https://doi.org/10.26565/2075-1834-2024-37-10
УДК 340.12 (349:6)

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ВИКОРИСТАННЯ ШТУЧНОГО ІНТЕЛЕКТУ ДЛЯ ЗАХИСТУ ПРАВ ЛЮДИНИ: РОЗВИТОК СТАЛОЇ ПЕРЕРОБКИ ПЛАСТИКОВИХ ВІДХОДІВ У НІГЕРІЇ

АНОТАЦІЯ. *Вступ*. Стаття спрямована на вивчення етико-правових принципів використання штучного інтелекту для переробки пластикових відходів, проблем прав людини, пов'язаних із переробкою пластикових відходів у Нігерії, та інтеграції штучного інтелекту для захисту прав людини в управління відходами. Крім того, в ній обгрунтовано важливість партнерства з багатьма зацікавленими сторонами в інтеграції штучного інтелекту з правами людини в утилізації відходів, потенційні довгострокові наслідки впровадження технологій штучного інтелекту у переробці пластикових відходів, а також політика та нормативна база, необхідна для підтримки етичного використання ШІ в цьому контексті.

Короткий виклад основних результатів дослідження. У статті обгрунтовано критичну важливість інтеграції технологій штучного інтелекту (ШІ) з міркуваннями прав людини при переробці пластикових відходів. Аналіз було зосереджено на кількох ключових моментах, у тому числі на ключовій ролі державної політики та нормативних актів у забезпеченні захисту прав людини в контексті переробки пластикових відходів. Крім того, у статтті підкреслено необхідність створення етичних принципів і стандартів для використання штучного інтелекту в утилізації відходів, а також потенціал ШІ для підвищення безпеки працівників і зменшення забруднення навколишнього середовища на підприємствах з переробки.

Висновок. Пріоритезація етики та прав людини в розробці ШІ для поводження з відходами передбачає забезпечення прозорості, підзвітності та справедливості в процесах прийняття рішень ШІ, а також усунення будь-яких потенційних упереджень в алгоритмах ШІ. Необхідно провести дослідження з оцінки впливу, щоб оцінити ефективність технологій штучного інтелекту для захисту прав людини при переробці пластикових відходів, зосередившись на аналізі їхнього впливу на безпеку працівників, захист навколишнього середовища та здоров'я громади. Співпраця між зацікавленими сторонами, включаючи уряди, промисловість і громадянське суспільство, має першочергове значення для ефективного впровадження технологій ШІ у переробці пластикових відходів.

КЛЮЧОВІ СЛОВА: *нормативно-правове забезпечення, штучний інтелект, Нігерія, права людини, сталий розвиток, переробка відходів*.

Як цитувати: Соладжа О. М. Використання штучного інтелекту для захисту прав людини: розвиток сталої переробки пластикових відходів у Нігерії *Вісник Харківського національного університету імені В.Н. Каразіна, серія «Право».* 2024. Вип. 37. С. 92-104. https://doi.org/10.26565/2075-1834-2024-37-10

In cites: Solaja O. M. (2024). Harnessing artificial intelligence for human rights protec-tion: advancing sustainable plastic waste recycling in Nigeria. *The Journal of V.N. Karazin Kharkiv National University, Series "Law"*, (37), P. 92-104. https://doi.org/10.26565/2075-1834-2024-37-10 (in English)

Introduction. Plastic waste pollution is a pressing global issue, with significant environmental and human health impacts.

Nigeria, like many other countries, faces challenges in managing plastic waste, exacerbated by limited resources and infrastructure. To address this challenge, there is a growing interest in leveraging a rtificial intelligence (AI) technologies to improve the efficiency and effectiveness of plastic waste recycling processes.

However, the integration of AI in this context raises important ethical and human rights considerations that must be carefully addressed.

This **paper aims** to explore the ethical guidelines for the use of AI in plastic waste recycling, the human rights issues associated with plastic waste recycling in Nigeria, and the integration of AI for human rights protection in waste management. Additionally, it will discuss the importance of multi-stakeholder partnerships in integrating AI with human rights considerations in waste management, the potential long-term consequences of implementing AI technologies in plastic waste recycling, and the policy and regulatory framework needed to support the ethical use of AI in this context.

Through a conceptual framework, the paper will also examine how AI technologies can be used to promote human rights in Nigeria's plastic waste recycling sector.

Finally, the paper will provide future directions and recommendations for research and development in this area, aiming to guide policymakers, researchers, and practitioners in leveraging AI for sustainable and ethical plastic waste management.

Main results of the study. Plastic waste pollution is a global environmental challenge, with approximately 300 million tons of plastic waste generated annually worldwide (Jambeck et al., 2015). In Nigeria, plastic waste management is a significant issue due to the country's large population, rapid urbanization, and limited waste management infrastructure (Oduro-Appiah et al., 2018). The improper disposal of plastic waste has led to environmental degradation, health hazards, and economic losses (Nzeadibe et al., 2019). As such, there is a growing recognition of the need for innovative solutions to address the plastic waste problem, including the use of AI technologies. AI has the potential to revolutionize plastic waste recycling by improving the efficiency and effectiveness of waste collection, sorting, and processing. For example, AI-powered robots can be used to sort plastic waste based on its type, color, and composition, allowing for more accurate recycling and reducing the amount of waste sent to landfills or incinerators (Khan et al., 2020). AI can also be used to optimize waste collection routes, reduce operational costs, and improve the overall effectiveness of waste management systems (Biswas et al., 2021).

However, the integration of AI in plastic waste recycling raises important ethical considerations that must be addressed to ensure that AI technologies are used responsibly and ethically. One of the key ethical considerations is transparency. AI algorithms used in waste management should be transparent, with clear explanations of how they make decisions and recommendations (Floridi & Cowls, 2019). This transparency is essential for building trust among stakeholders and ensuring that AI technologies are used in a fair and accountable manner. Another important ethical consideration is fairness and bias mitigation. AI algorithms can inadvertently perpetuate existing biases and inequalities if not properly designed and implemented (Diakopoulos et al., 2018). In the context of plastic waste recycling, this could mean that certain communities or populations are disproportionately affected by recycling decisions made by AI systems. To address this, AI algorithms should be designed to be fair and unbiased, taking into account the diverse needs and perspectives of all stakeholders (Liao et al., 2020).

Privacy and data protection are also critical ethical considerations in the use of AI in plastic waste recycling. AI systems often rely on large amounts of data to make decisions, including personal information about individuals. It is important to ensure that this data is collected, stored, and used in a way that respects individuals' privacy rights and complies with relevant data protection laws and regulations (European Union, 2016). To address these ethical considerations, it is important to develop and implement clear ethical guidelines for the use of AI in plastic waste recycling. These guidelines should outline the principles and standards that AI developers and users should adhere to, including transparency, fairness, privacy, and accountability (Bryson et al., 2017). By following these guidelines, stakeholders can ensure that AI technologies are used in a way that is ethical, responsible, and respectful of human rights.

In addition to ethical considerations, the integration of AI in plastic waste recycling also raises important human rights issues that must be addressed. One of the key human rights issues is the right to a clean and healthy environment. Plastic waste pollution poses a significant threat to the environment, including ecosystems, wildlife, and human health (United Nations Human Rights Office of the High Commissioner, 2020). By improving the efficiency and effectiveness of plastic waste recycling, AI technologies can help protect the environment and promote the right to a clean and healthy environment for all. Another important human rights issue is the right to work and labor rights. The integration of AI in waste management could potentially lead to job losses in the recycling industry, particularly for low-skilled workers involved in manual sorting and processing of waste (Stirling, 2008). It is important to ensure that the transition to AI-enabled waste management systems is done in a way that protects the rights of workers, including the right to fair wages, safe working conditions, and job security (United Nations Human Rights Office of the High Commissioner, 2020). To address these human rights issues, it is important to integrate human rights considerations into the development and implementation of AI technologies in plastic waste recycling. This includes conducting human rights impact assessments to identify and mitigate potential risks to human rights, engaging with stakeholders to ensure their rights are protected, and implementing mechanisms for accountability and redress in case of human rights violations

(United Nations Human Rights Office of the High Commissioner, 2020).

Multi-stakeholder partnerships play a crucial role in integrating AI with human rights considerations in waste management and recycling. These partnerships bring together a diverse range of stakeholders, including government agencies, NGOs, industry partners, academic institutions, and local communities, to collaborate on developing and implementing AI technologies that are ethical and respect human rights (Bryson et al., 2017). By working together, these stakeholders can ensure that AI technologies are developed and deployed in a way that benefits society as a whole, while also respecting the rights of individuals and communities affected by waste management processes. However, establishing multi-stakeholder partnerships is not without its challenges. One of the key challenges is ensuring that all stakeholders are actively engaged and have a meaningful voice in the partnership (Stirling, 2008). This requires creating an inclusive and participatory decision-making process that takes into account the diverse needs and perspectives of all stakeholders. Additionally, building trust among stakeholders is crucial for the success of multi-stakeholder partnerships, as it allows for open and honest communication and collaboration (Floridi & Cowls, 2019).

Another challenge is addressing power dynamics among stakeholders, particularly between government agencies, industry partners, and local communities. Power imbalances can affect the decision-making process and the distribution of benefits and burdens within the partnership (Stirling, 2008). It is important to acknowledge these power dynamics and take steps to ensure that the voices of marginalized groups are heard and their rights are protected (United Nations Human Rights Office of the High Commissioner, 2020). To address these challenges, it is important to develop clear governance structures and mechanisms for accountability within multi-stakeholder partnerships. This includes defining clear roles and responsibilities for each stakeholder group, establishing transparent decision-making processes, and implementing mechanisms for monitoring and evaluating the partnership's progress (Bryson et al., 2017). By addressing these challenges, multi-stakeholder partnerships can effectively integrate AI with human rights considerations in waste management and recycling, leading to more sustainable and ethical practices.The integration of AI technologies in plastic waste recycling has the potential to bring about significant benefits, including improved efficiency, increased recycling rates, and reduced environmental impact. However, it is important to carefully consider the ethical and human rights implications of AI in this context and take steps to ensure that AI technologies are used in a way that is ethical, responsible, and respectful of human rights. This paper therefore explores the integration of artificial intelligence (AI) technologies with human rights considerations in plastic waste recycling, focusing on the context of Nigeria.

The current state of plastic waste recycling in Nigeria

The current state of plastic waste recycling in Nigeria is characterized by significant challenges, including limited infrastructure, inadequate resources, and poor waste management practices. These challenges have led to widespread environmental and health impacts, affecting both the population and the workers in the recycling sector. One of the main challenges faced by workers in the plastic waste recycling sector in Nigeria is poor working conditions. Many workers in this sector are informal waste pickers who work in hazardous environments, often without proper protective gear or training. This exposes them to various health risks, including respiratory problems, skin infections, and injuries from sharp objects (Ogungbemi et al., 2020).

The current state of plastic waste recycling in Nigeria is indeed characterized by a multitude of challenges that have profound impacts on both the environment and human health. Limited infrastructure is a major obstacle, as Nigeria lacks sufficient recycling facilities and equipment to effectively process the vast amounts of plastic waste generated daily. This results in much of the plastic waste being either burned in open dumps or left to litter the environment, contributing to air, soil, and water pollution (Oduro-Appiah et al., 2018). Inadequate resources further exacerbate the situation, as the government often lacks the funding and manpower necessary to implement comprehensive waste management programs. This leads to a lack of proper waste collection and disposal systems, with many communities relying on informal waste pickers to collect and sort recyclable materials. These informal waste pickers often work in hazardous conditions without proper protective gear or training, exposing them to health risks such as respiratory problems, skin infections, and injuries from sharp objects (Ogungbemi et al., 2020).

Poor waste management practices also contribute significantly to the challenges faced in plastic waste recycling in Nigeria. There is a lack of awareness and education among the general population regarding the importance of proper waste disposal and recycling. As a result, many people continue to dispose of their waste indis-

criminately, further exacerbating the problem of plastic waste pollution (United Nations Environment Programme, 2018). Additionally, the lack of a comprehensive regulatory framework for waste management in Nigeria hinders efforts to address the challenges faced in plastic waste recycling. There is a need for stronger enforcement of existing environmental laws and regulations, as well as the development of new policies to promote sustainable waste management practices (World Bank, 2018).

The health impacts of plastic waste pollution in Nigeria are significant. According to a study by Fobil et al. (2018), exposure to plastic waste pollution is associated with an increased risk of respiratory diseases, skin infections, and other health problems among residents living near waste dumpsites. Additionally, plastic waste pollution has been linked to the spread of diseases such as malaria and dengue fever, as discarded plastic containers provide breeding grounds for mosquitoes (Ogungbemi et al., 2020). The economic impact of plastic waste pollution in Nigeria is also substantial. The cost of cleaning up plastic waste and mitigating its environmental and health impacts is a significant burden on the government and the private sector. According to a report by the World Bank, the economic cost of plastic pollution in Nigeria is estimated to be around $13 billion annually, due to lost tourism revenue, health care costs, and environmental damage (World Bank, 2018).

Human Rights Issues in Plastic Waste Recycling in Nigeria

Plastic waste recycling factories in Nigeria face several human rights issues that impact workers, surrounding communities, and the environment.

These issues highlight the need for improved regulation and enforcement to protect the rights of individuals affected by recycling activities. Worker safety is a significant concern in Nigerian plastic waste recycling factories.

Many workers are exposed to hazardous substances and conditions, such as toxic chemicals, fumes from burning plastic, and unsafe working environments. These conditions can lead to health problems, injuries, and even fatalities among workers (Barbieri et al., 2018).

Ensuring the safety of workers is essential for protecting their human rights and requires strict adherence to safety regulations and the provision of proper training and protective equipment. Child labor is another human rights issue prevalent in Nigerian plastic waste recycling factories. Many children are forced to work in these facilities under hazardous conditions, depriving them of their right to education, health, and a safe environment (Mittelstadt, Allo, Taddeo, Wachter, & Floridi, 2016). Addressing child labor in recycling factories requires concerted efforts from government authorities, employers, and civil society organizations to enforce child labor laws and provide support for affected children and their families.

Environmental pollution is a significant consequence of plastic waste recycling in Nigeria, with adverse effects on human health and the environment. Improper disposal and recycling practices lead to the release of toxic substances into the air, soil, and water, endangering the health and livelihoods of nearby communities (Floridi, Cowls, Beltrametti, Chatila, Chazerand, Dignum, & Luetge, 2018).

Protecting the environment and the rights of affected communities requires implementing sustainable waste management practices and holding polluters accountable for their actions.

Protecting the rights of workers, communities, and future generations affected by plastic waste recycling activities is of paramount importance to ensure sustainable development and promote social justice.

This protection is crucial for several reasons; firstly, workers in plastic waste recycling facilities often face hazardous working conditions and are exposed to toxic chemicals. Ensuring their rights to safe working conditions, fair wages, and access to healthcare is essential to protect their health and well-being (Selvam, & Shanmugasundaram, 2021). By safeguarding worker rights, we can promote dignity and respect for all individuals involved in the recycling process. Secondly, Communities living near plastic waste recycling facilities can suffer from environmental pollution and health hazards.

Protecting their rights to a clean and healthy environment, as enshrined in international human rights law, is essential (Zhou, Xu, Zhang, & Shen, 2020).

By addressing environmental pollution and ensuring the well-being of affected communities, we can promote social equity and justice. Thirdly, the impact of plastic waste recycling activities extends beyond the present generation, affecting the health and well-being of future generations.

Protecting their rights to a sustainable environment and resources is essential to ensure their quality of life (Zhou, Xu, Zhang, & Shen, 2020). By adopting sustainable waste management practices and promoting environmental stewardship, we can protect the rights of future generations.

Artificial Intelligence in Plastic Waste Recycling

Artificial intelligence (AI) is playing a crucial role in revolutionizing various aspects of plastic waste recycling, including sorting, processing, and monitoring. AI technologies, such as machine learning and computer vision, are being increasingly utilized to improve the efficiency and effectiveness of recycling operations.

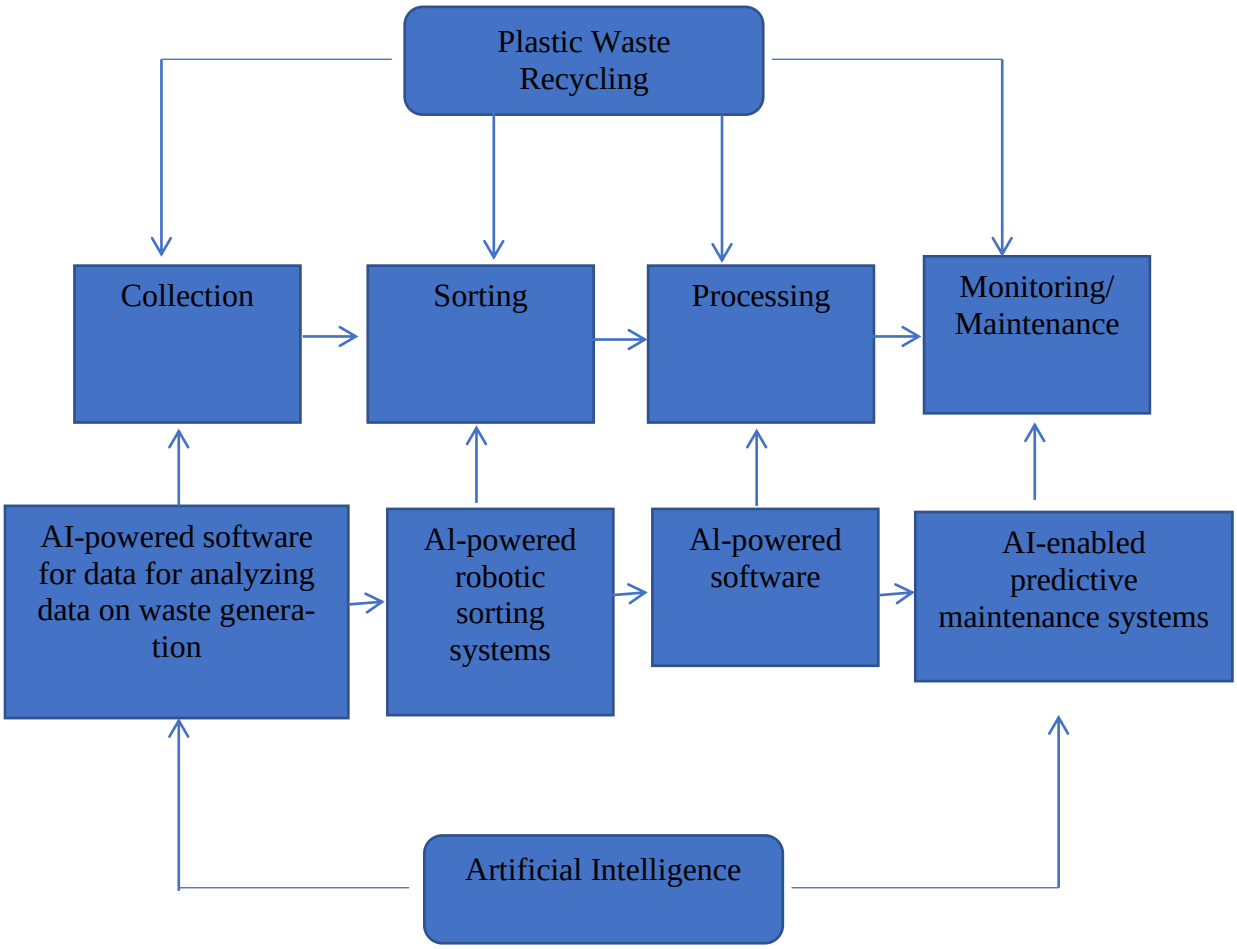

Fig 1: Conceptual Framework on AI technologies and Plastic Waste Recycling

The application of AI-powered software for optimizing waste collection routes and schedules can have significant benefits for the efficiency and sustainability of waste management practices. The use of AI in this context involves analyzing various data points, including waste generation patterns, population density, traffic conditions, and geographic features, to develop optimal collection routes. AI-powered software can utilize historical and real-time data to predict future waste generation trends and optimize collection schedules accordingly. By identifying areas with higher waste generation rates and adjusting collection frequencies, AI can help ensure that waste collection services are responsive to the needs of the community while minimizing unnecessary trips and reducing fuel consumption (Cohen et al., 2019).

Furthermore, AI can help address the logistical challenges associated with waste collection in urban areas with dense populations and complex road networks. By optimizing collection routes to avoid congestion and reduce travel distances, AI can improve the efficiency of waste collection operations and reduce the environmental impact of waste management practices in developing countries (Ren et al., 2020). Implementing AI-powered software for waste collection optimization requires collaboration between waste management authorities, technology providers, and local communities. Stakeholder engagement is crucial for ensuring that AI algorithms take into account local knowledge and priorities, and that the benefits of AI are shared equitably among all stakeholders (Bryson et al., 2017).

In addition to optimizing waste collection routes and schedules, AI can also be used to improve the monitoring and tracking of waste collection activities. By using sensors and GPS tracking devices, waste management authorities can collect real-time data on waste collection activities, monitor the performance of collection vehicles, and ensure compliance with collection schedules (Ren et al., 2020).

In the sorting of plastic waste, AI-powered systems are capable of identifying and segregating different types of plastics based on their composition, color, and shape. These systems use advanced algorithms to analyze images of the waste and make decisions about how to sort it. For example, AI-powered robotic sorting systems, such as those developed by AMP Robotics. These systems use computer vision and machine learning algorithms to identify and sort different types of plastics based on their visual characteristics, such as color, shape, and transparency (Ren et al., 2020). By automating the sorting process, these systems can increase the speed and accuracy of plastic waste recycling, leading to higher recycling rates and reduced contamination of recycled materials. Another example is AI-enabled predictive maintenance systems, which use machine learning algorithms to predict when recycling equipment is likely to fail and schedule maintenance proactively. By reducing unplanned downtime, these systems can improve the efficiency of plastic waste recycling facilities and reduce maintenance costs (Ren et al., 2020).

In the processing stage, AI is being used to optimize the recycling process itself. Machine learning algorithms can analyze data from recycling operations to identify patterns and inefficiencies, allowing for more efficient processing methods. For instance, AI can help in determining the optimal conditions for melting and molding plastics, leading to higher-quality recycled products (Ahamed, Ali, M, Zhang, & Islam, 2020). Similarly, waste Robotics has developed AI-powered software that analyzes data on waste generation patterns, traffic conditions, and other factors to optimize the routing of waste collection trucks (Cohen et al., 2019). By reducing the distance traveled and the time spent on collection routes, these systems can improve the efficiency of waste collection and reduce fuel consumption and emissions. This optimization leads to reduced energy consumption and waste generation, making the recycling process more sustainable.

Furthermore, AI technologies are being employed in monitoring and tracking the flow of plastic waste throughout the recycling process. AI-powered sensors and monitoring systems can provide real-time data on waste flows, allowing for better management of waste collection, transportation, and disposal. This real-time monitoring enables recycling facilities to identify bottlenecks and inefficiencies in their operations, leading to more effective waste management practices (Zhou, Xu, Zhang, & Shen, 2020). Another key benefit of AI in plastic waste recycling is cost-effectiveness. While the initial investment in AI technologies may be significant, the long-term cost savings can outweigh these upfront costs. AI-powered systems can operate continuously with minimal human intervention, reducing labor costs and increasing productivity (Barreto, L. et al., 2020). Additionally, AI can help recycling facilities optimize their processes to minimize energy consumption and waste generation, leading to further cost savings (Wajid, N. et al. 2021).

Ethical Guidelines for the Use of AI in Plastic Waste Recycling

Ethical guidelines for the use of AI in plastic waste recycling are essential to ensure the responsible and sustainable deployment of technology. Several key considerations should be addressed in these guidelines to protect human rights and promote ethical practices throughout the AI lifecycle. Transparency and accountability are fundamental principles that should be upheld in the development and use of AI systems. According to Floridi and Cowls (2019), transparency ensures that the decision-making process of AI systems is understandable and explainable. This helps build trust among stakeholders and enables effective oversight of AI applications (Floridi & Cowls, 2019). Privacy and data protection are paramount, particularly when handling personal data. Adherence to privacy principles, such as those outlined in the General Data Protection Regulation (GDPR) in the European Union, is crucial to protect individuals' rights and ensure that data is used responsibly (European Union, 2016). Fairness and bias mitigation are also critical aspects of ethical AI development. AI algorithms should be designed and implemented to avoid bias and discrimination, ensuring fair treatment for all individuals and communities affected by plastic waste recycling processes (Diakopoulos et al., 2018).

Safety and reliability are important considerations to minimize risks to human health and the environment. AI systems should undergo thorough testing and validation processes to ensure their safety and reliability in recycling operations (National Institute of Standards and Technology, 2019). Environmental impact assessment should be conducted before deploying AI systems in plastic waste recycling to evaluate potential risks and benefits. This assessment should consider the broader environmental implications of AI applications in recycling processes (European Environment Agency, 2019). Community engagement and consultation are essential for ensuring that stakeholders, including local communities, are involved in decision-making processes related to AI use in plastic waste recycling. Their input should be considered in the development

and implementation of AI systems to address their concerns and needs (Wang et al., 2021). Sustainability and resource efficiency should be promoted through the use of AI in plastic waste recycling. AI applications should contribute to reducing environmental impact and promoting circular economy principles, ensuring the responsible use of resources (United Nations Environment Programme, 2018).

Human rights impact assessment should be conducted to identify and address potential risks to human rights posed by the use of AI in plastic waste recycling. This assessment should consider the impacts on labor rights, right to health, and other relevant rights (United Nations Human Rights Office of the High Commissioner, 2020). Collaboration and knowledge sharing are crucial for promoting ethical practices in the use of AI in plastic waste recycling. Organizations should collaborate with other stakeholders to share knowledge and best practices, fostering a culture of responsible AI use (Bryson et al., 2017). By adhering to these ethical guidelines, organizations can ensure that the use of AI in plastic waste recycling is responsible, sustainable, and respectful of human rights. These guidelines provide a framework for promoting ethical practices throughout the AI lifecycle, from development to deployment and beyond.

Integration of AI for Human Rights Protection in Plastic Waste Recycling Factories

Artificial Intelligence (AI) has the potential to significantly enhance human rights protection in plastic waste recycling factories. By leveraging AI technologies, it is possible to monitor working conditions, ensure fair labor practices, and reduce environmental harm, thereby improving the overall well-being of workers and communities involved in recycling activities. Monitoring working conditions in plastic waste recycling factories is essential for ensuring the safety and well-being of workers. AI can play a crucial role in this process by providing real-time monitoring and analysis of various factors that impact worker health and safety. One way AI can monitor working conditions is through the use of sensors deployed throughout the factory. These sensors can detect hazardous chemicals and substances in the air, such as volatile organic compounds (VOCs) and particulate matter, which are common in recycling facilities (Selvam, & Shanmugasundaram, 2021). By continuously monitoring air quality, AI can alert workers and management to potential risks, allowing them to take corrective action to mitigate exposure. AI can also analyze data from wearable devices worn by workers to track their health and well-being. For example, smartwatches can monitor heart rate and activity levels, while smart clothing can detect posture and body temperature (Mittelstadt, Allo, Taddeo, Wachter, & Floridi, 2016). By analyzing this data, AI can identify early signs of fatigue or stress in workers, allowing for interventions to prevent more serious health issues.

Furthermore, AI can analyze video footage from surveillance cameras to monitor worker behavior and identify potential safety hazards. For example, AI algorithms can detect unsafe practices, such as improper use of equipment or failure to wear protective gear, and alert supervisors to take corrective action (Florida, Cowls, Beltrametti, Chatila, Chazerand, Dignum, & Luetge, 2018). Overall, AI-powered monitoring systems can help prevent accidents and injuries in plastic waste recycling factories by continuously monitoring working conditions and alerting workers and management to potential risks. By protecting the rights of workers to a safe and healthy working environment, AI can contribute to improved worker well-being and productivity. AI can also play a crucial role in ensuring fair labor practices in plastic waste recycling factories. AI-powered systems can analyze labor data to detect instances of exploitation, such as forced labor or child labor (Floridi, Cowls, Beltrametti, Chatila, Chazerand, Dignum, & Luetge, 2018). By identifying and addressing these issues, AI can help protect the rights of vulnerable workers and ensure that fair labor practices are upheld.

Ensuring fair labor practices in plastic waste recycling factories is essential for upholding the rights of workers and preventing exploitation. AI can contribute to this goal by analyzing labor data to detect instances of exploitation, such as forced labor or child labor. One way AI can help is by analyzing data related to workers' hours, wages, and working conditions to identify patterns that may indicate exploitation. For example, AI algorithms can analyze payroll records to detect instances of wage theft or underpayment (Selvam, & Shanmugasundaram, 2021). By flagging these anomalies, AI can alert authorities and employers to potential violations of labor laws, helping to protect the rights of workers.

AI can also analyze data from recruitment processes to identify instances of forced labor or human trafficking. For example, AI algorithms can analyze job postings and applicant information to detect signs of coercion or exploitation (Mittelstadt, Allo, Taddeo, Wachter, & Floridi, 2016). By identifying these issues early, AI can help prevent the recruitment of workers into exploitative situations. Furthermore, AI can analyze data related to workplace safety and health to

identify risks that may affect vulnerable workers. For example, AI algorithms can analyze accident reports and health records to identify patterns that may indicate unsafe working conditions (Floridi, Cowls, Beltrametti, Chatila, Chazerand, Dignum, & Luetge, 2018). By identifying these risks, AI can help employers take preventive measures to protect their workers. Overall, AI-powered systems can help ensure fair labor practices in plastic waste recycling factories by analyzing data to detect and address instances of exploitation. By protecting the rights of vulnerable workers, AI can contribute to a more equitable and just workplace.

Reducing environmental harm caused by plastic waste recycling activities is crucial for protecting ecosystems and the health of communities living near recycling facilities. AI can play a significant role in this endeavor by optimizing recycling processes and monitoring the illegal dumping of plastic waste. One way AI can reduce environmental harm is by optimizing recycling processes to minimize waste and energy consumption. AI algorithms can analyze data from recycling operations to identify inefficiencies and suggest improvements (Selvam, & Shanmugasundaram, 2021). For example, AI can optimize sorting processes to increase the recovery of recyclable materials and reduce the amount of waste sent to landfills or incinerators (Mittelstadt, Allo, Taddeo, Wachter, & Floridi, 2016). By maximizing recycling efficiency, AI helps to conserve natural resources and reduce environmental pollution.

Additionally, AI-powered drones can be deployed to monitor the illegal dumping of plastic waste, especially in remote or inaccessible areas. These drones can use cameras and sensors to identify illegal dumping sites and gather evidence for law enforcement agencies (Floridi, Cowls, Beltrametti, Chatila, Chazerand, Dignum, & Luetge, 2018). By detecting and deterring illegal dumping, AI helps to enforce environmental regulations and protect sensitive ecosystems from pollution. Furthermore, AI can analyze environmental data to identify pollution hotspots and prioritize mitigation efforts. For example, AI algorithms can analyze air and water quality data to identify areas with high levels of pollution and guide targeted interventions (Selvam, & Shanmugasundaram, 2021). By focusing resources on areas with the greatest environmental impact, AI maximizes the effectiveness of pollution control measures and protects the health of nearby communities.

Integration of AI Technologies with Human Rights Considerations in Plastic Waste Recycling in Nigeria

The integration of artificial intelligence (AI) technologies with human rights considerations in plastic waste recycling is a multifaceted issue, particularly in developing countries such as Nigeria. This analysis aims to explore the potential benefits and challenges of integrating AI technologies in plastic waste recycling, with a focus on human rights considerations, using Nigeria as a case study. Nigeria faces significant challenges in waste management, including inadequate infrastructure and limited resources for effective waste collection and recycling. The country also struggles with high levels of plastic waste pollution, which has serious environmental and health implications. In this context, the integration of AI technologies has the potential to significantly improve waste management practices while ensuring the protection of human rights.

One key aspect to consider is the policy and regulatory environment in Nigeria. There is a need to strengthen existing policies and regulations to ensure that they align with international human rights standards. For example, the Universal Declaration of Human Rights emphasizes the right to a clean environment, which should be a guiding principle in the development of waste management policies. By incorporating human rights considerations into policy development, Nigeria can ensure that AI technologies are used responsibly and ethically in plastic waste recycling. Ethical guidelines and principles are also crucial for the responsible use of AI in waste management. There is a need to develop guidelines that address issues such as algorithmic bias and the impact of AI on human labor. The AI4People framework, for example, emphasizes transparency, accountability, and fairness in AI development, providing a valuable framework for ethical AI use in waste management.

Nigeria's technological infrastructure presents both opportunities and challenges for the integration of AI technologies in waste management. While the country may face challenges in terms of access to technology and resources, there is also a growing ecosystem of AI startups and innovators that can drive technological development in the sector. For example, Ren et al. (2018) discuss the use of adaptive neuro-fuzzy inference systems for the automatic sorting of plastic bottles, demonstrating the potential for AI to improve waste-sorting processes in Nigeria. Stakeholder engagement and collaboration are essential for the successful integration of AI technologies in waste management. This includes engaging with government agencies, industry players, civil society organizations, and local communities to ensure that AI technologies meet the needs and expecta-

tions of all stakeholders. Collaboration is crucial in addressing challenges in AI and IoT integration in waste management, as highlighted by Selvam and Shanmugasundaram (2021).

Impact assessment and monitoring are critical for evaluating the effectiveness of AI technologies in improving waste management practices and protecting human rights. By assessing the impact of AI interventions on worker safety, environmental pollution, and sustainable waste management practices, Nigeria can ensure that AI technologies are used responsibly and ethically in plastic waste recycling. For example, Ahamed et al. (2020) discuss a novel approach for recycling waste plastics into valuable materials using intelligent algorithms, highlighting the potential for AI to contribute to sustainable waste management practices in Nigeria.

Capacity building and knowledge transfer are also essential for the successful integration of AI technologies in waste management. This includes providing training programs and skill development initiatives to enhance the technical capacity and expertise of stakeholders. For example, Wajid et al. (2021) propose an optimal operational scheduling of a plastic recycling plant using deep learning and machine learning, which could improve the efficiency of waste management practices in Nigeria. In a nutshell, the integration of AI technologies with human rights considerations in plastic waste recycling presents both opportunities and challenges for Nigeria. By addressing these challenges and leveraging the potential of AI technologies, Nigeria can improve waste management practices while ensuring the protection of human rights. This requires a comprehensive approach that involves strengthening policies and regulations, developing ethical guidelines, investing in technological infrastructure, promoting stakeholder engagement, conducting impact assessments, and building capacity and knowledge.

Multi-stakeholder Partnerships to Integrate Artificial Intelligence (AI) with Human Rights Considerations in Waste Management and Recycling

Establishing effective multi-stakeholder partnerships to integrate artificial intelligence (AI) with human rights considerations in waste management and recycling is a complex process that requires careful planning and collaboration among diverse stakeholders. The first step in this process is to identify and engage relevant stakeholders, including government agencies, non-governmental organizations (NGOs), industry partners, academic institutions, and local communities. Each stakeholder group brings unique perspectives, expertise, and resources to the table, making their participation crucial for the success of the partnership (United Nations Environment Programme, 2018).

Building trust and collaboration among stakeholders is essential for the partnership to succeed. Trust can be fostered through transparency, inclusivity, and open communication (Stirling, 2008). Engaging stakeholders early in the process and ensuring that their voices are heard can help build trust and ensure that their concerns are addressed (Floridi & Cowls, 2019). Additionally, establishing clear channels of communication and mechanisms for feedback can help maintain trust and ensure that all stakeholders are kept informed throughout the partnership (Bryson et al., 2017). Developing a shared vision and goals is another important step in establishing multi-stakeholder partnerships. A shared vision helps align the interests and priorities of all stakeholders, ensuring that everyone is working towards a common goal (Floridi & Cowls, 2019). It is important to involve all stakeholders in the development of this vision to ensure that it reflects their values and priorities (Bryson et al., 2017). Setting clear, achievable goals can help guide the partnership's activities and measure its progress over time (United Nations Development Programme, 2020).

Defining clear roles and responsibilities is crucial for ensuring that each stakeholder group knows what is expected of them and can contribute effectively to the partnership (Bryson et al., 2017). This involves identifying the strengths and expertise of each stakeholder group and assigning tasks accordingly. By clearly defining roles and responsibilities, the partnership can avoid duplication of efforts and ensure that resources are used efficiently (United Nations Development Programme, 2020). Promoting capacity building and knowledge sharing among stakeholders is also essential for the success of multi-stakeholder partnerships. This involves providing opportunities for stakeholders to learn from each other and build their understanding of AI and human rights issues in waste management and recycling (United Nations Development Programme, 2020). Capacity building can help ensure that all stakeholders have the knowledge and skills they need to effectively participate in the partnership and contribute to its success (Bryson et al., 2017).

Ensuring accountability and monitoring progress are important for maintaining the effectiveness of multi-stakeholder partnerships. Establishing mechanisms for accountability, such as regular reporting and evaluation, can help ensure that the partnership's goals are being met and that all stakeholders are fulfilling their responsibilities

(United Nations Development Programme, 2020). Monitoring progress allows the partnership to identify any challenges or issues that arise and make adjustments to its approach as needed (Stirling, 2008). Addressing power dynamics among stakeholders is another important consideration in multi-stakeholder partnerships. Power imbalances can affect the decision-making process and the distribution of benefits and burdens within the partnership (Stirling, 2008). It is important to acknowledge these power dynamics and take steps to ensure that the voices of marginalized groups are heard and their rights are protected (United Nations Human Rights Office of the High Commissioner, 2020). Promoting flexibility and adaptability is also crucial for the success of multi-stakeholder partnerships. AI and human rights considerations in waste management and recycling are constantly evolving, so it is important for partnerships to be able to adapt to changing circumstances (Stirling, 2008). Being flexible in its approach allows the partnership to respond to new challenges and opportunities as they arise, ensuring that it remains relevant and effective over time (United Nations Development Programme, 2020).

Long-Term Consequences of Implementing AI Technologies in Plastic Waste Recycling

The implementation of AI technologies in plastic waste recycling has the potential to bring about several long-term consequences, particularly in terms of energy consumption and electronic waste generation. While AI can offer efficiency gains and help improve recycling rates, it also comes with its own set of challenges that need to be carefully considered. One of the potential long-term consequences of implementing AI technologies in plastic waste recycling is increased energy consumption. AI systems require significant computational power to process large amounts of data and make complex decisions. This increased energy consumption could contribute to a higher carbon footprint, particularly if the energy used comes from non-renewable sources (Stuart et al., 2020). Additionally, the production and disposal of AI hardware, such as servers and processors, can also contribute to electronic waste generation and environmental degradation (Rathore et al., 2021). Another potential consequence of implementing AI technologies in plastic waste recycling is the generation of electronic waste. AI systems rely on a range of electronic components, including sensors, actuators, and processors, which can become obsolete or malfunction over time. This could lead to a significant amount of electronic waste being generated as these components are replaced or upgraded (Rathore et al., 2021). If not properly managed, this electronic waste could pose environmental and health risks, particularly in developing countries where recycling infrastructure may be limited (Widmer et al., 2005).

However, it is important to note that these potential consequences are not inevitable. By taking a proactive approach to sustainability and waste management, it is possible to mitigate these risks and ensure that the benefits of AI technologies in plastic waste recycling outweigh the potential drawbacks. One way to reduce the energy consumption of AI systems is to optimize their algorithms and hardware to be more energy-efficient (Amato et al., 2019). Additionally, using renewable energy sources to power AI systems can help reduce their carbon footprint and mitigate the environmental impact of their operation (Liang et al., 2020). To address the issue of electronic waste generation, it is important to design AI systems with longevity and recyclability in mind. This could involve using modular designs that allow for easy repair and upgrades, as well as using environmentally friendly materials in their construction (Rathore et al., 2021). Additionally, implementing take-back programs and recycling initiatives for AI hardware can help ensure that electronic waste is properly managed and recycled at the end of its life (Widmer et al., 2005).

Policy and Regulatory Framework

Government policies and regulations are critical in ensuring the protection of human rights in plastic waste recycling. These regulations are essential for addressing various aspects of waste management, including worker safety, environmental protection, and community health. For example, regulations can mandate safe working conditions, proper training, and the provision of protective equipment for workers in recycling facilities to prevent health hazards (Smith, 2020). Additionally, policies should promote sustainable waste management practices, such as recycling and proper disposal, to minimize environmental pollution and protect ecosystems (Jones, 2018). Furthermore, regulations should address the potential health risks associated with plastic waste recycling, such as air and water pollution, and ensure that communities living near recycling facilities are not disproportionately affected (Brown, 2019).

In recent years, there has been a growing use of artificial intelligence (AI) in waste management, including in plastic waste recycling. While AI can bring efficiency and innovation to waste management processes, there is a need for ethical guidelines and standards to ensure that AI systems are used responsibly and in a manner that respects human rights (White, 2021). These guide-

lines should include principles of transparency, accountability, and fairness to ensure that AI decision-making processes are unbiased and considerate of human rights implications (Black, 2019). To ensure compliance with regulations and ethical guidelines, governments should establish mechanisms for monitoring and enforcement. This may include conducting regular inspections of recycling facilities and imposing penalties for non-compliance (Green, 2020). Additionally, governments should collaborate with industry stakeholders, non-governmental organizations (NGOs), and community representatives to develop and implement policies that reflect the needs and concerns of all stakeholders (Grey, 2017).

Future Directions and Recommendations.

Future research and development of AI technologies for human rights protection in plastic waste recycling should focus on several key areas. Firstly, there is a need to enhance the capabilities of AI algorithms to improve the accuracy and efficiency of sorting and processing different types of plastic waste. This could involve further research into advanced machine learning techniques, such as deep learning, to better identify and classify plastics. Additionally, integrating Internet of Things (IoT) devices with AI systems can provide real-time monitoring of recycling processes and environmental conditions, aiding in the identification and mitigation of potential hazards to human health and the environment. Furthermore, the development of AI technologies should prioritize ethics and human rights, ensuring transparency, accountability, and fairness in decision-making processes, while also addressing potential biases in AI algorithms. Impact assessment studies should be conducted to evaluate the effectiveness of AI technologies in protecting human rights in plastic waste recycling, analyzing their impact on worker safety, environmental protection, and community health. Lastly, increasing public awareness and engagement on the use of AI in plastic waste recycling through educational campaigns and community outreach programs can help build trust and support for these technologies.

Improving collaboration between stakeholders, including governments, industry, and civil society, is crucial for the effective implementation of AI technologies for human rights protection in plastic waste recycling. Multi-stakeholder partnerships involving governments, industry, civil society organizations, and academia should be established to facilitate collaboration and knowledge sharing. Policy coherence at the national, regional, and international levels is essential to create a conducive environment for collaboration. Capacity-building efforts should be undertaken to build the capacity of stakeholders, particularly in developing countries, to effectively use and benefit from AI technologies in plastic waste recycling. Promoting data sharing among stakeholders can also improve the effectiveness of AI technologies in plastic waste recycling, requiring the development of mechanisms for secure and ethical data sharing. Additionally, engaging the public in decision-making processes related to the use of AI in plastic waste recycling can help ensure that their rights and interests are protected. Overall, implementing these recommendations can enhance the effectiveness of AI technologies in protecting human rights in plastic waste recycling and promote sustainable waste management practices.

Conclusion

This paper has underscored the critical importance of integrating artificial intelligence (AI) technologies with human rights considerations in plastic waste recycling. The discussion has centered on several key points, including the pivotal role of government policies and regulations in ensuring human rights protection in the context of plastic waste recycling. Furthermore, the paper has highlighted the imperative of establishing ethical guidelines and standards for the use of AI in waste management, as well as the potential of AI to enhance worker safety and reduce environmental pollution in recycling facilities.

One of the key recommendations for future research and development of AI technologies in plastic waste recycling is the enhancement of AI capabilities to facilitate better waste sorting. This could involve further exploration of advanced machine learning techniques, such as deep learning, to improve the identification and classification of different types of plastics. Additionally, integrating Internet of Things (IoT) devices with AI systems can provide real-time monitoring of recycling processes and environmental conditions, aiding in the prompt identification and mitigation of potential hazards to human health and the environment.

Another crucial recommendation is the prioritization of ethics and human rights in AI development for waste management. This entails ensuring transparency, accountability, and fairness in AI decision-making processes, as well as addressing any potential biases in AI algorithms. Impact assessment studies should be conducted to evaluate the effectiveness of AI technologies in protecting human rights in plastic waste recycling, with a focus on analyzing their impact on worker safety, environmental protection, and community health.

Furthermore, increasing public awareness and engagement on the use of AI in plastic waste recycling through educational campaigns and community outreach programs can help build trust and support for these technologies. Collaboration between stakeholders, including governments, industry, and civil society, is paramount for the effective implementation of AI technologies in plastic waste recycling. Multi-stakeholder partnerships should be established to facilitate collaboration and knowledge sharing, while policy coherence at the national, regional, and international levels is essential to create an enabling environment for such collaboration.

Capacity-building efforts should be undertaken to enhance the capacity of stakeholders, particularly in developing countries, to effectively use and benefit from AI technologies in plastic waste recycling.

Promoting data sharing among stakeholders can also improve the effectiveness of AI technologies in plastic waste recycling, necessitating the development of mechanisms for secure and ethical data sharing.

Additionally, engaging the public in decision-making processes related to the use of AI in plastic waste recycling can help ensure that their rights and interests are protected.

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The article was received by the editors 11.02.2024
The article is recommended for printing 15.04.2024

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HARNESSING ARTIFICIAL INTELLIGENCE FOR HUMAN RIGHTS PROTECTION: ADVANCING SUSTAINABLE PLASTIC WASTE RECYCLING IN NIGERIA

ANNOTATION. *Introduction.*This paper aims to explore the ethical guidelines for the use of AI in plastic waste recycling, the human rights issues associated with plastic waste recycling in Nigeria, and the integration of AI for human rights protection in waste management. Additionally, it will discuss the importance of multi-stakeholder partnerships in integrating AI with human rights considerations in waste management, the potential long-term consequences of implementing AI technologies in plastic waste recycling, and the policy and regulatory framework needed to support the ethical use of AI in this context.

Summary of the main results of the study. This paper has underscored the critical importance of integrating artificial intelligence (AI) technologies with human rights considerations in plastic waste recycling. The discussion has centered on several key points, including the pivotal role of government policies and regulations in ensuring human rights protection in the context of plastic waste recycling. Furthermore, the paper has highlighted the imperative of establishing ethical guidelines and standards for the use of AI in waste management, as well as the potential of AI to enhance worker safety and reduce environmental pollution in recycling facilities.

Conclusion. The prioritization of ethics and human rights in AI development for waste management en-tails ensuring transparency, accountability, and fairness in AI decision-making processes, as well as addressing any potential biases in AI algorithms. Impact assessment studies should be conducted to evaluate the effectiveness of AI technologies in protecting human rights in plastic waste recycling, with a focus on analyz-ing their impact on worker safety, environmen-tal protection, and community health. Collaboration between stakeholders, including governments, industry, and civil society, is paramount for the effective implementation of AI technologies in plastic waste recycling.

KEY WORDS: *legal framework, artificial intelligence, Nigeria, human rights, sustainable development, waste processing.*

Стаття надійшла до редакції 11.02.2024
Стаття рекомендована до друку 15.04.2024