Media and Communication Review (MCR)
Volume 5 Issue 2, Fall 2025
ISSN (P): 2790-8356, ISSN (E): 2790-8364
Homepage: https://journals.umt.edu.pk/index.php/mcr

Title:	**Exploring the Use of Artificial Intelligence and Mixed Reality in Conservation Efforts for Endangered Wildlife in Pakistan**
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DOI:	https://doi.org/10.32350/mcr.52.08
History:	Received: July 19, 2025, Revised: September 20, 2025, Accepted: September 24, 2025, Published: November 15, 2025
Citation:	Imran, H., & Shahid, L. (2025). Exploring the use of artificial intelligence and mixed reality in conservation efforts for endangered Wildlife in Pakistan. *Media and Communication Review*, *5*(2), 172–197. https://doi.org/10.32350/mcr.52.08
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Conflict of Interest:	Author(s) declared no conflict of interest

A publication of
The School of Media and Communication Studies
University of Management and Technology, Lahore, Pakistan

Exploring the Use of Artificial Intelligence and Mixed Reality in Conservation Efforts for Endangered Wildlife in Pakistan

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Abstract

Pakistan is a country with a rich and diverse wildlife. However, it is under considerable anthropogenic and environmental pressures (poaching, habitat destruction, and global warming) that pose significant threats to endangered species, including the snow leopard and the Indus River dolphin. To address this urgent conservation need, it is important to adopt new, high-tech solutions. This paper explores the transformative potential of artificial intelligence (AI) and real-time mixed reality (MR) to strengthen wild animal conservation efforts in Pakistan. The study is based on a synthesis of the recent scholarly literature (2019-2024). It examines the successful international implementation of these technologies, particularly in Australia, which is renowned for its unique biodiversity. It expands on how AI can change real-time species recognition, habitat conservation, and anti-poaching solutions. At the same time, augmented reality (AR) and virtual reality (VR) are practical means to foster empathy, raise awareness, and support environmental education. Despite the relevant issues, including data biases, limitations of technological infrastructure, and the ethical implications of privacy, this study argues for the phased implementation of advanced digital applications that do not conflict with traditional cultural and modern conservation processes in Pakistan. The purpose of the presented conceptual framework is to convey the proposed ideas to professionals and stakeholders in the field, thereby helping them endorse the hybrid strategy, which would make the conservation of endangered species in the country more effective and efficient in the long run.

Keywords: artificial intelligence (AI), augmented reality (AR), endangered wildlife, mixed reality (MR), virtual reality (VR)

Introduction

Wildlife is defined as all undomesticated life forms, including animals, birds, insects, and plants, that exist in their natural habitats without direct human control. All species perform important ecological functions

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necessary to maintain the health and stability of an ecosystem (Ahmad et al., 2022). For example, predators control herbivore populations and limit overgrazing, allowing plants to regenerate. Bees and birds are pollinating species that help maintain biodiversity by pollinating and dispersing seeds. Similarly, fungi and insects are decomposers that break down the bodies of organisms, returning nutrients to the soil and ultimately providing the support and nutrients necessary for plant life (Ahmad et al., 2022; Khan & Ghramh, 2023; Störmer et al., 2019).

Wildlife is also essential for human Survival, providing vital resources such as food, protein, and traditional medicines. Many significant innovations in the medical field have resulted from the study of nature and wildlife, and the problems they face (Ahmad et al., 2022). In addition, wildlife can prevent disease spread by reestablishing cyclic ecology (Buddin et al., 2024). Nature-based tourism has served as a source of income and employment in both developing and developed countries. The cultural, spiritual, and recreational value of wildlife fosters well-being and strengthens people's connection to nature (Ashley & Barnes, 2020).

There are many rare species of wild animals in Pakistan, including the snow leopard, the Indus River dolphin, and the Baluchistan black bear (Sheehan et al., 2014). Moreover, the vast majority of them remain unknown due to a lack of surveillance and data. Many of these animals are facing near extinction due to unlawful poaching and deforestation, as well as climate change (Mukul et al., 2019). The first step in protecting wildlife is to adopt emerging technologies such as artificial intelligence (AI) and mixed reality (MR), which integrates elements of augmented reality (AR) and virtual reality (VR) (Tang et al., 2023).

Recent technological advancements have introduced AI, which is being used in almost all fields of life. AI can identify wildlife species yet to be described and can also be used to monitor animal locations with high precision (Kumar & Ghosh, 2025). It can also read vast amounts of data from available databases (Petso et al., 2022).

A perfect example of how AI can identify animals is Google Lens, which provides image recognition technology to its users with ease of access, where they only have to point their smartphone cameras at the unidentified species to know the suggested results (Bilyk et al., 2022)

AI is used to process images and provide immediate information about

them, such as their names and locations (He, 2020). Machine learning (ML) algorithms can also be used to identify poaching hotspots and analyze patterns that enable rangers to intervene and stop poachers (Doull et al., 2021). These methods for wildlife conservation can only be implemented if there is sufficient public awareness (He, 2020; Ladykova et al., 2024).

AR/VR is also used to achieve these conservation goals. A virtual, immersive tour of Pakistan's national parks, for instance, can show visitors what life is like for endangered species. In protecting wild animals, the general public can become active participants and put themselves in the concerned animal's shoes, thereby developing a sense of responsibility (Cosio et al., 2023).

This paper recognizes the dire need to use such technologies efficiently in animal conservation. It examines how AI and MR can be applied to wildlife conservation in Pakistan. The goal is to explore the potential of these technologies to study unknown species, track their habitats, and raise awareness to help protect them. It also provides a conceptual map that may indicate actions to improve wildlife conservation approaches and considers the mechanics of data interpretation through AI, AR simulations, and VR experiences. Moreover, it identifies potential challenges arising from gaps in previous studies. Ultimately, this research aims to inspire and encourage professionals and stakeholders in Pakistan to adopt innovative approaches that improve conservation efforts for endangered species in the region.

Research Objectives

1. To examine the particular uses of AI in the discovery of unidentified wildlife species and tracking their habitat in Pakistan.

2. To investigate the possibility of AR and VR/MR being used internationally to create awareness and empathy towards endangered wildlife species in Pakistan.

3. To analyze the main issues and ethical problems connected with the use of AI and MR technologies in implementing wildlife protection in Pakistan.

4. To suggest a conceptual framework that can be used to combine these advanced technologies with traditional conservation practices in Pakistan in order to make the whole process more effective and sustainable.

Methodology

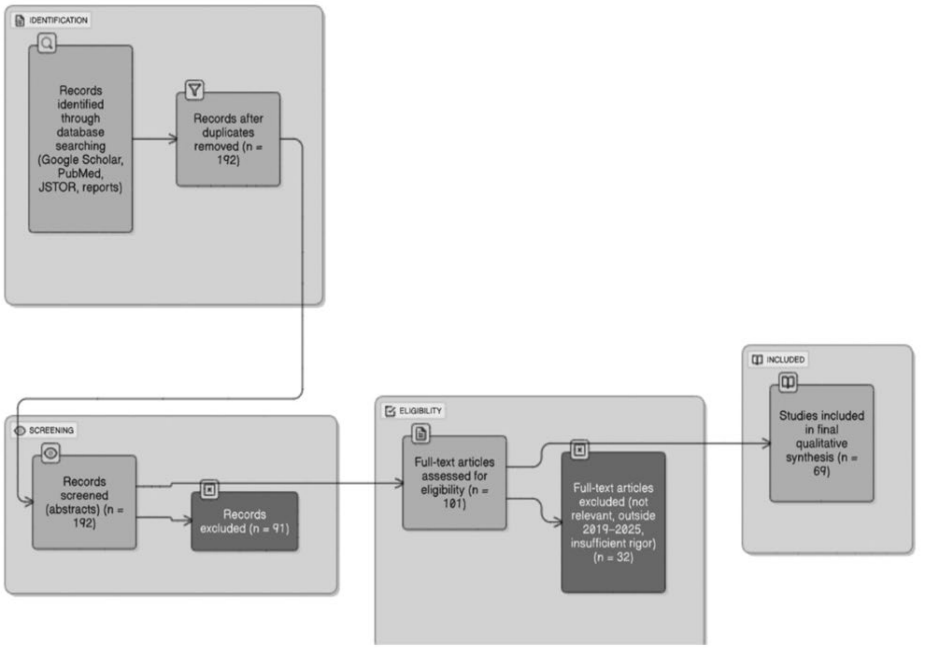
This study employs a qualitative research methodology and a conceptual review of the literature published between 2019 and 2025 to examine how AI and MR are applied in wildlife conservation. Systematic reviews aim to answer specific empirical questions, whereas a conceptual review is better suited to unite various strands of literature, establish interconnections, and develop new models. The object of the study remains Pakistan and its socio-ecological setting, with a focus on species under threat, including the snow leopard, the Indus River dolphin, and the Baluchistan black bear.

The current study is based on 69 peer-reviewed articles, policy reports, and field studies retrieved from various databases, such as Google Scholar, PubMed, and JSTOR, as well as current conservation field reports. The search strategy involved both Boolean operators and search keywords, such as AI, AR, VR, MR, wildlife conservation, Pakistan, and endangered species. The databases were searched using the search terms (AI) or (ML) and (wildlife) or (biodiversity) and (Pakistan) or (South Asia). A systematic review of these sources would help understand how biodiversity can be better conserved using these technologies, define priorities, and offer culturally relevant solutions applicable to the realities of conservation in Pakistan.

As a rigor requirement, the following inclusion criteria were considered: (a) peer-reviewed journal articles, policy reports, or credible organizational publications; (b) published during the period 2019-2025; and (c) directly related to AI, AR/VR, or wildlife conservation. While blogs that were not peer-reviewed, duplicate reports, literature published before 2019 or after 2025, and literature not directly related to conservation technology were excluded. The search was conducted in a PRISMA-inspired sequence: 312 records were identified, 192 abstracts were reviewed, 101 texts were evaluated against the eligibility criteria, and 69 sources were ultimately included in the synthesis of concepts. A PRISMA-style flow diagram is provided below to summarize this process visually.

Figure 1

PRISMA-style Flow Diagram



For analysis, the included studies were coded thematically. Some key concepts were identified and clustered into larger categories (e.g., real-time species monitoring, community integration, data ethics, and immersive education). This thematic synthesis allowed the study to extract cross-cutting insights, while highlighting knowledge gaps and opportunities in the Pakistani context.

Theoretical and Technological Background

The combination of AI and MR offers an opportunity to transform environmental conservation processes through intelligent data processing and immersive, interactive technologies (Tang et al., 2023).

AI is particularly good at real-time wildlife monitoring. It supports targeted preservation by enabling the identification of individual animals using AI-powered video traps (Kumar & Ghosh, 2025). In addition to monitoring, historical data and animal trend analysis using predictive algorithms offer conservationists an opportunity to allocate resources

(Chisom et al., 2024). Satellite, acoustic, and drone data can be processed using AI to support conservation decisions, with relevant volumes of data available in real time, such as species identification, habitat quality assessment, and threat detection through machine learning and computer vision (Robbins, 2025; Wang et al., 2024).

AR acts as a real-time interface and uses AI insights to provide field instructions. AR smart glasses can display real-time information in a ranger's field of view, such as animal locations, poaching risks, or sensor maps (Chokkattu, 2024). Such systems do not remain fixed but are refreshed through user gestures or geolocation, creating a real-time feedback loop between the environment, the user, and AI analytics (Rasch et al., 2025).

On the other hand, VR is used to develop training and scenario-planning environments. In realistic, safe conditions, conservation teams can practice the most crucial tasks, including navigating protected zones and conducting medical procedures, using real-world terrain and AI-simulated animal behavior (Ennakri et al., 2024; Gerup et al., 2020). Tools such as Gaussian splatting can now be used to make hyper-realistic 3D simulations of drone or Light Detection and Ranging (LiDAR) data using laser lights and GPS for environmental monitoring (Zhou et al., 2025).

This combined technology platform gives intelligence, visualization, and real-time decision-making to conservation teams. This is unlike conventional methods, which provide lengthy strategic plans in wildlife protection (Business Research Company, 2025).

Global Examples: Lessons from Australia

Technological innovation and adherence to nature as a cultural value have made Australia a global leader in integrating AI and MR into wildlife conservation (Taronga Conservation Society Australia, n.d.). AI is key to these initiatives, as it can monitor endangered species in real time, track poaching threats, and forecast habitat degradation (Kuruppu, 2023). A good example is the WWF's "Project Platypus," which uses AI to monitor platypus populations and guide necessary interventions (University of Melbourne, 2018). The project "An Eye on Recovery" can be similarly described as utilizing Google-driven AI sensors to quickly identify and swiftly follow up bushfire-affected species in a data-driven manner (WWF-Australia, 2020). At the University of Queensland, AI models are used to map and forecast koala habitats, enabling conservation planning to account

for climate change (University of Queensland, 2023).

Mixed Reality (MR) is also transforming public engagement. The VR experience "Beyond the Reef" immerses users in the world of corals to show how climate change impacts marine diversity (Australian Government, 2023). The University of Melbourne uses AR to gamify the citizen science approach through its PossumSpotter application. Users are asked to report brushtail possum sightings, which helps build wildlife databases and raises awareness of them (Cosio et al., 2023; Wagner & Nitschke, 2025). These tools highlight the strength of integrating immersive technology with people's participation. The integration of native ecological knowledge and modern tools is also encouraged in Australia. For instance, on Minjerribah (North Stradbroke Island), indigenous rangers use AI-powered drones alongside traditional fire management practices to preserve koala habitat (Gleeson, 2025).

An important distinction between Australia and Pakistan lies in the results they produce. In one example, the 'An Eye on Recovery' program in Australia reported detecting species affected by bushfires 35% more quickly than before, enabling timely action (WWF-Australia, 2020). In comparison, the majority of Pakistani attempts remain in the pilot phase and are not quantified with such impact reporting. Such an absence of monitoring and assessment complicates the ability to demonstrate effectiveness to funders or policymakers.

Challenges and Opportunities in Pakistan

Illegal wildlife trade and habitat loss due to climate change endanger various species, potentially eradicating them from the planet (Prepp, 2023). Limited resources and pollution also cause issues (Brondízio et al., 2019). A thorough approach toward habitat protection and awareness campaigns is necessary for sustainable practices (Hoffmann, 2022).

Poaching and habitat degradation are among the greatest threats to biodiversity in Pakistan and endanger species such as the Indus River dolphin, Marco Polo sheep, and snow leopard (ZunNurain, 2025). The use of AI and MR is significant to facilitate conservation efforts. Pakistan has made an exceptional commitment to animal welfare by establishing over 225 conservation zones (Wildlife of Pakistan, n.d.). The effectiveness of such initiatives can be observed in the ban on diclofenac sodium to protect vulture populations and in the successful dolphin rescue efforts in the Indus

River (Galligan et al., 2021). Nevertheless, issues such as habitat degradation, illegal wildlife trade, and climate change remain persistent and require continued attention (Kumar & Ghosh, 2025).

In Pakistan, jirga-led and community-based hunting regulations, sacred groves, rotational grazing, the Shashgaddi anti-poaching system, and judicious harvesting of medicinal plants are some of the ancient community-based conservation practices that consistently maintain biodiversity and ecological balance (Buddin et al., 2024; Jabeen et al., 2025; Khan & Ghramh, 2023). These cultural practices are based on spiritual and social values, as well as on the sustainable use of natural resources and the ensuring of food Security. However, their resilience is threatened by modern pressures, such as changes in land use, population shifts, and climate variability (Jabeen et al., 2025). By combining AI and MR with traditional structures and practices, local stewardship of wildlife can be strengthened rather than replaced.

Nonetheless, efforts to implement VR-awareness campaigns in rural Pakistan have yielded both positive and negative outcomes. In rural regions, where digital literacy rates are lower than in metropolitan areas, there is usually no reliable internet or electricity. This implies that VR tools are likely to marginalize the same populations that are nearest to biodiversity hotspots. These kinds of failures indicate that infrastructure and literacy disparities are not merely technical problems but also structural ones that dictate whether the intervention will actually scale.

The application of AI and MR can be practical if they are employed while considering local beliefs and value systems, as well as the relevance of the local culture. Only in this way would communities become more engaged, potentially increasing their role in wildlife conservation (Ahmad et al., 2022). The frame of protecting and caring for animals, as stated in Islam, can also be used to engage and promote the acceptance of using these technologies (Gulzar et al., 2024).

Integrating AI and MR in Pakistan's Biodiversity Conservation

Pakistan has significant wildlife biodiversity, exemplified by Himalayan snow leopards and Arabian Sea coral reefs (Ali & Hussain, 2023). However, amid numerous threats to natural ecosystems, the application of AI could improve wildlife conservation. Drones, camera traps, and acoustic sensors are used to detect poaching threats in real time, enabled by AI technologies

worldwide (Fergus et al., 2024). WWF-Pakistan and the LUMS program in Gilgit-Baltistan used AI-enabled trail cameras that helped avoid retribution killings of snow leopards, prompting surrounding communities to prepare trails to see their spots (Shahid & Nagri, 2024). What made these pilot projects successful was not just the technology but also the way communities got involved in their implementation. The reason the AI camera traps in Gilgit-Baltistan were effective was that they were compatible with local herding norms and also reduced livestock losses. This demonstrates that conservation technology can be effective in Pakistan only when it addresses ecological objectives and meets short-term human needs.

This model can be modified to safeguard other endangered species, such as the Baluchistan black bear and the Indus River dolphin, which are threatened by poaching and human-wildlife conflict.

Augmented Reality (AR) promotes civic engagement and education by providing participatory experiences within conservation settings such as zoos and museums (Ladykova et al., 2024; Pimentel, 2022). AR has also been applied in wildlife education in Pakistan via the project ZAR (Zoo Augmented Reality) at Peshawar Zoo, which combines image-based localization and offline mapping technology to enhance visitor engagement and general awareness of endangered organisms (Khan & Khan, 2024). AR, and by extension the Extended Reality (XR), technologies have proven to be incredibly effective in teaching environmental education globally, as they provide participants with an opportunity to navigate virtual worlds, learn to impact the species, and simulate the impact of climate change (Bajaj & Amin, 2025). These methods can be tailored to the conservation zones in Pakistan, such as the Changa Manga Forest Reserve or the Margala Hills, to implement biodiversity conservation and online environmental management with the local community and students.

It is possible to foster empathy and train rangers through VR, replicating real-life conservation scenarios. VR-based ranger training is not a new concept. It has been deployed in response to similar training programs in other parts of the world, such as the program "Beyond the Reef," developed by WWF Australia, which allows people to experience coral reefs and develop empathy for marine biodiversity (Australian Government, 2023) It is helpful to cite such precedents to explain how the same VR training may be applied to snow leopard or Himalayan brown bear rescue squads operating in Pakistan (Snow Leopard Trust, 2023). The training programs

simulate high-stakes field conditions, preparing team members to act in similar real-life scenarios.

This trend can be observed in recent digital innovations. In March 2025, WWF-Pakistan introduced the Paws and Justice mobile app, which enables citizens to report cases of poaching and trafficking, where information is directly fed into AI-powered law enforcement systems (Business Recorder, 2025). This application offers a solid case study: it shows how a citizen-led reporting tool, when combined with AI-driven enforcement, takes the discussion beyond speculation and into the realm of action. The project is a regional equivalent of WWF Australia's Eye on Recovery initiative, which also uses Google-based AI to track the effects of bushfires on animal species, suggesting that conservation technology is more successful on a regional scale when it is tailored to local needs (WWF-Australia, 2020).

In the meantime, the PRSC-EO1 satellite, launched in January 2025, provides high-resolution imagery of protected habitats such as the Deosai plains in Gilgit-Baltistan and mangroves in Sindh, which can be monitored using AI (Ahmed 2025).

Community mobilization is essential for promoting respectful storytelling and ensuring cultural sensitivity. AR immersive experiences urge students to visit natural environments, and VR transports people to remote wilderness destinations to raise awareness and attract valuable funding (Conservation International, n.d.). AR and VR experiences are an innovative way to advocate and educate (Ladykova et al., 2024). VR experiences that place users on the Karachi coral reef explain the environmental risks to support conservation efforts (Ahmad et al., 2024). Such technologies are also practical lobbying tools. This can be illustrated by the displays of the Baltistan Wildlife Conservation Trust, demonstrating the impact of deforestation (Baltistan Wildlife Conservation & Development Organization, n.d.). For instance, rotational grazing systems in Gilgit-Baltistan can be enhanced through the use of AI-enabled drones and sensor networks. These tools can be used to monitor pasture health and analyze erosion risk in real time, enabling community leaders to make informed decisions without altering traditional grazing patterns (Jabeen et al., 2025).

Likewise, Baluchistan Shashgaddi (green guards) may facilitate the use of AI camera traps, initially deployed by WWF Pakistan snow leopard

programmes, to detect and warn of poaching incidents, bringing together local and routine patrols and more high-tech surveillance (Associated Press Pakistan [APP], 2024; Shahid & Nagri, 2024). The drone-based 3D-mapping method and AI forest-fire coverage may be applied to the sacred groves preserved throughout Punjab and Sindh without violating sovereign territory, as practised under the protection of the Punjab Forest Department (Shirazi, 2025).

Kalasha communities can benefit from using these tools by merging them with their traditional honey-harvesting practices. Memon people, with integrated selective fishing, can use mobile applications enabled by AR to advise them on when and which stocks to harvest. This makes ecological knowledge easily spreadable and shareable among the youth, particularly. Furthermore, medicinal plant collectors in rural areas of Pakistan may be offered VR-based training modules that simulate sustainable harvesting practices to preserve plant populations (Buddin et al., 2024; Jabeen et al., 2025).

Community engagement and the integration of indigenous knowledge into conservation, as seen in Australia, can also be replicated in Pakistan through collaboration with communities with ecological knowledge, such as the Kalash, Broghil herders, and Baloch nomads. This collaboration, enabled by AI-governed drones and camera traps, would help improve conservation efforts and their local ownership. Secondly, Pakistan can follow Australia's lead by implementing habitat monitoring using AI-powered sensor networks and bioacoustics monitoring in biodiversity hotspots, such as Gilgit-Baltistan, Khunjerab, and Hingol National Park, to conserve snow leopards, Indus River dolphins, and Baluchistan black bears. Finally, educational policies can be adjusted to immersive AR and VR experiences. Conservation in the Deosai plains, Indus delta, or the Himalayan forests could be replicated through Pakistani NGOs and institutions. The aim would be to promote public transparency in the conservation process through interactive, technology-friendly learning mediums.

Moreover, AI-based surveillance interventions implemented in Gilgit-Baltistan have demonstrated the effective integration of innovative technology with traditional practices to protect livelihoods, as snow leopard attacks on livestock have significantly decreased. This was achieved through AI-enabled trail vision systems installed in corrals, which also align

with local community-level corraling systems (APP, 2024; Latif, 2024; Shahid & Nagri, 2024). Finally, 'smart forestry' projects like the Rakh Jhok smart forest in Punjab, which combines drone mapping with forest quantity using an innovative approach to GPS locations and community-based inventories, can be replicated and implemented in sacred groves and community reserves, enabling accurate ecological surveillance without interfering with the local custodianship of sacred forests (Business Recorder, 2021).

Proposed Conceptual Framework

Conceptual models help translate new technologies into viable conservation measures. The socio-ecological systems (SES) framework by Ostrom (2009) is a classic example that integrates community governance, norms, and environmental feedback.

Later models, including the Conservation Technology Framework (Berger-Tal & Lahoz, 2018), still incorporate some digital innovation but often lack guidance on how to modify the use of AI and MR in the Global South, where native systems are present and significant environmental deterioration and infrastructure issues persist.

To resolve this, the Integrated Tech-Conservation Model (ITCM) is proposed, tailored to Pakistan's ecological, cultural, and technological realities. By integrating the literature synthesis (2019-2025) and ongoing local case studies (APP, 2024; Shahid & Nagri, 2024), the three pillars of ITCM— community-led integration, contextual adaptation, and interdisciplinary collaboration — are proposed.

Community-led integration emphasizes co-creating technology with local actors. Conservation should align with traditions such as the jirga, Shashgaddi guards, and Kalasha ecological beliefs (Jabeen et al., 2025). Joint design with communities enhances the performance and trustworthiness of AI tools (Cosio et al., 2023).

Contextual adaptation requires inexpensive, offline, or mobile-friendly instruments that can be used in the remote areas of Pakistan. The alternatives are viable mobile AR applications and locally trained AI models (Segun-Falade et al., 2024). Using locally relevant data is crucial to ensure that lesser-known native species, such as the Indus River dolphin and the Balochistan black bear, are not overlooked (Reynolds et al., 2024).

Interdisciplinary collaboration unites ecology, governance, education, and technology. Drone initiatives to find snow leopards in Pakistan are a bright example of collaborative work among engineers, conservationists, and local communities (APP, 2024; Shirazi, 2025). In this regard, ITCM offers a scalable, responsible system for integrating AI, AR, and VR into the Pakistani conservation environment. Notably, technologies must complement, rather than substitute for, current practices and provide a model that can be replicated in other Global South settings.

Gaps in AI and MR Applications in Wildlife Conservation

Although AI and MR may offer exciting opportunities to conserve wildlife, the opportunities in Pakistan are accompanied by unique challenges that must be addressed locally through an interdisciplinary approach. One of them is the lack of structured, high-quality ecological data. To operate, AI systems require vast amounts of data. However, in places like Gilgit-Baltistan and Baluchistan, this data is inadequate or completely absent (Wang et al., 2024). As a result, generalized or foreign data used to train such models may misidentify endemic species unique to Pakistan, such as the Markhor or the Indus River dolphin, leading to gaps in conservation (Reynolds et al., 2024). It is critical to work with local ecologists, universities, and NGOs to build Pakistan-specific datasets to ensure the applicability and precision of AI.

Misclassification occurs due to the lack of locally curated datasets and erodes trust in the system. When an AI model consistently fails to identify a species, rangers and local communities lose trust in the technology and thus underuse it. In this way, the failure of AI in these situations concerns not necessarily the algorithm but also the lack of long-term investment in localized data infrastructure (Nandutu et al., 2023).

There is also the chance of data misuse. Ethical and Security concerns are important when using AI-enabled tools, such as drones or camera traps, in politically sensitive areas. They can be used without permission to conduct unauthorized surveillance activities or poaching (Associated Press Pakistan, 2024). Sharing GPS records of rare species can unintentionally facilitate the black-market trade in wildlife. Such risks require robust data governance rules, secure platforms, and culturally appropriate ethical principles (Nandutu et al., 2023).

Physical deployment should also be context-sensitive. In Pakistan,

conservation areas often encroach tribal land or pastoral routes, where a perceived invasive technology can create conflict. This means that areas where wildlife thrives may be disrupted by improperly placed installations (Associated Press Pakistan, 2024). Engagement with locals through the application of traditional mechanisms, including the Shashgaddi green guards, can facilitate integration and mitigate the underlying tension inherent with AI deployment.

One issue that may arise during AI implementation is data privacy and accessibility (Solove, 2025). Among the topics that need discussion in rural areas are access and infrastructure (Alabdali et al., 2023). Pakistan's rural infrastructure is insufficient to make AR/VR viable. The vast majority of locations lack high-tech solutions due to unstable electricity, limited internet access, or digital illiteracy (Luccioni & Rolnick, 2022).

Problems can also occur in managing the vast amounts of data and their storage. Once data exceeds storage capacity, it cannot be processed effectively, leading to delays (Luccioni & Rolnick, 2022). In rural areas, technology is not easily affordable. Further, there may be other issues, as locals often resist new technologies that could threaten their way of life (Alabdali et al., 2023). A massive amount of energy is required to process large datasets, so it is necessary to consider sustainable methods to conserve energy (Manikandan et al., 2020). Another factor that may contribute to delays in real-time data transfer for early warning systems and budget management for poaching incidents is poor connectivity in remote areas (Ronoh, 2023).

One should address potential problems related to data privacy, ownership, and misuse. AI deployment needs to be open source and take into account moral values and consequences of AI and MR technologies (Nandutu et al., 2023). Therefore, local communities must be involved in adopting these tools, and their cultural practices must be taken into account.

Implications for Stakeholders

The implications are extensive. Policymakers understand that the use of technology in conservation is not a luxury but a necessary investment. Investment programs, national AI plans, and green technology policies should include conservation measures, especially given Pakistan's high vulnerability to climate change and biodiversity loss. Local and international conservation organizations should also seek to work with

indigenous peoples and groups to establish trust and long-term stewardship. The effectiveness of these technologies for local communities, particularly tribal and rural communities, depends on their active involvement as direct beneficiaries and co-developers.

For example, in Namibia, where poaching is no longer allowed, illegal hunting cases reportedly decreased over three years by 23% (Ashley & Barnes, 2020) after implementing AI-enabled anti-poaching systems. As long as such tools are not compared with similar metrics in Pakistan, policymakers may view them as experimental rather than essential. Local projects will become more credible and fundable by embedding measurable indicators, such as the number of poaching cases prevented or the percentage change in community participation.

Conclusion

This study reviewed the transformational capabilities of AI and MR in wildlife conservation by examining how these technologies can be used in Pakistan. It offers a conceptual review of the issues that professionals and policymakers may consider when addressing the serious problems posed by endangered animal populations in the country. The paper also highlights effective measures to identify new species, protect vulnerable environments, and raise public awareness of the ecological and cultural importance of flora and fauna.

With AI, one can identify species, track their habitats, and detect illegal poaching using drones and camera traps (Hua et al., 2022; Shahid & Nagri, 2024). This has already proven effective in Pakistan through pilot programs in areas like Gilgit-Baltistan, especially for protecting the snow leopard (APP, 2024). Further, these applications can be used to protect the Indus River dolphin, the Baluchistan black bear, and the desert fox.

Moreover, AR and VR technologies integrate dimensions of emotional involvement and empathy into immersive platforms. They can also be educational by modelling the lives and habitats of endangered species in zoos, schools, and reserves to foster stronger emotional and psychological associations (Ladykova et al., 2024; Talgorn & Ullerup, 2023). As highlighted in this research paper, the above digital innovations are not isolated solutions but should be incorporated into Pakistan's existing cultural and ecological conservation system. Shashgaddi green guards in Baluchistan, rotating pasturing in Gilgit-Baltistan, and coastal fishing

culture can be supplemented in a healthy balance with AI and immersive media (Ali & Hussain, 2023; Jabeen et al., 2025).

Such opportunities, however, are not without their problems. One potential reason for species bias in AI systems is the lack of locally curated information, which could otherwise lead to misclassification or the inability to identify native species (Luccioni & Rolnick, 2022). Additionally, there are privacy, surveillance, and ethical concerns associated with technological solutions such as drones and camera traps, especially in geopolitically sensitive areas (Nandutu et al., 2023). There are challenges to implementing AR and VR; successful implementation is often contingent on existing infrastructure and digital literacy (Luccioni & Rolnick, 2022), which may not be present in rural or resource-poor environments.

To conclude, the use of AI and MR can present an unlimited range of opportunities for the effective and adaptive conservation of wildlife in Pakistan. By using such a combination of tools for community-driven, heritage-based conservation activities, supported by ethical data flows and ready designs, Pakistan would be able to develop an informed model of biodiversity protection akin to Australia and other nations. It is helpful to ground hypothetical proposals in working models, such as 'Paws and Justice' in Pakistan and 'An Eye on Recovery' in Australia (WWF-Australia, 2020), to show that these technologies are not theoretical but already in use. Their achievements highlight the feasibility of implementing conservation tech in Pakistan's socio-ecological context.

Research Contribution

This research contributes to the field of media and communication by showing how artificial intelligence (AI) and mixed reality (MR) can act as powerful new forms of environmental storytelling. Unlike traditional forms of awareness, AR and VR technologies can lead viewers to experience the feeling of being a threatened species at risk of extinction, resulting in an emotional connection and arousing empathy. In Pakistan, where conservation messages often fail to reach diverse communities, AI-powered apps, VR experiences, and AR tools offer new avenues for disseminating knowledge and directly involving citizens. These tools turn conservation into a two-way communication process, enabling policymakers, scientists, and the public to interact and collaborate. In this regard, this study demonstrates the potential of digital media to motivate action, transform

public perceptions, and enhance community ownership of conservation projects by presenting a wildlife protection issue as a scientific problem and a cultural and social story.

Recommendations and Limitations

The interventions are also to be co-designed and tested in other ecosystems through the creation of multidisciplinary work groups (conservationists, engineers, policymakers, and local leaders) (Nandutu et al., 2023). They also need to culturally localize AR/VR campaigns and launch them in schools and zoos to raise awareness and empathy for endangered species, such as the Indus River dolphin (Cosio et al., 2023). National AI and climate policies need to be interlinked through conservation and ethics (Kuruppu, 2023). Another limitation of this research is the use of secondary data; in the future, this could be enhanced by incorporating fieldwork, adopting an empirical approach, and incorporating participatory governance models.

Author Contribution

Huda Imran: conceptualization; methodology; writing – original draft; writing – review & editing; supervision; project administration. **Laiba Shahid:** writing – original draft.

Conflict of Interest

The authors of the manuscript have no financial or non-financial conflict of interest in the subject matter or materials discussed in this manuscript.

Data Availability Statement

Data supporting the findings of this study will be made available by the corresponding author upon request.

Funding Details

No funding has been received for this research.

Generative AI Disclosure Statement

The authors did not used any type of generative artificial intelligence software for this research.

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