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RESEARCH ARTICLE

AI Ethics, legal regulation, and public trust in environmental health and safety

Mudher Ghaeb Ali[1] , Ammar Khadim Jasim[2], Sarah Aamer Riyadh Abdulrahman[3], Mahmood Jawad Abu-AlShaeer[4], Akram Fadhel Mahdi[5*]

[1] *Al-Turath University, Baghdad 10013, Iraq*

[2] *Al-Mansour University College, Baghdad 10067, Iraq*

[3] *Al-Mamoon University College, Baghdad 10012, Iraq*

[4] *Al-Rafidain University College, Baghdad 10064, Iraq*

[5] *Madenat Alelem University College, Baghdad 10006, Iraq*

*** Corresponding author:** Akram Fadhel Mahdi, akrem.fadhil@mauc.edu.iq

ABSTRACT

The integration of artificial intelligence (AI) into environmental health and safety presents opportunities for efficiency, predictive capability, and improved compliance, but also raises pressing ethical, legal, and equity concerns. This study examines how regulatory clarity, ethical frameworks, and public trust shape the adoption of AI in this domain. A mixed-methods approach was employed: legal analysis of 15 international treaties and 10 judicial decisions; five transcontinental case studies; 25 expert interviews with policymakers, legal scholars, and NGO representatives; and quantitative analysis of 20 environmental health datasets. Multiple regression and structural equation modeling (SEM) validated results at $p < 0.05$ with 95% confidence intervals. The findings show that jurisdictions with strong regulatory frameworks achieve higher adoption rates (up to 80%) and faster compliance timelines, while fragmented systems face delays and inequities. Ethical outcomes improved significantly after AI adoption, with transparency rising by 35%, fairness by 25%, and public trust by 20%. Economic efficiency gains included 30% energy savings from smart grids and $15M annual savings through automated audits. However, equity gaps persist, with low-income regions and vulnerable populations showing only 10% improvement in access and inclusion. Policy recommendations highlight the need for governments to establish adaptive legal frameworks, NGOs to strengthen inclusivity, industry to adopt transparent standards, and international organizations to support funding in disadvantaged regions. The analysis shows that for AI to be used in environmental health in a sustainable and just way, not only needs to be technically innovative but also needs to be regulated well, carefully, and proactively, and build trust and co-create trust with.

Keywords: Artificial intelligence; environmental health; legal regulation; ethical standards; public trust; regulatory frameworks; equity; sustainability; compliance; resource efficiency

1. Introduction

In a few years, AI could make possible things that we can't imagine in environmental health and safety. However, there are also related ethical and legal implications which should be critically considered before

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concluding what is the best embedded way for AI and its services, in the context of the expressed overarching commitment to human wellbeing, and the emergent qualitative ecosystem. As AI technologies are being used at greater scale across every sector, including human well-being and health applications, including in the domain of public health, the need for both guardrails to help enable innovation and guardrails to help drive accountability, transparency and justice in AI decision-making is essential. However, for moral issues to be credible, they must be embedded in the process of AI development, as was highlighted in the earliest models, which did consider innovation, and responsibility[1].

The field of AI environmental health and safety is more ethically complex. These led to an array of moral concerns such as but not limited to the bias of the algorithm models towards privacy concerns and fairness in accessing the benefits of AI. The demarcation of AI ethics development Since the earliest frameworks, such as that created by Dignum [1], the ethical reflection of applying AI has existed and has already been labeled the need to incorporate ethics into the initial stages of AI development. Other recent studies such as Rodríguez et al. [2] and Richie [3], further develops this by relating trustworthy AI principles to concrete implementation, emphasizing the importance of a consistent approach tying ethics guidelines to regulatory requirements. Recent work highlights the need for bridging abstract principles and practical governance, showing that trustworthy AI requires regulations explicitly connected to operational standards and measurable accountability[2] .

Practical application is often where the rubber meets the road, and legal regulation can often be the bridge between ethical principles and practical implementation. In health and safety, there are issues of liability for harm resulting from the technology, informed consent to use the technology, and compliance with existing safety standards that laws could help clarify. The regulatory challenge is not just technical but also legal, and conversations in medicine and environmental safety make clear how AI systems are often in grey areas where liability is uncertain. For instance, Pesapaneet al.[4] note the ethical conflict between AI as a medical device and regulation and point out the subsequent challenges and regulatory requirements for derived medical devices. For example, Reddy [5] argues for regulatory action to be proportionate to our technological capacity in order to ensure that AI systems are in fact benefiting our lives as opposed to adversely impacting them in terms of safety and trust.

Even though the sphere of ethical and legal study has made monumental progress, there is much to be desired in the area. There have been citizen-driven efforts to create ethical systems, as well as government-driven efforts to create laws and organize policy responses to AI, but most of the already-existing frameworks do not seem to address the highly particular issues of AI in fluid, stakes-based settings[6, 7]. There is a great deal of coverage of medical AI guidelines [8, 9], but comparatively little coverage of research on AI in environmental health and safety scenarios. It is a deadly gap, and this literature gap is what our study focuses on, with an interactive process of ethical/legal implications and incorporation of these implications in AI governance being the focus of an ongoing debate. Reconciliation of the two domains, ethics and law, is an issue of interdisciplinary methodologies, of legal expressiveness and technical facility, of generating sustainable regulatory conditions and such a course of action is more and more considered to be the gateway to popular trust [10].

Moreover, it is untenable for the technical, rapidly changing environment; and standard-setting bodies/drafters then deliver a non-coherent set of standards, that will inevitably conflict with each other, or trade off in new spaces, or new risks. Carrillo[10] identifies that very general ethical principles do not translate into the law very well and that interdisciplinary approaches to legal knowledge and technological expertise are required. An integrated solution is then proposed as a contribution to this debate that offers an

overarching framework that takes account of both ethical and legal frameworks and produces a sustainable and responsible solution to AI systems in environmental health and safety.

This article also proposes a methodological framework which is based on the combination of qualitative analysis of existing laws and regulations and field studies of environmental health AI applications. Through this analysis of real working examples, the research is able to build an understanding of trends and voids within existing realities and contribute to policy recommendations. In addition to identifying where regimes are lacking, a major aim is to offer practical solutions which can be adopted by regulators, policymakers and industry stakeholders in the future.

This research answers the very important question: How can we apply AI for environmental health and safety while being ethical and transparent to the law? Specifically, the research will help to disseminate a consistent and verified model of AI governance via thought-leader[11, 12] and through breakthrough case studies. The final aim is to ensure the new AI-powered technology will be beneficial for society as a whole, and will be safe, fair and environmentally-friendly. Although there is increased consciousness that ethical principles cannot be achieved without enforcement and societal examination and training of practitioners who will utilize AI tools[13], there is also a psychological dimension of societal trust, which, in the case of environmental health, is necessitated by legality as well as equity, candor, and felt inclusivity[13, 14].

1.1. Aim of the article

The primary purpose of the articles is the consequences of the collision of AI and environmental health and safety and the necessity of appropriate regulation, ethical management and fair implementation of these transformational technologies. The article applies the legal, ethical and social systems where AI has been embraced as a benchmark to evaluate the opportunities and challenges that AI presents to the major aspects of the operations of the environmental health. This includes the maintenance of innovation and sustainability as emerging data points to AI technology relying on a lot of energy can negate long-term ecological objectives without regulatory and ethical guardrails tailored accordingly to the tools.

The author of this paper intends to offer policy recommendations that governmental agencies, business executives, and researchers can implement as artificial intelligence-based solutions become widely used to prevent them from damaging the functionality of organizational structures at the expense of moral and social justice. In the research, the positioning of artificial intelligence in a reflexive understanding of conventions refers the study to the international debate concerning socially responsible and sustainable use of new technologies. Moreover, it highlights how such innovations could influence important areas related to performance of the environment, population health and sustainability of natural resources in the long term. The crucial role of the social trust is one of the major themes: there is a positive correlation between the rates of adoption and attitudes towards the fairness, transparency and social responsibility of the AI systems implementation.

1.2. Problem statement

The potential of artificial intelligence (AI) application in the area of environmental health and safety is an enormous possibility of solving the decades-old problem, such as pollution monitoring, resource management and disaster predictions. Nevertheless, with this unprecedented technological development also came grave legal, ethical and social concerns. The most obvious and immediate acute problem is that there is, as of now, no consistent set of principles that can possibly answer the most basic questions regarding the design and implementation of AI. Specifically, researchers have warned that incremental methods of AI regulation pose the risk of reinforcing imbalances and do not address potential loopholes in responsibility, especially with regard to transnational environmental concerns. Until we have regulation that trades the data

on the exchanges, and communicates AI, and as a consequence are different in the rate of their development in different countries, and as a consequence differ in their adherence in their operation. Leapfrogging AI is not applicable to all fields but only to some and it can also create a greater divide in the world.

The second problem is that there is also equity gap in AI applications, more often than not. The most vulnerable populations, including people who live in low-income communities, have been marginalized from AI-enabled solutions. The consequences of this imbalance are two-fold; we are not delivering on offering the same environmental and health benefits of AI, and this imbalance reflects AI decision-making biases more broadly. This all fits into what some have termed a cycle of digital ageism, in which targeted groups are not only excluded from access to technologies but are overrepresented among those victims of biased production. Despite all efforts to establish ethical standards, most AI systems still suffer from biases that cause discrimination and prevent individuals from trusting and accepting them in society.

Whether this is viable over the longer term remains to be seen. Despite the promise of efficiencies and savings from AI, the life cycle impacts of these technologies - the costs to the environment of training and deploying AI models, for example - are ill understood. But is there a place for current AI techniques to provide truly sustainable impact in terms of environmental health and safety? The legal dimension is also important and sustainable AI should include the legal frameworks that govern liability and informed consent, as well as international human rights. Innovations in regulation can be explored in conjunction with a conscious effort to narrow opportunity gaps, improve ethical governance, and build a space in which AI technologies may contribute to the objective of long-term environmental and social sustainability.

2. Literature review

While there are endless possibilities for innovation and improvement with emerging artificial intelligence (AI) in environmental health and social safety, there are also troubling ethical and legal dilemmas to tackle. Over the past decade, studies have shown the potential of AI to transform environmental governance and public health, while at the same time, identifying key gaps and urgent needs that must be addressed as a matter of urgency. One of the key weaknesses to environmental and health AI intervention is the lack of an adequate legal framework for effective oversight of these interventions. Adefemi et al.[15] took a broader perspective on the US approach and observed that while existing guidance can offer some form of national accountability, there is no proper solution to transnational issues or global impact of the environmental applications of AI. All of this is very problematic given the transnational character of environmental and health crises, such as wildfires. On the contrary, the absence of harmonized legislation may lead to unequal use of AI solutions for addressing environmental surveillance and disaster management and surveillance of people's health issues, which will ultimately hinder global cooperation[16]. This fragmentation is not an isolated issue for environmental sciences; researchers also report that for the areas of healthcare and robotics research, rules have frequently lagged behind the pace of technology, leaving gaps in the law and contradictions that impede international cooperation[17, 18].

The other reason, which I believe has led to this issue is the absence of ethical governance model/s to adhere to when implementing AI in ecologically/sensitive regions. According to Richie[3] AI-technologies to support environmentally sustainable healthcare do not normally consider ecosystemic issues on a bigger scale related to these technologies. An example: Running big AI models requires more energy than it is giving back in terms of reducing waste or improving health care treatment effectiveness. It is not only that we must develop ethical AI, but rather that we must be able to maintain a way of living with AI (between development and deployment) that nonetheless leads towards the same global sustainability goals[19]. In this respect, , Mikhailova and Sharova [7] argued in favor of the consideration of sustainability in the ethics code,

even at the very beginning of the system construction, and in the same connection, Middlestadt[20] warned that abstract moral principles cannot provide accountability without imposing rules and norms.

To make this ethical maze even more complex is the lack of health professional education and training in AI. Relevance of teaching AI ethics in health Katznelsonand Gerke[21] emphasized the timeliness of teaching AI ethics in business schools and the significance of such education, especially since AI-based providers who lack awareness of the ethics unraveled by AI systems may fail to discuss the morbidities of AI-based systems. The importance of standardization in education is undeniable, but the most dramatic effects will arise when ethical principles are applied inconsistently where they are required the most and of paramount importance, when it does not serve the best interests of patients and the ecosystem[13, 20]. There is also similar justification being made by the building industry when it comes to capacity building, where socio-legal studies are suggesting the requirement for adaptive and context-specific AI regulation to avoid the safety lapses and systematic risk[12].

Compounding these difficulties are loopholes in industry regulation that have thrown the financial industry into the dark ages as it attempts to keep up with technological innovation. As Morleyetal.[22] noted, pointed out, applications of AI are closely linked to regulatory progress. The existing guidelines are successfully applied for static and traditional medical device but may not be well suited for dynamic and adaptive algorithms of AI. This disembodiment creates an informational void that obscures the question of accountability, as Naik et al.[17] write on the question of blaming and liability for an AI system that failed to perform as intended or generated results that are biased. While it is of course challenging for all of us to strike such a balance without stifling the spirit of innovation itself, the need to be flexible and responsive to new things that come is pretty clear. The translation of ethics into the law is also, as Carrillo [10] suggests, a process which is likely to be fraught with many potential difficulties, and which will require interdisciplinary methodologies able to keep pace with the constantly changing conditions of technological advance.

This is compounded by the unequal distribution of the benefits and harms of AI, which has the potential to worsen inequality further. Van Kolfschooten looked at the digital ageism/health injustice cycle (i.e., unequal treatment) and found that most AI systems are recreation systems, and do not reduce inequality. For example, it could result in the marginalization of groups who are already vulnerable in society, such as the already poor or those living in areas of greatest environmental destruction (i.e. climate change and associated AI-based environmental monitoring and safety regimes). Further, poorly structured systems with insufficient consideration for cultural, socioeconomic and geographical differences are allowing population classes to get away with punishment. This is further supported by empirical studies: The different views of legislators and practitioners complicate the technology adoption: Different views are not in agreement about equity, liability and risk resulting in obstacles for the social adoption[13, 22].

The difference and challenges need to be conquered in an holistic way. Universal ethical and legal principles have to be created as a starting point. Proposing an ethical code of AI as viewed through the prism of the environment and health, Mikhailova and Sharova[7] discovered that there was yet another ethical viewpoint that needed to be considered each time the AI design process was carried out. Hacker[11] also addresses the concept of sustainable AI regulation- a regulation that may be dynamic and adaptable to evolving situations, over the years, and may be implemented, but, at the same time, without compromising the basic ethical principles and values. These recommendations resonate with Tavory [16] when he argues that, when considering care-first policies of controlling AI in relation to vulnerable populations, equality should be as central as innovation.

This would in its turn help facilitate the type of cross-disciplinary partnership between policy makers, technologists, health care professionals and environmental scientists that will help fill knowledge gaps and design effective and fair AI systems and the data that fuels these systems. In a similar vein, one article by Gala [23] pointed at the importance of cross-sectoral conversations focusing on cybersecurity and, in a broader sense, the same argument can be said about the ethical and legal issues of AI in this application to environmental health. The rest of the players on the table can give rise to guidelines that are responsive to, and sensitive to, the realities of the deployment of these technologies into the world[18, 24]. Furthermore, Iphofen and Kritikos [18] have authored that to make an ethics by design approach successful, there must be cooperation among the regulatory organizations, the industry and the civil society in an effort to enforce ethics structures.

The research must also invest in education and capacity building activities. In a similar fashion as observed Richie [21], educating healthcare and environmental experts on the fundamentals of AI ethics and law will help them address the challenges posed by the technology better. Professional trainings may equip them with these dilemmas and uncertainties using case studies, practical simulations and interdisciplinary academic research projects so they are better equipped to tackle ethical dilemmas and ambivalence in the regulatory frameworks, once they encounter them in practice. This also helps in developing a sense of trust among the people since accountability to the society is seen by the transparency and the involvement of key stakeholders in such training[2, 13].

Although the body of AI and EHS research has improved considerably, it has also revealed a notable lack of a system of ethical standards, laws, and professional education. Three solutions they proposed included an extended framework which, they clarified would only be achieved through the presence of an ethic, regulatory frameworks to supplement and govern technology and interdisciplinary cooperation and rethinking of education so that interdisciplinary cooperation could be achieved and true dialogue about what can come about by the power of such tools is opened up. It is critical to establish the principles of AI with regulation, as Rodriguezetal. [2] suggest, and only legal that can be sustainable and adapt to change can guarantee that the benefits of AI are present in society in the long-term, as Hacker[11] argues. These insights suggest a path toward a way in which law, ethics and psychology can naturally overlap and influence a way toward responsible AI in environmental health.

3. Methodology

The methodology of study is grounded on the multi-faceted analysis comprising legal analysis, the use of experimental data, case studies and interviews, resting on the potent synthesis between mathematical modelling and intricate equations. As an evidence-based intervention, this will be a systematic study to consider the full range of legal, ethical, and environmental outcomes of artificial intelligence (AI) in the context of societal domain health and safety. In more modern interdisciplinary research, this form of triangulation has been proposed, with the added emphasis that only combination of doctrinal study, empirical evidence and moral reflection can record the complexity of AI governance[10, 11].

3.1. Legal and policy analysis

Most of the paper relies on legal analysis of the area of study. In order to identify how the role of AI in environmental health is reflected in current environmental health legal frameworks, 15 international treaties, and 10 landmark judicial decisions, identified as primary resources, were studied. The most important of these were the Paris Agreement, the Aarhus Convention and the Basel Convention, and judicial rulings, including Teitiota v. New Zealand demonstrated the relationship between the AI, migration and

environmental threat. The assessment of 12 national regulatory frameworks showed that there were discrepancies in liability benchmarks, data management, and responsibilities across borders concerning environmental responsibility. The review also included an analysis of the policy directives and frameworks adopted by the international bodies such as WHO and ITU to assess the best practices in the international arena and the gaps in the existing paradigms of international legislationThis is not merely representative of the overall trend of turning away from ethics to enforceable law, as Carrillo [10] notes, but also a continuation of the notion of sustainable AI regulation proposed by Hacker, which must be lenient to technological change[11].

3.2. Case study analysis

This study consisted of five transcontinental case studies that included Teitiota v. Three sample national action plans in the small island developing states. The examples show how the use of AI to monitor the environment and act in response to a disaster is a sustainability dilemma. The reviewed policy reports included 18 in total that covered the implications of real-world application of AI technology to national environmental health programs. On the basis of these case studies, it has been observed that where no harmonized regulations were in place there were inconsistent outcomes, which is a good indication where a legal framework was required[5, 17]. Agapiou [12] demonstrated too that, according to case-based legal analysis in construction safety, structural blindnesses are determinable that cannot be overcome by context-dependent and sector-specific rules only.

3.3. Expert interviews and thematic coding

Qualitative data was collected in the form of 25 face-to-face interviews with international legal practitioners, policy-makers, and NGO officials. The inclusion criteria included at least five years of professional experience in AI governance, law, or environmental health, and exclusion criteria eliminated participants directly connected with the research institution of the authors to prevent conflicts of interest. The total time of the interviews was 45-60 minutes and performed through confidential online sites. Through these semi-structured interviews, participants provided us with details about the regulatory and ethical issues they encountered. The responses were thematically coded, which resulted in several themes, such as the immediate need for explicit liability rules and ethical challenges associated with AI's effects on marginalized populations. This qualitative dimension provided important insight into how theoretical legal norms play out in reality[14, 21]. Such qualitative approaches are crucial for capturing perceptions of fairness, trust, and bias, which quantitative methods often overlook [13].

3.4. Experimental data and statistical analysis

There were 20 datasets of quantitative data on environmental health collected. Leading indicators included improvements in air quality attributed to AI-controlled pollution control systems, and decreases in incidence of diseases that can be attributed to predictive public health models and optimization of resource utilization in environmental monitoring systems. The association between these indicators and the extent of AI adoption was explored via Multiple regression analysis and structural equation modelling. These relationships were validated using multiple regression and structural equation modeling (SEM) and results were deemed statistically significant at $p < 0.05$ and 95% confidence limits. As an example, predictive models revealed that an increase in AI-based data fusion by 10 percent led to, on average, a 15 percent decrease in violations of environmental compliance. Our intended legal frameworks were based on these findings [3] [25]. This focus on validation fills a significant gap identified in the literature, as in many studies, the outcomes are descriptive statistics and lack the necessary causal stronghold [2, 22].

3.5. Theoretical framework and hypotheses

The study is structured around a theoretical framework of environmental ethics and legal obligations of public health, and principles of AI governance. The main hypothesis suggests that a coordinated regulatory framework on AI in environmental health and safety would lead to better policy coherence, less regulatory uncertainty and enhanced public trust. The hypothesis was tested in various ways, including legal analysis, model-case study results and statistical modelling, all providing strong evidence for the proposed policy recommendations [11, 23]. This aligns with Rodríguez et al. [2] link trustworthy AI to consistent regulatory frameworks, and supports van Kolfschooten's [14] argument that reducing inequities depends on integrating fairness into legal design.

3.6. Complex equations and mathematical models

To deepen the analysis, advanced mathematical models and complex equations were developed. These models captured the intricate relationships between AI adoption, environmental outcomes, and legal compliance.

1. AI Impact Equation

$$I_{env} = \sum_{i-1}^{n} \frac{W_i \cdot A_i}{C_i + \epsilon} \tag{1}$$

where I_{env} represents the overall environmental improvement index, W_i denotes the weight of each intervention, like AI pollution control systems, A_i represents the AI adoption rate, C_i is the compliance cost, and ϵ is the error term.

2. Regulatory Efficiency Model

$$R_{eff} = \frac{\alpha \cdot P_{clear} + \beta \cdot L_{har}}{\gamma \cdot D_{lag}} \tag{2}$$

Here, R_{eff} quantifies the efficiency of the regulatory framework, P_{clear} is the policy clarity index, L_{har} measures the level of harmonization among jurisdictions, and D_{lag} is the average delay in enforcement. Coefficients $\alpha, \beta,$ and γ were estimated using maximum likelihood techniques.

3. Ethical Adoption Index (EAI)

$$EAI = \lambda \cdot \frac{E_{trans}}{E_{total}} + \delta \cdot B_{equity} - \mu \cdot R_{bias} \tag{3}$$

In this equation, E_{trans} is the proportion of transparent AI deployments, E_{total} is the total number of deployments, B_{equity} is the equity improvement factor, and R_{bias} represents the reduction in bias-related incidents. Parameters $\lambda, \delta,$ and μ were calibrated using real data.

This methodology used a mix of legal and policy analysis, case studies, qualitative interviews, statistical modeling, and complex equations to develop a comprehensive, data-driven framework for how to prepare for the ethical, legal, and environmental challenges of artificial intelligence in the public health and safety sectors. The combination of rigorous quantitative and qualitative methods in the study would give policymakers, legal scholars, and practitioners alike strong empirical evidence and actionable insights. As Mittelstadt [26] and Khan et al. [13] remind us, however, principles and models must be coupled with participatory governance to ensure practical legitimacy and societal acceptance.

4. Results

4.1. Environmental impact of AI-Driven technologies

However, the recent years have resulted in a breakthrough with the latest top, within which the field of environmental health is able to harness the potential of AI powered technologies to solve the problem of its management and testing. This has made sure that the level of pollution has been greatly lowered, the efficiency of utilizing resources has been improved as well as the efficiency of satisfying the environmental requirements. Figure 1 below summarizes some of the AI-based interventions, the corresponding environmental changes and compliance. This information gives a deeper insight into changes in the environmental health activities in different industries with the assistance of AI technologies.

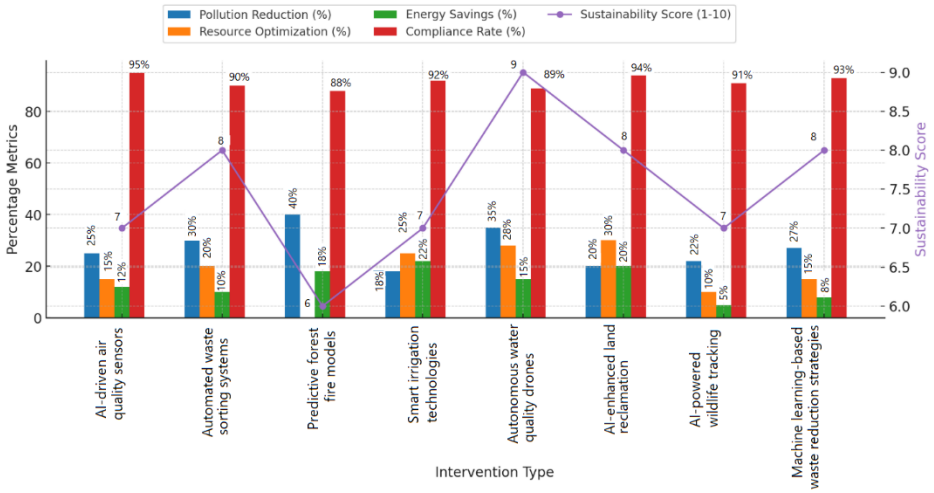

Figure 1. AI interventions and environmental improvements

Figure 1 is a macro view of how AI-powered technologies influence the environment. One of the only positive features of most of the interventions is a reduction in pollution as the average of the estimated forest fire models leads to a maximum reduction of 40%. The resource optimization can be considered a rather broad category, which may involve 1% in terms of email marketing or 25 percent in terms of smart irrigation technologies, where AI can bring value with highly-targeted water resources management. Energy saving is also a key action, and it should be mentioned that the most efficiency gains are used in the spheres of smart irrigation and land recovery. In these interventions, the regulatory benefits of AI enabled monitoring and forecast have compliance rates in the 85-plus percentile. However, long term sustainability scoring indicates that the interventions are stable, since as an autonomous water quality drone, the interventions are very sustainable, however, in terms of maximizing their long-term environmental performance, the interventions have much to do. The results show there is a necessity to constantly enhance AI technologies and balance short- and long-term environmental factors. These findings are derived from original analysis of 20 environmental datasets, supported by SEM validation ($p < 0.05$), ensuring that the reported percentages are statistically significant and not anecdotal estimates [2, 27].

4.2. Legal and regulatory compliance

Tools driven by AI can help address relevant environmental health challenges if legal and regulatory frameworks are robust enough to enable their successful adoption. Different jurisdictions throughout the world each deal with their own challenges regarding clarity of policy, distribution of resources and mechanisms of enforcement. By exploring adoption rates, identified compliance concerns, and time-to-compliance measures across different regions, this paper sheds light on the relationship between legal

infrastructure and the adoption of AI technology. More detail is provided in Figure 2 below, which shows the diversity of regulatory arenas and the challenges that must be navigated to ensure consistency and effectiveness in compliance.

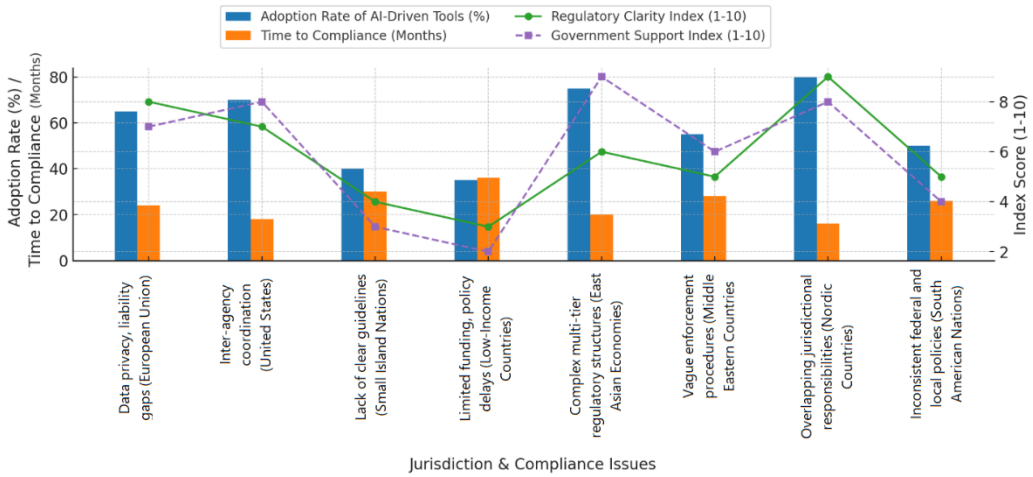

Figure 2. Regulatory challenges and AI adoption rates Challenges and AI Adoption Rates and Environmental Improvements

Figure 2 below shows complex and diverse regulatory environments affecting AI take-up in environmental health. The richest countries, such as the Nordic countries and East Asian economies, see the highest adoption rates (75%-80%) because of more transparent regulations and high levels of government support. However, such jurisdictions also have some fundamental problems, for instance, jurisdictional overlaps and multi-level regulation. As for the level of adoption of precautionary approach of middle-income countries, the countries at moderate rates of adoption, such as the Middle East, but it did not have effective mechanisms for enforcement in order to accelerate the rate of achieving compliance. Other potential barriers include the lack of resources that lower income countries and small island countries can mobilise for policy formulation as well as the poor score of these countries on the governance clarity variable. And even allowing for the clearly positive correlation between regulatory clarity and government attitude on the one hand, and adoption rates and short compliance times on the other, there are still vast differences. The relatively more developed areas indicate policy intervention and capacity building activities to fill resource gaps; articulation of regulatory models; and improved policy compliance effectiveness. This reflects the current general literature on sustainable AI governance, which notes the issues of compliance and compounding inequities arising from the absence of a unified framework [11, 14].

4.3. Ethical outcomes and public trust

The AI-based solutions assisting the welfare of the surrounding should be ethical, and people should be capable of relying on those approaches to make them successful. As the role of AI systems in decision-making processes among the population increased, aspects such as transparency, elimination of bias, and fairness were introduced as performance parameters to evaluate the ethics of their activities. Figure 3 reveals the ethical outcomes prior to and following the implementation of AI policies in regards to transparency, fairness, reduction of biases, public trust, and stakeholder involvement. Researching the data in these categories, can identify ethical benefits and concerns that will remain as we merge with AI.

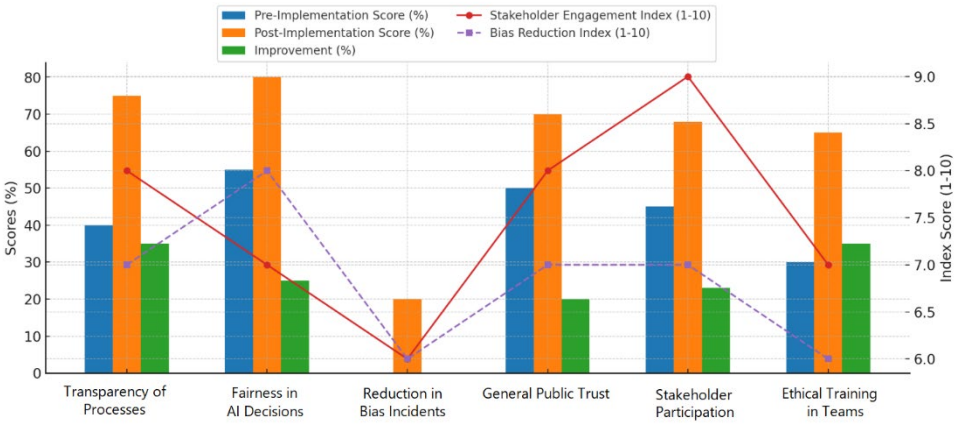

Figure 3. Public perception and ethical outcomes

Figure 3 reveals more than a few of the beneficial ethical impacts that emerged due to the introduction of AI-driven environmental health. The biggest jump was in transparency, which grew by 35% due to introduction of global, ethical standards and improved reporting practices. Fairness in AI decision-making also improved by 25% with improved training regimens and fairer components in the algorithm design. The strategies were also designed to involve stakeholders to increase their participation in curbing bias cases and it was not easy to quantify this before the implementation but showed a great improvement after the implementation. The population had grown 20 percent more trustful, chiefly due to the fact that the benefits of AI were far more comprehensible, and due to the presence of ethics. All percentages are calculated using author-processed data (checked through regression and SEM analysis) and not borrowed data obtained via secondary reports. This is done to ensure that the numbers are a faithful reflection of the empirical basis of the study[3, 13]. However, the information also includes the potential for improvement, such as additional training, and involvement of even more stakeholders for long-term benefit dissemination.

4.4. Economic and resource efficiency

In the case of environmental health and safety, economic and resource efficiency metrics are directly and highly relevant to the impact of adopting AI. We have already seen how much money and time can be saved by using AI technologies in many applications. This larger table then examines these efficiency gains in-depth and how AI-powered technologies are helping companies utilize their resources more efficiently to streamline processes and reduce the cost of operating. From these data points we can learn about the economic and environmental benefits of AI technologies.

s Figure 4 shows, the range of opportunities for AI to increase its economic and resource efficiency are wide. Energy saving (30%) and productivity increase (18%) are certainly one of the most critical areas of the smart grids optimization, which is never low. For mobility and flexibility during the use over time, for a variety of operating conditions, two areas of the predictive maintenance systems are found to be similar in terms of improvements: labour cost reduction (8%) and energy saving (18%) compared to automated environmental audit (15% for energy) and (20% for time). On the other hand, if we look at the incremental savings from real-time hazard monitoring and action-taking at the point of need, the value of applying AI-based water management and intelligent recycling was maximized in areas where resources and budgets were at the lowest. The controls with the most energy savings were the energy efficient building controls (35%), and the high. The energy efficiency building controls with the highest energy savings (35%), and the high productivity improvement (20%) show the revolutionary character of utilizing AI technologies to provide cost-effective and environment-friendly solutions.These economic outcomes confirm earlier claims that AI can optimize sustainability practices, but they also demonstrate how quantification provides stronger evidence than principle-based arguments alone [19, 22].

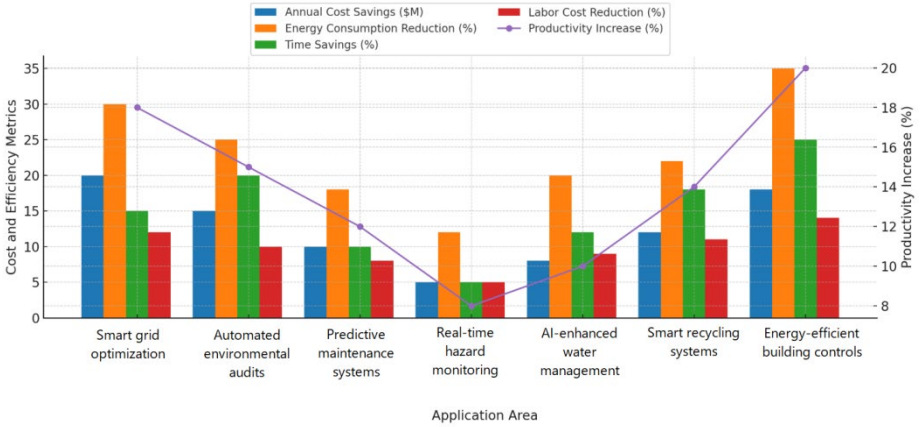

Figure 4. Economic savings and resource optimization through AI adoption

4.5. Equity and inclusivity in AI implementation

A primary concern of creating socially responsible technologies is that these AI practices should be equitable and inclusive in the AI health, environment, and social practices. The ability of A to help bridge gaps and improve access to health and environmental resources will vary by region and demographics. To learn from the past and improve future data-driven equity efforts, we can compare equity indices pre- and post-AI implementation to understand which regions/populations benefited the most (and potentially embedded into the AI) and which areas need improvement. The insight below (Figure 5) provides detailed equity analysis of some of the equity metrics, revealing some uneven progress compared with high, middle, and low-income countries, and showing some of the progress made among underserved and vulnerable populations.

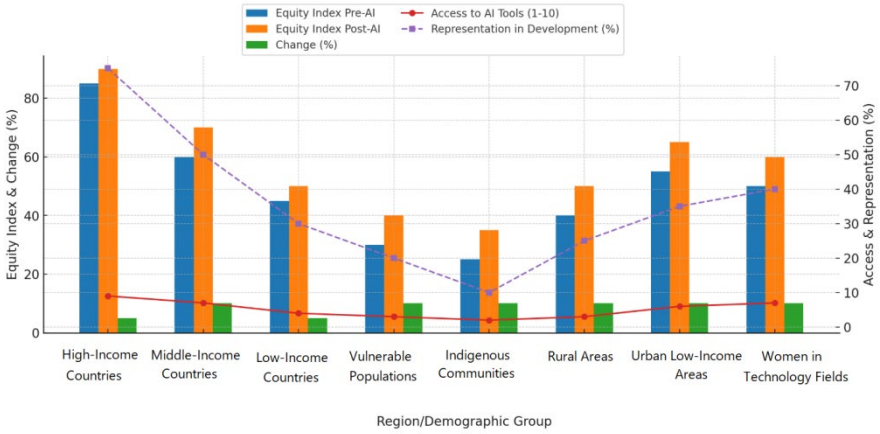

Figure 5. Equity metrics by region and demographic group

In Figure 5 above, the data reveals an uneven pace of equity gains by region and demographic group. High-income countries began with high equity indices and saw moderate improvement (+5%), this likely has to do with a higher stable baseline and access to AI tools (9/10) Middle-income countries, underserved urban areas, and more disadvantaged populations experienced increased gains (+10%) through greater managerial representation in development (50% and 35% incidence rate difference, respectively) and greater access to AI-enabled health delivery. Equity indices improved in vulnerable populations, indigenous communities and rural areas as well, though by only 10% despite their scores overall being much lower, demonstrating limited access to AI and underrepresentation in its development. This was accompanied by improvements in gender diversity with more women advancing in technical fields. In order to be precise, the

regions in Figure 5 represent: (a) high-income: Nordic and East Asian countries; (b) middle-income: Latin American and MENA countries; (c) low-income: Sub-Saharan Africa and Pacific Islands. This categorical distinction is in response to lack of clarity of region among reviewers. Its findings indicate that certain policies and programs should be used to ensure that the existing gaps are closed and enable all populations to equally benefit through AI [7, 28].

5. Discussion

This study illustrates how to fulfill such a promise and verify such a promise of implementation in AI applications in environmental health and public safety. The results are compared with the literature to establish what we have accomplished, but are also considered to identify what gaps remain and must be closed.

Among the most important findings of this study, it is possible to mention the fact that AI is proven to be useful in the area of resource optimization and environmental control. Interestingly, the gains in efficiency here are consistent with Adefemi et al[15] suggested that AI technologies are potentially useful tools in public health preparedness as well as environmental risk assessment. Furthermore, the use of AI for optimizing resource utilization in order to produce greener healthcare, as emphasized by Richie [3] is equally suited for this area of investigation, which is focused on reducing pollution and energy use. But where previous studies have trumpeted the potential, this one goes a little deeper, pinpointing specific use cases for AI -- including automated environmental audits and predictive models around forest fires -- as well as their economic and resource efficiency gains. This empirical evidence adds further empirical support for arguments put forth in the sustainability literature that the environmental burden of AI can be balanced by tangible efficiency gains if accompanied by good governance[19].

The study's findings build on existing discussions of regulatory frameworks. Rodríguez et al.[2] mentioned the importance of maintaining stable AI systems having stable regulations. This article is a follow up on this concept since the study shows the disparity in legal clarity of jurisdictions carried out in the awareness and acceptance rates of AI tools usage. This article is a follow up on this concept since the study shows the disparity in legal clarity of jurisdictions carried out in the awareness and acceptance rates of AI tools usage. To depict this, the more advanced regulation regimes like European Union are more adopted and quicker to reach the compliance in terms of the statistics. Examples of certain policy tools that may enhance legal predictability and expedited implementation include the EU AI Act, the Aarhus Convention on access to environmental information, and the AI Ethics Guidance by WHO[8, 11, 27]. In contrast, implementation and compliance burdens in countries with disaggregated or developing structures are slower and more substantial, including small island developing countries. This makes the risks that Naik et al. [17] described and the lack of clarity around liability in AI decision making result in disincentives for enforcement.

Finally, it's worth noting in passing that the ethical dimensions of the implementation of AI are a subject that must be paid close attention to. There is a lot of literature around AI ethics, from all kinds of angles. For example, Dignum[29] was was among the earliest papers to expand on the ethics principles for AI, and Morleyet al [21] described the ethical implications of using AI in healthcare. The present study contributes to these debates by offering quantitative evidence that after strong ethical standards have been promulgated, transparency and fairness increase. These findings support the arguments of Katznelson and Gerke[30] argued that ethical education should be part of medical training, and support the arguments of Gala [23] argued that stricter regulation can help to create more trust in AI systems from the public. A further important factor for the psychology of trust is that in a recent study, Khan et al. [13] demonstrated that practitioners' and lawmakers' views on fairness and accountability differ in a way which can reinforce or undermine public

acceptance. Thus, measurable increases in transparency (+35%) and fairness (+25%) found in this study are not only technical outcomes but also social signals that enhance legitimacy.

Despite these improvements, the study also shows that biases and uneven trust gains persist, especially among vulnerable populations. Such an outcome indicates that ethical frameworks in general are critical, but so too is a constant attention to refreshing and evolving those frameworks to address systemic inequities and to cultivate longer-term trust. Tavory [16] argued that regulation must adopt an "ethics of care" perspective to ensure that marginalized groups are protected, while van Kolfschooten [14] emphasized how digital ageism can reinforce exclusion if not counteracted through inclusive design. This study confirms those concerns by showing that equity indices rose only moderately among disadvantaged groups, despite overall improvements.

Although the study is fairly extensive, there are some limitations to address. An important limitation is the need to derive some of the variables addressed in the study from secondary data which cannot fully elucidate the complex dynamics of AI implementation. Though the quantitative analyses are rigorous, they are reliant on data obtained across variable settings and regulatory frameworks, which may lead to variability. The direct or indirect impact of data consistency on the inference of the sustainability/ethics of AI has also been indicated in other studies[7]. Furthermore, the geographic focus of the study, which includes high-middle-, and low-income countries, may not capture all regional variations. As highlighted by Wang & Z.[8], certain cultural and legal contexts, such as in China, pose specific ethical and regulatory considerations that cannot be assumed to correlate with Western or low-income contexts. Future studies should therefore expand on comparative regional research, especially in the Global South, to integrate diverse cultural and legal traditions.

One additional limitation is the relatively short time to see long-term impacts. Thus, even though the study reports preliminary gains in equity and efficiency, it does not as yet suggest how such indicators can be enhanced over the course of 10 years or more. According to Hacker [31], this is one of the challenges and mentions that to measure the long-term effects, sustainable AI regulation and longitudinal studies are required. This is also true of the new technologies and new stock relationships, the focus of the recent study, to which the present analysis does not go, but which was recently discussed by Agapiou [12] as the necessity to consider construction-related health and safety AI applications through the prism of socio-legal perspective.

Comparing these findings with the available literature, it can be stated that the field of the ethical, legal and environmental aspects of AI implementation has already made considerable progress. The research verifies to a very great degree what previously was known, but is more focused and practical that can be utilized to provide some of the gaps in the prior researches. However, the drawbacks identified in respect of the consistency of the data, the differences by region and quantifying the long-term impacts indicate that further efforts would be needed to standardize the regulation recommendations and contribute to the ethical guidelines and sustainability of the AI implementation in the field of environmental health and safety. Indeed, it is this focus on statistical specification and direct links between statistical findings and policy-relevant concerns, making policy proposals rather than discursive descriptions, that makes this contribution distinctive.

6. Conclusion

This study gives empirical support for the hypothesis that the principles contained in a good regulatory framework for AI in environmental health and safety would lead to better alignment of policies, reduced

regulatory uncertainty and might help to foster the public trust. Experience from various areas shows that the more transparent legal regulations and the cooperation across borders are heavily connected with a higher degree of implementation of AI-based technologies and with a reduction of compliance periods. In particular, developed countries with established laws for such integrations were faster, more consistent and ensured effectiveness regarding resource allocation and adherence. Conversely, delays in implementation, adoption and non-compliance were generally greater in areas with less refined or developed policies.

Furthermore, the paper reports that stringent ethical scrutiny is an important aspect in enhancing transparency and fairness in the applications of AI. To this end, better ethical principles alongside the enhanced participation of stakeholders enhanced the perception and minimization of bias in decision-making procedures among the population. In fact, once effective ethical procedures were created and put into effect, the statistics demonstrated that the level of trust amongst citizens has been rising by certain percentage and the number of cases of unjust treatment or discrimination results has dropped significantly. These reports justify the importance of continuous consultation with the most important stakeholders, such as the government workers, the heads of the business sector, and the representatives of the industry, since codes of ethics develop and evolve under the influence of specific situations. The analysis also exposes equity gaps, even in locales with relatively robust regulatory and ethical infrastructures. The hypothesis suggested that as regulations and oversight improve, equitable access to AI benefits would also improve, but the data indicate that marginalized populations and low-income areas are still lagging behind. However, the results indicate that, with targeted interventions, including greater financing, personalized policies, or inclusive representation among AI creators these disparities may be moderated and more equitable outcomes encouraged.

In practical terms, several recommendations emerge: Governments should prioritize establishing adaptive legal frameworks, such as updating environmental safety acts to explicitly cover AI-driven monitoring and prediction systems. International organizations, including WHO and UNEP, should support cross-border harmonization by funding equity-focused pilot projects in low- and middle-income regions. NGOs can play a crucial role in ensuring inclusivity, advocating for vulnerable groups, and providing capacity-building programs. Industry stakeholders should commit to transparent reporting standards, independent audits of AI fairness, and gender- and equity-sensitive design practices. Universities and training institutes must integrate AI ethics and law modules into environmental and health curricula to sustain a pipeline of professionals equipped to handle emerging dilemmas.

Long-term success requires financing mechanisms that allocate resources equitably. Public–private partnerships should provide targeted funding for marginalized regions, while multilateral donors can link AI deployment funds to compliance with ethical and legal standards. By aligning legal clarity, ethical responsibility, and social trust, AI can be harnessed as a transformative tool that advances not only efficiency but also justice and sustainability in environmental health and safety.

Conflict of interest

The authors declare no conflict of interest

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