introduced into lake Victoria in East Africa led eventually to the extinction of an ecologically unique assemblage of more than 200 species of cichlid fish in the lake.

Such species are harmful as they affect the ecosystem excessively compared to any other species. Most of the new species introduced in the ecosystem do not become invasive, but few of them turn into invasive species and adversely affect the ecosystem. The invasive species harm the native ecosystem in many ways such as they modify the habitat, import pathogens, are herbivorous on plants in native ecosystem, lead to decline of genetic diversity by hybridizing with natives, for the resources they directly compete with and prey on the native species.

Climate change: The biodiversity and climate change are strongly associated. Even though the climate has consistently altered during the whole of earth's history with ecological communities and species evolving and extinguishing, accelerated climate change disturbs ecological systems and species capability to acclimate and hence the loss in biodiversity enhances. The rapid climate change, stimulating biodiversity loss jeopardize human interests and security for clean water, air, medicines, and additional natural resources we depend on, would be difficult to attain due to reduced or vanished flora and fauna they are obtained from Everard, et al.

Water pollution: Water pollution had detrimental effect on biodiversity. Chemical fertilizers generally contain nitrogen and phosphorous and are added to soil to boost the crop productivity. Nitrogen and phosphorous sweep away from the soil to the water bodies or underground. The presence of these nutrients in the bodies leads to eutrophication or excessive plant growth. Eutrophication causes the depletion in the oxygen level which is deleterious for biodiversity. Fish and other aquatic animals die because of lack of dissolved oxygen in water.

Like fertilizers, pesticides may also accumulate in water bodies. The pesticides negatively affect non-flowing water bodies such as lakes and ponds given the fact that fertilizers are not washed away and animals in water bodies have difficulty in reproducing. Various anthropogenic activities such as production of cement, cars; mining etc. can leads to the introduction of heavy metals such as arsenic, cadmium, mercury into the water bodies. Heavy metals affect the behavior as well as the survival rates of aquatic animals specially fish.

Further, events such as oil spills greatly impact the wildlife especially in the deeper oceans. The birds and the larger animals display the apparent hostile effects. Oil spills cause disruption of the animal senses, suffocation, impair the vital organs of the organisms, reduction in growth rates and induce the higher mortality of the larvae, like the oil spills, plastic stays in the environment for longer time period and hence influence the wildlife. It has been noticed that the seabirds like Layson albatross upon consumption of plastic die prior to fledging the nest. Micro plastics in the environment also impact the survival rate of larvae, diminished food consumption and gradually weight loss in aquatic animals.

Soil pollution: Soil pollution is another factor adversely affecting biodiversity. Soil contaminated with heavy metals greatly impacts the welfare of the microorganisms essential for the sustaining life of the living organisms. The excess of heavy metals present in the soil are not easily broken down and are accumulated by plants. Especially the recent over use of fertilizers, pesticides and antibiotics used in agriculture is also very deleterious for the biodiversity. These agricultural pollutants such as nitrogen from fertilizers alter the pH and the nutrient level of the soil. The enhanced presence of nutrients in the soil causes the vigorous growth of grass species, leading to suffocate in the growth of wildflowers, essential for bees and other pollinating insects and this greatly impacts the biodiversity.

Natural disasters: Natural catastrophes, for instance volcano's, wildfires, floods, hurricanes, draughts, tsunamis etc. cause a heavy loss of biodiversity. The tropical areas harbor a lot of vegetation and vast numbers of animals survive in the vegetation. Due to flooding, large amount of nutrients from the soil gets washed away. Drought too led to dry soil and decline in the level of water table. In this situation, both animals as well as plants suffer. Similarly, wildfires in the thickly wooded forests and earthquakes significantly disrupt the life of the organisms and thus affecting biodiversity. Volcanoes frequently crash animals and plants in the adjoining areas. The occurrence of epidemics in nature is normally restricted to certain population of animal or plant since the pathogen is usually species specific.

Co-extinctions: According to Kumar and Verma when certain species becomes extinct, the plant and animal species associated with it in an obligatory way also become extinct. When a host fish species becomes extinct, its unique assemblage of parasites also meets

the same fate. Another example is the case of a coevolved plant-pollinator mutualism where extinction of one invariably leads to the extinction of the other.

Hunting: Hunting is the root cause of extinction of large numbers of animals holding position in food web. Due to this, the various species in the region are adversely affected as they face food scarcity or complete food unavailability compared with the normal situation. Hunting is extensive operator of loss of biodiversity. Hunting activities exert a considerable burden on wildlife, provoking immense downturn of wildlife and leading to disturbed and inefficient ecosystems. In most extrude situations; overhunting can lead to the elimination of large mammals in contrarily healthful unharmed habitat, compelling transition in forest structure.

CONCLUSION

Biodiversity includes a number of different organizational levels of variation and it can be measured at various levels. The most commonly used organizations' of biological diversity are genetic diversity, species diversity and ecosystem diversity and also include cultural diversity (bio cultural diversity). Biodiversity has environmental, cultural, social, economic, medicinal, scientific, educational and aesthetic values.

However, recently biodiversity is being lost at an alarming rate due to natural and more importantly anthropogenic factors. The threats to biodiversity are agricultural expansion, overexploitation, urbanization, industrialization, pollution, fire incidence, exotic species, Genetically Modified Organisms (GMO) s and global climate change, which are all driven by human population growth. In general the conservation of biodiversity is achieved by two broad approaches which are known as *in-situ* and *ex-situ* conservation. There is also a need to prioritize species, populations and ecosystems for conservation actions.

Moreover, promotion of indigenous resource management systems and practices, involvement of local people in conservation planning and endeavors, development of appropriate benefit sharing mechanisms, awareness creation will be essential. Moreover, promotion of the involvement of all relevant stakeholders and provision of adequate human, financial and physical resources for conservation efforts are important measures that should be taken in order to ensure the conservation, management and sustainable use of biodiversity.

Therefore, in order to ensure the sustainable conservation of biodiversity, there is a need to take urgent actions to protect biodiversity from different threats, while, to ensure the maintenance of biodiversity, employing complementary *in-situ* and *ex-situ* conservation is desirable. Furthermore, scholars, policymakers, local communities, academic institutions, conservation organizations, practitioners and all other relevant stakeholders need to work closely for conserving biodiversity and improving human wellbeing.

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