

Biodiversity Conservation Strategies in Urban Planning and Development – A Review

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Abstract

This paper examines the concept of conserving biodiversity in urban areas by making strategies and plans to help contribute to the development of the same. It explores the role of urban environments, what pressures it puts on biodiversity and helps us envision a pathway towards developing more bio-diverse urban environments that the masses can accept and support. It introduces the reader to several conservation policies, biodiversity-friendly management, socio-ecological systems and nature-based solutions that can aid us in urbanization without abusing and damaging our natural resources, the challenges faced and the opportunities that come with it.

Keywords: Biodiversity, Conservation policies, Biodiversity-friendly management, Socio-ecological system, Urbanization

Introduction

'Urban Areas' and 'Biodiversity' are the two keywords that form the word 'Urban Biodiversity'. The aim is the conservation of biodiversity in metropolitan areas where the depletion of biodiversity is occurring due to rapid urbanization. The term "Biodiversity" was coined by Walter G. Rosen. It introduces the concept of a variety of animals, plants, fungi, and prokaryotic organisms living together in a habitat in a symbiotic relationship to maintain the ecological balance of an ecosystem [1].

Charles Darwin was the one who identified the first principle of the origin of modern biodiversity, it states that all species were linked in a single great phylogeny, or tree of life and that all could be traced back to a presumed single original species at some distant time in the geological past. Sir Ebenezer Howard was the first major urban planning theorist, who brought urban planning to light. He initiated the garden city movement in 1898, which was a concept that revolved around small towns that were self-contained and surrounded by greenbelt [2].

On the other hand, Scotsman Sir Patrick Geddes is regarded as the modern-day father of city planning. He was born on 2 October 1854 in Ballater, Aberdeenshire. He introduced the world to town planning. Town planning according to Collins dictionary is the planning and design of all the new buildings, roads, and parks in a place in order to make them attractive and convenient for the people who live there. The aim of town planning is to protect historic buildings, coastlines, revitalizing and regenerating declining places and creating a new environment. Sir Patrick believed town planning was more than just "place" planning. Instead, it was primarily "people" planning. According to him the theory of city development combined geography, culture, and civic education reform toward city betterment. He combined the concept of lavishes and splendor of the city with nature and frondescence to give a more naturalistic feel, which contributes to the thought of conserving the flora of our environment [3].

Impact

Urbanization has a huge impact on the state of our environment. The process of urbanization produces an inversion of landscape patterns which become dominated by anthropic habitats. This entails a reduction and fragmentation of natural habitats, and the emergence of strong barrier effects that hinder or even prevent the movement of organisms and ecological connectivity [3].

Aims and objectives of biodiversity

The aim of Biodiversity is to acknowledge, appreciate and develop a deeper understanding of species, ecosystems and the interconnectedness of the living world and thereby avoid the mismanagement, misuse and destruction of biodiversity. Achieving a balance between human culture and the natural environment. A great example is Central Park, which represents an ecosystem fragment within a larger urban environment. Focusing on environmentally sound economic development, balancing growth needs, with a resilient mind bearing the capacity of ecological systems [4].

Role of sustainable development in urban cities

Sustainable urban development is important for many reasons, ranging from long-term economic benefits to improved quality of life and reduced environmental impact. By investing in sustainable initiatives, cities can create jobs and growth, while at the same time reducing energy usage, waste, and pollution.

Three levels of biodiversity:

Scientists often speak of three levels of diversity: species, genetic, and ecosystem diversity. The total number of species of flora and fauna in a given region is called the species diversity of that region. It is taken as a unit of measurement for balance of any ecosystem. The populace of microorganisms is impossible to count because the number is easily in billions. Only 10gm of soil may contain a billion bacteria and more than 50,000 fungi. Hence, the number of microorganisms is not counted while defining the biodiversity at a place.

The range of different inherited traits within a species is termed genetic diversity. For example, different varieties of rice show genetic diversity. Similarly, differences in height, skin color, facial features, hair color. etc. among human beings show genetic diversity. A higher level of genetic diversity among members of a species ensures that the species is innocuous to becoming extinct because genetic diversity increases the ability to adapt to the environment. Genetic diversity is accountable for bringing forth a new variety of species.

Ecosystem diversity is the type of system where interaction takes place between different creatures and the biotic and abiotic components of our environment. It is basically the difference in environmental and geographical conditions in different ecosystems. Grasslands, deserts, marshes, mountains, river valleys, tropical forests, ocean etc. are some types of ecosystems on our planet. Geographical and environmental features are idiosyncratic to each one's own ecosystem. These features are accountable for diversity among organisms in a distinct region [4].

Different types of urban ecosystems:

They include cities, smaller settlements and industrial areas, that are made up of diverse patch types (e.g., buildings, paved surfaces, transport infrastructure, parks and gardens, refuse areas).

Different elements of urban nature can be an abode to different types of biodiversity. For example, a city park with forested trails can be a home to many different types of trees, birds and animals, whereas a stream or a pond may be rich in urban biodiversity because it is home to a variety of frogs, fish, and beneficial microbes [4].

Five principles of urban ecology:

1. cities or urban areas are ecosystems
2. they are heterogeneous
3. they are dynamic
4. their human and biophysical components interact
5. Biophysical processes remain important in them.

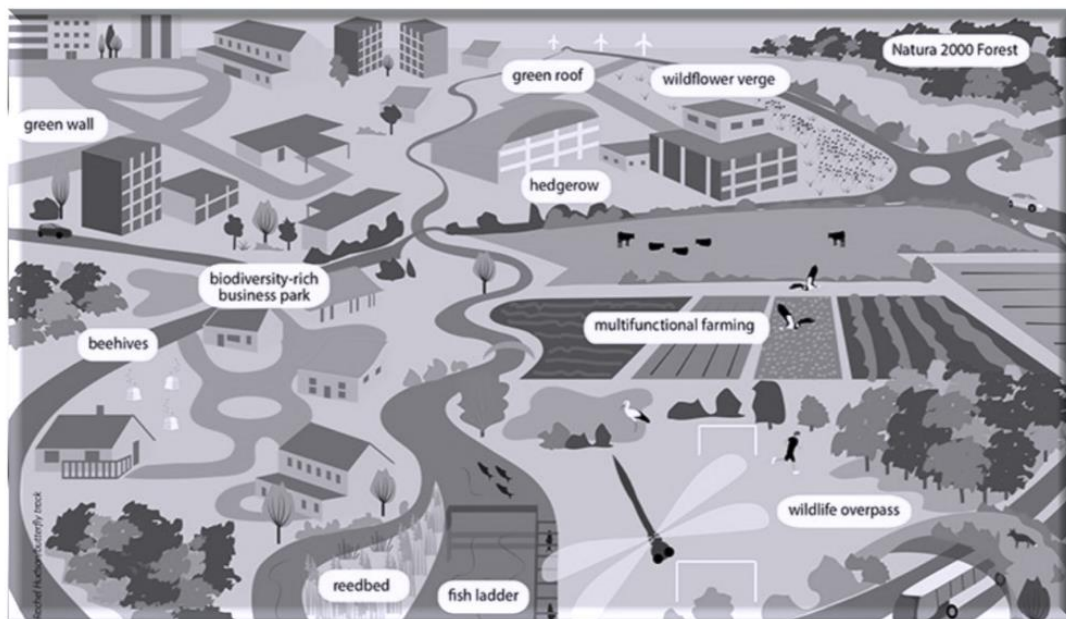


Figure 1. The different forms of Green infrastructures⁴

Main Factors

Several factors contribute to the diversity of species, such as habitat diversity, competition among species, and genetic diversity. Out of all these, genetic diversity is the main factor of diversity. Genetic diversity within a species not only is necessary to maintain diversity among species, but it also contributes to the diversity of food, fiber, and medicines available from nature [5].

Mega-Centers of Biodiversity

Nowhere can both the difficulties and rewards of preserving urban biodiversity be better seen than in the most biodiverse city in the world: Cape Town, South Africa. Cape Town's jurisdiction includes the major coastal nature reserves and expansive parkland that overlaps with human settlements. There are also mega centers of biodiversity. These are a collection of countries that house the majority of the world's species as well as many endemic species. Australia is home to 84% of plant species, mammals, and 45% of birds. Other countries are the United States, India, China, South Africa, Brazil, Mexico, Madagascar, Congo, Indonesia, Malaysia, Ecuador, Philippines, Venezuela, Peru, Colombia, and Papua New Guinea [6].

Biodiversity Conservation Strategies

Biodiversity conservation refers to the protection, preservation, upliftment and management of biodiversity to derive sustainable benefits for present and future generations. It is a series of conservation actions that collectively achieve the biological goals and objectives of the Habitat Plan. The conservation strategy provides mitigation for impacts on covered species based on species and habitat needs.[6]

Types:

There are 2 types of biodiversity conservations:

- 1) In-Situ
- 2) Ex-Situ



Figure 2. Green waterstorm infrastructure in Philadelphia⁴

In-Situ Conservation

In-situ conservation means the conservation of a species in its natural habitat, where the natural ecosystem and genetic variation is protected and maintained, habitat and the maintenance and recovery of viable population of species in their original place. It is the methods of conserving all the living species, especially the wild and endangered species in their natural habitats and environment. In-situ conservation of Biodiversity includes biosphere reserves, national parks, wildlife sanctuaries, etc. Different methods of In-situ conservation include biosphere reserves, national parks, wildlife sanctuaries, biodiversity hotspots, gene sanctuary, and sacred groves. This method of conservation allows animals flourish in their natural habitat and food chain and offers more mobility to the animals. The main purpose of in-situ conservation is to enable biodiversity conservation within the same ecosystem it belongs to. In-situ management approaches can either be targeted at populations of selected species or whole ecosystems [7].

Advantages of In-situ conservation:

1. It is a natural way to protect animals and plants.
2. Large populations can be protected at once.
3. This is a more discreet method than simply keeping the species away from their natural setting.
4. There is a higher chance of recovery than in situ preservation methods.

Disadvantages of In-situ conservation:

1. Some uncontrolled factors such as diseases, climate change etc. can cause a decrease in the population.
2. Endangered habitats can be fragmented, so the area may not be large enough for the species to exist

Ex-Situ Conservation

Ex situ conservation is the technique of conservation of all levels of biological diversity outside their natural habitats through different techniques like zoos, captive breeding, aquarium, botanical garden, and gene bank. It involves the transfer of genetic material away from the location where it is found. It includes national parks, wildlife sanctuaries, biosphere reserve, sacred grove, hot spots. It is the protection of organisms outside their habitat. Threatened species are taken from natural habitat and placed in special settings. It has several purposes such as rescuing threatened germplasm, producing material for reintroduction, translocation, reinforcement, habitat, landscape restoration and management Production of material for conservation biology research etc.[7]

Advantages of ex-situ conservation

1. Organisms are completely protected from predation and poaching
2. Health of individuals can be monitored, and medical assistance given as required
3. Populations can be more effectively managed and divided if disaster strikes
4. Genetic diversity of the population can be measured
5. Selective breeding programs can be put into place
6. Modern reproductive technology can increase the chances of reproductive success
7. Animals and plants can be bred to increase their numbers if endangered
8. research into reproductive physiology, lifestyle and ecology of an endangered species is made easier.
9. Conservation sites can be used as attractions to raise funds for further conservation efforts
10. Conservation sites can be used for education

Disadvantages of ex- situ conservation

1. Captive population have limited genetic diversity
2. Animals can be exposed to a wide range of different diseases
3. the organisms are living outside their natural habitat
4. Nutritional issues may arise
5. Animals may not behave as normal making reproduction difficult
6. Correct survival environmental conditions may be difficult to achieve
7. Expensive to maintain
8. animals may not survive reintroduction into the wild
9. There can be difficulties with acceptance by the existing wild members of the species

Strategies of biodiversity conservation (What can be done/ What we can do):

1. Maintenance of essential ecological processes and life-support systems
2. Preservation of genetic diversity
3. Sustainable utilization of species and ecosystems
4. Efficient utilization of natural resources.
5. Protected areas should be developed for animals where no human activities are allowed.

6. All the varieties of food, timber plants, livestock, microbes and agricultural animals should be conserved.
 7. All the economically important organisms should be identified and conserved.
 8. Unique ecosystems should be preserved first.
 9. Poaching and hunting of wild animals should be prevented, a ban should be implemented
 10. The reserves and protected areas should be developed carefully.
 11. The levels of pollutants should be reduced in the environment.
 12. Deforestation should be strictly prohibited.
 13. Environmental laws should be followed strictly.
 14. The useful and endangered species of plants and animals should be conserved in their nature as well as artificial habitats.
 15. Public awareness should be created regarding biodiversity conservation and its importance. [8]
- The most important strategy for conservation of biodiversity is biological reserves.

Biological Conservation Techniques:

1. Population viability analysis (PVA)
2. Bayesian statistics
3. Decision analysis

Population Viability Analysis (PVA)

It refers to the set of ideas, theoretical models, and conceptual and computational tools ecologists use to understand extinction risk and to forecast future scenarios of population growth and decline [9].

Calculation:

The growth rate λ of a population is simply (N_{t+1} / N_t) .

OR

The number of individuals at time $t + 1$ divided by the number of individuals at time t .

Applications:

1. Predict the future size of a population
2. Estimate the probability of a population going extinct over a given time
3. Assess which of a suite of management or conservation strategies is likely to maximize the probability of a population persisting
4. Explore the consequences of different assumptions [9]

Importance:

A viability study assists in determining whether a project, plan, or concept is worth pursuing. It restricts one from engaging in a business or undertaking that could result in significant losses. The research recommends spending time questioning a plan and examining it in detail.[9]

Example:

A good example in the field of medicine would be a study of the viability of heart, tries to determine whether the heart muscle is alive. This type of study also tries to determine whether the patient needs a revascularization procedure.

Bayesian Statistics:

Bayesian statistical inference provides an alternative way to analyze a given data that is more likely to be able to solve problems related to biological conservation than traditional statistical methods.

Applications:

1. Statistical data analysis
2. To find the probability
3. Make predictive analysis
4. Pricing decisions

Importance

Bayesian statistics give us solid mathematical means of incorporating our prior beliefs, and evidence, to produce new posterior beliefs. Bayesian statistics provide us with mathematical tools to rationally update our subjective credences considering new data or evidence [9].

Examples

the probability that the first population was declining faster than 5% per year was 0.00, compared to a probability of 0.86 for the second population. The Bayesian results appropriately identified which population was of greater conservation concern. (Completely copied from University of Washington Study).

Challenges Faced

Although it is true that urbanization has an important impact on biodiversity, rapid urbanization can end up damaging biodiversity.

Decision Analysis:

Decision analysis is the process of using various decision-making tools and research to decide and solve various problems. It can be used to figure out various methods to conserve and uplift biodiversity [10].

Urban Pressures**• Land resources changing demands**

Over the years there has been a growth in human population which has resulted in land fragmentation. The varying usage of land and fragmentation alters natural habitats. This can threaten the sustainability of the flora and fauna populations and the viability of their habitats. This increases the pressure on our natural resources.

• Introduction of new species

When foreign and unfamiliar species of flora and fauna, that are not native to a particular region, are introduced either purposefully or unintentionally

- **Overgrazing**

Overgrazing leads to depredation of vegetation and causes a decrease in the vegetative area. This will cause the plants to take up more nutrients from the soil for growth which leads to a decline in soil fertility.

- **Fire Suppression**

Fire suppressions cause the buildup of dead biomass in fireproof ecosystems. These might trigger changes in the vegetative community.

- **Reduces water Quantity**

Reduction of a huge quantity of water in a region may cause the flora and fauna of that area to die and in extreme cases species can also go extinct. His causes scarcity of biodiversity.

- **Reduced water Quality**

Reduced water quality, an increase in pollutants in a water body causes many animals to die and the biodiversity decreases.

- **Limited and Sparse knowledge of Natural Resources and Systems**

Limited knowledge of natural resources leads to misuse and mismanagement of our biological resources. This harms the biodiversity of a region

- **Climate Change**

Climate change impacts our environment in various ways. It leads to drought, forest fires, famine, storms, a rise in sea level, oceanic acidification, global warming etc. All of this leads to the degradation of our biodiversity [11].

There are several ways through which we can overcome these urban pressures.

Urban areas provide us with fresh, new opportunities to support diversity in the most feasible ways, which can also be implemented in rural areas.

Green roofs, constructing wetlands, conserving water in wetlands, reducing irrigation, planted roofs, green facades, roadside trees, constructing greater green infrastructures like parks wetlands etc.

What has been Done:

1. In 2021, USAID invested \$319.5 million to conserve biodiversity, reduce wildlife trafficking and other nature crimes, and support the resilience of vulnerable and marginalized communities who depend on biodiversity and healthy ecosystems for food, jobs, and security.
2. The Government of India passed the Wildlife Protection Act in 1972, which banned hunting.
3. The UK BAP set out a series of activities for a 20-year period.
4. The America the Beautiful initiative sets a nationwide goal to conserve 30% of US lands and waters by 2030.
5. Madagascar has received more than \$700 million in international funding for conservation since 1990.
6. Earthwatch planted the UK's first Tiny Forest in 2020 [12].

Conclusion

In this paper we have explored what strategies have been adopted and what has to be done to uplift biodiversity. Methods such as population viability analysis (PVA), Byesian strategies and decision analysis are some of the biological conservation strategies that have been discussed. It details the challenges that have been faced and how society has overcome them. We can conclude that Conservation of biodiversity helps in preserving the genetic diversity of our environment and ensures the continuation of the existence of all the species.

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