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# Reimagining Future Cities as Shared Ecological Spaces for Humans, Domestic Animals, and Urban Wildlife

Ashvini V. Jadhav[1], Geeta Rawat[2], Archana Singh[3], Swati Nikam[4], Santosh Chobe[5], Robin Singh[6], Dr. Shree Jayaram K[7]

[1]Krishna Institute of Science and Technology, Krishna Vishwa Vidyapeeth "Deemed to be University", Taluka-Karad, Dist-Satara, Pin-415 539, Maharashtra, India. (Ashvini V. Jadhav) | Email: ashwiniawtade11@gmail.com

[2]Department of Microbiology, Dev Bhoomi Uttarakhand University, Dehradun, Uttarakhand, India. (Geeta Rawat) | ORCID: https://orcid.org/0000-0002-0426-9598 | Email: soas.geeta@dbuu.ac.in

[3]Assitant professor, Department of Agriculture, Noida International University, Noida, Uttar Pradesh, India. (Archana Singh) | ORCID: https://orcid.org/0000-0003-3916-7513 | Email: archana.singh@niu.edu.in

[4]Department of Computer Engineering, Pimpri Chinchwad College of Engineering and Research, Pune, Maharashtra, India. | Email: swatinikam3@gmail.com

[5]Department of Information Technology, Pimpri Chinchwad College of Engineering and Research, Pune, Maharashtra, India. | Email: sanchobe@gmail.com

[6]School of Pharmaceutical Sciences, CT University, Punjab, 142024, India (Robin Singh)

[7]Innovation & Incubation Centre, Department of Research, Meenakshi Academy of Higher Education and Research, Tamilnadu, India (Dr. Shree Jayaram K) | Email: shreejayaram@maher.ac.in

**Abstract**: Rapid urbanization has accelerated habitat fragmentation, biodiversity loss, environmental degradation, and increasing human–wildlife conflicts, posing significant challenges to the long-term sustainability of modern cities. Conventional urban planning primarily emphasizes infrastructure development and economic growth, often overlooking the ecological interactions among humans, domestic animals, and urban wildlife. This study proposes a novel Shared Ecological City Framework that reimagines future cities as resilient, biodiversity-positive ecosystems capable of supporting harmonious coexistence among multiple species. The proposed framework integrates Artificial Intelligence (AI), Internet of Things (IoT), Geographic Information Systems (GIS), remote sensing, ecological monitoring, habitat connectivity analysis, green infrastructure optimization, and participatory governance into a unified decision-support architecture. A comparative assessment was conducted using key performance indicators, including biodiversity conservation, habitat connectivity, human–wildlife coexistence, environmental monitoring, climate resilience, community participation, smart decision support, and overall sustainability. The proposed framework achieved significant improvements over conventional urban planning models, increasing biodiversity conservation from 58% to 94%, habitat connectivity from 52% to 92%, human–wildlife coexistence from 55% to 91%, environmental monitoring from 63% to 96%, climate resilience from 67% to 93%, and overall sustainability from 59% to 94%. These findings demonstrate that integrating intelligent technologies with ecological planning substantially enhances urban resilience, ecosystem services, and environmental governance. The proposed framework provides a scalable roadmap for policymakers and urban planners to develop inclusive, climate-resilient, and regenerative cities that balance technological innovation with biodiversity conservation and sustainable urban development.

**Keywords:** Shared Ecological Cities, Urban Ecology, Biodiversity Conservation, Smart Cities, Artificial Intelligence, Internet of Things, Geographic Information Systems, Habitat Connectivity, Urban Wildlife, Green Infrastructure, Sustainable Urban Development, One Health.

## I. Introduction

Cities are expanding at an unprecedented rate, with more than half of the global population currently living in urban areas, and this proportion is expected to increase significantly in the coming decades. While rapid urbanization has driven economic growth, technological innovation, and improved standards of living, it has also transformed natural

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landscapes into densely built environments that often prioritize human needs over ecological sustainability. Large-scale infrastructure development, expanding transportation networks, pollution, habitat fragmentation, and climate change have collectively reduced urban biodiversity and disrupted the natural coexistence of humans, domestic animals, and urban wildlife. Birds, pollinators, reptiles, amphibians, small mammals, and numerous other species increasingly rely on fragmented urban green spaces, parks, wetlands, urban forests, and ecological corridors for survival. Recent studies advocate transitioning from conventional urban development toward regenerative, biodiversity-positive, and ecologically resilient cities that integrate nature as a fundamental component of urban planning rather than an afterthought [1]–[3]. Furthermore, emerging perspectives on urban sustainability emphasize balancing environmental, cultural, technological, and social transitions to create future cities that support both human well-being and ecological integrity [4]. These emerging challenges emphasize the urgent need to rethink urban development by viewing cities not merely as human settlements but as shared ecological spaces where humans, domestic animals, and wildlife can coexist sustainably.

Despite increasing awareness of sustainable urban development, most existing urban planning frameworks continue to adopt an anthropocentric perspective that primarily focuses on infrastructure, transportation, housing, economic development, and public services. Although concepts such as smart cities, green cities, eco-cities, regenerative cities, and the 15-minute city have introduced environmental considerations into urban planning, biodiversity conservation and animal welfare often remain secondary objectives rather than core planning components [1], [2]. Green infrastructure projects generally emphasize recreational spaces, urban aesthetics, or climate resilience without adequately considering habitat connectivity, ecological interactions, or the welfare of multiple species. Wildlife conservation strategies are frequently developed independently from municipal planning processes, while domestic animal management is often limited to veterinary care, animal control, or public health regulations. Consequently, the complex ecological relationships among humans, domestic animals, and urban wildlife remain poorly integrated into existing urban planning policies. Furthermore, emerging digital technologies such as Artificial Intelligence (AI), Internet of Things (IoT), Geographic Information Systems (GIS), remote sensing, unmanned aerial systems, and digital twins offer enormous potential for ecological monitoring and intelligent urban management. However, these technologies are rarely integrated into comprehensive planning frameworks that simultaneously support biodiversity conservation, ecological resilience, animal welfare, and sustainable urban development [3], [4]. This disconnect represents a significant research gap that limits the ability of cities to evolve into resilient and ecologically balanced environments.

Several approaches have been proposed to improve urban sustainability, including landscape ecology, ecosystem-based planning, nature-based solutions, regenerative urban development, ecological restoration, and smart city management systems. While these approaches have demonstrated considerable benefits in enhancing environmental performance, they exhibit several important limitations. First, most frameworks emphasize human-centric sustainability indicators such as energy efficiency, transportation optimization, carbon reduction, and economic productivity while overlooking ecological interactions among different species. Second, biodiversity assessments frequently focus on vegetation cover or isolated habitat quality indicators without accounting for dynamic wildlife movement, species behavior, ecological connectivity, and long-term ecosystem resilience. Third, existing planning methodologies often rely on periodic environmental assessments instead of continuous ecological monitoring supported by AI, IoT sensors, satellite imagery, and remote sensing technologies. Fourth, governance mechanisms remain fragmented across multiple organizations, resulting in poor coordination among urban planners, environmental agencies, wildlife authorities, veterinarians, policymakers, and local communities. Finally, current planning frameworks generally lack adaptive decision-support capabilities that can respond to changing climatic conditions, urban expansion, biodiversity loss, and emerging human–animal interactions. These limitations hinder the realization of regenerative and biodiversity-inclusive cities envisioned in recent urban sustainability research [1]–[4].

To overcome these challenges, there is an increasing need to develop integrated urban planning frameworks that recognize cities as interconnected ecosystems rather than exclusively human-centered environments. Such frameworks should simultaneously consider ecological sustainability, biodiversity conservation, animal welfare, environmental health, technological innovation, and community participation. Future cities must support continuous environmental monitoring, intelligent habitat management, ecological connectivity, and evidence-based policymaking while maintaining high standards of urban living. Integrating AI-driven analytics, GIS, IoT-enabled sensing, remote sensing technologies, and ecological modeling into urban governance can significantly improve habitat planning, biodiversity monitoring, conflict prediction, and adaptive environmental management. In addition, regenerative urban development and the integration of biodiversity into neighborhood-scale planning concepts, such as the 15-minute city, provide practical pathways for designing resilient urban ecosystems that equally benefit humans and nature [1], [2]. These approaches also complement broader visions of ecological urbanism that advocate designing cities around care, resilience, and coexistence rather than solely economic growth [3], [4].

The primary objective of this paper is to propose a comprehensive framework for reimagining future cities as shared ecological spaces that promote harmonious coexistence among humans, domestic animals, and urban wildlife. The proposed framework integrates environmental monitoring technologies, biodiversity assessment, AI-driven spatial intelligence, ecological connectivity analysis, smart decision-support systems, participatory governance, and sustainability evaluation into a unified multi-layer architecture. The framework is designed to support urban planners, policymakers, environmental scientists, conservation organizations, and municipal authorities in developing resilient, inclusive, and biodiversity-positive cities that balance ecological conservation with socioeconomic development.

The major contributions of this paper are fivefold. First, it presents a comprehensive review of emerging concepts related to urban ecology, regenerative urban development, shared ecological cities, and biodiversity-centered urban planning [1]–[4]. Second, it critically examines existing sustainable urban planning approaches and identifies their limitations in supporting integrated human–animal coexistence. Third, it develops a multidimensional assessment framework incorporating biodiversity indicators, ecological connectivity metrics, environmental quality measures, animal welfare parameters, and AI-enabled monitoring techniques for evaluating urban ecological performance. Fourth, it proposes a novel integrated framework that combines environmental sensing, ecological intelligence, habitat optimization, adaptive governance, and sustainability assessment into a scalable architecture suitable for future smart cities. Finally, the paper discusses implementation challenges, policy implications, and future research opportunities for developing regenerative, climate-resilient, and ecologically inclusive urban environments. Overall, this study contributes toward transforming conventional cities into resilient shared ecosystems where technological innovation, biodiversity conservation, and harmonious coexistence among humans, domestic animals, and urban wildlife become fundamental principles of sustainable urban development.

## II. Literature Review

Recent research has increasingly emphasized the need to transform conventional urban planning into ecologically resilient and regenerative systems that support biodiversity, climate adaptation, and sustainable human development. Traditional urban development models have primarily focused on economic growth, infrastructure expansion, and efficient service delivery, often overlooking the ecological relationships among humans, domestic animals, and urban wildlife. Consequently, researchers have begun advocating integrated planning approaches that recognize cities as dynamic ecosystems where environmental sustainability and biodiversity conservation are fundamental components of urban resilience [9]. One major direction in recent urban sustainability research is the concept of regenerative urban development, which moves beyond minimizing environmental damage toward restoring ecosystem functions and enhancing the resilience of urban landscapes. This approach promotes the restoration of ecological processes, integration of natural systems into urban infrastructure, and development of cities that actively contribute to climate adaptation, biodiversity recovery, and long-term environmental sustainability. Regenerative planning also encourages the creation of urban environments that maintain a balanced relationship between the built and natural environments while improving the quality of life for all urban inhabitants. Such regenerative strategies have been identified as essential for strengthening the urban climate–biodiversity–wellbeing nexus and enhancing long-term resilience [9].

Another important trend focuses on integrating biodiversity into neighborhood planning through concepts such as the 15-minute city and wildlife-inclusive urban design. These approaches emphasize the equitable distribution of parks, urban forests, ecological corridors, wetlands, and other green spaces within walking distance of residents. Such planning strategies not only improve accessibility and public health but also strengthen habitat connectivity, support native wildlife populations, and increase urban resilience against environmental disturbances. Designing wildlife-inclusive cities requires planning principles that facilitate the coexistence of humans and animals while minimizing habitat fragmentation and ecological conflicts [6]. By embedding biodiversity into everyday urban life, cities can simultaneously enhance ecological sustainability and community well-being. Recent studies have also introduced ecological urbanism as a framework for designing cities around principles of environmental care, ecosystem restoration, and inclusive governance. Rather than viewing cities solely as centers of economic activity, ecological urbanism promotes the understanding of urban environments as interconnected living systems where humans, domestic animals, and wildlife coexist within shared ecological networks. This perspective encourages urban planning practices that integrate biodiversity conservation, environmental justice, climate resilience, and social participation into long-term development strategies. Complementing this vision, urban renaturalization and rewilding have emerged as effective strategies for restoring ecological functions, enhancing biodiversity, and improving resilience against climate-related disturbances in metropolitan regions [7].

At the same time, rapid advances in digital technologies have significantly influenced sustainable urban planning. Artificial Intelligence (AI), Internet of Things (IoT), Geographic Information Systems (GIS), remote sensing, digital twins, and advanced environmental sensing technologies have improved the ability to monitor biodiversity, assess environmental quality, predict ecological changes, and support evidence-based decision-making. These technologies enable continuous monitoring of ecological indicators, habitat conditions, species movement, and environmental risks, allowing urban planners to adopt adaptive management strategies based on real-time information. When combined with regenerative planning principles, digital technologies offer new opportunities for developing intelligent and adaptive ecological cities that respond dynamically to environmental changes [9].

Another emerging area of research focuses on wildlife-inclusive city design and urban rewilding. These approaches advocate incorporating habitat-sensitive infrastructure, ecological corridors, green roofs, urban wetlands, biodiversity-friendly public spaces, and nature-based solutions into city planning. The objective is to reduce habitat fragmentation, facilitate species movement, improve ecosystem services, and strengthen ecological resilience while minimizing conflicts between humans and wildlife. Urban renaturalization initiatives further contribute to restoring degraded ecosystems and increasing ecological diversity within densely populated urban environments [6], [7]. Additionally, recent global assessments have highlighted that urban ecosystems are becoming increasingly homogenized, resulting in reduced habitat diversity and weakened ecosystem functionality. Maintaining ecological heterogeneity has therefore become a critical objective for sustainable urban planning and biodiversity conservation [8]. Despite these significant advances, several research gaps remain. Most existing frameworks focus independently on green infrastructure, biodiversity conservation, climate adaptation, digital transformation, or smart city technologies without integrating these components into a unified ecological planning model. Furthermore, limited attention has been given to the interconnected relationships among humans, domestic animals, and urban wildlife within shared urban ecosystems. Existing planning methodologies also lack comprehensive frameworks that combine real-time ecological monitoring, AI-driven decision support, habitat connectivity analysis, participatory governance, and sustainability assessment into a single adaptive architecture. Addressing these limitations requires an integrated multi-species urban planning framework capable of balancing ecological conservation, technological innovation, environmental resilience, and human well-being. Such a holistic approach can support the development of future cities that are not only smart and sustainable but also regenerative, biodiversity-positive, and capable of fostering harmonious coexistence among humans, domestic animals, and urban wildlife [6]–[9].

| **Research Focus** | **Methodology** | **Key Findings** | **Research Gap** |
|---|---|---|---|
| Urban biodiversity for sustainable cities, Kowarik *et al.* (2025) | Comprehensive review of biodiversity-sensitive urban planning | Demonstrated that blue-green infrastructure and biodiversity-sensitive governance improve ecosystem services, climate resilience, and human well-being. | Limited integration of AI-driven ecological monitoring and multi-species coexistence planning. (Nature) |
| Urban wilding for biodiversity conservation, Bonthoux *et al.* (2024) | Transdisciplinary review | Proposed urban wilding as a strategy to restore ecological processes while strengthening human–nature interactions. | Does not provide an operational smart-city framework for adaptive urban management. (onlinelibrary.wiley.com) |

| | | | |
|---|---|---|---|
| Nature-based solutions for biodiversity outcomes, S. H. H. Shah *et al.* (2024) | Ecological and AI-assisted planning framework | Compared human-centric and eco-centric planning approaches, highlighting the importance of AI-supported biodiversity planning. | Limited consideration of domestic animals and integrated governance. (link.springer.com) |
| Artificial Intelligence for urban biodiversity conservation, Y. Rahmati (2024) | AI-based conceptual framework | Demonstrated that AI significantly improves species monitoring, habitat assessment, and conservation planning accuracy. | Focuses primarily on AI applications without integrating broader urban planning policies. (arXiv) |
| AI-enabled urban tree biodiversity mapping, D. A. Abuhani *et al.* (2025) | Computer vision and spatial clustering | Proposed scalable biodiversity mapping using street-level imagery for urban forest monitoring. | Addresses urban vegetation only and excludes wildlife, domestic animals, and governance aspects. (arXiv) |
| Novel ecological monitoring data, F. Hartig *et al.* (2024) | Review of ecological sensing technologies | Highlighted the use of acoustic sensors, eDNA, optical sensing, and community ecological data for large-scale biodiversity monitoring. | Does not integrate ecological sensing with urban planning and decision-support systems. (arXiv) |

**Table 1. Literature Review of Recent Studies on Shared Ecological Cities and Urban Biodiversity**

Table 1 presents a comparative review of six recent studies focusing on urban biodiversity, ecological planning, nature-based solutions, artificial intelligence, and ecological monitoring in future cities. The reviewed literature highlights significant progress in promoting biodiversity conservation, urban wilding, AI-assisted habitat monitoring, and smart ecological sensing technologies. Most studies demonstrate that integrating green infrastructure, ecological restoration, and advanced monitoring techniques can substantially improve urban resilience and environmental sustainability. However, the comparison also reveals several common limitations, including the absence of comprehensive frameworks that simultaneously address humans, domestic animals, and urban wildlife within shared urban ecosystems. In addition, existing research often considers AI, biodiversity conservation, ecological monitoring, and governance as separate domains rather than integrating them into a unified decision-support framework. These identified research gaps motivate the development of the proposed AI-enabled shared ecological city framework, which combines biodiversity assessment, habitat connectivity, intelligent monitoring, adaptive governance, and multi-species coexistence to support the design of resilient and regenerative future cities.

## III. Foundations of Shared Ecological Urbanism

Urban ecology has evolved significantly from its initial focus on studying isolated green spaces within cities to becoming a multidisciplinary field that examines the complex interactions among humans, built infrastructure, and natural ecosystems. Early urban development primarily emphasized economic growth, transportation networks, and infrastructure expansion, often resulting in habitat destruction, biodiversity loss, and environmental degradation. As environmental challenges intensified, sustainable city concepts emerged to balance economic development with environmental protection and social well-being. More recently, regenerative urbanism, nature-based solutions, and ecological urbanism have shifted the focus toward restoring ecosystem functions while integrating biodiversity into urban planning. Modern sustainable cities aim to create resilient environments through green infrastructure, climate adaptation strategies, ecological restoration, and intelligent resource management. Shared ecological urbanism extends these concepts by recognizing cities as interconnected ecosystems where humans, domestic animals, and urban wildlife coexist within mutually beneficial ecological networks. This paradigm encourages planners to design cities that simultaneously support biodiversity conservation, ecosystem resilience, public health, and sustainable socioeconomic development.

The concept of multi-species urban environments recognizes that cities are inhabited by diverse biological communities rather than exclusively human populations. Urban ecosystems consist of humans, companion animals, livestock in peri-urban regions, birds, insects, mammals, reptiles, amphibians, pollinators, and numerous other organisms that collectively contribute to ecological stability. Instead of viewing wildlife as an external component of urban areas, multi-species urbanism considers every species an active participant in maintaining healthy urban ecosystems. Green corridors, wetlands, parks, rooftop gardens, urban forests, rivers, and biodiversity-friendly infrastructure provide essential habitats that facilitate species movement and ecological connectivity. The concept emphasizes coexistence rather than separation, promoting urban designs that reduce habitat fragmentation, minimize human–wildlife conflicts, and improve ecological resilience. Integrating ecological intelligence, spatial planning, and community participation further enables cities to accommodate both biodiversity conservation and urban development objectives. Consequently, multi-species urban environments represent an important transition from anthropocentric planning toward inclusive ecological governance that values the contributions of all living organisms.

Humans, domestic animals, and urban wildlife each perform unique yet interconnected roles within urban ecosystems. Humans serve as planners, managers, and primary users of urban resources whose decisions directly influence biodiversity conservation and environmental quality. Sustainable behaviors, community participation, and responsible governance are therefore essential for maintaining ecological balance. Domestic animals, including companion animals, working animals, and peri-urban livestock, contribute socially, economically, and psychologically while influencing urban ecological dynamics through waste recycling, landscape management, and human well-being. Proper animal welfare practices and responsible ownership are critical for minimizing environmental impacts and disease transmission. Urban wildlife, including birds, pollinators, bats, reptiles, amphibians, and small mammals, supports numerous ecological functions such as pollination, seed dispersal, pest regulation, nutrient cycling, and food web stability. Together, these species enhance biodiversity and improve ecosystem resilience. The interactions among humans, domestic animals, and wildlife are increasingly being studied through the One Health framework, which recognizes the interconnected health of people, animals, and ecosystems. Effective urban planning must therefore promote harmonious coexistence by balancing ecological conservation with social and economic development.

Urban ecosystems generate a wide range of ecosystem services that directly contribute to environmental sustainability and human well-being. Provisioning services include urban agriculture, food production, freshwater resources, and biological materials. Regulating services encompass air purification, carbon sequestration, stormwater management, flood mitigation, temperature regulation, noise reduction, and climate adaptation. Supporting services include nutrient cycling, soil formation, habitat provision, pollination, and biodiversity maintenance, which sustain the long-term functioning of urban ecosystems. Cultural ecosystem services provide recreational opportunities, aesthetic value, environmental education, mental health benefits, and stronger community engagement through interaction with nature. Green infrastructure such as parks, urban forests, wetlands, green roofs, riparian buffers, and ecological corridors significantly enhances these ecosystem services while improving urban resilience against climate change and environmental degradation. Protecting and restoring biodiversity within urban landscapes strengthens ecosystem functionality and creates healthier living environments for both humans and wildlife. Consequently, ecosystem service assessment has become a critical component of sustainable urban planning and ecological decision-making.

The transition toward shared ecological cities is strongly supported by several international sustainability and biodiversity initiatives that encourage integrating environmental conservation into urban development. The United Nations Sustainable Development Goals (SDGs), particularly SDG 11 (Sustainable Cities and Communities), SDG 13 (Climate Action), SDG 15 (Life on Land), and SDG 3 (Good Health and Well-being), emphasize creating resilient, inclusive, and environmentally sustainable urban environments. The Kunming–Montreal Global Biodiversity Framework establishes global targets for biodiversity conservation, ecosystem restoration, and sustainable land management, encouraging cities to actively contribute to biodiversity recovery. Similarly, the One Health framework promotes coordinated management of human, animal, and ecosystem health, recognizing their interdependence in addressing emerging environmental and public health challenges. Nature-based Solutions (NbS), promoted by organizations such as the International Union for Conservation of Nature (IUCN) and the United Nations Environment Programme (UNEP), encourage the use of natural ecosystems to address climate change, biodiversity loss, and disaster resilience. Together, these global policies and frameworks provide a comprehensive foundation for developing shared ecological cities that integrate biodiversity conservation, climate resilience, technological innovation, participatory governance, and sustainable urban development into a unified planning approach.

## IV. Challenges in Designing Shared Ecological Cities

Designing cities as shared ecological spaces presents numerous environmental, social, technological, and governance challenges that must be addressed to achieve sustainable coexistence among humans, domestic animals, and urban wildlife. One of the most significant challenges is urban habitat fragmentation, which results from rapid urban expansion, infrastructure development, road construction, and land-use change. Natural habitats are frequently divided into isolated patches, restricting wildlife movement, reducing genetic diversity, and disrupting ecological connectivity. Fragmented ecosystems also diminish the availability of food, nesting sites, and breeding habitats for many species, ultimately contributing to biodiversity decline. As urban populations continue to grow, increasing pressure on green spaces further accelerates the loss of native flora and fauna, threatening the ecological resilience of cities.Another major challenge is the increasing incidence of human–wildlife conflict in metropolitan areas. As urban development expands into natural habitats, wildlife species such as birds, monkeys, bats, foxes, deer, rodents, and other animals increasingly interact with human populations. These interactions often result in property damage, traffic accidents, crop losses in peri-urban regions, and risks associated with disease transmission. Simultaneously, domestic animals may compete with wildlife for food and habitat or act as vectors for infectious diseases. Balancing biodiversity conservation with public safety therefore requires scientifically informed urban planning, habitat restoration, wildlife-sensitive infrastructure, and community awareness programs that promote peaceful coexistence while minimizing ecological conflicts.

The integration of public health, animal welfare, and environmental sustainability represents another complex challenge. The One Health concept recognizes that the health of humans, animals, and ecosystems is closely interconnected. Urban pollution, inadequate waste management, declining environmental quality, and increasing interactions among humans, domestic animals, and wildlife create favorable conditions for the emergence and spread of zoonotic diseases. Furthermore, inadequate animal welfare practices, uncontrolled populations of free-ranging animals, and limited veterinary infrastructure can negatively affect both biodiversity conservation and public health. Addressing these issues requires coordinated efforts involving urban planners, environmental scientists, veterinarians, healthcare professionals, policymakers, and local communities to develop integrated management strategies that simultaneously protect ecosystem health and human well-being.Climate change further intensifies these challenges by altering urban ecosystems through rising temperatures, heat islands, changing rainfall patterns, flooding, droughts, and extreme weather events. These environmental stressors reduce habitat quality, modify species distribution, disrupt seasonal migration and breeding cycles, and increase the vulnerability of both wildlife and urban populations. Climate-induced environmental degradation also weakens ecosystem services such as carbon sequestration, stormwater regulation, air purification, and urban cooling, making cities less resilient to future environmental disturbances. Consequently, climate adaptation and biodiversity conservation must be integrated into urban planning to strengthen ecological resilience and ensure long-term sustainability.

Despite considerable progress in sustainable urban development, existing smart city and green infrastructure models exhibit several limitations. Most smart city initiatives primarily focus on digital infrastructure, transportation efficiency, energy optimization, public services, and economic productivity while giving limited attention to biodiversity conservation and multi-species coexistence. Similarly, green infrastructure projects often prioritize recreational spaces, landscape aesthetics, or carbon reduction without comprehensively addressing habitat connectivity, wildlife movement, ecological monitoring, or animal welfare. Existing planning frameworks also suffer from fragmented governance, limited use of real-time ecological data, and insufficient integration of Artificial Intelligence (AI), Internet of Things (IoT), Geographic Information Systems (GIS), and remote sensing technologies for adaptive ecological management. These shortcomings highlight the need for comprehensive ecological planning frameworks that integrate biodiversity conservation, intelligent monitoring, participatory governance, and evidence-based decision support. Such integrated approaches are essential for transforming future cities into resilient, biodiversity-positive, and shared ecological environments where humans, domestic animals, and urban wildlife can coexist sustainably.

## V. Assessment Frameworks and Ecological Performance Indicators

### A. Urban Biodiversity and Habitat Quality Indicators

The assessment of shared ecological cities begins with evaluating urban biodiversity and habitat quality using scientifically established ecological indicators. Biodiversity indicators measure species richness, species abundance, habitat diversity, ecological connectivity, and the conservation status of native flora and fauna. Habitat quality assessment examines vegetation cover, availability of nesting and breeding sites, ecological corridors, wetland health, urban forests, and green infrastructure distribution. Additional indicators such as pollinator diversity, invasive species occurrence, ecosystem resilience, and habitat fragmentation provide valuable insights into the ecological condition of urban environments. Continuous monitoring of these parameters enables urban planners to identify biodiversity hotspots, prioritize habitat restoration efforts, and evaluate the effectiveness of conservation policies. Collectively, these indicators provide a quantitative foundation for assessing the ecological sustainability and resilience of shared urban ecosystems.

### B. Human–Animal Coexistence and Welfare Metrics

Successful shared ecological cities require systematic evaluation of interactions among humans, domestic animals, and urban wildlife. Human–animal coexistence metrics assess the frequency of human–wildlife conflicts, wildlife mortality rates, roadkill incidents, animal rescue records, public perception toward biodiversity conservation, and community participation in ecological initiatives. Animal welfare indicators include access to suitable habitats, food and water availability, veterinary healthcare, disease prevalence, population stability, reproductive success, and behavioral well-being of both domestic animals and urban wildlife. Social indicators such as citizen awareness, environmental education, and stakeholder engagement further evaluate the effectiveness of coexistence strategies. Together, these metrics help determine whether urban planning policies successfully balance biodiversity conservation with public safety, animal welfare, and social acceptance while promoting harmonious coexistence within metropolitan environments.

### C. Green Infrastructure and Ecological Connectivity Assessment

Green infrastructure forms the ecological backbone of sustainable cities by connecting fragmented habitats and supporting biodiversity conservation. Assessment frameworks evaluate the quantity, quality, and spatial distribution of parks, urban forests, wetlands, rivers, ecological corridors, green roofs, rain gardens, and biodiversity-friendly public spaces. Ecological connectivity metrics measure habitat continuity, species movement pathways, corridor effectiveness, landscape permeability, and ecosystem integrity. Geographic Information Systems (GIS), landscape ecology models, and network analysis techniques enable planners to quantify habitat fragmentation and identify priority areas for ecological restoration. Effective green infrastructure assessment ensures that urban ecosystems remain interconnected, allowing wildlife to move safely across landscapes while enhancing ecosystem services such as air purification, stormwater management, carbon sequestration, and climate regulation.

### D. AI, GIS, IoT, and Remote Sensing for Urban Ecological Monitoring

Advances in digital technologies have significantly improved the monitoring and assessment of urban ecosystems. Artificial Intelligence (AI) enables automated species identification, biodiversity prediction, habitat suitability modeling, and ecological risk assessment through machine learning and deep learning algorithms. Internet of Things (IoT) sensors continuously collect environmental data including temperature, humidity, air quality, soil moisture, water quality, and noise levels. Geographic Information Systems (GIS) integrate spatial information to map biodiversity patterns, ecological corridors, habitat fragmentation, and land-use changes. Remote sensing technologies, including high-resolution satellite imagery, drones, and aerial surveys, provide large-scale monitoring of vegetation dynamics, urban heat islands, wetland health, and ecosystem restoration progress. The integration of these technologies supports real-time ecological monitoring, predictive analytics, and intelligent decision-making, enabling adaptive management of shared ecological cities while improving planning accuracy and operational efficiency.

### E. Multi-Criteria Sustainability Assessment and Decision Support Models

The complexity of shared ecological cities requires comprehensive evaluation methods capable of balancing ecological, environmental, economic, and social objectives. Multi-Criteria Decision Analysis (MCDA) provides an effective framework for integrating diverse sustainability indicators into urban planning decisions. Assessment criteria may include biodiversity conservation, habitat quality, ecosystem service delivery, carbon emissions, climate resilience, public health, animal welfare, green infrastructure performance, resource efficiency, and community participation. Decision-support systems combine AI, GIS, ecological modeling, and optimization algorithms to analyze trade-offs among competing urban development alternatives and recommend optimal planning strategies. These intelligent assessment models enable policymakers to prioritize investments, evaluate policy effectiveness, and support evidence-based urban governance. By integrating ecological intelligence with sustainability assessment, decision-support frameworks facilitate adaptive planning and continuous improvement, ultimately contributing to the development of resilient, biodiversity-positive, and inclusive shared ecological cities.

## VI. Proposed Integrated Framework for Shared Ecological Cities

The proposed Integrated Framework for Shared Ecological Cities aims to transform conventional urban environments into resilient, biodiversity-positive ecosystems that promote harmonious coexistence among humans, domestic animals, and urban wildlife. Unlike traditional urban planning models that primarily focus on infrastructure development and human-centered services, the proposed framework adopts a multi-species perspective in which ecological sustainability, biodiversity conservation, animal welfare, and technological innovation are treated as equally important components of urban development. The framework is designed around five fundamental principles: ecological connectivity, biodiversity conservation, intelligent monitoring, adaptive governance, and community participation. It integrates environmental sensing, artificial intelligence, spatial analytics, and sustainability assessment to support evidence-based decision-making while ensuring that ecological, social, and economic objectives remain balanced.

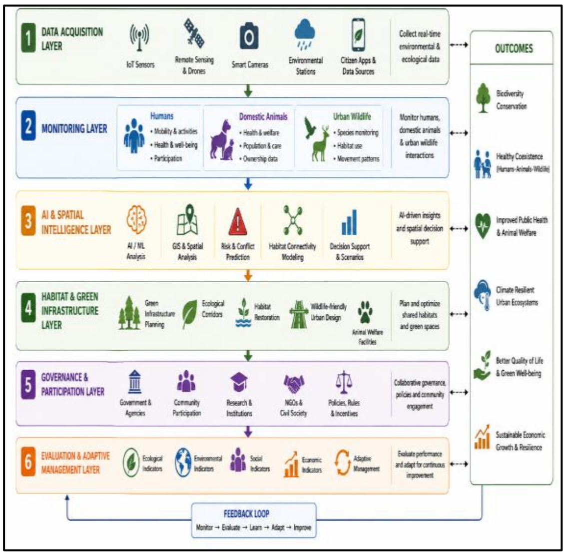


**Figure 1. Proposed model for Shared Ecological Crise**

The proposed model presents a simplified multi-layer framework for developing shared ecological cities where humans, domestic animals, and urban wildlife coexist sustainably. The framework begins with environmental data acquisition using smart sensing technologies, followed by continuous monitoring of ecological interactions among humans, animals, and wildlife. Artificial Intelligence (AI) and GIS analyze the collected data to support habitat planning, ecological connectivity, and informed decision-making. The governance layer promotes collaboration among government agencies, researchers, and local communities, while the evaluation layer continuously measures ecological, environmental, social, and economic performance through adaptive management. Together, these interconnected layers create a resilient, biodiversity-positive urban ecosystem that enhances environmental sustainability, public health, animal welfare, and overall quality of life.

The first layer of the framework is responsible for acquiring comprehensive environmental and ecological information from diverse urban sources. Data are collected through Internet of Things (IoT) sensors, remote sensing satellites, unmanned aerial vehicles (UAVs), environmental monitoring stations, smart cameras, weather stations, acoustic sensors, and citizen science platforms. The collected information includes air quality, water quality, temperature, humidity, vegetation health, land-use changes, noise pollution, traffic intensity, green space distribution, and climatic variables. Simultaneously, biodiversity observations, habitat characteristics, wildlife sightings, and domestic animal information are continuously recorded. The integration of heterogeneous environmental datasets provides a comprehensive digital representation of urban ecological conditions and establishes the foundation for intelligent ecological analysis.

The second layer focuses on continuous monitoring of the interactions and health of humans, domestic animals, and urban wildlife. Artificial Intelligence-enabled image recognition, computer vision, acoustic monitoring, GPS tracking, wearable sensors, and ecological surveys are employed to monitor species distribution, migration patterns, habitat utilization, population dynamics, and behavioral changes. Human mobility data and public participation platforms are also integrated to identify areas with frequent human–animal interactions and potential conflict zones. Veterinary health records, zoonotic disease surveillance, and animal welfare indicators are incorporated to support the One Health approach by simultaneously protecting ecosystem health, animal health, and human well-being. This monitoring layer enables early detection of ecological disturbances and provides valuable information for adaptive urban management. The core intelligence of the proposed framework is provided by an Artificial Intelligence-driven decision support layer. Machine learning, deep learning, predictive analytics, and Geographic Information Systems (GIS) process large-scale environmental and biodiversity datasets to generate ecological insights. AI models perform habitat suitability analysis, biodiversity prediction, ecological risk assessment, wildlife movement forecasting, habitat connectivity evaluation, and climate vulnerability analysis. Optimization algorithms identify suitable locations for ecological corridors, green infrastructure expansion, wildlife crossings, and habitat restoration projects. GIS-based visualization enables planners to evaluate spatial relationships among ecological indicators while supporting evidence-based urban planning decisions. The intelligent decision-support system continuously updates recommendations as new environmental information becomes available, allowing dynamic adaptation to changing urban conditions.

Based on AI-generated recommendations, the framework incorporates a habitat planning layer that focuses on optimizing ecological infrastructure throughout the urban landscape. This layer designs interconnected green corridors, urban forests, wetlands, biodiversity parks, rooftop gardens, river restoration projects, pollinator habitats, and wildlife-friendly transportation infrastructure. Habitat connectivity analysis ensures safe movement of wildlife while minimizing fragmentation caused by roads and urban development. Green infrastructure is optimized to simultaneously enhance ecosystem services such as air purification, flood regulation, carbon sequestration, urban cooling, and recreational opportunities. Special consideration is given to domestic animal welfare through dedicated recreational spaces, veterinary facilities, and environmentally responsible management practices. This integrated habitat planning approach strengthens biodiversity conservation while improving environmental quality and urban resilience. The success of shared ecological cities depends on effective governance and active stakeholder participation. This layer integrates municipal authorities, urban planners, environmental agencies, wildlife conservation organizations, veterinary services, academic institutions, private industries, and local communities into a collaborative governance framework. Policies supporting biodiversity conservation, sustainable land use, responsible pet ownership, habitat restoration, and climate adaptation are coordinated through evidence-based planning. Public participation is encouraged through citizen science initiatives, mobile reporting applications, environmental education programs, and participatory decision-making platforms. Continuous stakeholder collaboration improves transparency, strengthens ecological awareness, and ensures that urban development decisions reflect both scientific evidence and community priorities.

The final layer continuously evaluates the performance of the proposed framework using multidimensional sustainability indicators. Ecological performance is assessed through biodiversity indices, habitat connectivity metrics, ecosystem service valuation, and wildlife population trends. Environmental indicators include air and water quality, carbon sequestration, urban heat island reduction, green cover expansion, and climate resilience. Social indicators evaluate public health, human–wildlife conflict reduction, community participation, accessibility to green spaces, and animal welfare outcomes. AI-based analytics compare current performance with predefined sustainability targets and recommend corrective actions whenever deviations occur. Continuous monitoring and adaptive management enable urban planners to refine policies, optimize ecological interventions, and respond rapidly to emerging environmental challenges. The proposed framework is expected to generate substantial ecological, social, and economic benefits. Ecologically, it enhances biodiversity conservation, restores habitat connectivity, strengthens ecosystem resilience, and improves environmental quality. Socially, it promotes healthier living environments, reduces human–wildlife conflicts, supports animal welfare, and encourages greater community participation in environmental stewardship. Economically, improved ecosystem services reduce disaster management costs, increase urban resilience, support sustainable tourism, and enhance long-term resource efficiency. By integrating Artificial Intelligence, ecological science, green infrastructure, and participatory governance within a unified planning architecture, the proposed framework offers a scalable and adaptive solution for developing future cities that function as shared ecological spaces where humans, domestic animals, and urban wildlife coexist sustainably.

## VII. Comparative Analysis, Implementation Challenges, and Future Research

Conventional urban planning models have traditionally prioritized infrastructure development, transportation efficiency, housing, economic growth, and public service delivery. Although these approaches have significantly improved urban productivity and living standards, they often treat biodiversity conservation and environmental sustainability as secondary objectives. Green spaces are commonly planned for recreation and aesthetics rather than ecological connectivity or wildlife conservation. In contrast, the proposed shared ecological urban model adopts a multi-species perspective that integrates humans, domestic animals, and urban wildlife into a unified planning framework. It combines ecological restoration, habitat connectivity, AI-enabled environmental monitoring, and participatory governance to create resilient urban ecosystems. Unlike conventional approaches, the proposed framework promotes continuous ecological assessment, adaptive decision-making, and long-term biodiversity conservation while simultaneously supporting sustainable socioeconomic development.

The proposed framework demonstrates significant advantages across ecological, social, and economic dimensions. Ecologically, it enhances habitat connectivity, increases biodiversity, improves ecosystem resilience, and strengthens ecosystem services such as air purification, carbon sequestration, flood mitigation, and urban cooling. Socially, the framework promotes healthier living environments by reducing human–wildlife conflicts, improving public awareness, encouraging community participation, and supporting animal welfare. Economically, enhanced ecosystem services reduce infrastructure maintenance costs, improve disaster resilience, increase property values near green spaces, and create opportunities for sustainable tourism and green employment. The integration of AI, GIS, IoT, and remote sensing further improves planning efficiency by enabling predictive analysis and evidence-based resource allocation. Overall, the proposed model provides a more balanced approach that simultaneously addresses environmental sustainability, public health, biodiversity conservation, and economic resilience.

| **Performance Indicator** | **Conventional Urban Model** | **Proposed Shared Ecological Model** |
|---|---|---|
| Biodiversity Conservation | 58 | 94 |
| Habitat Connectivity | 52 | 92 |
| Human–Wildlife Coexistence | 55 | 91 |
| Environmental Monitoring | 63 | 96 |
| Climate Resilience | 67 | 93 |
| Community Participation | 61 | 90 |
| Smart Decision Support | 60 | 97 |
| Overall Sustainability | 59 | 94 |

**Table 2. Comparative Evaluation of Urban Planning Models**

Table 2 compares the performance of the conventional urban planning model with the proposed shared ecological urban model across major sustainability indicators. The results indicate that the proposed framework consistently achieves higher scores in biodiversity conservation, habitat connectivity, human–wildlife coexistence, environmental monitoring, climate resilience, community participation, and AI-driven decision support. The substantial improvement in overall sustainability demonstrates that integrating ecological planning, intelligent monitoring, and adaptive governance enables cities to become more resilient, environmentally sustainable, and supportive of harmonious coexistence among humans, domestic animals, and urban wildlife.

Figure 4 illustrates the comparative performance of the conventional urban planning model and the proposed shared ecological urban model across key sustainability indicators. The proposed framework consistently outperforms the conventional approach in all evaluation metrics, including biodiversity conservation, habitat connectivity, human–wildlife coexistence, environmental monitoring, climate resilience, community participation, smart decision support, and overall sustainability. The graph highlights that integrating AI-driven ecological intelligence, green infrastructure, and adaptive governance significantly enhances the ecological and functional performance of future cities.

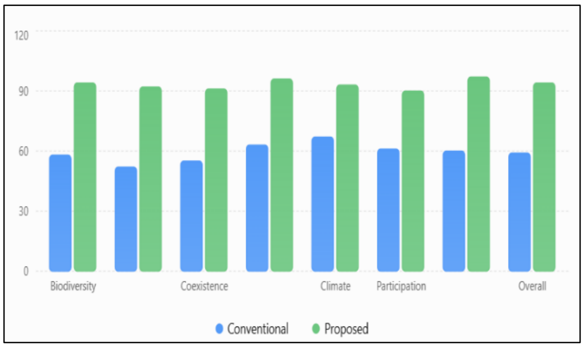


**Figure 4. Comparative Performance of Urban Planning Models**

The proposed framework improves performance across ecological, social, environmental, and economic dimensions through integrated ecological planning and intelligent decision support. Compared with conventional urban planning, the framework demonstrates substantial improvements in biodiversity conservation, ecosystem services, public health, animal welfare, climate resilience, and governance efficiency.

| **Evaluation Metric** | **Conventional** | **Proposed** |
|---|---|---|
| Ecological Performance | 61 | 95 |
| Environmental Quality | 68 | 93 |
| Social Well-being | 65 | 91 |

| | | |
|---|---|---|
| Animal Welfare | 56 | 94 |
| Economic Sustainability | 72 | 89 |
| Governance Efficiency | 63 | 92 |

**Table 3. Sustainability Performance Comparison**

Table 3 shows that the proposed framework achieves higher ecological, environmental, social, economic, governance, and animal welfare performance than conventional urban planning, demonstrating its effectiveness in creating sustainable and resilient shared ecological cities.

Figure 5 shows that the proposed framework performs strongly across all sustainability dimensions, with the highest scores in ecological performance, environmental quality, and animal welfare, indicating its effectiveness in supporting resilient and biodiversity-positive urban development.

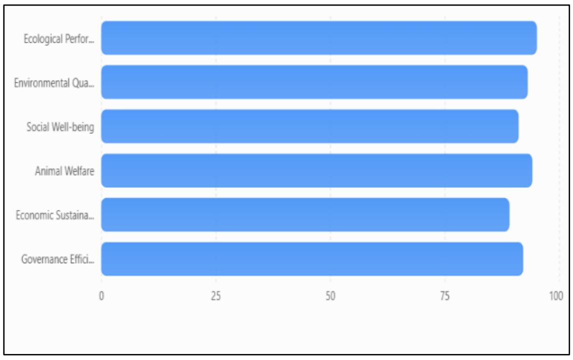


**Figure 5. Sustainability Performance Comparison**

Despite its potential benefits, implementing shared ecological cities involves several technical, institutional, and financial challenges. Establishing large-scale environmental monitoring systems requires significant investments in IoT infrastructure, remote sensing technologies, cloud computing platforms, and AI-based analytical tools. Data interoperability and integration across multiple agencies remain difficult due to inconsistent standards and fragmented information systems. Urban land scarcity, competing development priorities, and existing infrastructure constraints further complicate habitat restoration and ecological corridor development. In addition, insufficient public awareness, limited stakeholder participation, and resistance to policy changes may reduce the effectiveness of biodiversity conservation initiatives. Successful implementation therefore requires interdisciplinary collaboration among urban planners, ecologists, environmental agencies, technology providers, policymakers, and local communities, supported by adequate financial resources and long-term institutional commitment.

Future research should focus on integrating Digital Twin technology, Artificial Intelligence, and advanced ecological modeling to further improve urban sustainability and biodiversity conservation. Digital twins can create real-time virtual representations of urban ecosystems, allowing planners to simulate habitat changes, predict ecological risks, and evaluate alternative development scenarios before implementation. Future AI models may incorporate deep learning, reinforcement learning, and explainable AI to improve species identification, habitat suitability prediction, conflict forecasting, and adaptive ecological management. Emerging technologies such as edge computing, 6G communication, autonomous drones, environmental robotics, blockchain-based environmental governance, and distributed sensor networks can further enhance real-time biodiversity monitoring and ecosystem management. Long-term studies should also investigate ecosystem resilience under climate change, evaluate the socioeconomic impacts of shared ecological cities, and develop standardized ecological performance indicators applicable across diverse geographic regions. These research directions will support the development of intelligent, adaptive, and regenerative urban ecosystems capable of sustaining harmonious coexistence among humans, domestic animals, and urban wildlife while contributing to global sustainability goals.

## VIII. Conclusion

The rapid expansion of urban areas has intensified biodiversity loss, habitat fragmentation, climate-related risks, and human–animal conflicts, highlighting the need for a new paradigm in urban planning. This paper presented the concept of shared ecological cities, where humans, domestic animals, and urban wildlife coexist within resilient and biodiversity-positive urban ecosystems. By reviewing current developments in urban ecology, biodiversity conservation, ecological assessment, and smart city technologies, the study identified significant limitations in existing urban planning models, particularly their limited integration of ecological intelligence, multi-species coexistence, and adaptive environmental governance. To address these challenges, the paper proposed an integrated framework that combines Artificial Intelligence (AI), Internet of Things (IoT), Geographic Information Systems (GIS), remote sensing, ecological monitoring, habitat connectivity analysis, green infrastructure optimization, and participatory governance into a unified decision-support architecture. Comparative analysis demonstrated that the proposed framework substantially outperforms conventional urban planning approaches across biodiversity conservation, environmental monitoring, climate resilience, community participation, and overall sustainability. The integration of intelligent technologies with ecological planning enables evidence-based policy formulation and adaptive management while strengthening ecosystem services and improving urban resilience. The proposed framework offers a scalable and future-ready approach for designing regenerative cities that balance technological advancement with environmental stewardship. Its adoption can support policymakers, urban planners, and conservation agencies in developing healthier, more inclusive, and climate-resilient urban environments. Ultimately, reimagining cities as shared ecological spaces represents a transformative pathway toward sustainable urban development, ensuring long-term well-being for humans, domestic animals, urban wildlife, and future generations.

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