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Original Research Paper

Emerging Challenges and Opportunities in Human-Animal Coexistence Within Rapidly Urbanizing Regions

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Abstract: Natural habitats are being rapidly transformed by the process of urbanization, increasing the intensity of human-wildlife interaction, and generating what is almost a "messy mix" of ecological, social and public health issues. Anticipating the challenges of urban wildlife, such as increased encounters, changed behavior, habitat fragmentation, and loss of biodiversity, it is essential that sustainable strategies are developed to deal with coexistence. The paper aimed to highlight the new challenges and opportunities of human-animal coexistence in the context of the rapid urbanization of the regions, through the synthesis of recent advances in urban ecology, environmental planning, artificial intelligence and smart city technologies. It covers the impacts of land-use change, habitat fragmentation, adaptation of urban wildlife and socio-ecological dynamics on the outcomes of coexistence. In addition, the study assesses technological innovations, such as Artificial Intelligence, Computer Vision, sensors from the Internet of Things, Geographic Information Systems and Remote Sensing, for the purposes of wildlife monitoring, conflict prediction, the assessment of ecological connectivity and for evidence-based urban planning. The need for a framework supporting co-existence of multiple environmental sources, intelligent detection of wildlife, predictive analytics and policy-based decision support is proposed to optimize biodiversity conservation while simultaneously improving public safety and ecosystem resilience. The proposed approach is adaptive governance, the One Health principle, and sustainable urban development using data for conservation planning. The review identifies key research areas for future research focusing on interdisciplinary approaches, resilient infrastructure, ecological connectivity, and intelligent technologies to promote long-term, sustainable and equitable human-animal interactions in growing cities.

Keywords: Human-animal coexistence; Urbanization; Urban wildlife; Artificial intelligence; Smart cities; One Health; Biodiversity conservation,Sustainable Cities and Communities

I. Introduction

Due to its unprecedented rate of transformation, urbanization has emerged as one of the most important drivers of global environmental change, transforming landscapes, ecosystems and biodiversity at an unprecedented rate. Recently, it has been estimated that over half of the world's population is living in urban areas and that this urbanization will continue to rise in the next few decades. The cities have grown rapidly, leading to urban sprawl, habitat fragmentation, and alteration of natural ecosystems, which has led to changes in

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wildlife species distribution, abundance and behavior. Although urban development is important for economic development, improved infrastructure and improved living conditions, it also poses severe challenges to ecological systems, and challenges the ability to sustain harmonious relations with animals. With the loss of natural or wild areas to housing, industry and transportation development, many wildlife species are being forced to adapt to the urban environment or relocate to more human-dominated areas. Birds, mammals, the reptiles and insects are some of the growing number of species making use of peri-urban environments, green spaces, parks and wetlands in cities for food and shelter. Many species suffer from habitat loss, pollution, artificial lighting, noise and a lack of ecological connectivity in urban areas, while others flourish in the city [1]. Thus, urban biodiversity patterns are becoming more and more complicated, and an integrated approach to planning and conservation is needed that includes consideration of developmental goals and ecological sustainability. Human-wildlife interactions have grown in the rapidly urbanized areas as a result of the growing overlap of human lives with the wildlife. These interactions can pose opportunities and challenges. Urban wildlife plays an important role in the functioning of the ecosystem, such as pollination, seed dispersion, pest control, nutrient cycling and ecosystem balance. The effects of urban biodiversity on human well-being also include better recreational experiences, environmental awareness, mental health and nature connectedness from interaction [2]. As animal-human interactions increase, however, these interactions can also lead to conflicts involving livestock predation, road collisions, damage to livestock, property, and public safety. In addition, the increasing contact between human, domestic animal, and wildlife populations has the potential to cause zoonotic diseases to spread, underscoring the need for coordinated One Health strategies that take into account the interlinkages of human, animal and environmental health.

Traditional urban planning has focused on economic development and building more, and has mostly neglected ecological processes and wildlife protection. This has led to broken habitats, green spaces that are becoming isolated, and wildlife corridors being disconnected, thereby decreasing landscape connectivity and the resilience of ecosystems. Urban planning is now much more aware of the need to integrate biodiversity protection into sustainable urban development via ecological infrastructure, green corridors, NbS, and land-use planning that takes into account biodiversity [3]. These aim to increase ecological connectivity while reducing the impacts of human activities and the potential for conflict with wildlife movements. New technological developments have occurred in recent years, which have led to new opportunities in the field of monitoring, understanding and managing coexistence of humans with the animals in the urban setting. These technologies, including artificial intelligence, computer vision, machine learning, Internet of Things sensors, geographic information systems, remote sensing, unmanned aerial vehicles and edge computing, allow for continual monitoring of wildlife, species identification, habitat suitability analysis, wildlife movement prediction, and risk of conflict. The technologies enable data-driven decisions, combining environmental observations and predictive analytics to help inform proactive conservation strategies and intelligent city management. Digital technologies are used to enhance ecological monitoring alongside citizen science and participatory governance, to foster community engagement in biodiversity conservation [4].

Although there has been considerable advances in urban ecology and conservation science, there are still many areas of research that remain unfilled on how to integrate the ecological, technological, social and policy aspects into a holistic coexistence framework. Previous studies tend to address individual ecological processes, species or technologies rather than the socio-ecological dynamics of rapidly urbanizing areas. A real need is for integrated solutions that combine Artificial Intelligence, smart city infrastructure, urban planning, public health, environmental governance, and biodiversity conservation to create strategies for living with nature. This review focuses on the challenges posed, namely, new trends in urbanisation, human-animal relations, ecological connectivity, technological innovations and sustainable urban planning [5]. It critically reviews the recent developments in AI, IoT, GIS and remote sensing in the context of aiding wildlife conservation and conflict mitigation efforts. Moreover, the paper introduces a framework of human-animal coexistence integrated from multi-source environment data, intelligent wildlife monitoring, predictive risk assessment and policy-oriented urban decision support. The proposed framework is designed to address the needs of biodiversity, ecological resilience, public safety and sustainable urban development; to encourage the long-term coexistence of people and wildlife in an increasingly urbanized world.

II. Urbanization Trends and Their Influence on Human-Animal Interactions

The expanding urban population has driven a dramatic shift in land use, habitat fragmentation and infrastructure development with the associated interactions between humans and wildlife. The changes cause changes in species distribution, loss

of biodiversity and increased ecological pressures. It is important to have an understanding of urbanization patterns to design sustainable planning strategies that ensure a balance between development, biodiversity conservation, ecological connectivity and long-term human-animal coexistence.

A. Global Urban Expansion and Land Use Change

Urbanisation has become one of the most important characteristics of the twenty first century, altering natural landscapes and ecological processes around the world at a rapid pace. The population, industrialization, infrastructure, and economic activity has led to the rapid development of residential, commercial and transportation networks from forests, wetlands, grasslands and agricultural areas. These land-use alterations decrease the area of nature's habitats and increase the area of contact between people and wildlife [6]. Urban sprawl can spread to peri-urban and rural areas, which can lead to imbalances in the ecosystems and impact on species distribution. Changes in natural vegetation to impervious surfaces alter local factors affecting climate, hydrology and resources, which affect survival and movement of many species of animals. There are some resilient wildlife species that take advantage of cities by using parks, gardens and green spaces, while other species of wildlife that are habitat specialists suffer from a decline in their populations, as there is a lack of shelter and food. Land-use change can also cause break-up of migration corridors and breeding areas, restricting gene flow between animals [7]. Sustainable land use planning, therefore, has taken on a new importance for minimizing ecological degradation and building resilient urban ecosystems and ensuring long-term coexistence between humans and animals is an imperative.

B. Urban Habitat Fragmentation and Biodiversity Loss

Rapid urbanisation causes habitat fragmentation in the urban area, which is one of the most severe ecological impacts of urbanisation, leading to the fragmentation of contiguous natural habitat into smaller and more fragmented patches. But construction of roads, settlement expansion, industry and transport facilities break down habitat corridors and fragment connectivity between wildlife populations. Fragmented habitats may result in small population sizes and/or low genetic diversity, which may lead to increased sensitivity to environmental changes, invasive species, and local extirpations [8]. The loss of biodiversity can cause the loss of rare and endangered species, as well as of common organisms that provide important ecosystem services, including pollination, dispersal of seeds, control of pests, and cycling of nutrients. Pollution, lights, noise and modified microclimates in urban areas are additional stressors affecting habitat quality that impact reproductive success and animal behavior. Fragmented landscapes pose a special threat to species with limited dispersal ability as they limit access to food, breeding and seasonal migration [9]. Networks of green corridors, ecological restoration, protection of habitats and planning with biodiversity in mind are essential to the conservation of biodiversity in urban areas. Incorporating an ecological network into urban development will improve movement capacity, ecological resilience and sustainable co-existence of growing human populations and a rich wildlife community.

C. Drivers of Human-Animal Encounters

There are several ecological, environmental and socio-economic drivers that are changing the landscape and creating more opportunities for human-wildlife interactions in rapidly urbanizing areas. Many species of animals are driven into residential neighborhoods, fields and farms, parks, and urban green spaces to find food, water and shelter due to habitat loss and changes in land use. Species distribution is further affected by climate change through changes in resource availability, precipitation and temperature, and favours wildlife to spread into human settlements [10]. Lack of proper waste disposal, open garbage disposals, artificial feeding and the vast amount of anthropogenic food attract opportunistic species like monkeys, wild boars, rodents, birds, and carnivores. Rising transport connectivity, and recreational activities, also enhance direct human-wildlife contact. Urban green infrastructure can have a positive effect on biodiversity, but if not planned well it can also help wildlife to move into high-density urban areas. Other factors shaping coexistence dynamics include public awareness, cultural attitudes, pets ownership and human behavioural practices [11]. A summary of recent advances, challenges, technologies and research gaps in coexistence are summarized in Table 1. An awareness of these various drivers is crucial for the development of preventive measures, adaptive urban planning, the creation of ecological connections, reduction of conflicts, and sustainable human-animal coexistence in integrated environmental management and evidence-based policy managements.

Study Focus	Methodology	Technologies Used	Key Findings	Limitations	Contribution to Present Review
Urban human-wildlife interactions	Literature review	Ecological assessment	Urban wildlife interactions are increasing globally	Limited technological perspective	Supports urban coexistence concepts
Urban wildlife ecology [12]	Ecological review	Field observations	Urban habitats influence species adaptation	Limited predictive analysis	Highlights urban biodiversity dynamics
Urban wildlife research priorities [13]	Review and framework	GIS, ecological analysis	Identified future urban ecology priorities	Limited implementation strategies	Establishes urban wildlife research directions
Human-wildlife conflict [14]	Global review	Conflict assessment	Effective mitigation requires interdisciplinary approaches	Limited urban technology integration	Supports conflict management strategies
Urban carnivore ecology	Field-based ecological studies	GPS tracking, GIS	Carnivores adapt to urban landscapes	Species-specific analysis	Demonstrates urban wildlife adaptation
Wildlife behavioral adaptation	Urban ecological monitoring	Camera traps, GPS	Wildlife behavior changes under urban pressure	Limited predictive capability	Supports behavioral assessment
One Health and biodiversity	Integrated review	Disease surveillance	Biodiversity conservation supports public health	Limited smart surveillance	Strengthens One Health perspective
Wildlife monitoring [15]	Sensor-based monitoring	Camera traps, AI, GPS	Automated monitoring improves species detection	High computational requirements	Demonstrates intelligent wildlife monitoring
AI for wildlife conservation	Deep learning framework	CNN, Computer Vision	High detection accuracy for wildlife species	Dataset dependency	Supports AI-enabled conservation
Urbanization and biodiversity	Ecological synthesis	Biodiversity assessment	Urbanization significantly reduces native biodiversity	Limited technological discussion	Explains biodiversity impacts
Urban green infrastructure	Socio-ecological assessment	GIS, landscape analysis	Green spaces improve biodiversity and well-being	Limited intelligent monitoring	Supports ecological infrastructure planning

Table 1. Related Studies on Human-Animal Coexistence Within Rapidly Urbanizing Regions

III. Human-Animal Coexistence in Urban Landscapes

Urban areas are home to a variety of wildlife that contributes to the provision of ecological services such as pollination, pest control, seed dispersal and nutrient cycling. Ecological resilience, community involvement, planning for biodiversity and environmental awareness are essential for successful co-existence. The inclusion of ecological knowledge in social engagement encourages a harmonious relationship between people and wildlife in increasingly urbanised areas.

A. Urban Wildlife Diversity and Distribution

The city environment allows a surprisingly large number of species to survive to varying extents in different habitats that have been modified and influenced by humans. Urbanscapes are diverse, dynamic ecosystems inhabited by a variety of birds, mammals, reptiles and amphibians, insects and many invertebrates, in urban parks, wetlands, rivers, gardens, green roofs and in peri-urban forests. Habitat quality and vegetation cover, water levels, climate, food availability and urban development affects species distribution. Generalist species like pigeon, crow, sparrow, squirrel, fox, rat, monkey, etc. are often able to flourish in cities by being able to take advantage of anthropogenic resources and by their behavioural plasticity. Conversely, specialist species which demand undisturbed habitats often become endangered due to degradation and fragmentation of their habitats. Urban biodiversity also varies between urban land use types; green corridors and connected ecological networks have a higher biodiversity than dense built up areas. Other factors that affect distribution of wildlife in an urban area include seasonal movements, breeding activities, and environmental changes. Spatial and temporal distribution patterns are being derived from ecological surveys, remote sensing, geographic information systems (GIS) and citizen science projects, allowing planners and conservationists to determine biodiversity hotspots, prioritise habitat restoration, enhance ecological connectivity and create evidence-based conservation strategies that help people and wildlife coexist sustainably in areas that are increasingly human-dominated.

B. Ecological Roles of Urban Animal Species

Urban wildlife plays vital roles that are crucial for the stability of ecosystems, preservation of biodiversity and environmental sustainability in growing cities. Pollinators (bees, butterflies, birds and bats) promote reproduction and thereby sustain urban vegetation and ensure genetic diversity. Seed dispersing animals play a role in natural regeneration of forests, parks and green corridors when they spread seeds between patches of these areas. Predatory animals, such as insects, reptiles, owls and raptors, control pest populations, decreasing reliance on chemical pesticides for pest control, thus promoting ecological balance and consequently public health. The soil organisms, insects and scavengers play a role in nutrient cycling, decomposition, and waste breakdown, thereby promoting soil fertility and ecosystem productivity. Urban rivers and wetlands also support aquatic species which help maintain water quality and ecological resiliency. The ecological roles in figure 1 play a good part in the sustainability of urban ecosystems. Besides ecosystem services, urban wildlife offers educational, recreational, cultural and psychological values, enhancing the people's link to nature and environmental awareness.

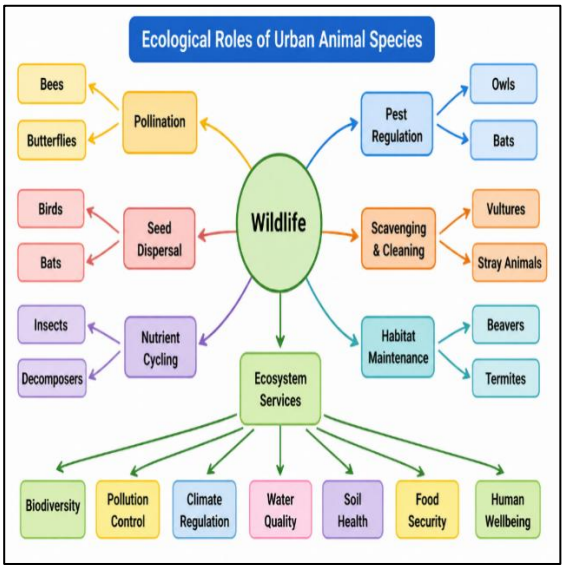


Figure 1. Ecological Roles and Ecosystem Services of Urban Animal Species in Sustainable Urban Ecosystems

In some instances, however, such as when biodiversity is eroded due to habitat destruction, pollution and/or invasion, these ecological services can diminish. Conserving functional diversity through habitat restoration, ecological infrastructure, biodiversity-oriented urban planning and adaptive conservation measures guarantees that biodiversity in cities remains to provide valuable ecosystem services and enhance resilience towards environmental impacts and climate change.

C. Socio-Ecological Dimensions of Coexistence

Complex socio-ecological dynamics between human and animals in urban environment are influenced by governance, economic activities, cultural values, community participation and environment. There is also a wide range of public reaction to wildlife in terms of education, experiences, culture and risk assessment of various species. Urban dwelling people have many reasons to appreciate wildlife for recreation, aesthetics, environmental health and wellbeing, but they also see wildlife as a source of conflict, damage to property, disease transmission and/or public safety issues. For this reason, there is the need for balance between ecological conservation goals and human needs, thus the need for inclusive planning, and evidence-based policy development for effective coexistence. Engaging communities in conservation, environmental education and citizen science projects helps to promote an understanding of biodiversity conservation and responsible action to minimise unnecessary human-wildlife conflict.

Access to an equal amount of urban green space further enhances social acceptance of conservation efforts and also enhances physical and mental health. Adaptive management is fostered by collaborative governance processes between local communities, conservation groups, urban planners, researchers and government agencies, where they consider ecological and social priorities together. By combining socio-economic analysis with ecological monitoring, decision-makers can find opportunities to live and let live, test the success of the policies, and create resilient urban ecosystems that benefit biodiversity, public safety, environmental justice, and sustainable development, all while building on a long-term cross-disciplinary collaboration.

IV. Challenges Affecting Human-Animal Coexistence

Loss of habitat, ecological fragmentation, conflict between people and animals, and zoonotic disease threats are significant challenges for sustainable co-existence. Urban development drives resource competition, public safety and reduces the resilience of the ecosystems. In addition to all these challenges, integrated conservation planning, One Health approaches, ecological restoration and adaptive management, subject to scientific evidence and collaboration, are needed to address these interconnected challenges.

A. Habitat Loss and Ecological Connectivity

Loss of habitat is one of the biggest challenges to sustainable humans-wild animal relationship in the quickly urbanizing areas. Urban encroachment, development, industrialization and transportation infrastructure eliminates and diminishes habitats, food, shelter and migration routes for wildlife. Landscapes are becoming fragmented, reducing ecological connectivity between patches and the ability of species to move, exchange genes and be resilient. Isolated populations of wildlife are more susceptible to inbreeding and environmental changes, invasive species and local extinction. Frequent vehicle collisions and disruption of migration routes also kill wild animals by roads, railways and urban barriers. Wetlands and forests, riparian corridors and grasslands are also lost, reducing the provision of ecosystem services which benefits biodiversity and environmental stability. The challenges these pose are exacerbated by climate change, which affects the distribution and suitability of habitats for species. Ecological connections via wildlife corridors, green infrastructure, ecological bridges, urban forests and biodiversity-focused land use planning can greatly enhance species movement and ecosystem resilience. Ecological network analysis, landscape ecology, geographic information systems, and long-term monitoring of biodiversity can be incorporated into urban planning to assist in the development of strategies that are adaptive and ensure that development and wildlife protection can coexist and that there is a resilient human-wildlife component to both.

B. Human-Wildlife Conflicts and Public Safety

The escalation of human-wildlife conflict has been significant due to the growing location of people and wildlife in cities, which poses a threat to public safety, conservation of biodiversity, and sustainable development. Wildlife is often found in residential areas, in farms and fields, in transportation corridors and in public recreation areas in search of food, water, or refuge. These encounters can cause crop damage, livestock predation, property destruction, traffic accidents, attack of domestic animals and in some cases, may lead to injuries or death of human beings. Opportunistic species like monkeys, wild boars, elephants, deer, foxes, stray animals, and even large carnivores take advantage of humans altered environments where natural resources are depleted. Public fear, misinformation, negative perceptions could exacerbate conflicts further, resulting in retaliatory measures that could push back wildlife conservation. Local communities' economic losses also affect public support for biodiversity protection activities. To be effective, conflict mitigation should involve a multidisciplinary approach that includes habitat rehabilitation, wildlife corridors, waste disposal management, early warning systems, community awareness and education, and science-based policy measures. The use of advanced technologies such as artificial intelligence, camera traps, UAVs, geographic information systems and predictive analytics allow for real-time monitoring and conflict forecasting. To reduce risks and encourage safe and sustainable co-existence, it is necessary to build a collaborative governance framework including local communities, conservation agencies, research and policy makers.

C. Disease Transmission and One Health Concerns

Many infectious diseases have the potential to spread from humans to domestic animals and from domestic animals to wildlife, especially in the context of urbanizing areas where there are more opportunities for contact. Emergence and spread of zoonotic diseases due to habitat fragmentation, environmental degradation, climate change and expansion of the urban population. Wildlife species can act as reservoirs for viruses, bacteria, parasites and other infectious agents that can impact human and animal populations under certain ecological conditions. The risks of transmission are further increased by poor waste management, contaminated

water sources, poor sanitation and illegal wildlife trade. Domestic animals that are raised in cities or those that are allowed to roam the streets can also spread disease between wildlife and humans. The One Health framework has started to acknowledge the close connection between human health, animal health and ecosystem health, all of which must be addressed in a multidisciplinary, integrated approach. Sustained disease surveillance, environmental monitoring, wildlife health assessment, genomic surveillance and epidemiological prediction help with early detection and prevention of outbreaks. AI, IoT sensors, remote sensing and GIS offer useful sources of data to pinpoint high-risk regions and aid in making informed decisions. The integration of multiple sectors in the healthcare, veterinary medicine, ecology and environment, and policy areas is crucial to enhance disease preparedness, protect biodiversity, and promote resilient urban ecosystems.

V. Technologies Supporting Human-Animal Coexistence

The applications of Artificial Intelligence, computer vision, Internet of Things technologies, geographic information systems and remote sensing, allow for intelligent monitoring of wildlife, assessment of habitat and prediction of conflicts. The technologies deliver real-time environmental information, better conservation planning, better ecological decision making and better proactive management approaches in cities to improve biodiversity conservation and sustainable human-animal co-existence.

A. Artificial Intelligence and Computer Vision

Overall, the convergence of AI and computer vision holds promise for revolutionizing the way we engage with wildlife, offering intelligent solutions to enhance human-wildlife interactions and mitigate ecological challenges.In conclusion, the integration of artificial intelligence (AI) and computer vision (CV) presents a promising opportunity for advancing the field of human-wildlife coexistence.The future of human-wildlife coexistence is bright with the potential of AI and computer vision to provide intelligent solutions that support human-wildlife interactions while addressing ecological challenges. Camera traps, surveillance cameras, unmanned aerial vehicles and satellites can now be used for accurate detection, classification and tracking of wildlife using deep learning algorithms, convolutional neural network, vision transformer and object detection models like YOLO, Faster R-CNN and Mask R-CNN. These technologies can drastically decrease the amount of manual observation that needs to be completed and provide an immediate and accurate understanding of animal abundance, animal movements, habitat use and behavioral shift. AI-powered predictive models also forecast foreseeable conflict situations, using ecological, climatic and land-use data to enable conservation efforts to be taken in advance of the event. Explainable AI can help increase transparency in models, and better inform trust in these models amongst conservation practitioners and decision makers—showing what influential environmental factors are informing predictions. AI systems can also be used for the assessment of biodiversity, for detecting illegal wildlife activity, and forecasting ecological risks. Computer vision technologies can be used to create automated cameras that can help monitor the environment in real time and provide quick decision-making. Therefore, ecological intelligence facilitated by AI has the potential to promote adaptive wildlife management, enhance biodiversity conservation, reduce human-wildlife conflict and help build resilient urban ecosystems by providing evidence-based and data-driven environmental planning.

B. Internet of Things and Smart Monitoring Systems

The Internet of Things (IoT) has drastically changed the monitoring of wildlife by allowing continuous monitoring, transmission and analysis of environmental and animal related data in the urban and peri-urban ecosystems. The IoT systems involve the use of animal collars, GPS trackers, environment sensors, acoustic recorders, motion detectors, camera traps, weather stations, and smart gateways to track the movement of animals, changing conditions of their habitats and ecological disturbances in real-time. Distributed sensors can reliably exchange data with cloud and edge computing via wireless communication technologies like LoRaWAN, Zigbee, Wi-Fi, Bluetooth Low Energy and cellular networks. Going around continuously allows early detection of unusual animal behaviour, degradation of habitat, environmental hazards and potential situations of human-wildlife conflict. Edge computing also enhances the time response as it processes information at the edge and communicates only summarized data to the central platforms, which decreases bandwidth consumption and communication delays. Figure 2 shows the monitoring of the coexistence of humans and wildlife in an intelligent manner based on IoT.

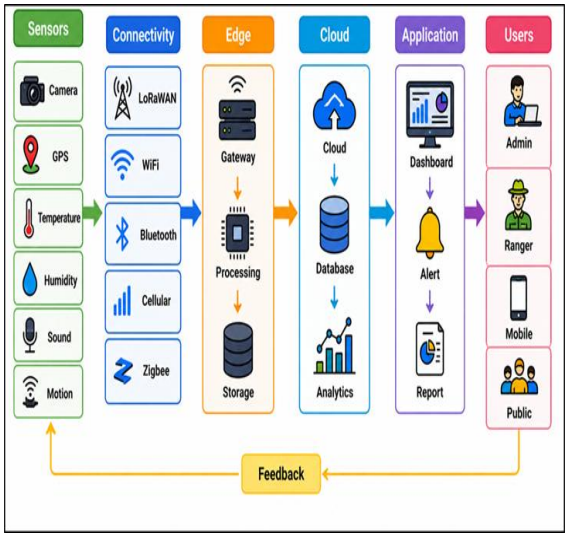


Figure 2. Internet of Things–Based Smart Monitoring Framework for Intelligent Human–Animal Coexistence Management

By combining multiple sensing modalities and enabling aggregation into an ecological monitoring network, IoT systems also help to monitor the health of wildlife, environmental quality and infrastructure management. The integration of AI and predictive analytics with IoT platforms enables real-time alerts, better conservation strategies, enhanced emergency response, and adaptive environmental management. The smart monitoring systems help to improve biodiversity protection and ensure more peaceful and sustainable coexistence between man and animal in rapidly urbanizing landscapes.

C. Geographic Information Systems and Remote Sensing

Geographic Information Systems (GIS) and remote sensing technologies offer great spatial analysis tools to help understand wildlife distribution, habitat quality, ecological connectivity and land-use patterns in urban settings. Satellite imagery, aerial photography, UAVs and multispectral sensors provide the ability to monitor vegetation cover, water resources, environmental changes, urban development, habitat fragmentation and more on a continuous basis over extensive areas. GIS combines these spatial layers with biodiversity, climatic, infrastructure network and socio-economic data to detect locations of wildlife corridors, biodiversity hotspots, migration routes and human-wildlife conflict hotspots. Spatial modeling techniques can be used to aid in habitat suitability assessment, landscape connectivity analysis, ecological risk mapping, and conservation prioritisation. Additionally, remote sensing allows for monitoring of deforestation, wetland degradation, urban heat islands and ecosystem restoration over a long time period because it provides consistent temporal observations. GIS platforms, when combined with AI and IoT information, can offer and support a more holistic approach to environmental decision making, based on predictive modelling and on-line visualization.

VI. Proposed Integrated Human-Animal Coexistence Framework

The suggested model combines various environmental data sources, AI, internet of things monitoring, GIS and predictive analytics as a single decision support platform. It enhances wildlife detection, ecological connectivity, conflict avoidance and policy development, and facilitates adaptive urban planning, conservation and protection of biodiversity, public safety, and sustainable management of urban ecosystems.

A. Multi-Source Environmental Data Collection

The integrated human-animal coexistence plan starts with gathering more environmental data from various sources to provide a solid basis for ecological evaluations and intelligent decisions. It integrates multi-source, multi-sensor datasets from satellite imagery, unmanned aerial vehicles, geographic information systems, camera traps, acoustic sensors, weather stations, Internet of Things, GPS tagged wildlife collars and citizen science observations. Other datasets such as land-use maps, vegetation indices, hydrological data, climate data, transportation network, population density and biodiversity inventory are combined to gain a comprehensive understanding of the urban ecosystems. Data processing involves quality control, georeferencing, filling missing data, temporal synchronization, noise reduction and feature extraction which help to enhance the analytical accuracy. Cloud and edge computing infrastructures can provide a way to continuously acquire and store large-scale environmental information, and perform monitoring in real time. Standardized data integration makes it easier to integrate ecological, environmental and socio-economic data providing interoperability for detailed analyses of ecosystems. This multi-source approach represents both spatial and temporal variation in wildlife habitat, ecological connectivity, environmental disturbances and anthropogenic activity. Therefore, the environmental data is vital to the inputs of the AI models, ecological risk assessment, biodiversity monitoring, and evidence-based urban planning for human-animal coexistence that is resilient and sustainable.

B. AI-Based Wildlife Detection and Risk Prediction

After data integration, the framework uses artificial intelligence to automate the detection, behaviour analysis, habitat assessment, and prediction of

conflict risks of the wildlife. Images and video captured by camera traps, surveillance, drones and satellites are used as input for computer vision models, which will identify the species, estimate the population density, track movement patterns and detect abnormal behavior. The deep learning models, such as convolutional neural networks, vision transformers and object detection, are able to accurately identify wildlife across a variety of environmental conditions. Machine learning models also incorporate information related to environmental conditions, like vegetation cover, climatic conditions, traffic density, land-use, and past human-animal conflict records to forecast hot spots where such interactions are expected to happen. Explainable Artificial Intelligence (XAI) techniques enhance the transparency of the models, fostering increased trust in the models among planners and conservation managers, and increasing the likelihood that environmental factors that play a major role in predictions are captured.Explainable Artificial Intelligence (XAI) techniques increase the transparency of the model and contribute to more trust in the model by planners and conservation managers, while increasing the chances that the key environmental factors that influence more significantly the predictions are captured.

C. Urban Planning and Policy Decision Support

The last step in the proposed framework involves applying the analytical results to inform the urban planning and policy process for a more sustainable human-animal relationship in the long run. The data are combined with AI forecasts, geographical information systems (GIS), ecological indicators, and biodiversity assessments, which are then used to support decision-making platforms for planners, conservation organisations, and policy-makers as they assess various development options. Spatial analyses provide areas of priority for wildlife corridors, ecological restoration, protected green infrastructure, wetland protection and biodiversity-sensitive land use planning. Other aspects of the framework include transportation route optimization, urban expansion, waste management and recreation infrastructure, which all help to decrease habitat fragmentation and potential conflict issues. The interactive dashboards offer real-time data visualization of ecological conditions, wildlife movements, environmental hazards and conservation performance, and help direct adaptive management and evidence-based governance. Policy recommendations include the integration of One Health principles, climate resilience, ecosystem restoration and sustainable development goals and call for inter-agency partnership, research and community engagement, and environmental organizations. Regularly reviewed and tested, planning processes are continually improved as ecological conditions and urban growth evolve. In this way, the proposed approach allows for an integrated environmental governance, by balancing the protection of biodiversity, the protection of public safety, the ecological resilience and sustainable urban development, using intelligent and data-driven decision support.

VII. Results and Discussion

Comparative evaluation shows that the integrated ecological and technology-driven approaches are more effective than traditional methods in creating habitat connectivity, detecting wildlife, reducing conflict, enhancing public safety and improving urban sustainability. The proposed framework achieves good ecological, social and technological results, proving its efficiency for smart environmental management and, in the context of the growing urbanization of the areas, for the coexistence and resilience of human and animal life.

A. Comparative Assessment of Existing Urban Coexistence Strategies

The comparative assessment shows that the strategies taken towards the city's coexistence with nature are mainly reactive, characterized by a low level of integration of ecological connectivity and advanced technologies. The integrated solutions, on the other hand, that combine ecological infrastructure, biodiversity-integrated planning, AI, IoT monitoring, and GIS-based decision-making projects a greater efficiency in wildlife conservation, conflict prevention, habitat restoration and decision-making. The multidisciplinary integrated solutions will improve the ecological resilience, improve adaptive urban management, support proactive conservation interventions and offer a balanced approach to ensuring sustainable human-animal coexistence in the context of fast urbanization.

Performance Indicator	Conventional Urban Planning	Green Infrastructure Strategy	Smart Monitoring Strategy
Habitat Connectivity (%)	48.6	74.9	79.4
Wildlife Detection Accuracy (%)	56.8	68.2	91.3
Human-Wildlife Conflict Reduction (%)	34.5	61.8	78.5

Public Safety Improvement (%)	63.5	75.8	88.6
Monitoring Response Time (min) ↓	132.4	74.8	24.6
Urban Sustainability Index (%)	60.8	79.2	87.5

Table 2. Comparative Assessment of Existing Urban Coexistence Strategies

As is clear from Table 2, all the indicators considered prove that integrated urban coexist strategies always perform better than classical urban planning. Enhanced ecological connectivity in the form of an improved habitat connectivity, which is improved from 48.6% conventional planning to 79.4% for smart monitoring. The accuracy of wildlife detection improves significantly from 56.8% to 91.3% to allow more confident management and monitoring of wildlife species.

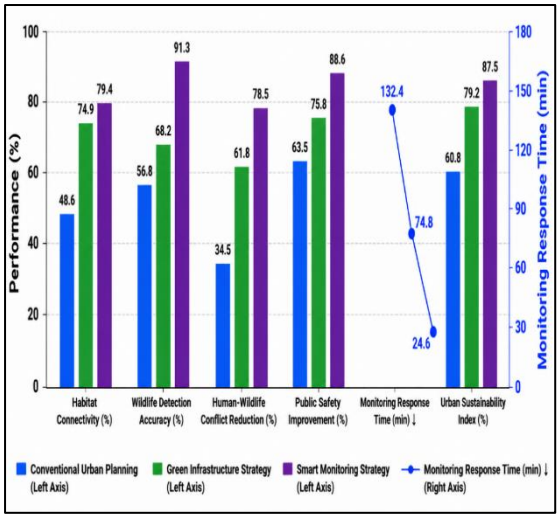


Figure 3. Comparative Performance of Urban Coexistence Strategies Across Ecological, Safety, and Monitoring Indicators

The ecological performance, safety, efficiency of monitoring and sustainability of strategies are compared in Figure 3. The proportion of humans and wildlife conflict reduced increases from 34.5% to 78.5%, which is achieved through better preventive measures. The technology also improves public safety from 63.5% to 88.6%. Moreover, the response time becomes very low from 132.4 minutes to 24.6 minutes for monitoring incidents, which helps in quick incident management.

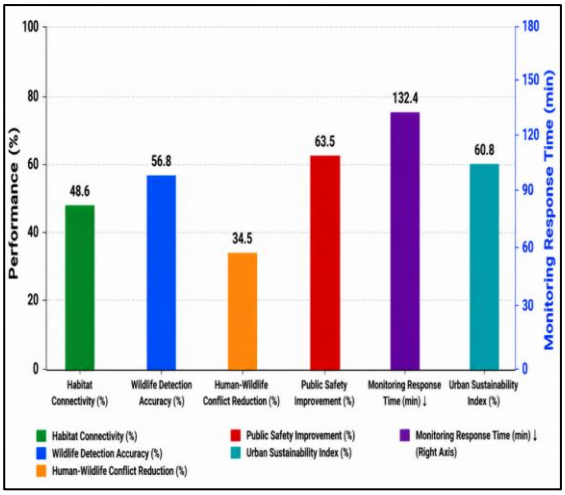


Figure 4. Environmental Performance Assessment of Conventional Urban Planning for Human–Wildlife Coexistence Indicators

The conventional urban planning is judged based on the following key human-wildlife coexistence performance indicators in Figure 4. The Urban Sustainability Index goes from 60.8% to 87.5%, showing the effectiveness of smart monitoring strategies over conventional urban planning strategies in terms of ecological, operational and sustainability results.

B. Evaluation of Ecological, Social, and Technological Outcomes

The proposed integrated framework can deliver positive ecological, social and technological benefits, as it supports increased biodiversity conservation, habitat connectivity, ecosystem resilience and minimises potential human-wildlife conflict. Artificial Intelligence, Internet of Things (IoT) systems, and Geographic Information Systems (GIS) improve the precision of wildlife monitoring and predictive risk assessment, as well as decision making for the environment. Socially, greater involvement in and evidence-based governance enhances the awareness of conservation and public safety within the community. The overall framework is aligned with sustainable urban planning, with the use of intelligent technologies, interdisciplinary approaches, adaptive environmental management and co-habitation between human and wildlife.

Evaluation Metric	Value
Biodiversity Conservation Improvement (%)	94.8
Habitat Connectivity Enhancement (%)	90.5
Wildlife Detection Accuracy (%)	97.6
Conflict Risk Prediction Accuracy (%)	95.9

Ecological Resilience Index (%)	93.7
Community Participation Rate (%)	86.4
Public Safety Improvement (%)	94.2
One Health Preparedness Index (%)	91.8
AI Prediction Precision (%)	96.8

Table 3. Evaluation of Ecological, Social, and Technological Outcomes of the Proposed Framework

Table 3 shows that the proposed integrated human-animal coexistence framework has a good overall performance in the ecological, social and technological aspects. The ecosystem integrity values for biodiversity conservation and habitat connectivity are 94.8% and 90.5%, respectively, showing improved ecosystem integrity. The results of the AI's predictive analytics and intelligent monitoring show a high level of accuracy in wildlife detection, with a score of 97.6% and a 96.8% accuracy rate in AI predictions. Predicting conflicts has a success rate of 95.9%, which makes it possible to act in advance to prevent conflicts.

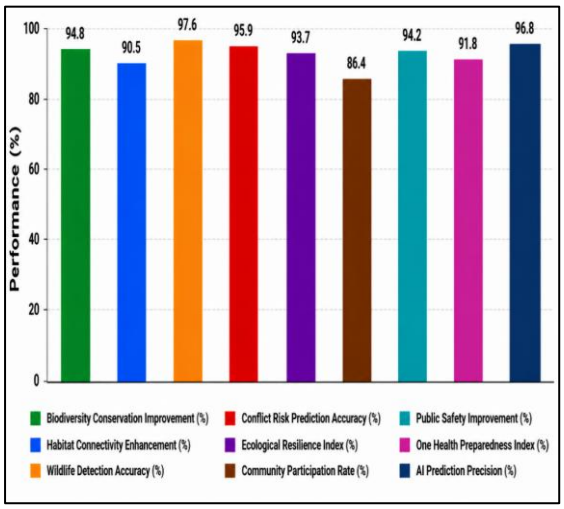


Figure 5. Performance Evaluation of the Proposed Human–Animal Coexistence Framework Across Ecological, Safety, and AI Metrics

Fig.5 shows that the performance of the proposed framework is superior in terms of ecological, safety and AI performance. An ecological resilience index of 93.7% means that the ecosystem is more resilient in the presence of urban pressures. The level of participation in the community is 86.4%, indicating good involvement of stakeholders. The index of public safety has risen to 94.2%, while the index of preparedness for One Health has reached 91.8%, which reflects the improvement of the integration of environmental, animal and human health in the planning of living together in a sustainable way.

VIII. Conclusion

The human-wildlife interface is now a central and major issue in today's rapidly urbanizing world, with great potential for sustainable coexistence. The challenges arising from habitat loss and fragmentation, rising human-wildlife conflict, and the potential for zoonotic diseases are expected to be exacerbated with urbanization, and require whole-of-place approaches that reconcile development with biodiversity. Meanwhile, advances in artificial intelligence, computer vision, Internet of Things, geographic information systems, and remote sensing offer cutting-edge solutions for live monitoring and tracking wildlife, foreseeable risks and exposures, and evidence-based environmental management. The review highlights the need for a single decision support framework that integrates ecological infrastructure, urban planning that is sensitive to biodiversity, One Health principles and intelligent digital technologies, to enable the successful co-existence of humans and animals. The integrated framework outlined will help to harness multi-source environmental data, AI technologies, and adaptive policy development to advance ecological connectivity, bolster public safety, and bolster ecosystem resilience in rapidly urbanizing areas. Moreover, robust cooperation between urban planners, conservationists, policymakers, researchers and local communities is crucial for the development and implementation of strategies for long-term coexistence. For future studies, the focus should be on EAI, climate resilient urban ecosystems, Citizen Science integration and adaptive governance models to enable resilient, inclusive, and biodiversity positive cities for harmonious and sustainable human-animal co-existence.

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