

## **Biodiversity Conservation in Urban Landscapes: Integrating Green Infrastructure for Sustainable City Planning**

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### **ABSTRACT**

*Infrastructure is at the core of efforts of G20 nations to boost the structure of development across the world to make it sustainable and cut down on its ill effects. Infrastructure may affect biodiversity in different ways, such as direct loss of habitat in the footprint of current infrastructure, deterioration and fragmentation of natural resources, and changes in ecosystem. The strategy of “green infrastructure (GI)” has been provided with the capability to manage those challenges and its application is a way to recover natural processes and patterns, and reduce the flows of material and energy.*

*Due to lack of environmental efforts, green infrastructural development overlooks environmental services and global biodiversity. It is important for sustainable construction to have green infrastructure and green buildings in recent projects of urban development. In urban landscapes, biodiversity can improve health and governments should empower, educate, and promote builders/developers and communities for the integration of green infrastructure to ensure sustainable city planning. Efforts related to urban planning for the conservation of biodiversity have usually been focused on building protected corridors and natural landscapes. Despite having the importance of green infrastructure, it is evident that nearby commercial areas and neighbourhoods have least effects on conserved regions. The biological integrity of eco-friendly infrastructure can be degraded by invasive stormwater runoffs. This study discusses challenges in integration of GI for sustainable urban planning and discusses the future directions for governments and researchers to come up with a systematic approach, which makes management and design of urban landscapes to be complying with green infrastructure. Residents, researchers, developers, and planners play a vital role in traditional development to be more compatible with green building.*

**Keywords:** green infrastructure, biodiversity conservation, urban landscapes, sustainable city planning, GI, G20 nations

## **1. Introduction**

Biodiversity conservation in urban landscapes is one of the major global concerns as city planning plays a vital role in conserving local species and offering a platform for citizens to know natural processes governing human and global sustainability at the end. For urban biodiversity, setting up green infrastructure is the common goal of growth management and planning efforts, which refers to protected open space and green corridors (residential sections or yards). For instance, the key is to conserve natural landscapes by setting at least 40% of open space aside in conservations. Proper design, management, and engagement of business districts and neighbourhoods are often ignored. Hence, eco-friendly urban infrastructure is affected heavily by covering commercial and residential landscapes (Hostetler et al., 2011). This study discusses challenges and future directions for biodiversity conservation in urban landscapes.

### **1.1 Background**

In the backdrop of green infrastructure (GI) development, effects may be ranging from management and design to human uses and behaviours degrading natural landscapes (Hostetler & Drake, 2009). For instance, green infrastructure and urban landscapes which are dominated by turf grass, exotic plants, and resistant surfaces can affect native animals and plant species in the conserved landscapes. In these landscapes, stormwater runoff can cover a lot of nutrients like nitrates and phosphates, leading to algal blooms in water bodies, loss of fish species, and growth of invasive plants. Homeowners and developers may want to add exotic plants to their landscapes that may be established in conserved regions, affecting animal and native plant communities.

In addition, effects of construction can affect biological veracity of green building. Even pets can affect biodiversity in conserved regions as they prey on reptiles, bird species, and mammals. To be specific, how people use nearby landscapes and view can affect biodiversity. Even those homeowners living in conserved subdivisions don't know the importance of actions for the functionality of waterways and natural regions (Meurk and McMurtrie, 2006; Hostetler and Noiseux, 2010). Merely the frequent availability of humans has been reducing the breeding nests and bird territories (Miller & Hobbs, 2000).

It is observed that plant life in open space was controlled by exotics, in a study on conservation of clustered subdivisions, they expected those subdivisions lacked on proper stewardship to manage native species of plants (Lenth et al., 2006). In established buffers and natural areas,

even trees cannot be cut by nearby residents like trees affecting their view. It is very important to address these problems to improve conservation of urban biodiversity.

## **2. Literature Reviews**

If strategy of “Renaturing of Cities” is aimed to enhance the provision of ecosystem services in “urban green infrastructure (UGI),” the in-depth knowledge of habitat services, multifunctionality, and biodiversity-oriented approach are important instead of depending on benefits of UGI. Connop et al. (2016) presented a preliminary information out of 3 case studies (1 in Germany and 2 in England), exploring how to achieve multifunctionality, stakeholders needed, and practicality of experimental approach to show transformation and how it can be added to policy again. It is argued that adding UGI design which is contextualized locally into policy and planning domains play a vital role in resilience and functioning of the city to offer adaptability to respond to challenges like flooding, overheating, health, air pollution, and biodiversity loss.

The proper integration of ecosystem services (ES), ecosystem functions, biodiversity, and indicators in conservation and planning of GI poses a significant challenge for urban planners and landscapers. Basnou et al. (2020) came up with an operational model for GI planning at the scale of landscape in Barcelona. This study underlines value of “peri-urban green landscapes,” such as crop areas or forests for ecosystem functions, urban biodiversity, and provision of ES. They further observed the significant mismatch among the demand and supply of ES at the scale of landscaping. Generally, peri-urban forests are highly diverse with urbanized settings, including metropolitan areas of Barcelona and areas around the coast while areas having combination of high ES demand and supply in rural and urban fringes. It is found that urban fringes must be focused critically on integration of biodiversity functions and ES into green infrastructure. This approach has been implemented well in landscaping in Barcelona.

A lot of GI projects have been planned, proposed, and implemented in cities in Europe when EU Commission had adopted GI strategy in 2013. Even though there is a close relation between this policy tool and targets for biodiversity conservation, some doubts have been raised related to the ability of urban GI for providing benefits not just to human societies, but also to environmental systems hosting them. Capotorti et al. (2016) conducted a review on the features which are important when looking for solutions supporting the ecosystem services and biodiversity in urban settings. They conducted a case study in metropolitan Rome to discuss the importance of urban forests and trees as proxies for overall ecosystem and biodiversity. The researchers have looked beyond the functional aspects of vegetation communities and plant species to encourage environmental coherence, biographical representativity, and connectivity of restored and new elements of GI.

Ronchi et al. (2020) discussed the outcomes of experience performed in Rescaldina at the north of Milan, Italy. Here, conventional quantitative standards were bridged for the approach of performance standards as per the provision of “Ecosystem Services (ES).” With spatial planning, ES provision has been supported with GI while NBS are supposed to be green design actions which can play a vital role in developing green infrastructure. The private and public areas in the GI have specific regulation for its operability and implementation. In the “Strategic Environmental Assessment (SEA),” the GI strategy was defined as a support tool to set planning patterns.

Government bodies in Germany started a discourse on green building as a planning method at federal level in 2016. Hansen et al (2023) used the example of Germany for discussing the concepts like urban green infrastructure as it could evolve due to diverse socio-political priorities. When it comes to call for action on biodiversity loss and ecosystem, it is important to shift focus of eco-friendly infrastructural planning especially towards biodiversity. However, reframing on any topic avoids actors with priorities and control the conceptual potential.

## **2.1 Research Gap**

It is important to engage both public and developers to promote conservation efforts in terms of urban biodiversity. Researchers and planners play a vital role in promoting proper management and design of developed areas to monitor the functionality of green building. There is a need to focus more on efforts related to sustainable city planning. This study shares some thoughts on future research to foster the compatibility of green building for conservation of urban biodiversity.

## **2.2 Research Question**

- What are the challenges in integrating Green Infrastructure (GI) for sustainable city planning?
- What are the future directions for urban planners and governments for biodiversity conservation?

## **2.3 Research Objectives**

- To address the challenges in integrating Green Infrastructure (GI) for sustainable city planning
- To discuss future directions for urban planners and governments for biodiversity conservation

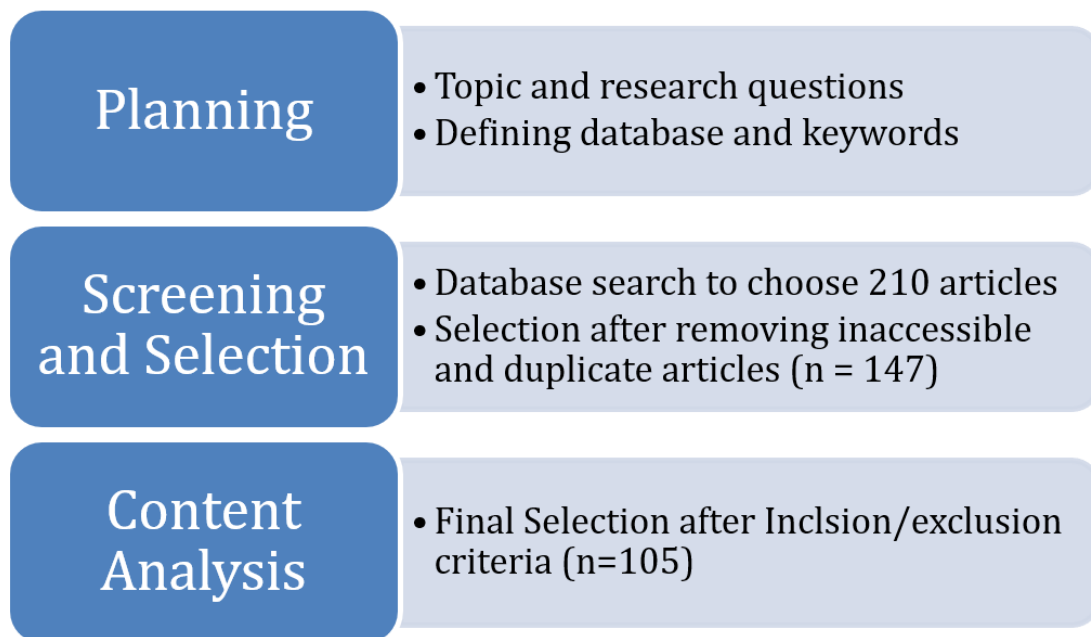
### 3. Research Methodology

#### 3.1 Research Method & Design

Green infrastructure is a very interesting and emerging research topic. There is a lack of consensus among practitioners, researchers, and political actors on principles to be considered when planning for green infrastructure (Grădinaru & Hersperger, 2019). This study is based on systematic literature review on biodiversity conservation in green infrastructure planning. This study gives researchers with a holistic perspective to the given topic of interest. The choice of conducting literature search to choose the principles in green infrastructure development is appropriate as it enables selection of relevant research with a wide sampling of various resources, such as empirical and theoretical sources, or non-experimental or experimental studies (Klein et al., 2020).

The literature review was structured with a combination of various processes suggested by various researchers (Moher et al., 2009; Suprayoga et al., 2020; Da Mota & Pickering, 2020). The research approach for this study relies on three stages – planning, selection and screening of publications, and content analysis of the rest of documents (Figure 1).

**Figure 1 – Overview of Research Approach adopted for this study**



Source - Klein et al (2020)

First of all, we identified and defined the concerned topic of research to ensure its originality and identified the questions to be addressed (Pickering & Byrne, 2014). We have identified total 210 documents using the search query on Scopus, Web of Science, Google Scholar, and other databases, which were run with selection and screening. This process includes developing criteria to scrutinize the studies and only relevant papers were selected (Ledda et al., 2020). After selection and screening, content analysis was performed and inclusion and exclusion criteria were applied to select only 105 documents (Mayring, 2004). Content analysis is an approach to test theoretical concerns to improve knowledge of data, where it can obtain a lot of categories or concepts to describe a research topic, theory, or phenomenon (Elo & Kyngäs, 2008).

### **3.2 Inclusion and exclusion criteria**

In order to ensure relevance with this study topic, abstracts, title, and full text of the samples were screened as per the criteria mentioned in Table 1.

**Table 1 – Inclusion and Exclusion Criteria**

<b>Criteria</b>	<b>Description</b>
Inclusion – Empirical and conceptual studies on green infrastructure and biodiversity conservation	These studies are focused on theoretical framework of the topic or may cover evidence with practical application
Exclusion – Duplicate or inaccessible papers or research papers written in other language	Those papers may contain similar information related to green infrastructure or may describe the planning principle

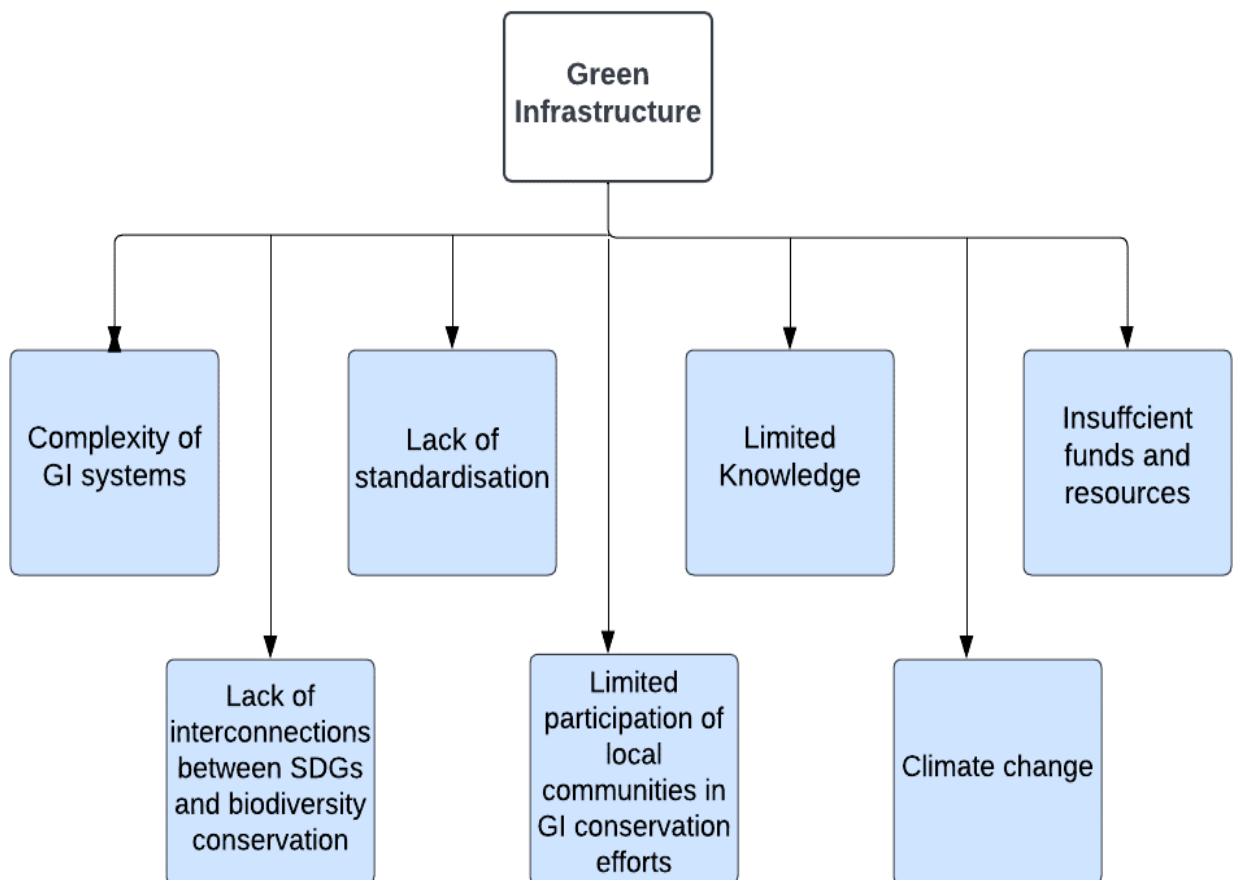
## **4. Analysis of Study**

### **4.1. Challenges in integrating Green Infrastructure (GI) for Sustainable City Planning**

Biodiversity is very important for the growth and health of human lives and ecosystems. However, anthropometric activities are known to be the threat to biodiversity with pollution, habitat loss, and climate change. This way, GI has been emerged as a natural solution to restore and conserve biodiversity. With semi-natural and natural elements like forests, parks, green spaces, and wetlands, GI offers a lot of environmental services which help in diverse ecosystems and species. To support and manage biodiversity conservation and infrastructure effectively, a national and international sustainability strategy should be implemented by the G20 nations.

With G20 presidency, India had different opportunity to keep the progress of grouping to develop international agenda for green infrastructure. A lot of significant global agreements have been introduced for conservation of biodiversity. Irrespective of those agreements, there is still loss of biodiversity and degradation. Overexploitation of natural resources, pollution, climate change, and highly fragmented mosaics of landscape include degraded and isolated environments are known to fuel the loss of biodiversity further. All of these adverse effects are based on intensive use of land and natural resources for consumption and development patterns (Figure 2). Loss of biodiversity has already surpassed the levels that can be tolerated by humans, which leads to far-reaching effects of human growth (Salomaa et al., 2016).

**Figure 2 – Challenges in integrating GI for Sustainable City Planning**



Source – Sharma & Kharbanda (2023)



From large-scale projects to simple household renovations, different kinds of construction projects affect natural ecosystems, making construction a leading sector playing a vital role in loss of biodiversity. GI refers to infrastructure which can reduce the ill effects of development and provide environmental services like reducing air temperature, runoff management, habitat conservation, and carbon sequestration. GI has not been adopted widely irrespective of those benefits “(Tayouga and Gagné, 2016). Mainstream adoption has been at the slow rate due to upfront cost of construction and design and need for conservation of natural systems. Some of the other impediments are lack of involvement of community, inefficient legal frameworks, and belief that GI is a stormwater management tool (Anderson & Gough, 2022).

Around 80% of global population belong to urban areas, making it important to extend amenities in urban infrastructure, such as zones for commerce, industry, recreation, and residences. Playgrounds, parks, residential landscapes, water bodies, highways, and courtyards are the important aspects of GI which combine people with nature. GI covers green buildings and other important techniques which cover those related to reduced heat stress, stormwater management, improved air quality, climate adaptability, clean water, healthy soil, sustainable development, and improved quality of living. When it comes to address drainage system and sustainable transportation, “urban green infrastructure (UGI)” can also rely on “carbon-free infrastructure” (Patel & Rangrej, 2021).

Next challenge is finding out about having the value of biodiversity of renovation and construction projects into urban green infrastructure (UGI) to design and assess the strategy to encourage biodiversity on project locations to improve their lifestyles. GI can be used differently with national-regional and municipal scales. The municipal one covers various playgrounds, parks, nearby parks, buffers, lakes, urban canals, floodplains, and rivers. The engagement of private and public companies varies in different nations and towns to pose various challenges related to non-standardization of beliefs. Along with above challenges, there is also lack of knowledge of ecosystem services provided by green infrastructure which are vital for sustainable growth of cities.

Implementing biodiversity in developing green infrastructure is important to achieve “Sustainable Development Goals (SDGs).” Relations between “SDG 9 (inclusive and sustainable innovation and industrialization, and resilient infrastructure), SDG 15 (sustainable use of terrestrial ecosystems and forests, reverse and halt land degradation and loss of biodiversity), and SDG 14 (sustainable use of sea, marine, and ocean resources)” are often overlooked or dismissed (Opoku, 2019). Table 1 highlights the potential SDGs and gaps when it comes to adopt green infrastructure.



**Table 1 – UN SDGs and Gaps for adopting GI**

SDGs	Conforming SDGs	Gaps	References
SDG 9 (Innovation, Industry, and Infrastructure)	SDG 2 (Zero Hunger) Target 2.A – Rural investment. SDG 12 (Responsible Production and Consumption) Target 12.2 – Sustainable use and management of natural resources	<ul style="list-style-type: none"> <li>• Policies are recommended for employing women with rural infrastructural growth.</li> <li>• Avoiding use of materials leading to greenhouse gas emissions</li> </ul>	Opoku, 2019; Omer and Noguchi, 2020
SDG 14 (Life under water)	SDG 7 (Clean and Low-cost energy) Target 7A – To promote access to investments, research, and technology for clean energy. SDG 9 (Innovation, Industry, and Infrastructure) Target 9.4 – Upgrade all infrastructure and industries for sustainability.	<ul style="list-style-type: none"> <li>• Developing renewable energy technologies like offshore thermal and water energy, can affect marine ecosystems significantly.</li> <li>• Development of coastal infrastructure, sea ports, and shipping lanes can disrupt marine ecosystems.</li> </ul>	Ronzon and Sanjuán 2020; Virto, 2018
SDG 15 (Life on Land)	SDG 6 (Sanitation and Clean Water) Target 6.1 – Affordable and safe drinking water SDG 11 (Sustainable communities and cities) Target 11.3 (Sustainable and inclusive urbanization)	<ul style="list-style-type: none"> <li>• There is a need to maintain natural land which transfer clean water to downstream communities sustainably.</li> <li>• There is a need to reduce negative effects of urbanization on biodiversity and terrestrial ecosystems</li> </ul>	Mulligan et al. 2020; Vargas-Hernández and Zdunek-Wielgołaska, 2021

#### **4.2. Future Directions for City Planners and Decision-Makers**

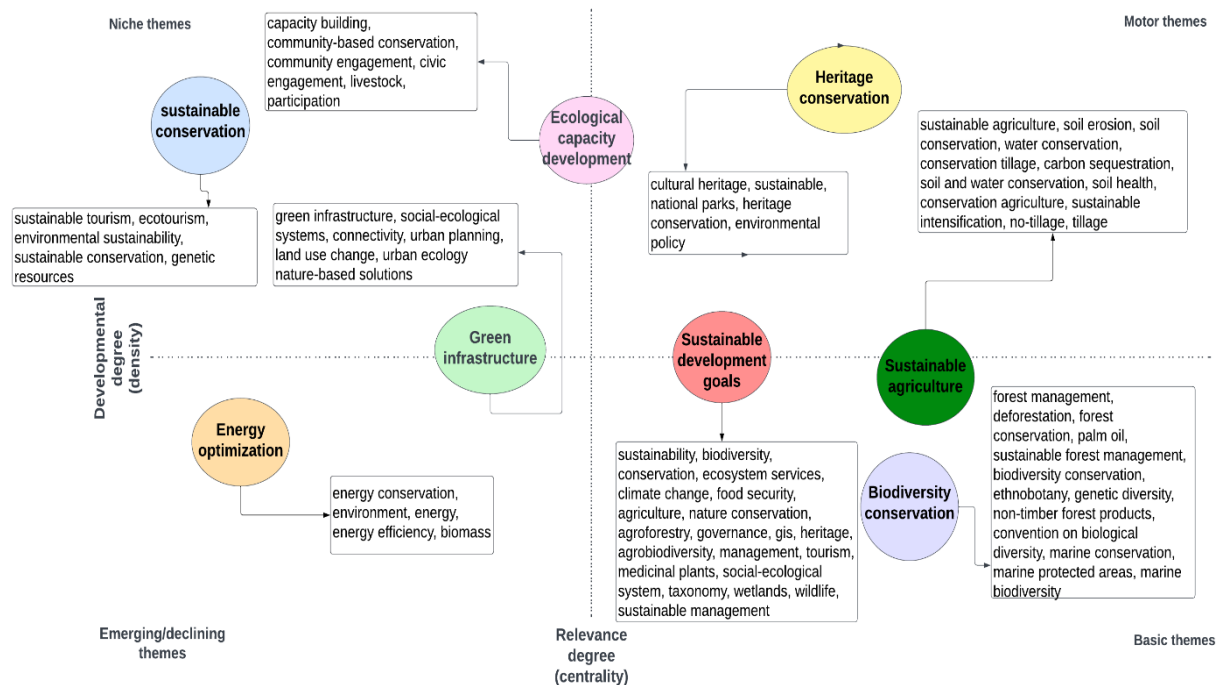
Global community may be required to focus on 4Ds – “De-escalating” the conflicts; adoption of equitable model for “decarbonization” to manage climate problems; inclusive and equitable “development”; and encouraging “digitalization” for these purposes as per presidency of India. In this day and age, urban planners and decision-makers should prefer sustainable and inclusive growth. A lot of G20 nations have taken initiatives to align their policies and laws with sustainable growth and reduce risks related to green infrastructure for biodiversity conservation. Considering the diversity of policies and laws related to G20, measures should be tailored to specific conditions and needs of each nation. Here are some of the G20 countries which have taken GI measures –

- **China** – The People’s Republic of China has introduced green banking and green bond standards.
- **Brazil** – Bilateral collaboration between the UK and Brazil can improve investment on sustainable development and projects to reduce inequality and encourage gender equality.
- **Indonesia** – There are 8 sustainable and green bonds have been issued by the “Ministry of Finance” to develop its infrastructure for green bonds.
- **France** – The government introduced certain measures to boost green mobility as part of “Resilience and Recovery Plan”. Around €550 million is being invested in development of transport infrastructure aligned with sustainable sector.
- **The UK** – The “Green Infrastructure Framework (GIF)” was announced by Natural England which can raise green cover in urban residential zones to 40%.
- **India** – Green infrastructure has been planned and announced by the “Union Budget 2023-24.” Green development, including green buildings, green energy, and green equipment were among the 7 key areas of focus acting as Seven Pillars or Saptarishi to direct the journey of India towards sustainable future, i.e., Amrit Kaal.
- **Germany** – The government has introduced new stimulus program with investment of €130 billion on June 3, 2020. It contains several robust programs to encourage carbon-free economy and green recovery in Germany.

Figure 3 highlights important themes of conceptual model. Density and centrality are some of the most important parameters to know thematic mapping (Cobo et al, 2015). Centrality represents the connection made by specific theme while density indicates the level of internal relations

within the themes (Bamel et al., 2021). Figure 3 focuses on the thematic illustration of existing knowledge on biodiversity and GI.

**Figure 3 – Thematic Mapping of Existing Biodiversity and GI Knowledge**



Source - Sharma & Kharbanda (2023)

## 5. Results

GI may play a vital role in aesthetic and cultural impact of historical monuments by providing functional and pleasant spaces to residents and tourists. In heritage sites, design of GI projects should consider their different cultural and historical importance and aspirations and needs of locals (Williamson, 2003). Sub-themes are being explored in niche theme of sustainable conservation widely. Some of the sub-themes like eco-tourism, environmental sustainability, and sustainable tourism have been focused. In Figure 3, two themes are overlapping with the motor, emerging, and niche themes in the bottom right and left corners. GI which is connecting to the niche theme has both negative centrality and density.

Sub-themes like urban planning, social-ecological, and natural solutions have significant potential as there is a huge gap between green infrastructure and development. Hence, a significant transformation is needed for GI to consider social and environmental standards to efficiently and effectively matches sustainable and global standards. Environmental capacity-

building is other theme relying on the study of communities as well as engagement to conserve environment with a network of projects and groups (Jerome, 2017).”

Energy saving is another important theme evolved as a key them with reduced density value. There are three themes in basic quadrant – sustainable agriculture, biodiversity conservation, and SDGs moving for a motor theme. There is a low potential and density for future growth in sustainable agriculture. Renewable energy has got a lot of boosts by the SDGs and room to grow and innovate (Brazovskaia et al., 2021). The thematic map in Figure 3 further scrutinizes the gaps and assesses the unexplored areas.

## **6. Conclusion**

Loss of biodiversity affects living beings, economy, environment, and even society. Biodiversity is associated with sustainable development. Hence, biodiversity plans should not be all about setting natural habitats aside to cover community education about the conserved environment. Construction-led biodiversity loss affects both animals and plants as well as ability of ecosystem to protect assets against landslides, floods, and wildfires due to climate change. It becomes important to encourage green infrastructure to rebuild effectively and improve climate resilience. There is a need to design a centralized approach integrating various GI policies.

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