Influence of Resilience and Uncertainty Induced Risk on Sustainability Performance of Built Environment

Ruimin Sha(✉)

Data Science and Engineering, University of New South Wales, Sydney 2052 NSW, Australia
z5384544@ad.unsw.edu.au

Abstract. The attainment of social peace and human welfare depends fundamentally on biodiversity, which is the cornerstone of sustainable development. The built environment significantly contributes to the loss of biodiversity and places a great strain on natural resources [1]. Therefore, fulfilling Sustainable Development Goals depends on development that incorporates biodiversity into the built environment. In the current field of built environment research, the connection between biodiversity and social well-being in sustainable development is rarely taken into account. To this end, this paper aims to examine the connections between the built environment, biodiversity, and Sustainable Development Goals. In addition, the development of physical ecological solutions for buildings in the context of environmental sustainability is reviewed, and architectural spatial analysis is described through a green building framework to produce beneficial urban effects. This will effectively address the invisible hazards associated with elasticity and uncertainty. The aim of this paper is to examine the linkages between the built environment, biodiversity and the Sustainable Development Goals. This paper explores the role of sustainable built environments in biodiversity conservation, which is central to the achievement of the Sustainable Development Goals, in particular Sustainable Development Goal 15. In this project, buildings and open Spaces as well as urban management systems based on technology and nature will be derived using a blue-green building approach. A "Research-by-Design" approach will also be adopted to improve the relationship between biology and sustainability through effective management of the urban environment. This research is beneficial to the environment, human health and spatial harmony of urban structures. The scientific and technological developments demonstrated in this study will help to integrate sustainability into urban architecture and open new opportunities for the integration of sustainability and the built environment. This will provide new ideas for governments and urban planners.

Keywords: Built environment · Sustainability. Biodiversity · Urbanization

1 Introduction

The usage of non-renewable resources by the building sector is regarded as having one of the lowest sustainability levels in the world. Because so many resources are needed to keep the construction sector running, it has a significant negative impact on

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the ecosystem [2]. Urban development is significantly impacted in a sustainable way by the interdependence and interaction between the natural and built environments. However, despite the incorporation of biodiversity strategies to support the growth of sustainable cities, the majority of fundamental social and urban construction features do not take biodiversity into account [3]. It is evident that new architectural projects and renovations of existing ones can be designed sustainably to lessen the adverse effects of ecological diversity and increase the ecological worth of buildings [4]. A sustainable built environment has the potential to lessen the loss of biodiversity since the building sector is strongly linked to the consumption of several resources and their damage [2]. Through actions like development and protection, the built environment may create greater chances for green urban spaces and improved public health. Ultimately, natural variety needs to be restored inside the structure in order to meet sustainability objectives. However, most research does not make the connection between the built environment, biodiversity and sustainable development. Often only a single link is found between the two, leading to a gap in the study of biodiversity and other elements. This research contributes to understanding the linkages between the built environment, biodiversity and the Sustainable Development Goals; Provide opportunities for relevant industry stakeholders and decision makers to put biodiversity at the heart of policies and strategies to drive the Sustainable Development Goals. This paper identifies best practices and approaches in the construction industry that support the restoration of biodiversity in the built environment to achieve the Sustainable Development Goals.

2 Literature Review

2.1 Biodiversity for the Sustainable Development Goals

Due to the limited nature of resource consumption, architects have been forced to reconsider the use of conventional resources, explore previously unexplored possibilities, and search for innovative ways to arrange living spaces in a way that conserves energy. The United Nations' 2030 Agenda for Sustainable Development includes 17 Sustainable Development Objectives and 232 specific goals. Among these are the protection, restoration, and promotion of sustainable use of terrestrial ecosystems, and Sustainable Development Goal 15 (Table 1) establishes the global goal of preserving and using the earth's environment and species. The sustainable development agenda of 2030 provides a framework for society to provide problems in the economic activities of the people's well-being and sustainable development. In addition to the basis of ecosystem services, biodiversity plays a major role in most Sustainable Development Goals (SDGS) [5]. In great part, biodiversity is necessary for human existence and quality of life. However, as cities expand in size, the burden on biodiversity grows. As a result, sustaining the links between the built environment, biodiversity, and sustainable development is critical to its implementation.

2.2 The Built Environment and Urban Development Influence Biodiversity

The built environment has an impact on biodiversity, which causes habitat loss and fragmentation [6]. Man-made environments can play a key role in supporting biodiversity

Table 1. SDG 15 Target. Source: (UN, 2015)

15.1	Ensure the conservation, restoration, and sustainable use of terrestrial and inland freshwater ecosystems, forests, wetlands, mountains, and drylands by 2020
15.2	Promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally by 2020
15.3	Combat desertification, restore degraded land and soil, including land affected by desertification, drought, and floods, and strive and achieve a land degradation-neutral world by 2030
15.4	Ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development by 2030
15.5	Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species
15.6	Promote fair and equitable sharing of the benefits arising form the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed
15.7	Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both the demand and supply of illegal wildlife products
15.8	Introduce measures to prevent and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species by 2020
15.9	Integrate ecosystem and biodiversity value into national and local planning, development processes, poverty reduction strategies and accounts by 2020

function. Providing green urban space in the built environment fosters biodiversity and also gives people the opportunity to connect with nature. Man-made settings may play a significant role in sustaining biodiversity [6]. The delicate ecological environment is damaged throughout the urban growth process, necessitating the strategic management of habitat replication technology to assure the achievement of sustainable development goals [7]. The built environment in general, and the building sector in particular, play a key role in maintaining biodiversity since they are the industries that have the most influence on the biological environment. But for the building business, this is typically not a top concern. Therefore, the agenda to place biodiversity at the core of sustainable development may be guided by the building sector.

Climate change is a result of the removal of land cover by buildings, which affects biodiversity [8]. Green roofs will contribute to the preservation of urban biodiversity by supplying green urban Spaces (such as green roofs) to integrate biodiversity into the built environment [9]. Therefore, incorporating biodiversity into new developments should be considered a key component of the application process for urban planning. Providing biodiversity close to people in urban environments provides positive environmental benefits, such as urban areas that promote biodiversity help the environment by

cooling the air and absorbing pollutants from the atmosphere. The capacity to deliver a variety of ecosystem services is increased in man-made environments with strongly integrated biodiversity, which also improves the well-being of individuals living and working in urban areas [10]. As an integral part of the built environment, biodiversity is beneficial to individuals, businesses and communities, as a healthy and functional natural environment is essential to driving sustainable economic growth.

To establish a sustainable built environment where biodiversity is a key component of the design and delivery of the built environment, a new biodiversity model should be developed. Biodiversity, which may be found in man-made habitats like waterways, parks, street plants, gardens, and open spaces, should be included in the value of the built environment. In order to attain this goal, the Department of Built Environment encourages the use of building techniques that can better safeguard more natural plants during construction concerns [11]. This issue focuses on a novel effort in this area: the integration of biodiversity planning in new construction and rehabilitation projects in the built environment.

Urban development must offer an ecological design that balances the built and natural environments, but it is challenging for specialists in the built environment to comprehend the connection between biodiversity and human well-being [11]. To stop the loss of biodiversity and habitats, the built environment should incorporate ecological knowledge into urban planning methods. Planning the built environment with biodiversity should try to preserve and improve the habitat's current resources while attempting to offer favorable possibilities for the built environment to interact with nature in a beneficial way.

2.3 Biodiversity for Sustainable Built Environments

The urban environment is defined as 0including "huge areas of parks, playgrounds, open spaces, roadsides, street plants, private backyards, community and botanical gardens, and playing fields" by McGranahan et al. [12]. Create plans to increase biodiversity that use tiny tree and shrub green spaces, or green roofs and walls, as a crucial component of urban development projects [13]. The constructed environment is enhanced by the presence of trees, which also reduces air pollution and, more crucially, offers habitat for wildlife. Urban regions with limited space resources may nonetheless be integrated into new natural development zones with the use of green roofs and green walls. The use of good urban design to enhance biodiversity is poorly understood by professionals in the building industry [4].

In addition, wildlife must be considered in the management of existing building assets in addition to biodiversity considerations in new buildings. The local environment should be supported in urban contexts. But to do so calls for a fundamental change in urban planning and architecture [14]. Sustainable built environments should promote the incorporation of biodiversity into urban development initiatives by offering suitable habitats for local and endangered plant and animal species. As part of urban development initiatives, creating ecological corridors like parks and rivers may boost biodiversity and encourage animals to live in these places [13]. Urban development needs to promote more biodiversity and biological landscapes that are thoughtfully planned to provide homes for both plants and animals. Buildings that include biodiversity offer possibilities for

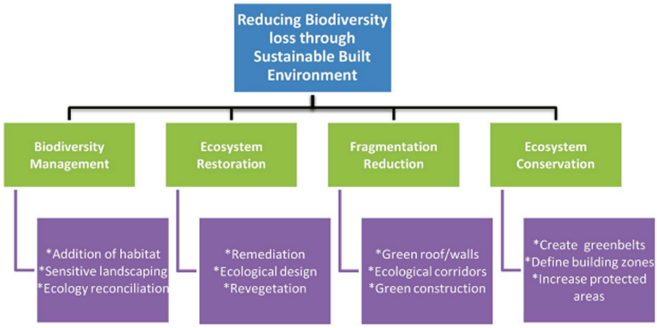

Fig. 1. Reducing biodiversity loss through sustainable built environments

healthy physical activity, which improves the quality of life. A sustainable constructed environment can help stop the loss of biodiversity, as seen in Fig. 1.

3 Methodology

A planning tool (the IBP Biodiversity Potential Index) was created by AECOM in 2011 to evaluate how well urban development projects might sustain biodiversity. The building and real estate industries don't fully comprehend how urban growth affects biodiversity or how to maximize this influence via environmentally friendly design, architecture, and asset management of buildings. Development projects' design, conservation, and building procedures have a substantial influence on biodiversity, which is crucial for both the present and future welfare of humanity. Municipal governments should evaluate the level of biodiversity and ecosystem functioning within their administrative regions to understand the impact of their policies and incentives as well as the motives of different stakeholders [15]. These evaluations are also required to monitor biodiversity status, conservation efforts, and associated policies and actions. In this study, the social and ecological aspects of particular cities were examined together with their effects on efforts to conserve urban biodiversity. Socio-ecological traits and urban conservation efforts to determine their influence on such efforts to conserve biodiversity in cities.

In the essay "Application of the Urban Biodiversity Index to Densely Populated Cities in Japan: The Impact of Social and Ecological Characteristics on Index-based Management," written by Mori Hide Uchiyama and Ryoshi Kosaka, the link between urban social and ecological factors and the status of conservation actions in these cities is examined in an examination of 20 major cities designated by legislation in Japan. These cities are found in or close to large urban regions. For instance, the Tokyo metropolitan region includes Saitama, Yokohama, and Chiba. Because the requirement for such a plan frequently depends on the natural resources accessible to the city, differences in their land-use patterns may be reflected in the status of their biodiversity protection initiatives.

Indicators reflecting the social and ecological character of the city were included in both types of indicators utilized in the study. There are specifically three indications linked to the first category and 10 indicators. The link between conservation efforts and the social and ecological character of the city was examined using indicators of the latter

kind. These metrics were developed after considering the comparability across cities and the viability of questionnaire surveys [16]. Data on the indicators was gathered through surveys, statistics, and GIS data on land use.

Investigating and analyzing the following metrics will provide information on local conservation actions in cities: (3) Implementing inter-departmental collaboration within a single city. (1) Quantitative evaluation of biodiversity and environmental services. (2) Participatory monitoring of biodiversity. Using quantitative indicators, indicators 1 and 2 demonstrate how biodiversity monitoring is being implemented in each city; indicator 3 illustrates the level of collaboration attained by various city administrations. Indicator 1 shows how biodiversity monitoring is being implemented in each city.

They also looked into and assessed the following variables for neighborhood conservation efforts in cities: (1) Quantitative evaluation of environmental services and biodiversity; (2) Participatory monitoring of biodiversity; and (3) Implementation of inter-departmental collaboration within a single city. The 10 indicators also contain three additional sets of biodiversity indicators. To establish the fundamental social and ecological features of cities and to ensure comparability across cities, ten indicators were looked into and analyzed. The following information was gathered for all target cities: (a) the total urban population; (b) the yearly budget of the city; (c) the budget per capita; (d) the number of officials participating in biodiversity conservation strategies; and the number of officials involved in biodiversity conservation strategies. (e) the amount of the budget for the urban biodiversity strategy;(f) the percentage of the annual budget allocated to the municipal biodiversity strategy; g) the percentage of forested land; (h) the amount of forest per person; (I) the percentage of agricultural land; and (j) the proportion of agricultural land that is built up.

The questionnaire results of projects related to the number of officials actively involved in biodiversity conservation, the size of the budget for conservation activities, and the status of biodiversity conservation activities are first presented based on the data provided, in order to understand the general trend of the cities under study. In Figs. 2 and 3, trends in the amount of money allocated to biodiversity protection and the number of government employees actively participating in this cause are depicted.

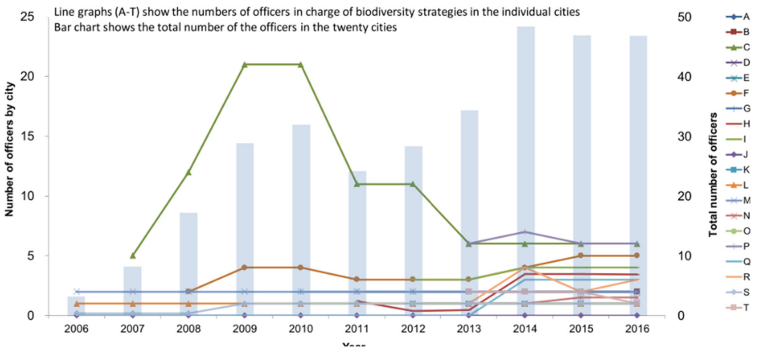

Fig. 2. Number of officials responsible for biodiversity strategies in 20 selected municipalities

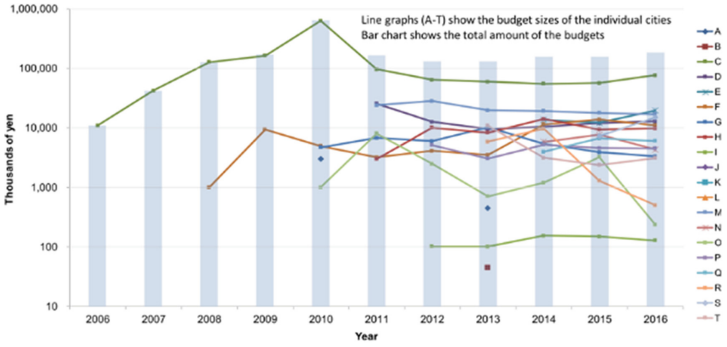

Fig. 3. Budget for biodiversity strategies allocated to 20 selected municipalities.

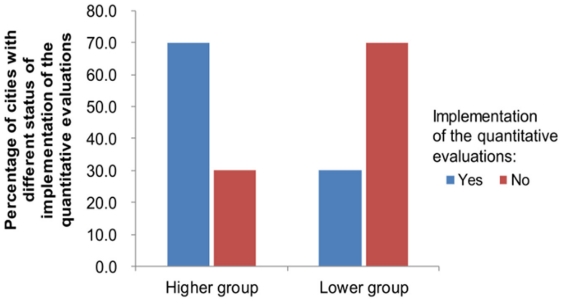

Fig. 4. Percentage of cities with different status of implementation of the quantitative evaluations

The findings demonstrated that in the chosen cities, the number of authorities engaged in biodiversity practice remained mostly steady. The overall number of government employees engaged in biodiversity management has progressively grown since 2006 (Fig. 3). Following 2010, a number of municipalities created biodiversity policies based on Japan's Basic Law on Biodiversity. The implementation of these operations was subsequently assigned to the appropriate government agencies and staff by these cities, which increased the number of individuals working in biodiversity management. The formulation of stable budgets required for the sustainable management of ecosystem services and biodiversity will be facilitated by an increase in the number of officials with expertise in policy formation and related conservation operations. Changes in budget allocations in these cities appear to have been impacted by internal events as well. For instance, one of the towns had a celebration honoring the city's emblematic bird in a year with a sizable budget; but, in years with little budget, the city has trouble implementing sustainable environment and biodiversity monitoring. As a result, changes in the amount and distribution of municipal budgets may have a detrimental effect on activities connected to sustainable management.

Only half of the 20 selected cities have conducted a quantitative evaluation of biodiversity, according to the study's indicators 1, 2, and 3 regarding the state of initiatives to conserve biodiversity (indicator 1). Contrarily, 16 municipalities have incorporated

participatory monitoring as a component of their conservation efforts (indicator 2), as opposed to just 3 municipalities that haven't done anything at all. In response to a query about whether it engaged in surveillance, one city made no comment. Additionally, 12 cities have fostered collaboration across various government agencies (indicator 3).

Each index combination of neighborhood conservation efforts and urban social and ecological traits was statistically examined in order to examine the link between the state of conservation efforts and the city's social and ecological features. Within a 10% confidence range in both tests, the Chi-square test and the Fischer precision test revealed a statistically significant association between indicators (1) (application of the quantitative evaluation of biodiversity and ecosystem services) and (j) (percentage of built-up area). Additionally, in both tests, there was a statistically significant link between indicator (h) (area of forest per capita) and indicators (h) (implementation of collaboration across different sectors) within the 5% range. The relationship between neighborhood conservation efforts and the social and ecological features of the city, however, was not statistically significant for other indicator combinations. Results of the association study between indicators (1) and (j), indicators (3) and (4) (h) Here is a description of it. In Fig. 4, the median percentage of floor area is used as a distinction criterion to determine the higher and lower groups, as defined in Sect. 2.2, and shows the percentage of cities in each group that implement quantitative assessment or do not, with regard to the relationship between indicators (1) and (j). In the "upper" group (7 cities), a larger percentage of built-up regions than in the "lower" group (3 cities) applied quantitative biodiversity assessment (Fig. 4).

This finding suggests that cities with more densely populated regions frequently use quantitative evaluation. Municipal administrations in cities with huge built-up areas can readily shift their focus to evaluating the city's sparse natural areas (which need to be conserved) in order to preserve urban biodiversity and the welfare of its residents. In the cities practicing intergovernmental cooperation, the "upper" group (9 cities) has a bigger per capita forest area than the "lower" group (4 cities), according to the link between index (3) and (h) (Fig. 5).

The intergovernmental collaboration between the departments of agriculture, tourism, and welfare is becoming more and more varied in cities with relatively substantial per capita forest areas. There are several methods for utilizing forests and other natural resources in cities with significant per capita wooded areas;

Figure 4 percentages of cities with different status of implementation of the quantitative evaluations in two city groups.

Figure 5 percentages of cities with different status of implementation of governmental inter-sector collaborations in two city groups.

These findings suggest that most of the cities under study share the problem of quantitative, target-based management, which is defined by intersectoral collaboration. This could be due to the fact that cities with a high proportion of floor space prefer to evaluate things quantitatively using indicators, but towns with a lot of forest land per person tend to have a better degree of intersectoral collaboration. These two traits, nevertheless, do not coexist in the same city (Fig. 6). Implementing quantitative index-based management based on inter-departmental coordination is necessary to counteract the effect of urban ecological features represented in urban land use patterns. In a variety

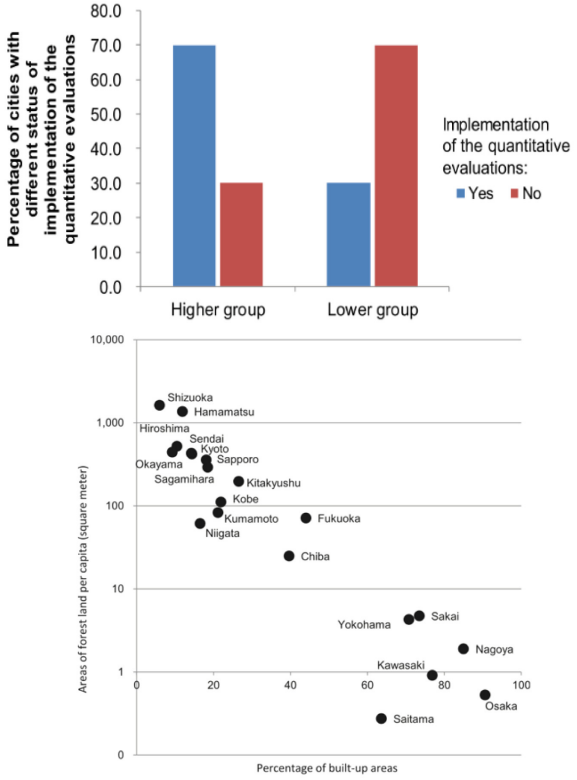

Fig. 5. The percentages of built-up areas and the amounts of forest land per capita in the studied cities.

of land use scenarios, this index-based management technique aids in maintaining urban biodiversity.

4 Results and Discussion

In order to achieve Sustainable Development Goals, workshop participants addressed how to leverage the built environment as a driving factor for biodiversity preservation and promotion. Improved biodiversity in the built environment may be a major force in the development of the building sector. If biodiversity loss is to be slowed, a new strategy that incorporates complex interactions between people and creatures in the design, construction, management, and control of man-made habitats is necessary. An asset in a structure that is well-designed and built produces a habitat where animal species can thrive. Given that more than half of the urban development required by 2030 has yet to be constructed, there is a significant opportunity to address biodiversity loss through urban development. New urban developments should adopt sustainable building practices to provide low-carbon structures and green infrastructure. All building

materials' effects on biodiversity should be evaluated, as well as the carbon footprint of certain materials. The local protected species may be impacted by construction materials from unauthorized forests.

According to Edwards [17], architects have a significant responsibility to take biodiversity measures into account when planning a development. Sustainable planning, design, and construction of built assets improve the quality of the built environment necessary for human health and well-being. I, the participant, commented on the topic of using bionic design and natural vegetation to address biodiversity loss. There is evidence of significant biodiversity at the planned development site, thus specialists in the construction industry should be involved in safeguarding the habitat during construction by creating a management plan to protect the biodiversity of development [18]. For instance, ecologists may instruct laborers on building sites to be cognisant of biodiversity. By arranging high-noise operations at specified periods of the year and avoiding such activities, noise from construction activities should be reduced.

In order to create chances for biodiversity conservation, urban planners should create management plans with an ecological viewpoint for new development projects [19]; biodiversity corridors and urban green spaces should play a significant role in urban development [20]. While effective implementation of integrated ecological component planning policies may face technical and political obstacles in some regions of the world, support from all levels of political and organizational leadership is necessary for the SDG to stand a chance of becoming a reality by 2030. Participants agree that "the importance of promoting the effect of building operations on biodiversity across the construction sector with the involvement of key industry stakeholders" [21]. Ponds and rivers, which act as ecological corridors and are small but important animal habitats, should be safeguarded during development. Urban development initiatives can be employed to improve building sites' ecological value rather than devastate it. For instance, by planting trees and protecting naturally existing flora, building sites and their surroundings can be safeguarded for the benefit of animals. In order to avoid desertification, man-made settings should offer infrastructure, and solar energy may be deployed in desert regions to supply power pumps for irrigation and afforestation projects. Plans for managing biodiversity should be incorporated into a company's basic business strategy for tracking, reporting, and evaluating all operations that have an environmental impact [22].

5 Conclusion

The Sustainable Development Goals, which are at the core of the study, are to conserve biodiversity and create sustainable built environments. It looks at how using sustainable building methods may better maintain and promote biodiversity as a vital component of the built environment. The ability of the earth to adapt to climate change, the quality of the air, the ability to reduce floods, and the general health and well-being of civilization may all be improved by man-made habitats that contain biodiversity. Political leadership in terms of policy direction and new laws to safeguard biodiversity will be necessary in order to accomplish this on both the national and international levels. The best approaches to leverage the interplay of natural and man-made settings to suit human requirements and the interests of existing animals should be taken into account by biodiversity policies and plans.

This study demonstrates unequivocally that the built environment, through the planning, development, and upkeep of building assets, contributes significantly to minimizing biodiversity loss. To properly take into account the effect of all building operations on biodiversity, it is necessary to upgrade the currently available sustainability assessment methods. Not only should new construction and infrastructure projects incorporate biodiversity, but so should the management of existing building assets. Including biodiversity in the built environment can have a positive impact on the economy. The worth of development land, the marketability of developments made thereon, and, most significantly, the well-being of occupants and end users. Adopting sustainable purchasing procedures, in which only FSC Forest Stewardship Council-certified wood is used for building operations, helps to preserve biodiversity and accomplish the Sustainable Development Goals. The importance of biodiversity to many economic activities and its significant impact on human growth and welfare. Because of this, the statement suggests that national and local planning and development procedures and policies incorporate biodiversity value. The building sector as a whole should offer training and awareness programs on the connections between biodiversity and the built environment to all professionals. Finally, the findings imply that the built environment may be made more sustainable by the construction industry as a whole by creating legislative and regulatory frameworks that encourage the use of sustainable building techniques. The construction industry must be forced to act and adopt more sustainable business practices, so it is crucial to keep in mind that adopting sustainable practices and processes that support the conservation of biodiversity in the built environment requires a government policy and regulatory framework. Because there is little to no literature connecting the three concerns, the study has significance for both academic and policy organizations. This article explains the connections between the built environment, biodiversity, and the objective of attaining sustainable development.

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