



Research article

AI in public administration-transformative opportunities for climate resilience and sustainable development

IA en la administración pública: oportunidades transformadoras para la resiliencia climática y el desarrollo sostenible

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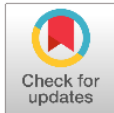
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Abstract.- *The accelerated growth in demands for natural resources such as water and energy has generated a potential energy and water crisis, while the requirements have been hastily driven by the development of emerging technologies that have spanned the various sectors, so the intersection of these technologies, such as Artificial Intelligence (AI), in sustainability, governance and public policies, offers transformative opportunities to combat climate change and promote sustainable development. This study explores the integration of AI in public administration to promote climate resilience, equity and innovation, highlights the applications of AI in resource management, disaster prediction, renewable energy optimization and planning. sustainable, highlighting the priority role of public policies, ethical frameworks and public-private collaborations to ensure the equitable and transparent deployment of AI. Challenges such as data accessibility, resource allocation and adjacent regulatory balance are analyzed with strategies to overcome them, including capacity development and infrastructure investment. The innovative findings suggest that AI as a tool for efficiently managed climate action helps to address environmental challenges, highlighting key elements such as sustainable development through AI that requires collaborative integration between stakeholders, such as those across sectors, integrating equity and ethical principles into climate action and resource management policies. This integrated approach positions AI as a fundamental tool for a more sustainable and equitable future.*

Keywords: Artificial intelligence (AI); Climate change sustainable development; Renewable energy; Public policies; Governance.

Resumen.- *El crecimiento acelerado de las demandas de recursos naturales como el agua y la energía ha generado una potencial crisis energética e hídrica, mientras que los requerimientos han sido impulsados apresuradamente por el desarrollo de tecnologías emergentes que han abarcado los diversos sectores, por lo que la intersección de estas tecnologías, como la Inteligencia Artificial (IA), en la sostenibilidad, la gobernanza y las políticas públicas, ofrece oportunidades transformadoras para combatir el cambio climático y promover el desarrollo sostenible. Este estudio explora la integración de la IA en la administración pública para promover la resiliencia climática, la equidad y la innovación, destaca las aplicaciones de la IA en la gestión de recursos, la predicción de desastres, la optimización de las energías renovables y la planificación sostenible, destacando el papel prioritario de las políticas públicas, los marcos éticos y las colaboraciones público-privadas para asegurar el despliegue equitativo y transparente de la IA. Se analizan desafíos como la accesibilidad de los datos, la asignación de recursos y el equilibrio regulatorio adyacente con estrategias para superarlos, incluido el desarrollo de capacidades y la inversión en infraestructura. Los hallazgos innovadores sugieren que la IA como herramienta para la acción climática gestionada de manera eficiente ayuda a abordar los desafíos ambientales, destacando elementos clave como el desarrollo sostenible a través de la IA que requiere la integración colaborativa entre las partes interesadas, como las de todos los sectores, integrando la equidad y los principios éticos en la acción climática y las políticas de gestión de recursos. Este enfoque integrado posiciona a la IA como una herramienta fundamental para un futuro más sostenible y equitativo.*

Palabras clave: Inteligencia artificial (IA); Cambio climático; Desarrollo sostenible; Energías renovables; Políticas públicas; Gobernanza.



1. Introduction

One of the most pressing global challenges of our time is the climate crisis. Over the past century, human activities, particularly fossil fuel combustion, industrialization, and unchecked economic growth have led to unprecedented levels of greenhouse gas emissions, resulting in a rapid rise in global temperatures. According to the Intergovernmental Panel on Climate Change (IPCC), the global temperature has increased by 1.1°C above pre-industrial levels, already exacerbating extreme weather events, accelerating biodiversity loss, and driving sea-level rise at an alarming rate. The IPCC further warns that, without immediate and significant intervention, temperatures could rise by an additional 1.5°C by 2050, leading to irreversible impacts on ecosystems, economies, and communities worldwide [1].

This multifaceted crisis demands urgent and coordinated global solutions, alongside localized action, to address the various symptoms of climate change and mitigate its ongoing impact. However, current commitments fall far short of the necessary actions outlined in scientific and policy frameworks. For example, the Paris Agreement has set ambitious goals to limit global warming to well below 2°C, yet the progress in meeting these targets remains insufficient. To accelerate this process, the integration of cutting-edge technologies, particularly Artificial Intelligence (AI), presents a unique opportunity to expedite efforts in climate action and foster the development of resilient system action across syndromes of impact urgently [2]. AI has emerged as a transformative tool in the fight against climate change, offering innovative solutions across multiple domains, including renewable energy management, environmental monitoring, disaster prediction, and urban planning. The ability of AI to process vast amounts of data, identify complex patterns,

optimize resource allocation, and predict future climate trends presents an extraordinary opportunity for enhancing climate resilience. As AI continues to advance, it holds the potential to revolutionize our approach to combat climate change, enabling more efficient, data-driven strategies for adaptation and mitigation [3].

The International Energy Agency expresses the need to adapt to emerging technologies, especially in the field of renewable energy, AI has been identified as a fundamental tool to optimize the efficiency of the energy network and improve the integration of renewable sources. Machine learning (ML) algorithms, for example, can analyze data in real time to improve energy distribution, predict fluctuations in demand and facilitate the efficient use of renewable resources. These capabilities are necessary in the global transition towards cleaner and more sustainable energy systems [4]. In addition, AI is being applied in the monitoring of environmental pollutants, where it helps track changes in air and water quality and provides early warnings of dangerous conditions, thus preventing environmental degradation and protecting public health. This information is a platform for government decision-making and a platform for smart public policies.

The experience and background to address the potential of AI in relation to climate change is immense, and its successful implementation requires strong public sector engagement. The policies, regulations and funding mechanisms needed for the effective implementation of AI technologies in sustainability initiatives. Governments and public administrators have a responsibility to create an enabling environment that supports the large-scale adoption of AI solutions for climate action, ensuring that AI is developed and used in an ethical and sustainable manner [5].

Public administrations have access to vast data sets, such as demographic information, health records, and infrastructure data, which are often unavailable or costly to obtain for private entities. These large data sets provide AI models with the basic knowledge needed to address climate change on a global scale. By leveraging these data sets, AI can help inform policy decisions, predict climate impacts, and optimize interventions in national and global contexts. This data-driven approach can improve the effectiveness of climate action, making it more targeted, equitable, and efficient. AI has recently been identified as a viable solution in numerous domains of climate action, including renewable energy management, environmental monitoring, disaster prediction, and urban planning [6]. AI could use public health data to model the effects that climate change will have on disease transmission, and urban planning data to plan more resilient cities. These resources can spur innovation, enabling more inclusive and data-driven climate action when governments make them available. Government leadership is also critical to guiding AI deployment toward equitable outcomes. Climate change affects all people, and generally the impact can be greater on the socially vulnerable population, who are also those who have the least impact on the environment in terms of Greenhouse Gas (GHG) emissions, as they are communities in developing countries [7].

2. Methodology

This research employs a multidisciplinary approach and a qualitative and quantitative research design to explore the implementation of AI in climate change mitigation and adaptation, with a particular emphasis on the role of public administration. The study seeks to understand how governments can use AI to promote sustainable solutions, enhance climate resilience, and ensure equitable outcomes for the most vulnerable sectors. The phases of the methodological process are described below.

Literature Review: To theoretically underpin the research, a systematic literature review on AI applied to climate change and sustainability will be conducted. Peer-reviewed scientific articles, reports from international bodies (such as the IPCC and the UN), and public policy documents will be included. The review will focus on three main areas.

Applications for AI in climate change: Identification of key areas in which AI has been successfully applied, such as renewable energy management, natural disaster prediction, and urban infrastructure optimization.

Role of public administration in sustainability: Analysis of the role of governments and public bodies in the implementation of sustainable technologies, with an emphasis on public policies that facilitate the development and adoption of AI.

Ethical and social challenges: Review of current debates on the ethics of AI, equity in access to its benefits and the risks associated with algorithmic bias and the protection of personal data.

The selection of studies will be carried out following criteria such as the impact of the research, its relevance to the practical application of AI in sustainability and its contribution to understanding the interaction between AI and public policies.

A government-driven approach guarantees Extending the Scope of AI-Powered Solutions for Climate Action and Equity

Artificial Intelligence holds transformative potential in addressing climate change while ensuring equity in its application. For populations often marginalized by systemic inequalities, AI-powered solutions can help bridge disparities instead of exacerbating them.

For instance, AI can significantly improve early warning systems for natural disasters, which are traditionally less accessible to vulnerable and underrepresented communities. By integrating AI-driven predictive analytics, these systems can provide timely alerts and more precise forecasts, enabling at-risk populations to take necessary precautions and reducing the overall impact of such events [2].

Innovation and development for climate change mitigation by Innovation and development for climate change mitigation by applying AI tools, integration into public policies and quality governance, is closely aligned with all the United Nations Sustainable Development Goals, in particular SDG 10 (reduced inequalities), SDG 7 (affordable and clean energy) and SDG 13 (climate action). The ethical and equitable implementation of AI can help these technologies reduce the gap between emerging and developing economies, as well as empower vulnerable areas, addressing inequalities in addition to being tools that help public health and can save lives with access to life-saving innovations and reduce economic losses [8]. Ensuring inclusion in AI applications is essential to foster global sustainability and avoid a technological divide.

The Role of Public Administration in AI Deployment: Although the potential of AI is undeniable, its meaningful application requires robust public administration to guide its development and use. Governments and policymakers play a critical role in creating a supportive ecosystem for AI applications tailored to specific climate challenges. This involves a regulatory framework that encourages innovation while ensuring ethical data use and equitable outcomes. Policies must also address concerns about bias in AI algorithms and prioritize transparency to build trust and promote widespread adoption [9]. Public administration must further support AI initiatives by providing funding mechanisms and fostering public-private

partnerships that incentivize research and development of climate-focused AI solutions. For example, initiatives like the European Union's Green Deal have demonstrated how strategic government-led investments can drive innovation in AI applications for energy efficiency and carbon reduction [10].

Public Administration and Sustainable Innovation: The emergence of AI and other advances in technology as essential tools for sustainable development is creating a new responsibility across public administration to play an active role in their ethical deployment. Governments in many countries have started to see the power of AI for solving environmental issues from mitigation measures such as carbon emissions reduction process to adaptation and biodiversity conservation and are also likely to play an essential role in ensuring that these solutions develop and scale through public administration [11].

Public administration can take a variety of approaches to promote sustainable AI, ranging from incentive program implementation to regulatory frameworks that ensure responsible adoption of AI. These roles range from guidelines and policies that promote innovation, standards of data privacy and transparency as well as incentives for the private sector to employ sustainable practices. With consistent regulations and policies, public institutions can reduce the possible risks of AI while increasing their potential for sustainable innovation. For instance, public administration can be a driver of sustainability in AI via providing financial incentives/grants for research and development (R&D) on green technologies [12].

AI projects in the field of environmental sustainability and modelling for climate change mitigation, waste reduction, renewable energy optimization and other fields related to reducing GHG emissions in developing countries maintain funds and economic resources for program

development. One program that takes advantage of this situation is the European Union's Horizon 2020, which has allocated billions of euros to research projects, many of them related to the use of AI to address climate and energy challenges [10]. Funding for research institutes, universities and private industries promotes the creation of AI models designed for use in issues related to our environmental problems [13]. Public administration is also responsible for creating the ethical code and regulatory frameworks that allow them to be accountable for the responsible and transparent use of AI in relation to climate objectives. Governance policies that align the needs of climate change mitigation strategies, climate solutions, and AI tools are critical, as many of these AI-powered climate solutions rely on the integration and alignment of all stakeholders.

Strategic Policy Approaches and Recommendations

To maximize the benefits of AI in climate action, governments must adopt a comprehensive policy framework that addresses the key drivers of AI innovation while ensuring ethical, equitable, and sustainable outcomes. By implementing strategic approaches, public administrations can effectively facilitate the deployment of AI in climate action and sustainable development. Governments play a critical role in shaping the policy landscape, ensuring the responsible development and use of AI technologies, and fostering the equitable distribution of their benefits. Public administrations can also act as key enablers, addressing challenges such as regulatory complexities, infrastructure gaps, and capacity shortages. The following strategies and policy recommendations outline a roadmap for integrating AI into climate action:

Regulatory Support: Governments should establish clear and comprehensive regulatory frameworks to guide the ethical development and deployment of AI technologies in climate action.

These frameworks should include guidelines to ensure transparency, accountability and fairness in AI systems, addressing critical concerns such as data privacy, algorithmic biases and unintended consequences of automation in environmental decision-making. The Organization for Economic Co-operation and Development (OECD) recommends offering support to provide regulatory approaches that balance innovation with accountability. By promoting transparent and accountable AI systems, governments can mitigate risks and maximize the potential of AI to advance climate action [14].

Infrastructure Investment: A foundational component of AI innovation is the availability of infrastructure that enables access to large datasets and powerful computational resources. Governments should invest in creating shared platforms for climate data, making these accessible to the public and open for AI-driven research and innovation. Such investments can also promote collaborations among academia, industry, and government, leading to the development of AI tools that address pressing environmental challenges. For example, Microsoft's AI for Earth initiative provides access to advanced AI models to support environmental protection [15].

Capacity development: To ensure the effective and equitable implementation of AI solutions, governments should prioritize capacity development initiatives, particularly in developing countries and marginalized communities. Education and training programs in AI and sustainability are essential to create a skilled workforce capable of addressing the complexities of climate change with AI tools. Governments should support the integration of AI curricula in universities, research institutions, and platforms that offer valuable opportunities for capacity development in AI applications for sustainable development [16].

Fostering Local Innovation and Entrepreneurship: Governments should encourage local entrepreneurship in AI-driven sustainability solutions. Supporting the creation of startups focused on leveraging AI to focus environmental challenges will foster innovative, context-specific solutions. Facilitating access to resources such as funding, technical expertise, and support networks is crucial for enabling entrepreneurs to scale their AI solutions, thereby contributing significantly to climate mitigation efforts.

Monitoring and Managing Natural Resources with Artificial Intelligence: has the potential to transform the way natural resources are managed, including everything from water to vegetation cover. Governments should encourage the adoption of AI technologies that enable more efficient monitoring and management, to increase climate resilience. These technologies not only increase resource use efficiency, but also contribute significantly to climate resilience, helping communities better adapt to the impacts of climate change.

Integrating AI into Climate Policies: AI can play a critical role in developing policies to predict and mitigate the impacts of climate change. Governments should incorporate AI tools into their national climate adaptation plans, allowing them to predict risks and design proactive and effective solutions, such as early warning systems such as those implemented by the World Bank for floods and tropical cyclones have proven to be essential to save lives and reduce economic losses [17]. Climate impact modeling, and proactive mitigation policies that have been developed by countries such as Germany, AI systems have been implemented to predict the impact of urban expansion on ecosystems and develop more robust environmental regulations. The integration of AI into climate policies allows governments to act more quickly and accurately in the face of environmental challenges. Furthermore, by combining these

technologies with participatory strategies, inclusive solutions can be generated that consider the needs of the most vulnerable communities [18].

Promoting Research and Development (R&D) in AI for Climate Action: To establish AI as a cornerstone in combating climate change, governments must invest in R&D for new technological applications. Public funding should support scientific research on AI for sustainability, encouraging collaborations among universities, research institutes, and industry. Facilitating public-private partnerships can maximize resources allocated for R&D and foster knowledge exchange across sectors, accelerating the development of impactful AI solutions. By implementing these strategic approaches, governments can harness the transformative potential of AI to address climate challenges, fostering a sustainable and resilient future [19].

Design finances Design of Financial Incentives for Artificial Intelligence Startups: The design of specific financial incentives can be a relevant factor to boost the growth of startups that address sustainability-related challenges through the application of AI. Measures such as tax breaks, subsidies and low-interest loans have proven to be effective tools to accelerate the development of startups focused on high-impact solutions to environmental, social and economic problems. Some examples can be the Acceleration Programs in Germany where financial support has been incentivized for startups that develop AI technologies applied to sustainability. These include tax incentives and access to low-cost capital, which has allowed the creation and scaling of innovative solutions in areas such as renewable energy and efficient water resource management. In addition, subsidies in the Netherlands in the Dutch government offers subsidies to companies that integrate AI in sustainability projects, such as agriculture and sustainable urban mobility [14].

In resource management and the formulation of sustainable policies, elements such as the following should be considered:

Data Collection – Sensors, satellites, and databases gather real-time climate, energy, and environmental information.

AI Analysis – Machine learning and deep learning algorithms process the data to detect patterns and generate predictions.

Resource Optimization – Smart grids, water efficiency, and sustainable urban planning are enhanced through automation.

Government Decision-Making – Control panels with key metrics enable leaders to design data-driven strategies.

Policy Implementation – Sustainability regulations and strategies are approved and executed based on predictive models.

Sustainable Impact – Reduced CO₂ emissions, green urban development, and resilient communities reflect the benefits of technological integration.

As mentioned, environmental and social challenges require increasingly strategic responses. From the points mentioned above, it can be understood that the integration of AI, Research and Development (R&D) in AI projects that promote sustainability, integrated through adequate public administration management, can strengthen the fight against climate change, the reduction of emissions and sustainability. The following diagram (Figure 1) through connections and visual elements illustrates how all these elements are key components to achieve sustainable development.

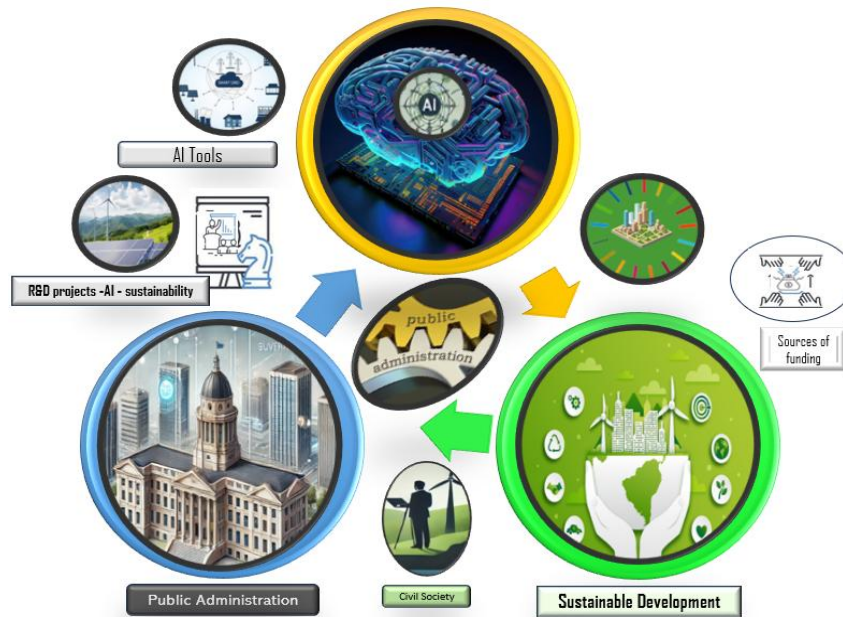


Figure 1. Methodology for the Role of Public Administration in Implementing Sustainable Solutions. Source: Own development

Challenges in public administration and the implementation of public policies

Although progress has been made in using AI to promote sustainable development, public administration faces several challenges that hinder the effective implementation of AI-based

public policies. These challenges include:

Resource Allocation: Implementing AI solutions for sustainability requires significant financial resources and a reorganization of human capital. However, governments often face budget constraints and competing political priorities,

making it difficult to secure the necessary investment [20].

Access to Quality Data: AI models rely on large volumes of accurate and up-to-date data. In many regions, especially in developing countries, accessing high-quality environmental data is a challenge. It is crucial for governments to establish frameworks for data sharing and ensure data quality.

Data Availability and Quality: AI systems need complete and consistent datasets to function effectively. In many areas, data is incomplete or inconsistent, limiting the effectiveness of AI solutions [21].

Balancing Innovation and Regulation: Striking a balance between fostering innovation and establishing regulations is complex. Overly strict regulations can hinder progress, while overly lenient ones may lead to ethical or environmental risks. Governments must continuously adopt regulatory frameworks to keep pace with rapid technological advancements.

Training AI Models: Training AI models, especially in areas like energy consumption, require significant computational power, which in turn generates carbon emissions. Developing energy-efficient AI algorithms is essential to mitigate this impact [22].

Bias and Equity: AI systems can perpetuate existing inequalities if trained on biased datasets. Ensuring equitable access to AI technologies and addressing algorithmic biases is crucial for promoting inclusive climate action [23].

Regulatory and Ethical Frameworks: The rapid advancement of AI demands robust regulatory frameworks to ensure ethical implementation. Concerns such as data privacy, transparency, and accountability must be addressed to build trust in AI systems [24].

The International Energy Agency has begun to use AI as a tool to address the scale and complexity of climate change, offering opportunities to improve renewable energy management, monitor environmental pollutants, optimize transportation systems, and even improve urban planning. For example, machine learning models have been deployed to optimize power grid operations, allowing for better integration of renewable energy sources and reducing overall energy waste [4]. Though, challenges remain in ensuring that these technologies are accessible and scalable. Resource constraints, particularly in low-income regions, can hamper the deployment of AI solutions where they are most needed. Furthermore, the energy-intensive nature of AI itself raises concerns about its carbon footprint, necessitating advances in energy-efficient computing and greener AI development practices [25].

AI has emerged as a transformative technology with the potential to significantly address challenges related to climate change and environmental sustainability. Its unique capabilities, including advanced data analysis, pattern recognition, predictive modeling, and process optimization, align seamlessly with the complex demands of environmental science and resource management [26].

AI enables the analysis of vast datasets from diverse industries, providing actionable insights and fostering the development of innovative strategies that were previously unattainable with conventional methods. However, its implementation is not without obstacles and risks. These challenges span across technical, ethical, and environmental dimensions, highlighting the need for a balanced and responsible approach to integrating AI into climate solutions. AI presents transformative opportunities in areas such as:

Climate Modeling: AI enhances the accuracy of

climate models by analyzing historical data and simulating future scenarios with greater precision. Machine learning algorithms can uncover subtle patterns in weather and climate systems, helping scientists predict long-term changes and assess potential impacts.

AI for sustainability and climate change: Climate change is a global phenomenon that requires international cooperation. This requires governments to also participate in global regimes and enter into bilateral agreements and global alliances that promote the transfer of AI tools and technologies relevant to climate action [27], that promote collaboration between countries to use AI in sustainable development goals, with the aim that these associations facilitate the transfer of technology and R&D projects around AI and environmental sustainability [28].

Resource Management: AI applications in resource management range from optimizing energy grids to improving water usage efficiency. By leveraging real-time data, AI systems can identify inefficiencies, minimize waste, and support the transition to renewable energy sources.

Disaster Prediction and Mitigation: AI-driven tools have proven effective in predicting natural disasters such as hurricanes, floods, and wildfires. Early warning systems powered by AI can help mitigate risks, protect vulnerable populations, and reduce economic losses [29].

Sustainable Urban Planning: Through AI, urban planners can model sustainable city layouts, optimize transportation systems, and design buildings that minimize carbon footprints. This ensures that urban growth is aligned with environmental goals [29].

Methodology for Implementing Sustainable Solutions

This framework emphasizes the collaborative efforts required between governments, industries, and academia to foster AI-driven innovations while addressing ethical and environmental concerns.

Data Integration: Governments should facilitate the aggregation of diverse datasets, ensuring accessibility for AI-based climate research and applications.

Capacity Building: Training initiatives aimed at equipping stakeholders with AI literacy are pivotal for informed decision-making.

Policy Formulation: Developing inclusive policies that guide ethical AI deployment in climate-related applications forms the backbone of sustainable AI adoption.

Public-Private Partnerships: Collaborative ventures between public and private sectors can accelerate the scaling of AI solutions to address climate challenges effectively.

Figure 2 illustrates a representative example of the methodology for the role of public administration in implementing sustainable AI solutions, incorporating the need for a regulatory framework and infrastructure investment. By integrating these strategic components, public administrations can improve the effectiveness of AI applications in climate action and help ensure that the benefits of the technology are distributed equitably and sustainably across all sectors of society.

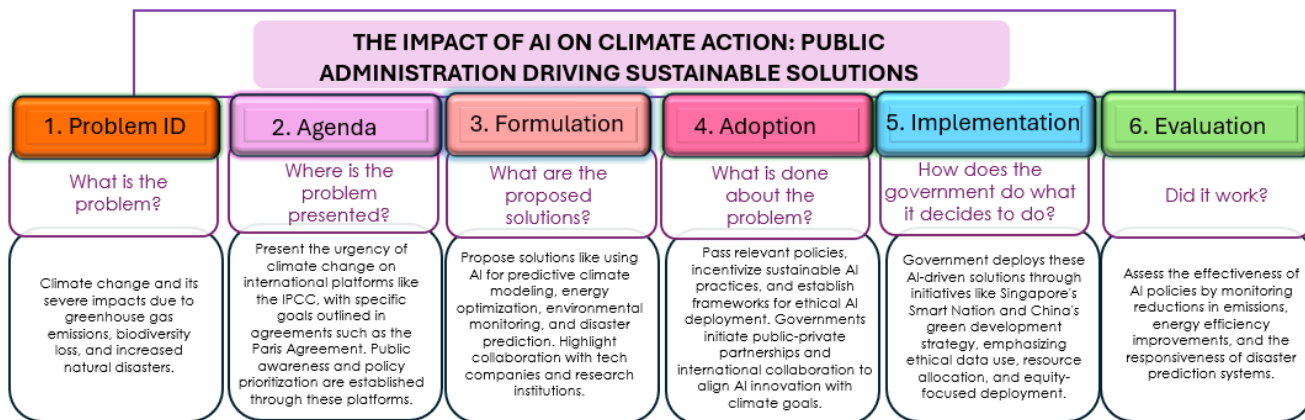


Figure 2. Methodology for the role of public administration in implementing sustainable solutions. Source: Own development.

Climate Modeling and AI One of the most fundamental areas where we can apply AI to climate action is in climate modeling. Climate models, however, are incredibly useful for scientists and policymakers because they can simulate how the global temperature will respond to things like emissions, deforestation or ocean temperatures. Since traditional climate models are computationally expensive and need terabytes of data and days to process the last simulations for even tiny geographical areas, Climate models driven by AI can speed these processes up to an exponentially higher range of accuracy and resolution, while incorporating a wider array of variables and scenarios [30]. Studies indicate that increasing or decreasing the precision of climate projections helps researchers explore a mitigation path with high resolution that was previously almost impossible. Currently, tools such as neural networks and machine learning algorithms predict the future with greater precision with relevant information regarding climate change such as energy potential, deforestation, water stress, etc. [31].

AI for Climate Action: Benefits, Challenges and Risks

Climate scenarios that use historical weather data to discern patterns that capture carbon emissions and trends in natural resource data, such as modeling weather predictions that allow for more accurate short-term forecasts, which is especially important during rapid response and long-term planning. By facilitating a proactive environmental decision-making system, such predictive capability can help policymakers prioritize conservation areas, plan climate-resilient infrastructure, and allocate mitigation resources more effectively [32]. While the benefits of AI are promising, its potential use in climate change does present several ethical and environmental challenges.

Resource intensive: Governments play a critical role in data that requires a lot of computational power. A single deep learning training is comparable to the lifetime energy consumption of an average car. The data centers within the AI model training process generated CO₂ emissions when powered by non-renewable energy sources. Researchers found data showing that training a large AI model can produce as much CO₂ as five cars over their lifetime. Data centers need to use

renewable energy to mitigate the environmental impact of AI [33].

Data privacy and security: Many AI applications for climate monitoring require significant data sets to process, aggregated data that includes geolocation data, weather, and population health records. These data sets are necessary for accurate climate models, but they also pose significant privacy risks that can hinder their responsible use. Especially if data subjects receive personal information, formulating strong data governance policies is very important to ensure that there will be no breaches [10].

Equity and access: Creating climate change solutions using AI will require a lot of funding, access to data and resources, and expertise in ML. Consequently, the immediate beneficiaries of these technologies are wealthy nations and corporations. This inequity can worsen inequalities that already exist, depriving communities that need it the most (those most affected by climate change) of these technologies. Public administration plays an important role in reducing the digital divide and ensuring that AI technology is available to all regions and demographic groups, as indicated by the International Development Research Centre (IDRC), and thus reducing the gap in the most vulnerable groups [34]. AI models must work to produce unbiased results, to obtain less biased results, and avoid making incorrect predictions for certain areas, which could affect disaster response or resource distribution [35].

Resource Management and Optimization: The potential of AI even extends to the way we manage our natural resources, allowing us to use them more efficiently and sustainably with a lower environmental impact. AI in energy management is used to forecast demand, optimize distribution, and combine renewable sources with current grids. AI reduces emissions and allows energy providers to respond to changes in supply and demand by improving grid

efficiency and ensuring that the cleanest forms of energy are used as much as possible. World-class companies such as “Google” have demonstrated the impact of this potential with the “DeepMind AI” initiative, which improved energy efficiency in its data centers by 40%, demonstrating the power of this technology to reduce carbon consumption in high-energy consumption sectors [36].

Applications in agriculture: In agriculture, AI helps sustainable practices by assessing soil health, observing crop health, and managing water consumption. Using the data available from satellite images and IoT devices in the fields, their machine learning models process them to make decisions about irrigation, early detection of pests and minimize the use of chemicals [37]. They can also improve the impact of water stress by using applications for optimizing water based on needs, which can help reduce environmental pollution in the agricultural sector, which is one of the economic activities that generates large GHG emissions.

Waste management: which is an integral part of the circular economy [38]. While computer vision algorithms manage the automatic sorting of recyclable materials, several predictive models collect and optimize collection routes for waste management to minimize fuel consumption and emissions during them. Previous analysis and experience indicate that many AI tools can be applications that speed up the process of sorting recyclable materials, leading to a reduction in the amount of waste thrown into landfills. These and many more advances in AI tools for environmental improvement show the ability of AI to enable sustainability in all economic sectors, just as these applications can be extended to the domestic sector.

Anticipation and response to natural disasters: This important use of AI in climate action is to predict and respond to natural disasters. Global

warming is making natural disasters such as hurricanes, floods, wildfires, and droughts more frequent and intense. These predictive models are powered by AI, so they not only predict, but they also do so with significantly greater accuracy and in less time, providing timely alerts to allow authorities and communities to prepare. Foresight allows for better resource gathering, evacuation measures, and the prevention of deaths and property damage when appropriate. Based on these AI models, hurricane trajectories and wildfire risks can be predicted, and timely alerts can be provided that save lives as well as economic losses [39]. Another essential application of satellite imagery and machine learning algorithms is disaster monitoring. In the aftermath of a disaster, AI models rapidly process satellite imagery to assess how much damage has occurred, speeding up the response and delivering resources where they are most needed. In partnership with private tech companies, the United Nations used AI to monitor areas at risk of flooding and pre-allocate resources to safeguard lives and assets [40].

Success stories in countries with governmental initiatives applying AI tools

In the current era, Artificial Intelligence (AI) has become a key tool for addressing some of the most pressing challenges related to sustainability

and climate change. Governments around the world are implementing innovative initiatives that leverage the power of AI to optimize resources, reduce emissions, and improve efficiency across various sectors. These projects not only demonstrate the potential of AI to transform environmental and energy management but also serve as inspiring models for other countries seeking sustainable solutions. Some of the benefits shown in projects when applying AI to sustainability can be the following:

Climate Prediction: AI can analyze historical climate data to identify patterns and predict extreme events, such as hurricanes or floods, enabling more effective planning and rapid response.

Natural Resource Management:

Sustainable Agriculture

Table 1 below shows success stories in countries with government initiatives that apply AI tools. These examples illustrate how technology is being used to predict natural disasters, manage waste, optimize the use of renewable energy, and improve energy efficiency, among others. Each project highlights the specific application of AI, its impact, and the technological tools used.

Table 1. Success stories in countries with governmental initiatives applying AI tools. **Source:** Prepared by the authors with information from OECD and EPA.

Country	Project	AI Application	Impact	AI Tool
Japan	Earthquake Prediction System	Real-time seismic data analysis to predict earthquakes and tsunamis.	Reduction in response times and optimization of emergency resources.	Real-time seismic data analysis
Denmark	AI4PublicPolicy	Data analysis for public policies in urban planning and sustainability.	Greater efficiency in resource allocation and improved data-driven policy formulation.	Data analysis for public policies
Singapore	Smart Nation Initiative - Waste Management	Intelligent waste management uses sensors and route optimization for collection.	Reduction in operational costs and lower carbon footprint in public services.	Sensors and route optimization
Kenya	AI for Renewable Energy Management	Optimization of renewable energy generation and distribution.	Contribution to the transition toward a low-carbon economy.	Renewable energy optimization
United States	Grid Modernization Initiative	Use of AI to modernize the electrical grid and improve energy efficiency.	Reduction in energy losses and greater integration of renewable energy sources.	AI for electrical grid management

Country	Project	AI Application	Impact	AI Tool
Mexico	Energy Efficiency Program for Buildings	Monitoring and optimization of energy consumption in public buildings.	Reduction in energy consumption and savings in operational costs.	Sensors and data analysis

The success stories presented in this table demonstrate how AI can support the fight against climate change and the promotion of sustainability. However, it is crucial to address associated challenges, such as resource intensity and privacy concerns, to ensure these technologies are used responsibly and equitably.

3. Results and Discussions

Policy Recommendations for Enabling AI Applications through New Sustainable Solutions

There are several measures that the government, together with different stakeholders such as academia, public and private institutions, as well as civil society, can adopt to facilitate the development and adoption of AI technologies that promote sustainability in sectors such as energy, agriculture and waste management. Key policy recommendations to support the implementation of AI at the intersection of these areas: Investment in research and development (R&D): Governments should increase funding for research projects, as well as generate new

grants that integrate AI with sustainability issues. This involves working with universities, research institutes and private companies that create AI-based renewable energy optimization solutions, carbon capture technologies, biodiversity and ecosystem monitoring tools and climate prediction model databases. By investing in green technologies and providing tax incentives for companies to take steps to reduce carbon emissions, the shift from conventional energy to clean energy can be combined with the development and stimulation of innovation and reduce costs by driving the adoption of AI for environmental protection. By creating AI innovation hubs, governments can establish collaboration between private and public sector stakeholders to develop and implement sustainable AI-based solutions. These hubs could help facilitate knowledge transfer, test new technologies, and effectively scale up the application of AI. Innovation hubs would facilitate the creation and mobilization of AI for climate action through visionary collaborative ecosystems [41]. Table 2 shows countries with successful cases of sustainability policies integrating government or public administration.

Table 2. Successful AI and Sustainability Policies As case studies within the realm of public administration.

Country	Policy/Initiative	Key Features	Outcomes
Singapore	Smart Nation Initiative	Integration of AI and IoT technologies for sustainable urban development. Real-time monitoring of energy, waste, and air quality.	Efficient resource allocation, pollution reduction, and enhanced urban management.
Finland	National AI Strategy	Collaboration with local businesses to optimize waste management, reduce landfill, and promote recycling.	Enhanced waste management systems, improved recycling rates, and public-private synergy.
Netherlands (Amsterdam)	AI for Good and SDGs	Policies leveraging AI for urban mobility, carbon mitigation.	Improved public transport systems, reduced carbon emissions.
United States	AI for Environmental Monitoring	Use of AI for wildlife protection, air quality analysis, and water resource management.	Advanced monitoring systems to prevent biodiversity loss and improve environmental.
Germany	Sustainability Accelerator Program for AI	Financial incentives such as subsidies and tax breaks for startups addressing sustainability challenges with AI innovations.	Boosted innovation and market entry for green AI startups, promoting long-term sustainability.

	Startups		
Canada	AI for Climate Adaptation Program	AI applications for early disaster detection, urban resilience planning, and sustainable agriculture.	Reduced vulnerability to climate-related risks and enhanced sustainable agricultural practices.

Source: Own development.

Public-private collaboration is essential for innovation to contribute to sustainable development. Its integration into the guidelines of public policies that drive the government are platforms that can generate radical changes in the transition to environmental sustainability. The support of public and private initiatives is especially important for emerging and complex technologies such as AI, which require significant financial investment, technical capabilities and access to data, as well as trained personnel with extensive experience. Public administration, in association with the private sector, can generate a link that can take full advantage of all the resources and innovation capacity obtained from industry [42]. This means that public-private partnerships, which allow governments to take advantage of knowledge and resources, could help build policies that drive regulations that ensure the long-term public interest without being sensitive to political changes, thus aligning themselves with the objectives presented by climate change. Integrating AI into climate change mitigation and adaptation strategies offers opportunities across sectors, as illustrated in the study. The findings reveal that AI’s ability to process large data sets, predict trends and optimize resource allocation has transformative implications for combating climate change.

Key findings include:

Establishing clear frameworks: AI governance frameworks should set boundaries on the things that society considers ethical when AI is being deployed and thus governments must come up with such stuff. These frameworks need to ensure that AI solutions used in the interest of our environment do not threaten the livelihoods of vulnerable communities or violate privacy rights

further exacerbating disparities between “rich and poor”. The EU, through its AI, is rolling out a whole new set of guidelines covering high risk.

Advocating for Transparency and Accountability: To earn public trust in AI technologies, governments must regulate transparency of AI algorithms and processes involved with decision-making. Transparency initiatives can involve companies having to disclose how their AI models were trained, what data was used and what steps are taken to relate outcomes. For instance, the U.S. has initiated AI transparency measures in government contracting that could be adapted to the same sector for assessing fairness and accountability in climate change mitigation.

Introducing Guidelines and Certifications for Ethical AI: Governments need to come up with some form of guidelines or certification process on ethically designed Ai systems. Such standards should be developed in association with international agencies, laying down points on fairness and accountability, along with non-discrimination principles governing AI systems.

Applications Across Sectors: AI technologies have successfully contributed to renewable energy optimization, disaster prediction, sustainable urban planning, and waste [43].

Public Administration's Role: Public administration has a pivotal role in facilitating the adoption of AI technologies by establishing regulatory frameworks, promoting public-private partnerships, and fostering local entrepreneurship. Case studies from countries.

Challenges Identified: Despite its potential, the application of AI faces barriers such as high energy consumption, data quality and

accessibility issues, and ethical concerns.

Policy Frameworks and Recommendations: Effective AI adoption requires comprehensive policies addressing ethical, equitable, and environmental dimensions. Recommendations include regulatory support, financial incentives for startups, investment in AI research, and the development of guidelines for ethical AI

deployment.

Table 3 highlights practical applications of AI in the field of sustainability, focusing on environmental conservation, resource efficiency and disaster preparedness, and shows AI solutions to address climate change and promote sustainable development.

Table 3. Applications for AI in Sustainability There are practical use cases for AI in sustainability and they are growing across sectors.

Applications for sustainability	Description
Renewable Energy	AI optimizes energy generation from renewable sources like solar and wind by predicting generation patterns and improving efficiency and reliability.
Conservation of Forests and Wildlife	AI-powered drones and satellite imagery analyze forest health, monitor illegal logging, and track wildlife populations, enabling rapid ecosystem protection.
Sustainable Urban Planning	AI aids in optimizing public transportation, reducing congestion, and lowering emissions by analyzing traffic patterns, supporting smart city initiatives.
Waste Management	AI identifies and sorts of waste to improve recycling efficiency and reduce landfill contributions.
Sustainable Agriculture	AI optimizes water, fertilizer, and pesticide usage through smart sensors and predictive algorithms, reducing environmental impact and boosting yield.
Climate Resilience	AI predicts natural disasters like hurricanes and wildfires, enabling communities to take preventative measures.
Energy Storage and Distribution	AI integrates and optimizes hybrid systems combining renewable sources with battery storage, reducing energy waste and improving grid reliability.

Source: Own elaboration based on information from OECD (2024), Global Forest Watch (2023), and IEA (2024).

Table 4 and Figure 3 indicate the level of development of AI applied to climate change challenges in various countries. These advances are essential to promote energy transition and mitigate the effects of climate change.

In this way, the map presented in Figure 2 complements the information in the table in a visual way.

The analysis shows that countries with emerging economies have a lower integration of AI tools in the climate context, compared to developed

nations. This highlights the need to provide greater support to reduce the technological gap and promote the adoption of more technological tools.

In addition, the application of these technologies has the potential to significantly accelerate socioeconomic development in countries with emerging economies, strengthening their capacities to face environmental and climate challenges.

Table 4. Level of application development and description of the application of AI in sustainability in different countries.

Country	Applications	Qualitative Level
Mexico	Power grid optimization, weather prediction	Low
Germany	Renewable energy planning, urban sustainability	Very High
United States	Disaster management, precision agriculture	High
India	Water resource management, flood mitigation	Low Medium
China	Industrial emissions monitoring, smart grids	High
European Union	Ethical certifications, sustainable transportation	Very High
Japan	Smart city energy planning, carbon tracking	High
Canada	Forest conservation, renewable energy expansion	High
Brazil	Deforestation monitoring, water resources	Low Medium
South Africa	Early warning systems, renewable infrastructure	Low

Source: Own elaboration based on information from OECD (2024), Global Forest Watch (2023).

Level of development of AI applied to climatic change in countries

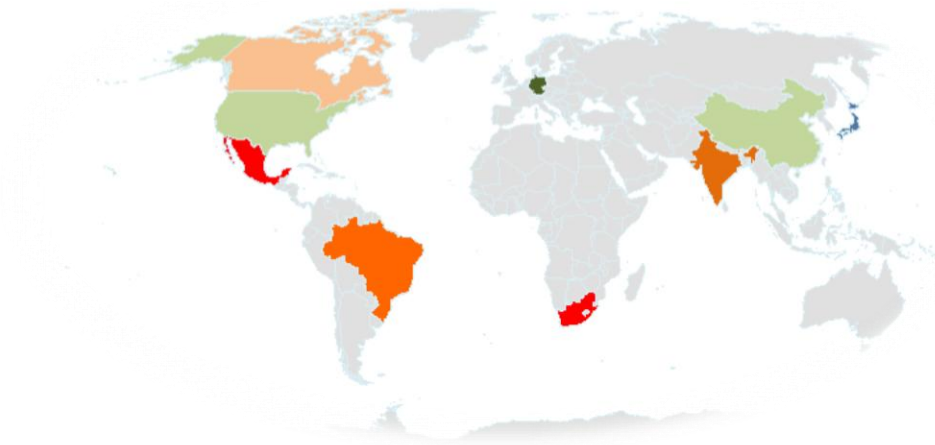


Figure 3. Visual Representation of Countries by Level of AI Development in Sustainability and Climate Change Applications. Source: Own elaboration based on information from World Economic Forum (2024), OECD (2024), IEA (2024) & European Commission (2024)

4. Conclusions

Artificial intelligence represents an innovative tool, which is currently being used in all activities and will begin with this trend towards greater application in each activity we carry out. It has the transformative potential to address global climate challenges and sustainable development,

if they are implemented under principles of equity, transparency and responsibility. The analyses and research highlighted the importance of public administration and public policies aligned with climate change and sustainability, through effective governance, comprehensive public policies and public-private collaboration to maximize the benefits of AI in sustainability.

Regulatory strategies due to the complexity of the AI issue must prioritize ethical frameworks, data quality and equitable access to technology and mitigation of technological and socioeconomic biases. Governments have a key position to lead initiatives that integrate AI into climate action, relying on robust data infrastructures and international alliances. The incorporation and use of these tools in government objectives and prospects are essential due to their extensive applications, as they can also improve resource management, disaster prediction, and renewable energy optimization. Regardless of challenges such as access to quality data and intensive resource consumption, the integration of AI in climate solutions can catalyze a transition to a more sustainable future. Currently, there is great progress in developed countries reaching different topics that comprise sustainability, while countries with emerging economies have begun a transition to the use of these technological tools. Undeniably, there continue to be great opportunities to reduce the gap that will help improve the economy of these countries. The key is to promote innovation while ensuring social justice and long-term sustainability.

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