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The Role of Government in Promoting Sustainable E-waste Practices in Uttar Pradesh

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Abstract

The government of Uttar Pradesh is stepping up its game in the fight against e-waste, and it's nothing short of exciting. With the rapid advancement of technology, electronic waste has become a pressing issue but fear not—Uttar Pradesh is paving the way for sustainable solutions. The state government is actively promoting responsible e-waste practices through innovative policies and initiatives that aim to reduce environmental impact while boosting economic growth.

To evolve a more stable state of sustainability, the fundamental strategy is to draw local businesses and societies into alliances with each other. The quintessential idea of which is the effective implementation of comprehensive e-waste management systems and the promotion of recycling programs. In addition to this, a very enthusiastic relationship with the entire population is included due to the educational campaigns that are for spreading the information on why it is important to get rid of e-waste properly. At the same time, the special discounts, of course, are given to the companies willing to contribute to the ecosystem which mainly is recycling or any other eco-fossil fuel usage. As a result of this action, they will not only strengthen the businesses, which will follow the regulations but also make them start the creation of newer ways in the fight with e-waste problems. Specifically, the dynamic drive-in place, the case study is of Uttar Pradesh that is witnessed by other promising regions in proposing a greener future.

Keywords: E-waste, Sustainable practices, public awareness, Policies, Regulations, Management

1. Introduction

The exponential growth in e-waste has turned into a very critical issue in the modern period and has gained far-reaching attention around the globe and brought about the problem for different spheres of society. It is clearly posing a threat to human health and the environment because e-waste is enmeshed with quite a huge number of toxic substances that are emitted to the air and the soil and after that, they reach the various environmental parts where they affect them (Kaviul Islam et al., 2024). Furthermore, when it comes to its disposal phase, technology can be extremely harmful because it can harm both the

environment and peoples' health. The enhanced use of electrical and electronic equipment has been the main reason for the rapid rise of e-waste, which is a very serious problem, but it can be solved quite easily. The total number of electrical and electronic equipment (EEE) that were produced and used in India has reached such a high level as they have grown at an annually compounding rate that has resulted in India being the fifth most e-waste generating country in the world and the accumulation increase of the E-waste has been one among many other reasons for it (Elizabeth Westgate, 2017). The technological development of electronic devices results in the growing quantity of them raising environmental pollution, thus increasing environmental waste. The development in science and technology and the increase in gadget consumption have transformed the consumer's behavior to regularly buy new things. As a result, it is necessary to employ proper strategies to control it, thereby reducing environmental damage considerably. The central objective of the article is to present and criticize the e-waste situation in Uttar Pradesh, detailing existing policies, initiatives, and programs and providing a set of sustainable measures for e-waste management that concentrate on the efficient governance of such a framework and the successful implementation of these policies in practice. In the face of an age of ICT, the focal point of this paper is to agrumentate the discourse about e-waste (because it is the major concern due to the ICT revolution), the role of gadgets, and the use of these devices in schools. In a nutshell, the article deals with the interventions adopted by the government to guarantee an efficient and successful waste management system that leads to environmental sustainability. The need for such an efficient management of those megatons of waste arose in the light of big global awareness and strict environmental policies as many developing countries themselves were submerged under the load of fossil-based economies. Governmental intervention is key; however, stakeholder activities should be considered seriously as well.

1.1. Background of E-waste and Its Impact

The electronic waste—referred to as e-waste—sector has gained momentum in the past few years. A growing share of digitally-dependent livelihoods has been found dumping their derelict technology and gadgets without proper disposal management. This studied sector of society has seen a sudden rise in demand for technologically advanced gadgets— gadgets that are not essential for their vocation. Most e-waste is composed of substances such as lead, chromium, and brominated flame retardants, which have the potential to cause adverse impacts over the environment and health (E Dawson, 2016).

Uttar Pradesh, an Indian state, annually contributes a major share of e-waste, despite having the largest population base. A major part of this e-waste is casually and informally dismantled in the vicinity of the abode, hence escalating the chances of exposure to these chemicals over vulnerable groups— especially children and women (Garg et al., 2023). There is a lack of expertise in understanding e-wastes, making the general populace regard it as just any other type of waste. Policymakers aim to strengthen environmental standards, although this sector of society is in dearth of proper infrastructure and vigilance to manage the disposal and recycle/reuse techniques of e-wastes. Hence, there is a need to comprehend various dimensions and propelling factors that are resulting in the poor state of e-waste governance.

The generation of e-waste has heightened globally, either frequently or cumulatively, not only due to discarded obsolete technology but also in the light of any diminutive trauma that an electronic gadget may go through accidentally. Post-Covid, telemarketing of gadgets like PC's and smart phones at nominal rates to the financially frail sections of the society has been ramped-up exhibits a rapidly evolving global landscape concerning the e-waste domain. Moreover, developing economies that are hubs to industries engaging in recovery, reuse, and recycle of e-waste have been found battling increased environmental risks and health hazardous impacts. However, there is a notable dearth in the domain of staggering

attention to safe and proper e-waste disposal/recycle/reuse equipment and infrastructure in this sector. To contribute to that, the studied site has an open-air casual and informal setting of dismantling, cleaning, and sorting of e-waste, thus escalating the vulnerable population's potential exposure to these chemical harassments.

1.2. Significance of Sustainable E-waste Practices

The Electronic Products Environmental Assessment (EPEAT) information requests that different States be seized with the implementation of other measures concerning environmentally friendly electronic waste processing, as directed by the government, in addition to the E-waste (Management) Rules, 2016, in India. It is further reported to the Information Technology Department that from the outset, took the initiative to adopt a policy of environment protection on the handling of electronic waste (Kaviul Islam et al., 2024). One pound of electronic waste will be the equivalent of seventy pounds of pollution. Uttar Pradesh, the largest state in India in terms of both population and area, is a state where electronic, e-waste processing concerns are the most predominant; it, therefore, calls for urgent policy intervention. India is among the leading countries in South Asia with one of the highest amounts of waste produced yearly. In total, India produces around 3.3 lakh tons of waste on an annual basis. E-waste is responsible for around 1 lakh tons of waste in total. As the number of electronics and customer products increases in the state of Uttar Pradesh, the problem of e-waste is getting worse. Uttar Pradesh's principal cities Noida - Greater Noida, Lucknow, Kanpur among others are the major sources of e-waste in the state. It is apparent, therefore, that the issue of e-waste processing at the state level requires emergency preparedness and action.

The electronic equipment or the products designed must be made considering the comfort of the consumer as well as the environmental protection, so that it can be discarded or stored for reuse or recycling without consuming space or energy. Both the electronic products and their packaging should be made with the least quantity of resources and easy to reuse or consume. Moreover, the electronic products must be designed considering the use of materials and components that are renewable and ready-to-use faster after recycling. Governments need to encourage the formation and viability of companies related to "cleaner" pollution. These companies must be independently responsible for the monitoring of their activities.

Ewaste is increasing on an unprecedented scale over the past decade with the industrial development in India, especially in electrical appliances. One of the strategies to reduce global warming because of carbon saturation in the atmosphere is to preserve the peripheral stability of soil, in which the kind of soil itself is an environmental friendly process along with recycling soil, as e-waste causes soil pollution, water pollution and diseases in human being because of toxic substance. Cameras, having used and been outdated and not repairable, are available in surplus to the student due to conversion of handy cam, thus a humble effort is made to convert an Ecamera to soil moisture tester. Concerning this, understanding e-waste and its effects are a must, which already revealed the fact that it is easily possible to convert an e-waste camera to soil moisture tester.

2. Objectives:

1. To examine the Current E-waste Scenario in Uttar Pradesh
2. To identify the Environmental Impacts of E-waste
3. To review the National Policies on E-waste Management
4. To assess Public Awareness Campaigns
5. To evaluate Existing Government Initiatives
6. To encourage Public-Private Partnerships
7. To promote Innovation in E-waste Recycling Technologies

3. Research Approach and Methodologies:

Mixed-Methods: Essential for a comprehensive understanding, combining quantitative data for trends and qualitative insights for context.

Quantitative: Analysis of e-waste generation statistics (from government sources, industry reports), surveys on consumer disposal habits, and data on collection and recycling rates.

Document Analysis: Comprehensive review of the E-Waste (Management) Rules, amendments, and related national policies. Review reports from the Uttar Pradesh Pollution Control Board.

Literature Review: Research emerging e-waste recycling technologies.

Analysis of government incentives: Analyze the effectiveness of governmental incentives that promote innovation.

4. Literature Review:

The "Green Computing in Developed and Developing Countries" article by (Taruna et al., 2014) gives a thorough analysis of the different roles that governments and other stakeholders carry and their support in sustainable e-waste practices, more specifically in the situation of less developed countries such as India. The authors reveal that the most important factor is the active choice of consumers among the electronic products that contain fewer toxic substances and are recyclable, reusable and that have fewer toxic substances. This personal behavior of the user is regarded as the main component in the general policy for sustainable measures in the e-waste management area.

In the 2017 State-Led Approaches to Electronic Waste Management in the U.S.: A Study of Stakeholder Involvement in Take-Back Legislation Efficiency article (Elizabeth Westgate, 2017), the true role of the government is the foundation for the regulations implementation that brings about no chances of the invasion of cyber dumpsite. The article analyzes the diversity of e-waste controlling in the USA where the lack of a federal one-system has generated many state laws. This difference in approach causes serious difficulties in effective e-waste management because each state has different rules for disposal.

(Elizabeth Westgate, 2017) stresses the import of the piecemeal approach, stating that while some states have already put in place the method of responsible e-waste disposal, others have still managed to maintain the practice of landfill disposal. This variation not only eliminates the mandatory requirements for both producers and consumers to follow when the regulations are disregarded but also leads to the complete functioning of e-waste management in the whole country. The author's attitude is that the creation of a coherent regulatory framework is essential in paving the way for the enhancement of environmental protection through e-waste management and for the promotion of sustainable practices.

The "An Assessment of the Waste Management Operation in Malaysia: a Case Study on Kuala Langat and Sepang" article, part of the (A. Jereme et al., 2019) compilation, managed to address in a concrete way the need of waste managing work for the local government as the most indispensable input in waste management system that is intended to be sustainable. Due to the article's particular focus on Malaysia, it is good that the findings extend that waste management is a necessary aspect in semiconductor processing waste, making the complex primary source a cheaper product. Through these instances, one can get a picture of the developing strategies for waste management in the future which will be the case in other poor regions like the U.P.

District councils, according to the authors, play a crucial role in enabling waste dealers to permanently use some strategic locations for their operations. Not only does this move maximize waste collection efficiency but it also guarantees that the sites are placed purposefully near infringe areas where residents live to give access to local communities for disposal (A. Jereme et al., 2019). This theory is a testimony to the central role wise planning and partnership play in the functioning of the computer-electronic waste (e-waste) management system duly in Uttar Pradesh.

Josiah Miner's (2021) "A critical evaluation of current e-waste management and recycling practices in the Jos Metropolis in Nigeria" gives a comprehensive assessment of the problems and the probable dangers associated with informal e-waste recycling in less developed countries. The author points out specific risky practices such as using machinery that is extremely harmful to the environment, like the dismantling, shredding, and burning components, which not only affect the environment but also cause a very significant health risk to workers who are doing that. Particularly, the area of Uttar Pradesh is analogous to locations such as Nigeria, which undergo reduced laborer and community health because of recycling e-waste very informally.

The article "Concepts of circular economy for sustainable management of electronic waste: challenges and management options" by (Lal Srivastav et al., 2023) comes forth with an expansive analysis of the environmental problems, including the area of e-waste disposal, mostly whereas it is the aspect of a circular economy. The authors are asking for the implementation of the 4Rs—reduce, reuse, recycle, and recovery—as the principal drivers for the transformation of e-waste management practices. The framework becomes a case study of Uttar Pradesh which has become the leading state in the electronic devices use and e-waste challenges increasing with the growth of the electronic sector.

The research report published by Moheb-Alizadeh and colleagues under the title "Reverse Logistics Network Design to Estimate the Economic and Environmental Impacts of Take-back Legislation: A Case Study for E-waste Taking is the process of recovering valuable used materials at the end of a product lifecycle and returning them to production processes. The take-back legislation is one of the methods for solving the growing problem of electronic waste by establishing standards for e-waste recycling and the reuse of information and communication technology (ICT) devices. The authors recognize that landfill disposal is the main method for dealing with end-of-life products, which leads to serious environmental concerns concurrently. They firmly maintain that take-back legislation comes out to be a prime policy tool which is inclined to penalize manufacturers that do not comply with a law mandating them to gather and dispose of their products properly after the end of their lifespan.

5. Current Scenario of E-waste Management in Uttar Pradesh

Electrical waste, which is also called e-waste or WEEE (Waste Electrical and Electronic Equipment), are the electronic devices used and disposed of. Waste from those home appliances like computers, TVs, refrigerators, radios, microwaves, is considered as an e-waste. There are harmful and non-hazardous parts among them, which have led to damage to the global ecosystem, health, and environment. (Josiah Miner, 2021) By the occurrence of health complaints, the incorrect exposure to various kinds of chemicals, the compounds being toxic to living organisms (including humans) have caused the emergence of a slew of illnesses, resulting in more comprehensive policies on global e-waste management and the practices of e-waste management. Besides, the state authorities took some crucial steps to confront the difficulties of e-waste management to avoid pollution. It has a direct regulatory influence over firms active in the manufacturing and electronics sectors. A few activities have been

carried out aimed at the improvement of the current system, such as regulations, strategies, and other initiatives to make them more environmentally and economically friendly.

In-line with other metro cities, e-waste management is Lucknow, the state capital of the state of Uttar Pradesh (UP). The total modern and basic population of UP is 199,661,808 according to 2011 Census of India and is 16.5% of the total population of the country. The oldest reason in India of various organizations is UP. It is also a very populated state. It is a central state in India, so in utilizing the largest SGDP. It is also the second-largest Indian state by economy and has a huge informal network to access the job market. Uttar Pradesh has the most regular population of all metro cities.

5.1. Challenges and Opportunities

The present scenario represents a complex picture of e-waste generation, basic recycling patterns, and rudimentary waste management systems within the emerging economy of Uttar Pradesh. Several issues addressed in this paper transcend the context and hold relevance for other global informal E-waste recycling settings, such as the challenges and potentials for more sustainable E-waste recycling practices in developing regions and the need for broader systematic environmental monitoring studies. The objectives of the present work are to investigate E-waste flows, practices, and impacts in the rapidly urbanizing region of Uttar Pradesh.

Recent initiatives have been taken in other geographic regions to address challenges presented by rapidly expanding E-waste streams in developing countries; some of which will be reviewed here. It is incumbent upon researchers and international policy communities to investigate, support, and implement these potential pathways and interventions that can provide economic, environmental, health, and development co-benefits for the broader society. The final section describes the potential benefits and co-benefits of possible interventions that could be developed and supported to improve the currently negative impacts of an expanding E-waste sector in developing countries (Kaviul Islam et al., 2024).

6. Government Policies and Initiatives

Government Policies and Initiatives Review of Legislation: The Indian government has adopted several national level policies promoting E-Waste practices. Attention is drawn to specific issues likely to arise in the state of Uttar Pradesh and adaptation of the policies is considered in this context. An emphasis is placed on the suitability of policies in reducing the challenges faced in majority of Uttar Pradesh. Similarly, another policy is the recent integration of waste pickers and street level workers within the government and extending social security benefits. Might a model like this be applicable to e-waste pickers and workers engaged in the dismantling and recycling of e-waste in order to bring them into the formal waste system and improve their socioeconomic status? By no means could an entire recycling infrastructure be formalized, but it could be conceivable that large scale printers, printer cartridges and appliances could be redistributed and/or incinerated. As a testament to the impact E-Waste is already having on children occupying migrant belonging to the denotified and nomadic tribes. Any policymaking should reflect an understanding of the current context and an attempt to address, thus UP/East-state specific recommendations will primarily seek to reduce the pressures faced by printers in Delhi. The end goal is a convergence of National and State policy, efficiently carrying out the Rules for the first time in districts. Monitoring the presence of toxic substances in turning practice, using soil samples from the printer areas, there is no sure support for burnt wires or the presence of lead (Kaviul Islam et al., 2024). There is also a discussion of the matter should be further explored in the determination and formulation of future policy initiatives. Energy Savings Regulations Quality/Energy Saving Order 2012 made under power of The Energy Conservation Act 2001, this has been expanding to Standard and Labelling Programme and Star Rating Systems for various electrical/electronic appliances (Elizabeth Westgate, 2017). National E-Waste Management Rules-2016: In line with the Hazards Wastes

Management Strategy, the Rules have the potential to formalize the recycling industry. Cradle to grave takeback schemes have the goal of streamlining the informal sector engagement with e-waste so as to receive all e-waste effectively, provide raw materials to formal recyclers and accept a disposal fee to cover recycling costs. Deregistration of dismantling units will be beneficial to environmental quality, allaying concerns over the lack of safety parameters and causing potential soil contamination. From the published report from FICCI, the direction of the current administration seems to be on simply enhancing the e-waste training of printers and retailers to improve their resale of toners and blatantly ignoring the other detrimental aspects of their trade. However, residential assistance is not productive unless the facilities are improved for e-waste separation, storage and disposal within the households. Therefore, robust recycling and collection infrastructure would necessarily precede any e-waste awareness campaigns. With the Punishment For Contravention a printer might think twice about separating and burning the lead of junk wires or selling the gold they have burned from PCB's or incinerating the large volume of E-waste goods that are not feasible to dismantle. Working With Bhalswa Closure the handling of E-waste will either be executed with the proper procedure or all waste will be bundled improperly labeled from source to incineration. Those in the cycle who surrender waste to be incinerated will either be legal registered recycling units or will be in violation of the Rules. Recommended Strategy: It is anticipated that e-Waste Management Plan implementation will commence at about the time of this publication. It is important also to be aware that the informal sector, whilst at this time the dominant form of recycling E-waste and crucial in the collection and recycling of ink cartridges and small E-waste, will be extremely slow to become a part of the formal system. While e-waste on wastepaper may pose a risk to hygiene, other forms of e-waste disposal will be a boon printer receipts and audit will discourage the formation of wastepaper.

6.1. National E-waste Management Rules, 2016

The Treaty of Amsterdam was the first to impose provisions with the aim of defining the trade barriers between European countries. E-commerce is generally perceived to cut down some trade barriers, but in fact, its nature is a bit more complicated. One of the most significant parts of the E-commerce Directive is the issue of the application of the country-of-origin principle to services delivered by electronic means. As of 1990, the Treaty of Maastricht is commonly connected with the manifestation of the internal market and the onset of the implementation of responsible social policy as one of the dimensions. The main objective of this directive is to generally make sure that the WEEE is correctly recycled and to transport it to the authorized recyclers in the best possible way. By 2010, the procedure will have been completely changed. The rules are "secure legally environmentally sound recycling of E-Waste, channel E-Waste to a registered dismantler or recycler, however, to educate the public through Extended Producer Responsibility (EPR) authorization of the Producer Responsibility Organizations (PROs) as well". The rules proclaim that within two years of publication of rules related responsibilities have got to be followed. As a result, all measures regarding the scientific disposal, collection, recycling, treatment, and control of e-waste finally getting close to the extended deadline. This is leading to increased pressure on stockpiling of collected e-waste for recycling. E-waste rules represent a paradigm shift in the approach by making the producers of electric and electronic equipment responsible for collecting the e-waste (JESIAH & LAKSHMI, 2013). However, due to an absence of implementation of the necessary mechanisms and pathway up till 2018, it seemed impossible to observe the stipulated ISTP and C&D norms, leading to criticism by both the Central Pollution Control Board and State Pollution Control Board. Consequently, there is a growing trend for cooperation between relevant stakeholders, including regulators and producers to ensure the implementation of rules (Kaviul Islam et al., 2024). In addition to understanding the current situation, attempts are also made to analyze what is to be learned by the

scenario. This describes the problems and the solutions; the e-waste rules as means to address these issues and the difficulties and opportunities related to those enforcement measures.

6.2. National E-waste Management Rules, 2022

The E-Waste (Management) Rules, 2022, of India along with the following amendments stand for a complete model aiming at fixing the e-waste problem. The rules will come into effect from the 1st of April 2023, they will replace the previous 2016 regulations and will contain many important adjustments in the Extended Producer Responsibility (EPR), treatment of the informal sector and environment-friendly recycling as well as the implementation of the extended producer responsibility (EPR) system through public-private partnerships.

In fact, the 2022 rules considerably expand the scope of the EEE, which also include solar photovoltaic moduli, panels, and cells, for the sake of example, and the target group of devices is also widen. In terms of which a key concept is EPR demanding manufacturers to take the entire life cycle of their products into account, namely from the line of production to the stage of recycling. This transfer of responsibility to producers who are ready to become active participants in sustainable e-waste management by incorporating green features into their products and setting up effective collection points is a wise move. Additionally, the regulations contain the growth of recycling targets for producers which should be fulfilled to reach higher material recovery rates. The recognition of the unorganized e-waste sector being the 2022 regulations is a way of showing the importance of the informal sector in creating a formal one. The rules outline the conditions that need to be met for the registration and authorization of the stakeholders, including producers, recyclers, refurbishes, and dismantlers, and the Central Pollution Control Board (CPCB) or State Pollution Control Board (SPCBs). This formalization system is designed with the aim of inclusion and transparency to limit the mistakes, emissions, and other waste crises, as well as risky situation preventing. Furthermore, to address unsafe situations through regulations and integration of the recycling sector with the informal sector, the regulations also stand for the regularization and the support of the recycling industries, training and registration.

The E-Waste (Management) Amendment Rules, 2024, add to the framework by guiding the major implementation issues. A substantial amendment is the obligation of the CPCB to enforce and penalize entities that violate the rules by imposing and collecting financial compensation, which, in turn, is expected to help strengthen enforcement and compliance. The introduction of an EPR certificate trading system to set a price range that ensures fair market practices will be the most significant amendment. This market activates the use of certificates for meeting the EPR which enhances competition and recyclers are more likely to be efficient. Moreover, those 2024 changes state clear-cut duties for each party, which thus reduce the e-waste management duration, and thus better and more streamlined communication among the parties can be developed. To recap, The E-Waste (Management) Rules 2022 and the above naming amendments are both applied to ensure the hazardous nature of e-waste, and its consequential environmental effects is addressed for the safety and well-being of communities and the environment. These regulations mandate EPR, legalization of the informal sector, recycling goal setting, and strict enforcement of the laws. Through this strategy, the environment is kept free from toxic materials and instead, resources are collected for the recycling factories, hence the conservation of the environment. It is the first significant step in electronic products' environmental impact reduction and growth of the ecological economy set in EEE.

6.3. State-specific Policies and Regulations

Because e-waste contains recoverable materials, including valuable substances like gold, it can generate income, and a professional sector to scavenge and recover this waste has developed over the last 15 years. Unlike professional recyclers, however, scavengers recover metals by burning materials. This process not only releases dangerous toxic chemicals, but it is also very destructive to health. Residues that remain after burning are dumped in the open and often end up in drains or the Yamuna river, contaminating local water supplies and the bassi river, which is a source of drinking water in okhla. This section is dedicated to focusing on state-level specific initiatives and laws, as opposed to the broader National-level rules and regulations that are in place. In this context, the policies and laws enacted in the north Indian state of Uttar Pradesh are examined, focusing on the strengths, weaknesses and overall suitability of state-specific initiatives in comparison to those of a National-level. Thereafter, case studies are provided, describing the measures taken by the Uttar Pradesh government to address the challenge of e-waste. These include proposals for a pilot take-back program and the advancement of civil society partnerships and green entrepreneurship.

7. Role of Different Government Departments

In the Indian state of Uttar Pradesh, e-waste management is primarily the responsibility of several government departments. The Department of Industrial Development has the task of developing the infrastructure and handling and transporting mechanisms to manage the e-waste. It also supports the entrepreneurs in setting up entire facilities and recycling plants for the e-waste. The Department of Infrastructure & Industrial Development becomes an active part of the process using the agencies under it to dispose of e-waste by supplying the facilities that are needed for it. The Trade Tax Department is always around, monitoring the industrial units regularly. That is the way by which it thrusts down, and the movement and disposal of e-waste is a mechanism of control. Dealers and distributors are closely watched to make sure that the e-waste ends up in the right places. In connection with e-waste, the Department of Environment takes the role of facilitator by issuing guidelines for safe disposal. The Department of Environment, along with the Environment Pollution (Prevention and Control) Board, has already initiated several steps to resolve this issue as far as possible. Increasing public awareness through newspapers and electronic media talks concerning ways to manage e-waste is already being taken up by the Department of Environment, U.P. Moving further steps in this direction, a budget allocation has been made by the government of U.P. Specific treatment and disposal of e-waste plants or industries are being planned during the current Plan Period. To ensure only e-waste products are dismantled or recycled, no e-waste items will be permitted to be imported without the consent of the Department of Environment. Concerned Departments like Industry, Trade Tax, Commerce, Environment, and Board plays a significant role in managing e-waste and will ensure that the roles and responsibilities that have been assigned are addressed at appropriate levels of accountability (Kaviul Islam et al., 2024). Accountability, responsibility, and transparency in operations have been considered to ensure effective work has been done.

7.1. Department of Environment and Climate Change

The Indian Government has done its duty and established the U.P. State Environment Impact Assessment Authority (SEIAA), Uttar Pradesh Pollution Control Board (U.P. PCB) and a Department of Environment and Climate Change all functioning in harmony to regain environmental safety and health that was lost and to diminish industrial activities with their adverse effects. Relocating one of its predecessors, the Environment Department, which was founded in 1983 The Department of Environment and Climate Change which has replaced one of the old departments, namely the Department of Environment, has the role of the major government in a state to ensure the

implementation of environmental law. The dumping of e-waste, storage, treatment, and disposal of this matter is a matter of global concern. Many analysts say that India is the greatest waste producer with more than 200 thousand tons every year; however, that amount is anticipated to go up in the forthcoming years. The process of e-waste management, which is environmentally friendly, is viewed as a very important task in this area nowadays.

The UP Department of Environment and Climate Change has accepted the task of proper and environment-friendly management of E-waste and decided to help the industries/concerned agencies in developing E-waste in conformation with the rules and regulations. Apart from various instructions and conditions stipulated by the Various Statutory Authority, the Department of Environment and Climate Change State Govt. has undertaken a series of judicious Initiatives and Programmes that are directed towards E-Waste management. These initiatives and steps aim at creating awareness amongst the various technical & non - technical persons associated with handling E-Waste, industries etc. in the state of U.P. Towards sound E-Waste management and sound environment. All the industries / agencies in U.P. which are involved in generation, storage, treatment and disposal of E-waste are recommended for sound, safe storage & proper management of E-waste (JESIAH & LAKSHMI, 2013).

7.2. Department of Industries and Commerce

The vision of the Federal E-Waste Management Policy is the implementation of eco-friendly, safe e-waste management. It is the Vision of the State being the first ICT (Information and Communication Technology) State of the country to come up with a solid and internationally accredited law on e-waste management and ascertain the leading role of the State Department of Industries and Commerce in it. The policy recognizes the changes taking place in the business model of the electronics industry, and hence responsible manufacturing practices could help in reducing environmental impacts. The role of multi-state accreditation, harmonization and collaboration in the development of these regulatory frameworks and guidelines is also acknowledged. In the State of Uttar Pradesh, the Department of Industries has a direct operational role in supporting and regulating the electronics industry in carrying out environmentally sound practices in the design and manufacturing of their products. The Department of Industries collaborates with electronics or plastic manufacturing industries for creating awareness and encouraging environmentally sound practices in production, which includes undertaking design development of product and process of production so that the ultimate products are user-friendly for recycling and environmental soundness in their usage as well as post-usage and developing and promoting industrial technologies. Industries have also been encouraged to promote innovation for environmentally sound practices, including waste minimization. Industries with their representations in industry associations approach the government for policy initiatives like incentivizing industries for adoption of environmental sound technologies or practices and preferential purchasing of environmentally friendly goods by government departments for market creation. Industry associations also play significant roles in disseminating government's message to industries on issues and initiatives taken on conservation of environment and gives feedback to government on the difficulties in adopting traditional and new standards, norms, and guidelines. The Department of Industries, a nodal entity responsible for the Federal Policy on e-waste management, hosts and has training from time to time on e-waste management, in collaboration with other government departments and regulatory agencies. Industries and industries associations are invited for participation. UP, the state having the largest electronics market in India, considers it as a major task and is in the process of formulating standard guidelines for the plastics and electronics manufacturing industry. The document discusses the challenges and concerns of the informal sector, which is still predominant, and its interface with the formal sector and government. There is a need to establish more recycling facilities for the sustainability

of the industrial base. Starting video conferencing between important Government and industrial clusters would prioritize important subjects among rapidly changing technologies and time schedules. Industry and its associations should also be encouraged to take up such actions. Two such industrial clusters, Delhi-NCR and Moradabad have already been identified. The Department of Industries has also prepared a strategy paper for expansion and strengthening of the e-waste management sector in the UP state.

8. Public-Private Partnerships in E-waste Management

The growing acquisition of electronic items in Uttar Pradesh has resulted in a pressing need for efficient disposal and recycling processes to prevent environmental degradation. This has led the state government to focus on advancing various strategies to promote sustainable e-waste management. Public-private partnerships have emerged as critical mechanisms to improve ineffective disposal and disposal practices. Several specific steps have been taken by the Uttar Pradesh government to act as a prime facilitator for private players in the e-waste management sector, encouraging recycling, disposal optimization, or other related activities. Also, an e-waste recycling facility has been set up in Lucknow by a private enterprise that collaborates with the UP-Pollution Control Board. This facility has accumulated substantial e-waste for recycling, retrieving valuable metals and other materials to be sold in nearby markets (Faibil et al., 2023).

One part of this paper is about the relationship between e-waste and different PPPs on the side of people who live in Uttar Pradesh. More especially, there has not been any research about PPPs in e-waste management in Uttar Pradesh or any other state of the country yet. The progress of technology and the increasing needs of people in this context have led to the rise of many used and discarded electrical and electronic products as a major issue of eco-friendly and sustainability. Hence, many countries have put in place several security measures that comprise cutting waste in collection, recycling, and disposal processes. That is to say, in Uttar Pradesh (UP), of which the disposal of the discarded items or the electrical and electronic equipment (EEE) is the state's main concern, the state has also been focusing on making the adopted measures sustainable in the long run. Within the context of this issue, PPPs are of primary significance as they are the efficient tools to manage e-waste. In the article, it is stressed that different actors are entitled to diverse obstacles due to the complex nature of the topic.

9. Capacity Building and Awareness Programs

E-waste has proved to be the greatest challenge the nations round the world have to deal with nowadays. Primary obstacles in the management of E-waste in the South Asian countries are identified. This exposes that there is great scope for betterment in terms of procedures related to waste collection, disassembly and recycling, treatment and disposal methods, and strategies to generate renewable resources or energy and their implementation. The major focus is on the most common way to retrieve resources from the severe pollution of E-waste parts and production processes. Particularly, the implementation and outcomes of the projects in various parts of the world should be known to everyone who looks forward to getting them done. Although world technology transfer is used to recover valuable resources like gold, silver, palladium, and copper from E-waste recycling processes, the transfer can be securely controlled if there is an established method. It is envisioned that this assessment will facilitate the establishment of attainable goals and the development of policies, laws, and regulations promoting energy and resource recovery in a sustainable manner (Kaviul Islam et al., 2024). In contrast with developed countries, recycling practices in developing countries are practically non-existent. Stakeholders must promote the common collection of E-waste from houses and workplaces. After collection, the products must be systematically separated, and useful resources should be filtered out by utilizing the skills of various stakeholders. It is a necessity to establish a secure recycling center for

contact with toxic compounds. The rest of the products after recovery could eventually be segregated in an eco-friendly manner. Moreover, an examination of previous E-waste management practices is crucial for the principle of the most efficient and well-off modes of recycling. E-waste management policies might be developed to minimize the conservation of E-waste so long as planned hazard is not limited by the risk level. Bioplastics from natural starch can be biodegradable and can replace plastic with fossil-based sources. The invention of competent commercial E-waste management strategies maximizes the optimum energy recovered by minimizing the risk in e-waste management.

9.1. Training Workshops and Seminars

Owing to the progressively rising growth of Information and Communication Technology, Uttar Pradesh, as a substantial consumer of electronic goods, generates considerable levels of e-waste. Furthermore, because e-waste is not well understood, most e-waste does not go to recycling or safe disposal places, and this in turn leads to an environmental and human health hazard. This problem is further enhanced by the quick development of technology within the country. Consequently, the issue of e-waste management education is an urgent and critical healthcare initiative to be addressed by the state. With this aim, the vision of the government and the procedures to involve is discussed here. The aim of the training is to provide fundamental knowledge about the aspects of e-waste and its handling, its methods of disposal, and its procedure to be recycled or safely disposed (Kaviul Islam et al., 2024).

Each year, the above training program will run for presentations at each of the industrial development offices, as well as additional regional events. It is important to generate feedback from participants at these events and adapt the workshop to better meet stakeholder needs. The potential obstacles to participation, such as travel restrictions, may necessitate exploring alternative mediums for delivery of training programs. The facilitators (“trainers”) are considered to play a central role in the delivery of the training programs. As such, it is imperative to engage the services of a qualified and experienced company with a demonstrable track record in delivering training programs that have achieved quantifiable industry outcomes. Additionally, there would be opportunities to collaborate with technical and further education facilities and other suitable organizations in the delivery of workshops. These partnerships can serve to broaden the reach of the training programs and can be a rewarding means to share resources and better meet the needs of a broader demographic.

10. Technological Innovations in E-waste Recycling

For the e-waste recycling processing, the solution lies in providing the necessary technological knowledge and implementation at the appropriate level. Technology related to e-waste recycling has been implemented in various locations around the globe, particularly in Uttar Pradesh, which does this more effectively and efficiently (Lal Srivastav et al., 2023). Particular new technologies or methodologies are soon to avail which won't be used to only recover an increased amount of valuable material from e-waste but minimize the discarding thereof. Efficiency of the recycling process should be increased using these technologies. The recovery of valuable metals like gold, silver, copper, etc. can be made much easier by the new method of technology & methodologies; robot-driven automation can be used that will help speed the processes, the focus of recycling on direct dismantling & recycling. The new recycling center in the future could be set up and that will be less expensive, faster and easier to start with when we want to expand the recycling operations. The e-waste recycling process can generate many jobs in robotics & its services. This will cause the cost to drop. The recycling of e-waste industry can be the development keynote tool even if a deal like a place where actually e-waste is treated does not count. Green deeds will emerge as e-waste recycling technology inspires companies to look for a more environmentally friendly method. A combination of technology and industry & government coordination is key to the new market trying to build a mature ecosystem. The focus will be on studying emerging technology and its positive

impact on recycling e-waste, cases that have been developed successful recycling technology an e-waste on a large & achievable level. Planning and direction support will be needed to develop & maintain the eco-pressure ecosystem, a focus on developing technology which adapted local good practice with adapt from outside Uttar Pradesh. Applying this technology & methodology of the scrap metal vendor's evaluation of this application. Challenge following the set-up of this technology adaptation location cost and the lack of a macro model of available technology infrastructure of the realization of the minimal work item or idea in discussion.

10.1. E-waste Recycling Technologies

The rapid advancement in science, technology and marketization, and the parallel development of electronic gadgets have made it possible to make use of the fastest consuming goods. The time arrives when all electronic renderings that are obsolete or not are recycled as WEEE. In the Indian subcontinent, WEEE provides avenues to the presence of metals (mainly rare) that are responsible for contamination and consequent harmful health impacts. The total generation of E-waste in the National Capital Region (NCR) annually is an amazing 20,00,000 metric tons. However, its recycling has not been offered in a passive way. The e-waste happens to be collected by an informal sector from the original generator and then comes reach to states like Delhi and Uttar Pradesh driving the recycling process. Among the 95% informal sectors, E-waste recycling leads to 5% recycling in the perfunctory sectors. 80% - 85% E-waste material is metallic E-waste. One of the most popular, yet ironic, ways of recovering E-waste in Delhi is to burn down metallic materials as conducted with the intervention of a robot program that manipulates the residues to get closer to the pure metals. Their explosion is a source of pollutants that comes from dioxins, furans and HCl. These chemicals, proving to be toxic substances, all over which the micro-dust particles are absorbed, and, because of dust they are released into the air, causing an increase in the air concentration of these substances and the gases of the HCl getting penetrated through the crops, so, it happens to be infected eventually.

In the last two decades thanks to science and technology, many manufacturing companies, including E-waste the digital waste and second-hand electronic goods, have begun to set up industries inside the state. Thus, at the end of their life, all these E-waste find refuge in the mantles of retail shops without any segregation, and are therefore transported to scrap dealers where the separation of the valuable constituent by the crudest modes of recycling practices results in an increase in the ambient toxicity in the air, water, and soil on the one hand and the lodging of heavy metals and toxic contaminants on the agricultural produce. Further, with the burning of the polymers, the ambient concentration of dioxins/furans increases, which are one of the 14 principal pollutants listed in the Pan-European standard, above which the consent of the competent authority is mandatory to emit in the ambient air. With this aim, the present study is exploring one of the biological modes being advanced for recycling purposes i.e., biometallurgical follow-tackling studies via the biomining and bioleaching of the E-waste components (Arya & Kumar, 2020).

11. International Best Practices and Collaborations

Electronic waste is any item holding electronic components which respectively can be broken or consumed and, as a result, being thrown away by its user. Increasing output of e-waste is the focal point for which the dramatic growth of technology and high obsolescence rates can be accounted for in the last few years. Worth it to mention that e-waste management is not only an activity of the preservation of the environment, but it is also the process of the development of the technologies of reduction, reuse, and recycling to have healthier, wealthier, and longer-life economic growth of the country. The state of Uttar Pradesh, India, leads the country in the production of e-waste due to the rapid growth of technology-driven Industry; however, e-waste management regulations are either non-existent or partially

successful. In this case, the organizations behind this movement are both the Indian Government and the nonprofit institutions holding political power in the region. Still, there are many successful case studies of e-waste management practices that can be adopted worldwide. These cases consist of using a software tool that can track the origin of an electronic item, conserving fashion technology by creating an elegant, recyclable jewelry (Kaviul Islam et al., 2024). Governments, corporations and non-profits working together are examples of both international success stories and prescriptions for action that contribute to enhancing outstanding practices in developing countries. The principal efficiency improvement in e-waste management should be commenced through improved global design, to facilitate reuse, refurbish, and facilitate a longer life span through more durables. Thus, at the global level, two efforts are needed: 1) Efforts to maintain international rather than free trade of E-waste for disposal 2) Continuing negotiation of global treaties to regulate the generation, export, import, and recycling or disposal of E-waste. Although this analysis principally concerns the situation of Uttar Pradesh in India, comparable scenarios seen in other South Asian nations such as Nepal, Bhutan, and Sri Lanka are often seen in India as well. Like routes and partnerships, owner or senior manager buy-in is equally necessary if instructional institutions are to lead the way in analyzing and applying innovative solutions. It is also crucial to underscore the profitable effects on the institute's brand value and global rankings that may develop and get promoted consequently, provided effective actions and robust collaboration in educational spheres materialize.

12. Economic and Environmental Benefits of Sustainable E-waste Practices

E-waste is seen as a growing form of dangerous waste material as it contains materials (metals and certain plastics) that are injurious to the environment and man. In 2012, India accounted for 1.8 million tonnes of e-waste. In 2013, Uttar Pradesh disposed of 143,000 tons of the total volume. The estimates state that by 2018, the state will become the equal fourth generator in Mexico by producing 800,000 tons of this kind of a large amount of waste. The objective of waste management is to handle it in a responsible manner. Properly recycling e-waste can eventually result in the efficient utilization of resources, predominantly metals, which are not renewable. It is expected that by 2050 three out of every nine people in the world will be middle-class citizens (Meadows, et al. 2020). In the past, widespread urbanization and industrialization committed to the accelerated growth of the Earth's population, which was the main driver of the people turning to consumerism. The amount of waste produced from this is declared to be 5-9 times as much. The recycling and reusing techniques of e-waste are used to recover such valuable materials which can then be used to produce other products. Recovery of gold from e-waste has an opportunity of saving huge amounts of gold from mining. Being a rare earth product on earth, saving it as e-waste will result in the extraction of a huge amount of money. SMEs are found to be more aimed at social development through job offers. The e-waste recycling parts are not nearly the same as the reverse logistical parts in terms of number of jobs. National social and development is a direct result of the introduction of safe e-waste management. The recycling sector is one of the major job creators. It provides entrepreneurs and wage earners with employment opportunities and, especially women and the underprivileged, it is the exit of everyone (Kim, et al. 2020). Sustainable management practices also ensure the environmentally sound management of e-management materials. In addition, people who are normally in contact with the toxic matter from e-waste would be much safer. Therefore, there would be a robust public health benefit. The notions of waste prevention, the reuse of products, and sustainability in manufacturing are integral to the idea of the circular economy. This is especially important for electronics due to the two distinct sides of the economy; the sales and the reuse/recycling

of the product. The reuse market in electronics has risen with online markets for second-hand electronic goods. The industry needs to also progress in the fierce sales environment. To maintain the highest value of electronic products, there is a need for dissention from the reuse market. In the upstream strategy design for sustainability growth, there is a need for proactive feedback from the recycling industries for products design. The single benefit effect of environmental protection from industries does not always work. There needs to also be a dual benefit strategy concerning economic growth. Setting up a monetary, fiscal and financial incentive could encourage enterprises to mobilize the transition towards sustainable e-waste practices. Such an investment in eco-adaptation practices could lead to significant cost savings in materials and energy used in industrial production. The number of SMEs was examined before and after the establishment of the subsidy policy. In the most recent years, SMEs equipped with pollution control facilities increased significantly. A sustainable e-waste management system required the involvement of agents through the supply chain such as manufacturers, retailers, consumers, research institutions, NGOs and the government. There was an absence of practical information and knowledge about eco-efficient cleaner production for minimizing all the general negative effects arising from waste e-waste processing activities in the global South, particularly India. Case studies of two e-waste hubs, Seelampur and Mandoli in Delhi, India, highlighted that the poor were involved in the informal dismantling, recovery and recycling activities due to several constraints. Several analytical tools provided recommendations towards eliminating, minimizing and controlling the wastes, emissions and pollutants, with a particular focus on Seelampur and Mandoli.

13. Challenges and Future Directions in E-waste Management

Energy consumption of various household electrical appliances may provide a guideline to consumers to manage energy utilization. The appliances included in the table are the most commonly used models in India. Efforts made by different organizations to introduce and promote cleaner technologies in the pulp and paper industry are discussed. The important role of Government in establishing a successful and sustainable waste to energy conversion program is also well understood due to the sophisticated nature of the technology and capital involved. An example of a flagship waste to energy program planned by the Govt. of India as on time-bounded program. In such a program, it would be necessary to involve various stakeholders, including the central and state Governments, investors and financial institutions, donors, technology providers, and other relevant organizations.

14. References

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