

## The use of digital technologies in wildlife conservation in Ghana

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**Abstract:** The recent convergence of digital technology with wildlife conservation in Ghana lately has opened a new exciting chapter. This technology, built on high-resolution camera traps, GPS tracking devices, and survey drones has significantly boosted monitoring to protect endangered species in Ghana. While the advantages are clear, challenges remain to realise these digital technologies in wildlife conservation are needed in keeping endangered species. The study employed a descriptive approach under qualitative research design using document analysis as a data collection tool sought to address some challenges in using digital technologies in Ghana. Lack of funding, the training requirements for locals to be able to properly utilize these tools, and a reliable power source in remote areas are some of the challenges hindering the smooth integration of digital technologies into conservation practices within Ghana. Addressing these challenges requires not only collaboration but also strategic planning and a focused strategy to address the dynamics manifest in Ghana's wildlife law enforcement. This will facilitate the accessibility of digital innovations in place for wildlife conservation thereby contributing effectively a sustainably to conserving some rich biodiversity found in Ghana.

**Keywords:** Artificial intelligence, Camera traps, Digital technologies, GPS tracking devices, Survey drones

### 1. Introduction

Technology is the best for monitoring some of nature's threatened species including their habitats hence saving wildlife in Ghana and beyond. Countries have been better able to understand, collect data, and follow animal migrations and threats and have contributed a lot by implementing effective conservation strategies over the past decade. Applying technology in wildlife conservation is not a novel idea but these rapid advancements in digital technologies that rely on Artificial Intelligence (AI) have opened new avenues to observe wildlife behaviour and management of wild resources (Arts et al., 2015). According to Adams (2019), technological contributions integrated in wildlife conservation have increased the vast of understanding from their presence which is focused on conserving nature and therefore provides values perception that helps determine management decision-making actions for preservation of all life. Technology, as Lahoz Monfort and Magrath (2021) aptly state using the example of Loop Systems for Education Suggestions Technology is boundless when aligned with conservation initiatives working towards bettering our planet for all inhabitants it supports. Some of the benefits which wildlife laws provide include the maintenance of biodiversity, and ecosystem function and also securing livelihoods for millions

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of species (Adom et al., 2021). It is necessary, as Ghana struggle to improve the world and preserve our fragile ecological equilibrium. Pacheco (2018) assumes that hurdles like pollution, poaching as well as other concerns for habitat destruction, and climate activism jeopardize ecosystems and wildlife conservation welfare. Webber et al. (2021) assert that digital technologies provide new methods for surmounting these conservation obstacles. It supports data collection and analysis from the wildlife population.

Marvin et al. (2016) support the view that these can be snapshots taken by camera traps, feeds from a local video surveillance network or footage collected via drones and other sensors that show how animals behave in particular areas and what habitats they need, all of which are information technology (both on ground-based devices as well as satellite) help to understand the threats wildlife is exposed to including impacts related with poaching activities signs of habitat degradation Furthermore, Toivonen et al. (2019) appreciates a good example, as identified by Rafizadeh (2024) shows how digital platforms in particular social media applications could help the masses comprehend with biodiversity preservation whilst giving almost real local community engagement. Hence, this is paved with any strategy that will demand natural wildlife presence along the nature's way help to beseech a future for Ghana.

Pukazhenthil et al. (2005) and Wagner (2021) argue that as ecology goes digital and reality becomes digitally mediated, countries become more sensitive to data ownership and access politics on the one hand but also potentially dangerous effects of autonomous technologies in altering animal behaviour on the other; powerful tools must therefore be considered within their general socio-ethics-political context. The purpose of this current study is a critically review the urgent development in wildlife conservation using digital technologies in Ghana. Drawing on various literatures, the research describes various state-of-the-art digital technologies, reviews their applications and potential for wildlife monitoring, some challenges, and explores the positive advances these technologies can be used in wildlife conservation and their involvement in society.

## **2. Theoretical lens for the study**

Vigna et al.'s (2021) study on SES (Socio-Ecological Systems) Analysis Framework was adopted for the study. In the conservation context, termed Socio-Ecological Systems (SES), it provides a useful theoretical framework to understand complex interactions between environmental variables and human communities. The SES framework stresses the connection between social and ecological systems, since human actions cannot be separated from changes in nature which are results of interaction. By applying the SES framework to digital technologies in wildlife conservation, the study shows that such tools may contribute significantly to reconciling ecological and social system components. In the SES, these include access to all tools required for effective conservation strategies; methods and guidelines for data collection, analysis and dissemination.

Digital technologies can be used to integrate human communities with wildlife habitats, allowing researchers an insight into practices of poaching and why the locals depend on it for their livelihood. One of things digital technologies facilitate is the monitoring and management of wildlife populations and their habitats in relation to SES. In addition, advanced wildlife monitoring tools like GPS tracking and camera traps enable real-time information about the movement and behaviour of animals that is offering us a remarkable opportunity for habitat protection and species conservation so as to avoid or prevent killing and poaching endangered wild species. Social media, internet providers and applications for mobile phones are also becoming increasingly important in the effort to raise awareness of nature conservation issues; strengthen support networks around powerful messages from conservation areas and heroic efforts to preserve them while calling attention any illegal or destructive activities therein.

These online and digital tools enable conservation organizations to increase involvement, foster knowledge transfer, and support best practices within social-ecological systems that benefit both human well-being as well wildlife. Additionally in researcher's studies, researchers have incorporated the SES framework. Berrouet (2018) referred to the SES framework when addressing vulnerability in socio-ecological systems determining the vulnerability of ecological, social and coupled socio-ecological systems to multiple threats from different extreme climate events or land use changes. Considering this kind of factors provides a little insight into about which variables and mechanisms are influencing our estimates either upwards (i.e., sensitive) when increased harm is expected as result of exposure to one type category concern a threat. Utilizing digital technologies within the SES theoretical framework allows for optimized conservation strategies that encourage cohabitation of humans and wildlife, elevating anthropogenic disturbances in socio-ecological systems leading to equilibrium structures which align with optimal scales

promoting long-term sustainability.

### **3. Digital technologies in wildlife conservation**

Throughout Ghana, digital technologies have revolutionised the approach to wildlife conservation and critically evolved new solutions for combating the multitude of challenges that face our efforts in protecting natural heritage. This has supported data acquisition, viewing, and community engagement in conserving nature activities over the years (Simlai & Sanbrook, 2021). In short, the discussion on the background of digital technology has been reflected through this chapter, which will argue about the spatial efficacy of different technologies and constrained usage to aid the threatened subject of biodiversity conservation as key interventions.

#### **3.1. Artificial Intelligence and machine learning**

Artificial intelligence (AI) as outlined by Raihan (2023) and Fang et al. (2021), suggests that the successful application of an artificial synaptic algorithm would help conservationists monitor and maintain nature better than ever before. Big Data and Machine Learning algorithms as one of the main use cases in conservation efforts that deal with wildlife comprise large digital datasets related to data from camera traps, GPS trackers, and many more. Machine learning algorithms can process huge amounts of information quickly and accurately so scientists can determine patterns, trends, and anomalies within dynamic populations as well not natural behaviour life stages. This data-based strategy allows conservationists to easily focus on which activities for conservation and also informed decisions (Isabelle & Westerlund, 2022).

Cheng et al. (2018) and Anand Kumar et al. (2018) argued that digital technologies with machine learning as a game changer is now widely used in the protection of endangered wildlife and their habitat by promoting conservation efforts. In a new study, Sipper and Moore (2021) showed how machine learning algorithms will be able to analyze millions of data points at once and form predictions as well; fundamentally changing the way that species are monitored or protected by conservationists. One major use case of machine learning for Wildlife Conservation which does toward data analysis as well is mentioned by Tuia et al. (Tuia et al., 2022). Using ML systems, massive data sets from diverse sources (e.g., camera traps, satellite images, and acoustic sensors) may be sifted out to inform about wildlife populations, behaviour, and life-stage changes (Genelza, 2024). Indeed, image recognition algorithms can be trained on camera trap images to identify with a certain level of precision the species they contain (Dujon & Schofield, 2019) enabling researchers to estimate population sizes and movements by individual animals over time or recognize threats such as poaching or habitat disruption.

#### **3.2. Camera traps and remote sensor technology**

According to Caravaggi et al. (2017), as highlighted by Ahumada et al. (2013), camera traps devices are provided with motion detectors and cameras, enabling conservationists to obtain images or videos of elusive and nocturnal species without human interference on them by reducing disturbances. Further Newey et al. (2015) contribute to the perspective that ecologists and conservation managers can deploy cameras at entrancing points to study species interactions, breeding events or migration corridors thereby providing an evidence base for effective management endorsements. Additionally, Abrahms and Hailer (2021) show photos, videos captured by these cameras can be used for estimating population sizes, detect individual animals identifies with unique labels and evaluate the health of species based on its condition. This work is crucial to evaluate conservation status of threatened species and prioritize conservation efforts. Furthermore, camera traps are widely utilised as a tool to detect and deter illegal activities including poaching or habitat destruction (Trolliet et al., 2014).

Wang et al. (2020) claim that typical use of remote sensing in their journal such as for the tracking and protection of wildlife, and wild lands to micro terrain details. This innovative method of capturing ecosystem and species distributional data with satellite imagery, drones, and other aerial platforms have provided a novel dimension to large-scale biodiversity monitoring without placing humans in the field. According to Sharma et al. (2021) and Kerry et al. (2022), remote sensing being able to allow a sector-wide view of the landscape and biodiversity is one of its greatest advantages regarding wildlife conservation. Also, Duan et al. (2020) assert that the type of cameras for camera traps by considering regional patterns and environmental variables and can help to find critical habitat as well when planning protected area management strategies based on data produced with them in addition to remote sensing. In addition, data

security and privacy issues may cause difficulties for collaboration in green informatics activities like sharing environmental information (Chavan & Penev, 2011; Adam et al., 2018).

### **3.3. Drones and aerial survey**

New ways for wildlife conservation drones (Unmanned Aerial Vehicle) have emerged, way above conducting aerial surveys and obtaining data points that were never available before such as through flying drones ready to catch birds (Kocer et al., 2021). Sauls et al. (2023) study indicated that these Unmanned Aerial Systems and robotics present a cost-effective, scalable solution for documenting wildlife populations/habitats/monitoring environmental change studies. Aerial drone surveys provide ecologists with aerial images and data of high resolution, enabling the close inspection of diverse ecosystems and wildlife behaviour (Ancin, 2020). Drones with custom cameras and sensors have the potential to provide images from various heights that can be used by scientists for monitoring wildlife populations, tracking migrations or assessing habitat quality in unprecedented detail.

Corcoran et al. (2021) also mention that this is one of the most notable advantages of drones for wildlife conservation, since it has allowed monitoring remote or very difficult areas to be accessed by foot. Its areas of application have been largely into assisting with wildlife conservation efforts like surveying endangered species, poaching and profiling illegal logging or trespassers while keeping a safe distance from animals going about their lives in rugged terrain, dense forest centres or near sensitive habitats (Beaver et al., 2020; Milner et al., 2021). Except for drones and aerial survey most of the inability to monitor, research and protecting biodiversity has been done. Conservationists can do more better by using those images to collect aerial data generated by digital technologies which enable them make informed decisions for wildlife conservation efforts and ensuring that Ghana's rich biodiversity is preserved in the interest of future generations.

## **4. Methodology**

To conduct a comprehensive qualitative study on the use of digital technologies in wildlife conservation, the researchers adopted a descriptive approach (Creswell et al., 2004). The purpose of this methodology was to offer a complete and systematic description of the study, specifically on using digital technologies in wildlife conservation. The research started by doing a literature review of how digital technologies are applied in wildlife conservation; a specific focus has been on the case studies and practices within Ghana. The researchers did this by evaluating government reports, conservation organizations publications, and a range of peer-reviewed articles that these studies targeted from governmental to non-governmental entities showcasing the successes as well as existing challenges in applying digital technologies for wildlife research. Most of the data used in this study was collected through document analysis as a key mode of inquiry, enabling access to and extraction from multiple sources (Bowen, 2009). Together, this made up an all-encompassing set of documents that included primary and secondary sources. This involved academic articles sourced through databases including Scopus and Sage, government policy documents, as well as reports from non-governmental organizations in the field of wildlife conservation.

The full corpus was about 50 relevant documents, from which a subset of 20 articles were chosen for closer scrutiny. The final documents were chosen based on their relevance to the themes, trends, and insights around digital technologies being used for wildlife conservation. The content analysis enabled to identification of current digital technology applications and provided knowledge on how this is influencing conservation strategies and stakeholder engagement, as well as the overall challenges and effectiveness of wildlife protection initiatives in Ghana.

## **5. Challenges in wildlife conservation**

According to Huang et al. (2010), wildlife conservation has hundreds of challenges complicating the overall preservation of biodiversity and ecosystems on our planet. All of these are derived from (even if indirectly) human activities, environmental change, political gaps, and socioeconomic matters which together shape the rather wacky landscape that is nature conservation. According to Berhanu and Teshome (2018), the degradation of the ecosystem is one of the hard challenges wildlife face, and due to this in turn ecosystems are lost, fragmented or even destroyed because of infrastructure development, agriculture, urban expansion, and deforestation. Jacobson (2008) demonstrated that as natural habitats are reduced and fragmented,

wildlife populations become isolated leading to lower genetic diversity, less migration connectivity among their subpopulation locations such as seasonal calving areas or lower winter range sectors, and many more.; making them more vulnerable not only to environmental stress-building pressures but also to human-induced factors.

Nyhus et al. (2003) confirm the very serious concern relating to illegal animal trading and poaching, both driven by a market for exotic pets or parts of animals used in traditional remedies. It also has implications for ecosystems which are destabilised by poaching of bigger land-based animals, and exposes many species to the possibility of extinction, while jeopardising conservation efforts aimed at protecting vulnerable species. Moreover, Muchapondwa and Stage (2015) noted that weak sanctions and corruption have also played into the hands of powerful syndicates making efforts by wildlife conservation authorities to control crime impossible. Climate change has the ability to severely impact wildlife conservation via changes in habitats, ecosystems, and species distribution or behaviour. Climate change could lead to habitat destruction, malnourishment, and higher competition among species due to extreme weather events with increased temperatures or altered precipitation systems which might exert additional pressure on already threatened wildlife populations (Kuvlesky et al., 2007).

According to Jing and Zhigang (2006), invasive species are also one of the main threats to the conservation and preservation of wild animals, as they compete with native ones and disturb the ecological balance in general by causing habitat degradation. Invasive plants, animals, and pathogens can spread rapidly outcompeting native flora that are often not adapted to effectively deal with them which leads to significant losses in biodiversity of the invaded systems including potential extinction events, reduced ecosystem stability, native species' individual health decreases, and impaired economic wheels. Conflicts between people and wildlife, pollution, loss of habitat, lack of funds as well resources for conservation initiatives are some global issues that pose a threat to wildlife survival (Clark & Milloy, 2014).

It is up to local governments, conservation organizations, and communities to work together with individuals who do more sustainable actions of the importance of its habits for wildlife. Yet, ongoing conservation measures still impact the development and implementation of research intent including community engagement as a pillar because this further denounced inertia move on public awareness for people living in Ghana to accept human-nature coexistence. Through solving the root causes of these challenges and cooperation, conservationists are able to work towards safeguarding biodiversity sustainably securing ecosystems for a stare down at the edge between wildlife in Ghana and our proboscidean companions on planet Earth.

## **6. Conclusion**

Translating wildlife conservation intervention with the progressiveness of technologies in Ghana to digital ecosystems opens up an opportunity for technological integration that could significantly help reduce the likelihood of extinction among some endangered species in Ghana. In this line, these technologies and tools have remained critical for monitoring endangered species in Ghana. Conservation concerns have various dimensions, and these are more or less significant depending on the type of system in focus as well as where it is located globally. They also highlight serious obstacles to species conservation. The biggest barriers remain the lack of funding, training, and long-life power tech. Pooled resources need to be applied strategically and efficiently on initiatives by improving the full use of digital technologies in addressing this advantage for safeguarding Ghana's multiple wildlife populations. The study recommends concrete ways these issues can be tackled. Capacity building programs are critical to train local conservationists and community members in using digital technologies effectively. Collaborating with tech companies can accelerate access to innovative solutions and resources. In addition, by promoting tailored policies at the governmental level which encourage the use of technologies for wider conservation efforts with an enabling environment for wildlife authorities and practitioners to adapt digital tools can be established. However, by strategically incorporating these digital technologies together, the biodiversity conservation community and practitioners in Ghana can work alongside each other to address them; thus, ensuring a fairer use of operationalized digital strategies for biodiversity conservations that will help protect both much-needed wildlife populations throughout the the entire country.

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