A LITERATURE STUDY ON ELECTRONIC WASTE FACILITY LOCATOR

ABSTRACT

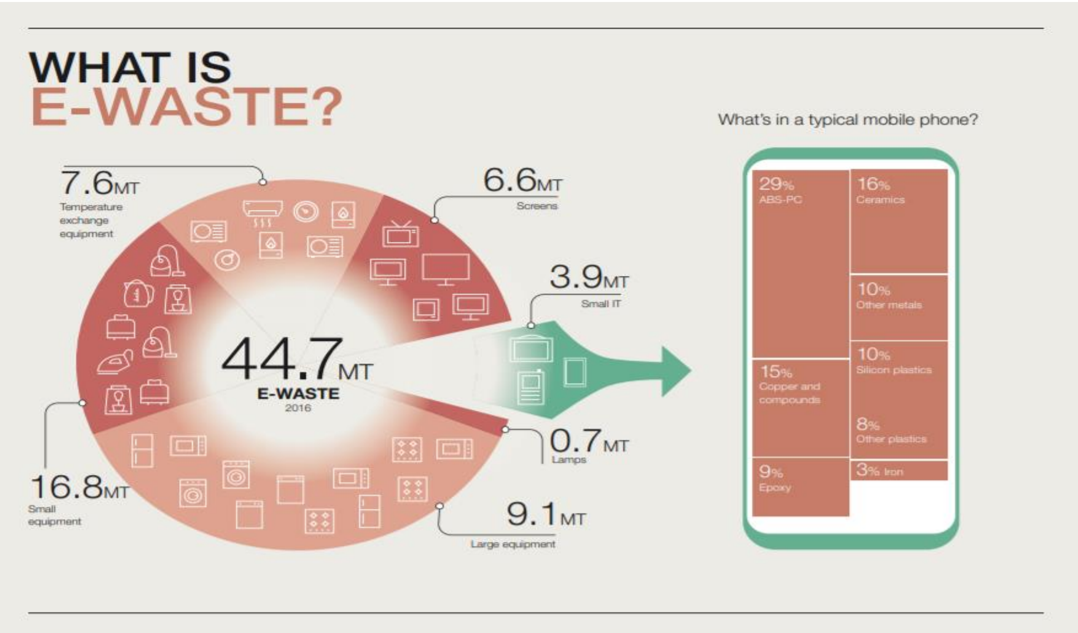
E-Waste Management Rules implemented in 2016 introduce significant changes to address the burgeoning issue of electronic waste. Notably, these rules now encompass Compact Fluorescent Lamps (CFLs) and other lamps containing mercury, broadening the scope of regulated electronic waste. For the first time, producers are placed under the umbrella of Extended Producer Responsibility (EPR), along with specified targets. This mandates producers to take accountability not only for e-waste collection but also for its safe disposal and exchange. In addition to producers, the rules involve a range of stakeholders, including manufacturers, dealers, refurbishers, and Producer Responsibility Organizations (PROs), fostering a collaborative and comprehensive approach to e-waste management. The regulations specifically address the environmental impact of Compact Fluorescent Lamps (CFLs) and other mercury-containing lamps, recognizing the need for their proper disposal. Various sectors, including hotels, residential colonies, bulk producers of consumer goods, ports, railway stations, airports, and pilgrimage spots, are targeted to ensure responsible handling and recycling of the solid waste generated in their facilities. To enhance transparency and accessibility, a WebBased E-Waste Facility Locator platform is introduced. This platform offers an intuitive user interface for both users and administrators, streamlining access to essential information related to e-waste disposal. Ultimately, these rules aim to not only regulate the disposal of electronic waste but also foster trust between device owners and the disposal process. The proposed platform incentivizes users by providing valuable information about their e-waste disposal, contributing positively to environmental sustainability.

Keywords:- An E-Waste recycling rate, electronic devices, Model, end-of life (EoL), Extended Producer Responsibility (EPR), locating, E-waste, Facility locator, Recycling centre, Disposal, Electronic waste, Eco-friendly, Sustainable, Environmental, Localized, Green technology, Waste management, Responsible recycling, Collection point, Ecycling, Authorized centres.

INTRODUCTION

E-waste, a prominent concern in contemporary times, often receives insufficient attention despite its significant impact on both the environment and human health. The inappropriate disposal of electronic waste, steadily increasing in volume, results in the emission of harmful chemicals, posing threats to ecosystems and human well-being. Furthermore, it contributes to the waste of valuable and precious metals that could otherwise be repurposed. The global challenge of e-waste has reached a critical stage, demanding immediate consideration and decisive action. In 2019, the global generation of e-waste amounted to a staggering 53.6 million tons (Mt), surpassing earlier predictions. Projections by Forti et al. suggest that this figure is expected to exceed 74 million tons (Mt) by 2030. Unfortunately, the rate of recycling is lagging behind the escalating production of e-waste, exacerbating the problem further. Moreover, the current rate of e-waste generation is rising alarmingly at a rate of 3–5%, posing a formidable challenge to both the environment and human health. Therefore, concrete measures are imperative for effective ewaste management and responsible disposal practices to mitigate the adverse impacts of this burgeoning crisis. The rate of e-waste generation is skyrocketing at an alarming pace, outpacing the growth of the global population. Remarkably, global e-waste production has surged three times faster than the increase in the global population. Despite this, a mere 17.4% of electronic waste was formally collected and recycled globally in 2019. Efforts to enhance global e-waste recycling have fallen short in keeping up with the escalating rate of e-waste generation. The recycling rate has only seen marginal improvement since its last calculation in 2014 (17%). Consequently, a substantial 82.6%

of e-waste remains either unrecycled or untracked, leading to illicit sales on black markets and eventual disposal in landfills (Forti et al., 2020; Li et al., 2013). Such practices pose severe threats to the environment and human health, given the hazardous materials present in e-waste, including lead, cadmium, and mercury, which can leach into the soil and groundwater, causing pollution and endangering human life. Thus, it is imperative to implement more effective and sustainable measures for ewaste management to counteract the adverse effects of this escalating problem. Recycling and recovering resources from electronic waste is a critical concern due to its potential hazards to both the environment and human health. The improper disposal of electronic waste can result in massive environmental and health problems, underscoring the urgency of addressing this issue. Electronic waste represents the fastest-growing waste category globally, and its environmental impact is becoming increasingly significant. While electronic waste recycling can yield tangible products, it also contains hazardous substances that must be appropriately treated before disposal. Substances such as lead, mercury, and cadmium, among others, pose environmental and health risks if mishandled. Therefore, effective management and disposal of electronic waste are crucial to mitigating the adverse effects of this burgeoning problem. Measures like improved collection and recycling systems, responsible disposal practices, and public awareness campaigns can help alleviate the negative impact of electronic waste on the environment and human health. Despite numerous attempts to manage e-waste, a lack of long-term sustainability plans, including collection, segregation, storage, transportation, and treatment methods, as well as supportive laws and regulations, has contributed to the ongoing problem of improper disposal of electronic waste worldwide. Figure 1 illustrates the projected generation of electronic waste and total solid waste, emphasizing the urgent need for effective management and disposal strategies. Currently, electronic waste constitutes 5% of global solid waste (SW), significantly contributing to the overall waste problem. Clearly articulating the issue of e-waste is a critical initial step in addressing the problem. Implementing effective collection and recycling systems, enacting regulations and laws to ensure responsible disposal practices, and increasing public awareness about proper e-waste management are essential measures for reducing the impact of electronic waste on the environment and humanhealth.



METHODOLOGY

The methodology for developing a Web-Based E-Waste Facility Locator platform involves a phased approach. Begin with careful planning and research to define objectives and understand market dynamics. Design the system with a focus on user-friendly interfaces and necessary features. Develop secure registration/login, information collection, and e-waste management modules. Integrate communication functionalities for user interaction. Implement testing for usability and security, followed by a strategic deployment. Collect user feedback for iterative improvements. Document processes comprehensively and devise marketing strategies for adoption. Maintain the platform with regular updates and security measures, ensuring a holistic and sustainable e-waste management solution.

LITERATURE SURVEY

In addressing the challenges posed by e-waste, scholars emphasize the adoption of suitable technological solutions. Key aspects highlighted for a holistic e-waste management approach include: A. Enhanced Transparency in E-Waste Movement: Recognizing the need for transparency, researchers stress the importance of understanding and monitoring the path of electronic waste. This involves tracking its journey from disposal to recycling or other final destinations. B. Implementation of Extended Producer Responsibility (EPR): The literature underscores the significance of embracing Extended Producer Responsibility (EPR) measures. This approach holds producers accountable for the entire lifecycle of their electronic products, including responsible disposal and recycling. C. Traceability throughout the E-Product Life Cycle: Scholars emphasize the necessity of traceability throughout the entire life cycle of electronic products. This encompasses tracking e-products from manufacturing through their use to eventual conversion into e-waste, ensuring a closed-loop system for recycling back into raw materials. D. Establishment of Appropriate Channels for E-Waste Collection: The review highlights the need for constructing efficient channels to collect e-waste. This involves creating accessible and convenient methods for individuals and organizations to dispose of electronic devices responsibly. E. Adequate Recycling Facilities and Technology-Driven Management: Literature emphasizes the critical role of a sufficient number of recycling facilities. Moreover, connectivity to a technology-driven e-waste management system is deemed essential for streamlining the recycling process and enhancing overall efficiency Despite the extensive research, there is a noticeable gap in the domain of electrical and electronic waste collection. The literature suggests a specific deficiency in the adoption of track-and-trace technologies and smart collection systems. This gap highlights the potential for advancements in technology-driven solutions to enhance the overall effectiveness of e-waste management, particularly in the context of monitoring, collection, and processing. Addressing this gap is crucial for developing comprehensive strategies that align with evolving technological landscapes and global In a study by Jalal Uddin Through innovative changes in product style below EXTENDED PRODUCER RESPONSIBILITY (ERP), use of environmentally friendly substitutes for dangerous substances, these impacts can be mitigated. A legal framework must be there for imposing EPR, RoHS for attaining this goal. Adoption of environmentally sound technologies for usage and employ of e-waste at the side of EPR and RoHS offers workable answer for environmentally sound management of e-waste. Manufacturers & suppliers need to set goals for reducing electronic waste. Encourage them to buy back old electronic products from consumers, disposing bulk e-waste only through authorized recyclers and send non tradable e-waste to authorized private developers for final disposal. According to Vijay N. Bhoi et al. most of the waste is inherently dangerous. It will degrade to provide leachate, which can contaminate water, and make lowland gas, that is explosive. Additionally, owing to the risks related to lowland sites, there are currently terribly strict needs on the development, operation and medical care of such sites. Most designing authorities desire a figured out quarry to be used for landscaping instead of a lowland web site that nobody desires in their "back yard". Product style should be used to assist to reduce not solely the character and quantity of waste, however conjointly to maximise end-of-life utilization. Makers, retailers, users, and disposers ought to share responsibility for reducing the environmental impacts of merchandise. A product-centred approach ought to be adopted to preserve and shield setting. Kuehr and Williams (2003) stated that an increasing market for reused PCs in developing countries is allowing people to own PCs and access technology at more affordable prices. Moreover, charitable organizations, such as Computer Mentor, Computer Aid, World Computer Exchange, Computers for Schools and others are expanding their boundaries and providing used and refurbished computers to organizations (e.g., schools) around the world. Furthermore, reuse also reduces the environmental impacts of technological artifacts by increasing their life spans and thereby reducing the demand for new equipment. Ramzy Kahhat, et al., (2008) stated in his article that some states are adopting e-waste regulations, but so far the U.S. does not have a federal regulation that addresses the complete e-waste situation, including residential and non-residential sectors. Federal level policies and regulations present the best way to address the e-waste situation (U.S. GAO, 2005) as they will overcome the lack of regulations in most states and will standardize regulations and policies in the country. This will create a more efficient national e-waste management system. In this scenario, the e-Market for returned deposit system will be the mechanism for residential customers to dispose of their devices in a way that motivates collection, recycle and reuse of e-waste. In a 2011 report, "Ghana E-Waste Country Assessment", found that of 215,000 tons of electronics imported to Ghana, 30% were brand new and 70% were used. Of the used product, the study concluded that 15% was not reused and was scrapped or discarded. Sivakumaran Sivaramanan confirmed that the public awareness and cooperation of manufactures are essential for the advancement of e-waste management system. And also it is the responsibility of government to allocate sufficient grants and protecting the internationally agreed environmental legislations within their borders. Licensing of certification like este wardship may ensure the security to prevent illegal smugglers and handlers of e-waste. As e-wastes are the known major source of heavy metals, hazardous chemicals and carcinogens, certainly diseases related to skin, respiratory, intestinal, immune, and endocrine and nervous systems including cancers can be prevented by proper management and disposal of e-waste. e-waste can be managed by developing ecodesign devices, properly collecting e-waste, recover and recycle material by safe methods, dispose of e-waste by suitable techniques, forbid the transfer of used electronic devices to developing countries, and raise awareness of the impact of e-waste. No single tool is adequate but together they can complement each other to solve this issue. A national scheme such as EPR is a good policy in solving the growing e-waste problems. Yamini Gupt & Samraj Sahay suggested that financial responsibility of the producers and separate collecting and recycling agencies contribute significantly to the success of the extended producer responsibility-based environmental policies. Regulatory provisions, takeback responsibility and financial flow come out to be the three most important aspects of the extended producer responsibility. Presence of informal sector had a negative impact on the regulatory provisions. In Sukeshini observed that proper e waste management will help efficient sourcing and collection right upto extraction and disposal of material, ensuring that e-waste will turn into lucrative products and business opportunity. The manufacturers have to take responsibility for adopting the guideline for manufacturing sound environment product and sustainability management should be started from the product manufacturing stage i.e raw material selection, product and process design can be the important factors for the designed for environment practices, which can facilitate the recycling and reuse. Manufacturer should also try and initiate a take back program to handle the waste so that proper management and disposal of e-waste can be done. This way as 60% e-waste is coming from industry, can contribute to a very large part of Electronic waste management collection and establishing clean e-waste channels. UNEP (2010) report predicts that by 2020, E-waste from old computers in India will increase to 500%; from discarded mobile phones will be about 18 times high; from televisions will be 1.5 to 2 times higher; from discarded refrigerators will double or triple; than its respective 2007 levels. Considering the growth rate, studies show that the volume of E-waste will reach nearly 2 million MT by 2025. Samarkoon M.B. (2014) in his study states that improper handling of e-waste can cause harm to the environment and human health because of its toxic components. Although the current emphasis is on end-of-life management of e-waste activities, such as reuse, servicing, remanufacturing, recycling and disposal, upstream reduction of e-waste generation through green design and cleaner production must be introduced to enhance a sustainable e-waste management system for Sri Lanka. Xinwen Chi et al. (2010) in their study gathered information on informal e-waste management, in China and identifies some of the main difficulties of the current Chinese approach. Informal e-waste recycling is not only associated with serious environmental and health impacts, but also the supply deficiency of formal recyclers and the safety problems of remanufactured electronic products. Experiences already show that simply prohibiting or competing with the informal collectors and informal recyclers is not an effective solution. New formal e-waste recycling systems should take existing informal sectors into account, and more policies need to be made to improve recycling rates, working conditions and the efficiency of involved informal players. A key issue for China’s e-waste management is how to set up incentives for informal recyclers so as to reduce improper recycling activities and to divert more e-waste flow into the formal recycling sector. Shubham Gupta et al. (2014) studied that in developing countries like India, China, Indonesia, Brazil, commercial organizations tend to focus more on economic aspects rather than environmental regulations of e- waste recycling. So, for the profitable recovery of reusable materials and sustainable environment, the efficient recycling of this waste has been rendered indispensable, and is considered as a challenge for today’s society. Sikdar & Vaniya (2014) in their research stated that government should introduce some topics related to disposal of e-waste materials and its recycling and adverse effects of e-waste on health of human body in Environmental Education as a compulsory subject from lower to higher grades. The researcher realized recently that the education system alone is a powerful medium to ensure environmental protection. It should reach most parts of the population at a young age, and more e-waste friendly behavior should be practiced on daily basis. studied that the repair shops of electronic goods of the study area contributed an important role in extending the life span of electronic goods and thus reduce the number of thrown away e-goods. The study indicated that the high repair cost of the electronic goods and availability of comparatively cheaper new electronic goods with more features attracts the consumers towards the throw away culture, leading to accumulation of obsolete electronic items. Strengthening of formal recycling of e-waste is very essential for attaining sustainable development.

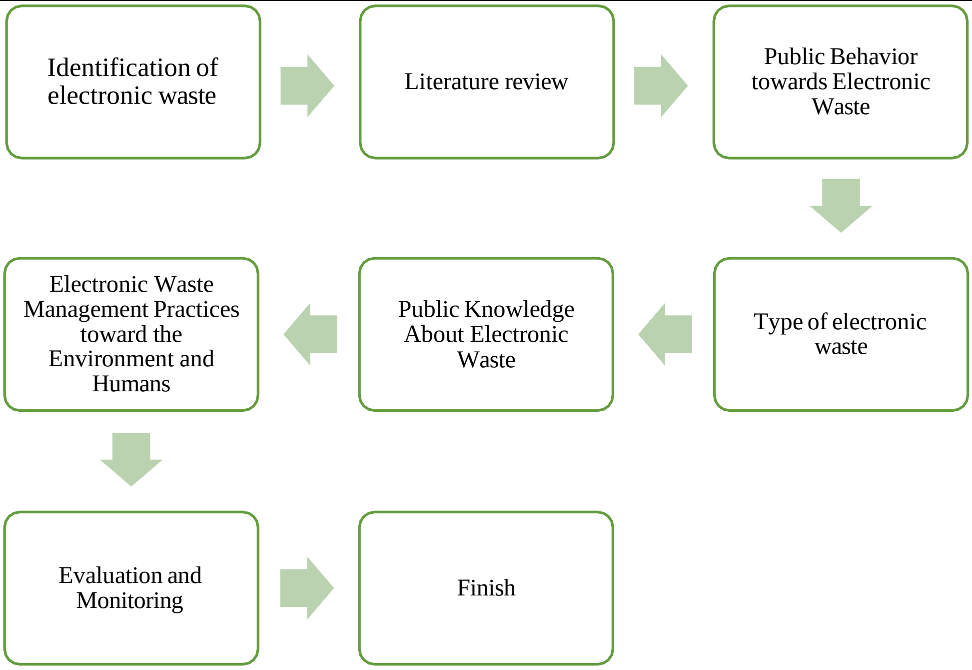


Figure 1: Flowchart of the electronic waste management model

Current Challenges for e waste tracking

Incomplete Database: Limited availability and accuracy of data on e-waste facilities, making challenging to provide comprehensive and up-to date information. Integration with Regulations: Adapting the locator to comply with diverse international, national, and regional regulations governing e-waste disposal practices. Public Awareness: Limited awareness among the public about the existence and benefits of web based e-waste facility locators, hindering widespread adoption. Accessibility: Ensuring the accessibility of the locator tool across various devices and internet speeds to reach a broader audienc Data Security and Privacy: Addressing concerns related to the security and privacy of user data when using the webbased e-waste facility locator. Funding and Support: Securing sustainable funding and support for the continuous development, maintenance, and promotion of the web-based locator. Integration with E-commerce: Addressing Challenges related to integrating the e-waste facility locator with ecommerce platforms to encourage responsible disposal after product purchases. Monitoring and Evaluation: Establishing mechanisms for ongoing monitoring and evaluation to assess the effectiveness and impact of the locator in promoting responsible e-waste disposal. Technological Barriers: Overcoming technological challenges, such as limited internet connectivity in certain regions, to ensure the inclusivity of the locator tool. Partnership Collaboration: Encouraging collaboration among governments, private sectors, and non-profit organizations to collectively support and promote the use of the e-waste facility locator. User Education: Providing educational resources within the locator to inform users about the importance of proper e-waste disposal and the environmental impact of their actions. Maintenance of Data Accuracy: Implementing strategies to regularly update and maintain the accuracy of information within the e-waste facility locator as facilities and regulations evolve over time.

INTERFACE

The process for creating an e-waste Web Based E-Waste Facility Locator platform includes four steps.

The first step: registration This First step divided into two options login is for already registered customer /vender and signup option for a new customer /vender.

The second step: collect the information of about material Evaluate it: In that step following options are available A. Add Detailed B. Pickup Point C. Contact A. Add Detailed: This option allows the user to provide detailed information about the material. Users may input specific details, such as the type of electronic device, its condition, and any relevant information that helps in assessing its value or determining the appropriate disposal or recycling method. B. Pickup Point: This option facilitates the selection of a pickup point for the electronic waste. Users can choose a convenient location for the collection of the material, making the process more user-friendly and efficient. This might involve selecting a designated drop-off point or scheduling a pickup service at a specified address. C. Contact: The "Contact" option enables users to establish communication regarding the evaluation or disposal process. Users may provide contact information, allowing for followup queries, clarifications, or updates on the status of the material. This could include email addresses, phone numbers, or other means of communication. Volume 8, Issue 12, December – 2023 International Journal of Innovation

The Third Step: Process on E-Waste A. Evaluation B. Collection C. Sorting D. 3R (Repair, Reuse, Recycle) E. Dispose A. Evaluation: This stage focuses on assessing the electronic waste to understand its condition, value, and potential for further use or recycling. The evaluation helps determine the appropriate course of action for each item, whether it be repair, reuse, recycling, or disposal. B. Collection: In this step, the systematically gathered electronic waste is collected from various sources. This may involve scheduled pickups from designated locations or drop-off points, ensuring a streamlined and organized collection process. C. Sorting: Sorting is a crucial aspect of the e-waste management process. It entails categorizing collected items based on their materials, components, and condition. This organized sorting facilitates efficient downstream processing, allowing for targeted recycling and proper disposal. D. 3R (Repair, Reuse and Recycle): The 3R process involves making decisions on whether electronic items can be repaired, reused, or recycled. Items that can be repaired or reused are directed toward those processes, promoting sustainability and resource conservation. Meanwhile, items not suitable for reuse undergo recycling to recover valuable materials. E. Dispose: For electronic items that cannot be repaired, reused, or recycled, proper disposal is necessary. This involves employing environmentally responsible methods to minimize the impact on the environment and human health. Disposal practices adhere to regulations and guidelines to ensure ethical and sustainable e-waste management. By incorporating these steps, the e-waste management process aims to address environmental concerns, promote sustainable practices, and contribute to the responsible handling of electronic waste.

Fourth Step: Implementation Phases and Support Processes A. Feedback and Iteration: B. Documentation: C. Marketing and Adoption: D. Maintenance and Updates: A. Feedback and Iteration: Collect feedback from users and stakeholders. Make necessary improvements based on feedback and evolving requirements. B. Documentation: Prepare user manuals for customers and vendors. Document the technical aspects for future reference. C. Marketing and Adoption: Develop strategies to promote the platform and encourage adoption. Explore partnerships with e-waste recycling facilities and regulatory bodies. D. Maintenance and Updates: Establish a schedule for regular maintenance and updates. Stay vigilant about potential security threats and implement timely updates

RESULTS AND DISCUSSION

Based on the literature study in some developing countries, India can implement similar electronic waste management by considering the types of electronic waste whose quality and features cannot keep up with IT development as well as over warranty periods. In India, electronic waste generated by households has increased due to the affordable prices of electronic devices such as smartphones and the increasing supplies from the black market. Most Indian people extend the life of electronic devices by visiting electronic service centers. Electronic components that can still be used are utilized to repair other devices that require similar components. Meanwhile, electronic waste that can no longer be used is disposed of at the landfill. However, extending the life of electronic devices means extending the flow of e-waste. The copper content contained in electronic waste is grouped into B3 waste. The informal scale of electronic waste management can Be be seen from the scavengers collecting electronic waste and selling electronic components to used electronic agents. This flow is a common business model in Indonesia. The solution for waste management in Indonesia is through Extended Producer Responsibility (EPR). EPR is responsible for the production stage of the device, financing after the use of the device, and labeling the active period of the device. Besides, India has the Polybromodiphenyl ethers (PBDE) Project, a collaboration with the United Nations Development Program (UNDP) with the support of the Global Environment Facility (GEF) and the Industrial Sector Government. The estimated generation of electronic waste is estimated to reach 705.49 tons/year in 2050 with the Indian population of 950,790 people. The estimated percentage of waste disposed is 27.42%.

FUTURE DIRECTION

Moving forward, the landscape of waste management operations is set to undergo significant transformations, embracing sustainability and efficiency through digital innovations like robotic systems, smart tracking, sensors, RFID applications, mobile apps, and autonomous vehicles. Within this evolving scenario, the tracking stage emerges as acritical but often overlooked component, demanding seamless integration with digitalization, particularly in the context of ewaste. The proposed platform outlined in this study is not only slated for implementation but also dissemination to actively monitor and enhance e-waste practices in future research initiatives. Moreover, the anticipated benefits can be further amplified by incorporating blockchain technology. This strategic addition holds the potential to secure tracking data through a privacy-centric identity validation process, ensuring the utmost confidentiality and safety. A promising avenue for future investigation involves delving into the integration of this tracking method with circular economy approaches embedded within the proposed platform. This holistic approach could yield valuable insights into the repercussions of the black market on e-waste, facilitating a comprehensive evaluation. To achieve a nuanced understanding, future research endeavors may include comparative studies across diverse counties in Norway. Such studies would seek to unravel both commonalities and disparities in e-waste management issues, contributing to a more insightful comprehension of the challenges faced. In subsequent phases of research, the proposed platform is slated for further refinement through the infusion of advanced tools and techniques, with a specific focus on leveraging block chain technology. This evolutionary step aims to fortify the platform's capabilities, fostering a transformative impact on e-waste management practices.

CONCLUSION

In conclusion, the proposed project outlines a systematic and user-friendly approach to create a Web-Based E-waste Facility Locator platform. The process is divided into three main steps, each with its own set of options and functionalities. The first step focuses on user registration, offering a seamless experience for both already registered customers/vendors through a login option and new users through a signup option. This establishes a secure and personalized entry point into the platform. The second step involves collecting detailed information about electronic waste and evaluating it. The provided options, including "Add Detailed," "Pickup Point," and "Contact," ensure a comprehensive understanding of the materials, streamlining the assessment process and enabling effective communication. The third step, the E-Waste processing stage, encompasses critical activities such as evaluation, collection, sorting, 3R (Repair, Reuse, Recycle), and disposal. These steps prioritize sustainability and responsible waste management, aiming to extend the life of electronic devices through repair and reuse, while also facilitating recycling for materials recovery. Proper disposal methods adhere to environmental regulations and guidelines, minimizing the impact on ecosystems and human health. By incorporating these steps, the project strives to address environmental concerns, promote sustainable practices, and contribute to the responsible handling of electronic waste. The platform not only facilitates efficient e waste management but also encourages users to participate actively in promoting a greener and more sustainable future.

REFERENCES

1) Ackah, M. (2017). “Informal E-waste recycling in developing countries: review of metal(loid)s pollution, environmental impacts and transport pathways”. In Environmental Science and Pollution Research, 24(31), 24,092–24,101. https://doi.org/10.1007/s11356-017- 0273-y

2) .Hazra, A., Das, S., Ganguly, A., Das, P., Chatterjee, P. K., Murmu, N. C., & Banerjee, P. (2019).

3) “Plasma Arc Technology: A Potential Solution Toward Waste to Energy Conversion and of GHGs Mitigation”. In Waste Valorisation and Recycling 7 th IconSWM— ISWMAW 2017, Volume 2 (pp. 203-217). Springer Singapore. https://doi.org/10.1007/978-981-13-2784- 1_19

4) Sahoo, S., Mukherjee, A., & Halder, R. (2021). “A unified blockchain-based platform for global e-waste management”. In International Journal of Web Information Systems, 17
    a. 449–479. https://doi.org/10.1108/IJWIS-03-2021-0024 [5].

5) Lopez Alvarez, J. L., Aguilar Larrucea, M., FernandezCarriÅLon Quero, S., & Jimenez del Valle, A. (2008). “Optimizing the collection of used paper from small businesses through GIS techniques: The LeganÅLes case (Madrid, Spain)”. In Waste Management, 28(2), 282–293. https://doi.org/10.1016/j.wasman.2007.02.036

6) Mishima, K., Rosano, M., Mishima, N., & Nishimura, H. (2016). “End-of-Life Strategies for Used Mobile Phones Using Material Flow Modeling”. In Recycling, 1(1), 122–135.

7) E-Waste Management: From Waste to Resource. Author: Kang, Haiyan, et al. Journal of Hazardous Materials, vol. 285, 2015, pp. 267-279. DOI: https://doi.org/10.1016/j.jhazmat.2014.11.040

8) Electronic Waste Management: Recent Progress and Emerging Challenges.Author: Li, Jinhui, et al. Environmental Science and Pollution Research, vol. 24, no. 10, 2017, pp. 8791-8793. DOI: https://doi.org/10.1007/s11356-017-8742-0

9) . E-Waste Management: A Review of Recent Patents and Technologies. Author: Kumar, Amit, et al. *Recent Patents on Engineering*, vol. 7, no. 2, 2013, pp. 122-135. DOI: [https://doi.org/10.2174/18722121113079990005](https://doi.org/10.2174/18722121113079990005]

10) E-Waste Management and Recycling: A Case Study in Brazil. Author: Soares, Mario L., et al. Resources, Conservation and Recycling*, vol. 55, no. 8, 2011, pp. 810-818. DOI: https://doi.org/10.1016/j.resconrec.2011.03.007

11) . Environmental and Health Impact of Electronic Waste: A Global Perspective. Author: Awasthi, Abha Kumar, et al. *Journal of Health and Pollution*, vol. 8, no. 19, 2018, pp. 1-11. DOI:https://doi.org/10.5696/2156-9614-8.19.180117

12) . E-Waste Management: Aspects, Challenges, and Solutions. Author: Wilson, David C., et al. Journal of Polymers and the Environment*, vol. 25, no. 3, 2017, pp. 724-731. DOI: https://doi.org/10.1007/s10924-016-0842-8

13) Electronic Waste Management and Its Effects on the Environment and Human Health. Author: Li, Jinhui, et al. Journal of Sustainability Research vol. 1, no. 1, 2019, pp. 1-10. DOI: https://doi.org/10.20900/jsr20190007

14)Recycling of Electronic Wastes: An Overview of Technologies, Challenges, and Environmental Impacts. Author: Su, Junyao, et al. Environmental Science and Pollution Research, vol. 27, no. 15, 2020, pp. 17712-17727. DOI: https://doi.org/10.1007/s11356-020-08340-3