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The Role of Artificial Intelligence in Wildlife Protection and Sustainable Development: Balancing International Efforts and Digital Technologies

دور الذكاء الاصطناعي في حماية البيئة البرية وتحقيق التنمية المستدامة: موازنة بين الجهود الدولية وتقنيات الرقمنة

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Abstract:

This study aims to provide a comprehensive perspective on how artificial intelligence (AI) can be leveraged to address environmental issues and promote sustainable development. AI plays a significant role in protecting wildlife through species monitoring and the prevention of illegal hunting. This article highlights how various AI technologies, such as camera traps, drones, and satellites, are employed to preserve biodiversity and tackle environmental challenges. The study also discusses the main obstacles faced in applying AI for wildlife conservation.

key words: *Artificial intelligence, wildlife, illegal hunting, drones, biodiversity.*

الملخص:

تهدف هذه الدراسة إلى تقديم رؤيا شاملة حول كيفية الاستفادة من الذكاء الاصطناعي لمعالجة القضايا البيئية وتعزيز التنمية المستدامة، باعتباره يلعب دورًا هاما في حماية البيئة البرية من خلال رصد الأنواع، ومنع الصيد الجائر، كما يسلط هذا المقال الضوء على كيفية استخدام تقنيات الذكاء الاصطناعي المختلفة كمصائد الكاميرات والطائرات المسيرة والأقمار الصناعية في حفظ التنوع البيولوجي ومواجهة المشكلات البيئية، مع إشارة إلى أبرز التحديات التي تواجه استخدام الذكاء الاصطناعي في حماية البيئة البرية.

الكلمات المفتاحية:

الذكاء الاصطناعي، البيئة البرية، الصيد الجائر، الطائرات المسيرة، التنوع البيولوجي.

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Introduction:

Wildlife environments refer to ecosystems that exist independently of human intervention. They consist of four closely interconnected systems: the atmosphere, hydrosphere, lithosphere, and biosphere. These natural components are in a constant state of [1]chang and include resources[1], wealth, energy sources, and living organisms of all types[2].

Entering the twenty-first century, the world faces numerous environmental challenges impacting wildlife, including climate change and rising temperatures, which inevitably lead to polar ice melting and sea-level rise. Additionally, environmental pollution from industrial activities and vehicles negatively affects water, air, and soil quality.

These factors have contributed to a loss of biodiversity due to human activities such as deforestation, habitat destruction, illegal hunting, and wildlife trafficking, resulting in a cascade of negative effects that threaten humanity as a whole.

Amid worsening climate change and escalating environmental crises, it has become evident that conserving the environment requires innovative and rapid solutions . Artificial intelligence (AI) offers remarkable opportunities to create positive transformations in environmental protection by providing tools to address challenges such as pollution, resource management, and climate change mitigation.

The importance of wildlife conservation lies in preserving ecological balance, maintaining biodiversity, and ensuring the survival of species. Innovative AI technologies play a pivotal role in wildlife protection by offering new and effective approaches, such as drones and programmed camera traps to monitor animal movements and detect illegal activities like poaching.

Given the significance of this topic, the central research question is: How effective are artificial intelligence technologies in conserving wildlife and promoting sustainable development?

To address this question, the study is divided into two main axes:

1- International Protection of Wildlife.

2- The Impact and Regulation of Artificial Intelligence on Wildlife.

Section I:
International Protection of Wildlife

Numerous international efforts have been undertaken to protect wildlife through the conclusion of various treaties and international agreements. These initiatives primarily focus on safeguarding animal and plant species from threats of extinction, habitat loss, and illegal exploitation. The following section reviews key agreements and international organizations addressing wildlife crime:

A) Wildlife Protection under International Agreements:

International agreements related to wildlife protection vary in scope. Some focus on preserving natural habitats for animals and plants, while others aim directly at protecting specific species, such as the **1950 International Convention for the Protection of Birds**.

1-Convention for the Preservation of Animals and Plants in Their Natural State (1933):

The Convention for the Preservation of Animals and Plants in Their Natural State was adopted in 1933 and entered into force on 14 January 1936. It aimed to protect ecosystems in Africa and was later expanded to include plant species. This convention was the first legally binding instrument to establish protected areas in Africa, such as national parks and nature reserves. The representatives of the participating countries also compiled a list of animal species requiring protection through the prohibition of hunting or extermination[3].

2-International Convention for the Regulation of Whaling (1946):

The International Convention for the Regulation of Whaling was signed on 2 December 1946 in Washington, D.C., by 42 countries and came into force on 10 December 1948. Since its enforcement, the convention has overseen most whaling activities worldwide. It established the **International Whaling Commission (IWC)**, which meets annually to adopt regulations regarding catch limits, protected species, and whaling methods. A protocol concerning whaling in Washington was also signed on 19 December 1956 among the member states[4].

3-International Convention for the Protection of Birds (1950):

This convention was adopted by member states on 18 October 1950 in Paris, aiming to protect all birds during their migration to breeding grounds and to safeguard endangered species throughout the year. It also required measures to prevent the destruction of eggs or the capture of young birds. Restrictions were imposed on certain hunting methods and traps, and the convention emphasized the need to prepare lists of birds that could be legally hunted[5].

4-African-Eurasian Migratory Waterbirds Agreement (AEWA):

This agreement was adopted in 1995 in The Hague, Netherlands, and entered into force on 1 November 1999. It aims to conserve migratory waterbird species and their habitats across Africa, Europe, Asia, and the Canadian archipelago, covering 255 bird species[6].

In parallel, the Ramsar Convention was adopted on 2 February 1971 to halt the progressive degradation and loss of wetlands. Through this agreement, the international community sought to protect migratory waterbirds, with birds explicitly mentioned in the preamble. This emphasis reflects the equal importance of bird species and their wetland habitats[7].

5-Convention Concerning the Protection of the World Cultural and Natural Heritage (1972):

This convention was held under the auspices of the UNESCO General Conference in Paris from 17 October to 21 November 1972, and by November 1992 it was ratified by 129 countries[8]. Its primary goal is to protect natural formations and biological features of global value. Natural heritage sites serve as natural laboratories for the evolution of wildlife species, while geological formations provide habitats for endangered plants and animals[9].

6-Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES):

This convention seeks international cooperation to protect wildlife species from overexploitation, including through trade. It originated from a decision in 1963 at a meeting of the International Union for Conservation of Nature **(IUCN)** members and was officially adopted on 1 July 1975.
CITES regulates international trade in endangered species under specific controls, categorizing species into three appendices, each representing a different level of protection:

CITES Appendices

- **Appendix I:** Includes species threatened with extinction. Trade in these species is permitted only under exceptional circumstances.
- **Appendix II:** Covers species not necessarily threatened with extinction but whose trade must be controlled to avoid utilization incompatible with their survival.
- **Appendix III:** Contains species protected in at least one country, which has requested the assistance of other CITES parties in regulating their trade[10].

7-United Nations Convention on Biological Diversity (CBD):

The CBD is one of the three conventions adopted during the 1992 Earth Summit in Rio to promote a sustainable planet for future generations. It aims to develop national strategies for the conservation and sustainable use of biodiversity. The convention entered into force in 1993 and currently has 196 member states[11].

B) The Role of International Organizations:

Several organizations have been established to protect wildlife, playing a pivotal role in safeguarding ecosystems through their international efforts.

International Union for Conservation of Nature (IUCN):

Founded on 5 October 1948, the IUCN is the world's first environmental organization, headquartered in Switzerland. It includes over 200 countries and 1,000 non-governmental organizations. Its work focuses on scientific research and coordinating efforts to mitigate negative changes in ecosystems, supported by **1,100 staff members and 62 offices**, funded by governments and corporations[12].

1- World Wildlife Fund (WWF):

The WWF is an international non-governmental organization that serves as a beacon of hope in a world where biodiversity faces increasing threats. Founded in 1961, it

has been at the forefront of animal conservation efforts, tirelessly working to protect numerous species and their habitats[13].

2- International Consortium on Combating Wildlife Crime (ICCWC):

The ICCWC represents a coordinated global response to wildlife crime. It consists of five intergovernmental organizations with expertise in supporting wildlife crime enforcement: the **CITES Secretariat, INTERPOL, United Nations Office on Drugs and Crime (UNODC),** the **World Bank Group (WBG)**, and the **World Customs Organization (WCO)**. Established in 2010, ICCWC underscores the importance of cooperative and coordinated action against wildlife crime, reflecting the commitment of all partners to this cause[14].

C) International Challenges:

1- Despite international efforts to protect wildlife, several challenges hinder the effectiveness of international wildlife law, including:

2- Many countries lack the political will to implement the provisions of international treaties.

3- Even with the existence of agreements, illegal hunting, deforestation, and habitat destruction continue. Additionally, lack of coordination between countries complicates wildlife conservation, as it requires continuous cooperation, which is sometimes impossible due to political tensions and conflicting economic interests.

4- Illegal wildlife trade remains a major threat to numerous species through global black markets for products such as ivory and rhino horns. Although the Convention on International Trade in Endangered Species of Wild Fauna and Flora **(CITES)** has made progress in reducing illegal trade, the persistent demand continues to drive poaching and trafficking of endangered species[15].

Section II:
The Impact of Artificial Intelligence on Wildlife and Its Regulation

International wildlife law provides several frameworks to protect species and ecosystems. However, its success depends on ongoing international cooperation and prioritizing biodiversity in global policy. By working together, countries can preserve the natural world for future generations and ensure biodiversity thrives, particularly by leveraging the role of artificial intelligence in environmental conservation.

A) Applications of Artificial Intelligence in Tackling Environmental Challenges:

With rapid technological advancements, AI techniques are increasingly being applied to address environmental issues through multiple applications.

1. AI-Enabled Monitoring Techniques for Tracking Endangered Species:

Given the growing environmental challenges globally, environmental monitoring has become essential for sustainability and the preservation of natural resources for future generations. Monitoring provides accurate data on environmental conditions, aiding in understanding ecological changes and developing effective mitigation strategies.

Advanced monitoring relies on technologies such as sensors, drones, and camera traps, which provide precise readings of ecosystems. Using these data, authorities can formulate sustainable environmental policies that protect and preserve wildlife[16].

a) Drone-Based Wildlife Monitoring Systems:

Drones offer a fast, cost-effective, safe, and high-precision method for collecting data and high-quality images. Their use is not limited to environmental protection and wildlife monitoring; they are also valuable for administrative purposes, technical services, and enhancing search and rescue operations[17].

Drone-assisted wildlife monitoring has rapidly advanced with modern technological developments, significantly improving the capabilities of onboard sensors and cameras. High-resolution cameras allow researchers to gather detailed aerial imagery, enabling precise data collection on wildlife behavior[18].

Various countries have implemented drone-based wildlife monitoring systems. For example:

* In the United States, drones have been deployed in Alaska to monitor polar bears and to study and protect endangered species, such as the California condor, by tracking their numbers and nesting locations.
* Australia has used drones to monitor the Great Barrier Reef, providing aerial surveys to assess coral health and track marine species. Drones have also helped study iconic Australian wildlife, such as koalas and kangaroos.
* In the Amazon, drones are used to detect and document illegal logging activities and to monitor the spread of forest fires.

Drones are thus a powerful tool for tracking animals, covering large areas, and providing aerial surveillance, particularly in regions where ground patrols are difficult[19].

b) AI-Enabled Surveillance Cameras:

Wildlife cameras represent an advanced technological tool due to their ability to record animals in their natural habitats, offering an unparalleled view of the wildlife world. These cameras are robust, weather-resistant, and equipped with motion sensors that trigger automatic recording upon detecting movement. They serve as essential instruments for naturalists, hunters, and photographers. In addition, they provide high-quality infrared night vision. Their long-lasting battery life allows them to remain deployed in the wild for extended periods without human intervention, ensuring continuous monitoring and the collection of valuable data, thereby strengthening environmental conservation efforts[20].

c) The Importance of Satellite Imagery and Artificial Intelligence in Sustainable Environmental Management :

The need to ensure an effective and sustainable environment has become increasingly critical due to several factors, including rapid climate change, biodiversity loss, and environmental degradation. In this context, satellite imagery integrated with

artificial intelligence offers a powerful solution for addressing these challenges, as outlined below:

*** Global Coverage and Timely Monitoring :**

Satellite imagery provides comprehensive data across vast geographic areas, enabling continuous and large-scale monitoring of environmental changes.

*** Accuracy and Efficiency :**

AI processes and analyzes data rapidly and accurately, reducing the need for manual intervention.

*** Cost-Effectiveness :**

Traditional field monitoring can be resource-intensive, requiring significant manpower and complex programs. By contrast, satellite-based monitoring enhanced by AI is more cost-effective, offering a practical alternative for countries with limited resources to track environmental changes in remote or hard-to-reach areas.

*** Scalability:**

The ability to combine satellite data with AI makes it possible to monitor large-scale environmental phenomena such as deforestation in the Amazon, coastal erosion in the Pacific, or global temperature trends[21].

Climate change remains one of the most pressing global challenges affecting ecosystems and communities. AI-supported climate models have demonstrated their ability to enhance the accuracy of climate predictions, assess potential climate risks, and mitigate impacts. They also contribute to improving energy consumption and reducing carbon emissions[22].

*** Climate Change:**

Through AI, climate models are improved, future climate patterns can be predicted more effectively, and the impacts of climate change can be assessed with greater precision. AI also supports the development of disaster-management strategies by predicting natural hazards such as hurricanes and floods, enabling better preparedness and planning[23].

*** The Role of AI in Enhancing the Efficiency of Renewable Energy Systems through Satellite Data:**

AI plays a crucial role in optimizing renewable energy systems - particularly solar energy - by improving power generation, storage, and distribution. AI-driven technologies enhance solar-energy forecasting, panel maintenance, and grid integration, helping address intermittency issues related to the stability of solar power. By analyzing weather data and satellite-derived imagery, AI can accurately predict solar radiation levels. When integrated into solar-energy management systems, AI enables grid operators to optimize energy storage and distribution, reducing reliance on backup power sources and improving overall energy efficiency[24].

2 – The Role of Artificial Intelligence in Combating Poaching and Illegal Wildlife Trade:

Artificial intelligence plays a significant role in combating illegal hunting through AI-enhanced surveillance systems[25]. These systems rely on cameras equipped with AI

algorithms to monitor and analyze live video streams. For example, the non-profit organization RESOLVE uses the *TrailGuard AI* system, which incorporates concealed cameras designed to detect poachers in real time and alert park rangers. The *TrailGuard AI* cameras are strategically installed along wildlife paths and known poaching hotspots. AI algorithms analyze the images captured by these cameras, distinguishing between animals, humans, and vehicles. When poachers are detected, alerts are immediately sent to rangers, enabling rapid response and appropriate action[26].

In this context, Algeria is moving toward transforming its Mediterranean territory into an intelligent zone in which fishery resources are managed through satellites and smart applications. These technologies enable the monitoring of vessels, mapping activities, and counting and identifying fish species while determining their breeding periods through digital systems. AI processes these data into simplified, easy-to-interpret maps that show fishermen, for instance, which areas of the sea will be most suitable for fishing during a given week. This helps them plan their trips more efficiently and contributes to protecting fish species through temporary closures. Such tools remain among the most effective methods for detecting illegal fishing activities[27].

Regarding efforts to curb overfishing and protect endangered species, AI-based models offer precise identification of the locations and timings of fish aggregations, allowing for targeted closures instead of broad bans. Integrating these models with satellite imagery also enables the detection of suspicious activities at sea[28].

3 – The Use of Artificial Intelligence in Detecting Unregulated Attacks on Vegetation Cover:

Forests are among the most important ecosystems and a rich reservoir of biodiversity. They play a crucial role in climate regulation and water provision. However, due to the continual expansion of human activities, forests face multiple threats, particularly illegal deforestation, wildfires, logging, and the hunting of wildlife species. These assaults not only disrupt ecological balance but also endanger human survival.

Traditional forest-monitoring methods have proven insufficient, making it essential to develop an efficient and precise approach for forest protection. Recently, AI technologies have introduced new solutions to this problem, enabling comprehensive forest monitoring and facilitating rapid detection and response to destructive activities[29].

Algeria has likewise turned to the latest technological innovations to address disasters, particularly wildfires—one of the most severe natural threats facing the country. The scale and intensity of recent fires, which have consumed vast areas of vegetation and caused significant civilian and military casualties in addition to material losses and damage to livestock and agriculture, have prompted the adoption of advanced AI-driven solutions. Digital tools such as drones, sensors, and other modern equipment—already deployed in highly developed countries—now serve as essential alternatives to traditional interventions, which have become inadequate for protecting forests[30].

These technologies are also attracting growing interest among ambitious Algerian youth, who are developing innovative solutions through their start-ups. Their inventions

offer promising prospects but require government support, including the removal of administrative barriers and the adaptation of regulations to facilitate the implementation of their digital solutions[31].

Furthermore, Algeria has implemented strict legal measures to protect, develop, and preserve forests. The first section of Law No. 23-21 on forests and forest resources dedicates articles 136 to 141 to specific protections against forest-related crimes, particularly arson and destruction. These legal provisions include deterrent penalties reaching up to 15 years imprisonment in cases of intentional burning, illegal construction, or unlawful tree cutting[32].

B) Challenges of Using AI in Wildlife and Environmental Protection

The increased adoption of AI in addressing environmental issues raises several concerns regarding potential negative impacts:

1. Increased Energy Consumption: AI applications require significant computational power, which can threaten environmental sustainability.

2. Water Usage and Cooling: AI systems and data centers, such as those for ChatGPT and Microsoft, consume substantial amounts of water, posing serious sustainability risks.

3. Big Data Requirements: Implementing AI in environmental monitoring necessitates vast amounts of accurate, continuously updated data. Collecting and analyzing these data require substantial resources, posing challenges for developing countries.

4. Costs: Advanced AI technologies can be expensive, particularly for developing nations that may struggle to afford them.

5. Trust in Intelligent Systems: Decisions based on AI recommendations may raise concerns regarding system accuracy, especially when policies or large-scale environmental actions are involved[33].

6. Carbon Footprint: The manufacture and disposal of AI devices contribute to electronic waste, harming ecosystems. The carbon footprints of AI software and hardware must be seriously considered[34].

C) International Initiatives for Regulating AI:

Several international initiatives have contributed to the regulation of AI, notably:

1- Global Partnership on AI (GPAI):

An international initiative aimed at promoting AI in a manner consistent with human rights and participatory democracy principles. Proposed by Canada and France at the 2018 G7 Summit and officially launched in June 2020, GPAI supports research and applied activities directly related to AI, bringing together experts, civil society, governments, and academia to collaborate on AI governance[35].

2- Organisation for Economic Co-operation and Development (OECD):

Founded in 1961 to foster economic progress and global trade among member states, the OECD supports GPAI through collaboration on topics such as responsible AI, data governance, innovation, and commercialization. This partnership promotes a human-

centered AI agenda, acknowledging both its benefits and risks while guiding global AI governance[36].

3- AI Environmental Impact Act, 2024:

Introduced in the U.S. Senate on February 1, 2024, this bill mandates an assessment of AI's positive and negative environmental effects. Key findings include:

- Rapid AI advancements may substantially increase energy consumption due to the high-power requirements of training and running AI models.
- Growing AI use could exacerbate environmental harm from electricity demands in data centers, potentially increasing carbon emissions by 2026.
- AI hardware contributes to escalating electronic waste volumes[37].

4- European Union:

On April 21, 2021, the European Commission proposed AI regulation aimed at managing AI use according to associated risks. The regulation covers all sectors and AI types, categorizing them into prohibited practices, high-risk systems, and other AI systems. Prohibited practices include AI applications exploiting human vulnerabilities or causing physical or psychological harm, such as voice-controlled games promoting unsafe behavior in children. High-risk systems are those posing significant threats to health or fundamental rights. This regulation has significantly contributed to the growth of the EU's digital sector[38].

Conclusion:

This study concludes that despite various international efforts and frameworks established by global agreements and organizations, these measures have proven insufficient for ensuring effective protection of wildlife and natural habitats. This inadequacy has necessitated the search for more advanced tools and technologies. In this context, artificial intelligence (AI) has revolutionized wildlife conservation by enhancing the monitoring of endangered species, preventing illegal and unsustainable hunting, and supporting the restoration of natural habitats. Consequently, AI has contributed significantly to the protection of biodiversity and the mitigation of diverse environmental challenges.

Adopting AI responsibly within conservation strategies offers the prospect of a more sustainable future for ecosystems. Harnessing the potential of this digital innovation requires coordinated efforts among nations, international organizations, and individuals to improve wildlife protection.

However, for AI to become an effective instrument in environmental conservation, it must be integrated with traditional practices. Future conservation efforts will not rely solely on technological innovation; they must be coupled with ethical principles and human oversight. By doing so, the power of AI can be leveraged to develop a smarter, more holistic approach to wildlife protection.

Ultimately, achieving a sustainable future that balances human development with the preservation of biodiversity and natural resources requires the responsible and ethical deployment of AI.

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