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NEW FUTURES FELLOWSHIP PROJECT

RESPONSIBILITY AND RESOURCES FOR CLIMATE JUSTICE

THE USE OF TECHNOLOGY AND CLIMATE-JUST SYSTEMS TO MANAGE SOLID WASTE

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Project Overview:
This paper explores waste management strategies, focusing on composting, waste banks, and technology integration for a circular economy and climate justice.

Keywords:
Waste, Climate justice, Composting, Textile Waste, Waste Bank, Circular Economy

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#WASTENOTIME

Executive Summary

Alternative waste management methods of composting and waste banks can combat social injustices of individuals and communities. Using technology to develop compost and waste bank systems makes them more efficient methods of waste management and moves them towards contributing to circular economies. Circular economies recycle as many different types of waste as possible to benefit local economies and reduce their carbon footprints.

The definition of waste is subjective, so waste is generally categorized by its origin and its traits. All steps in an item's lifecycle, from its production to how it is managed once it is considered waste, can be considered when evaluating the effects that waste has on climate change. Organic waste emits more greenhouse gases when decomposing in landfills as opposed to alternative waste management systems. Urban areas of high income countries produce the most waste, but rural areas of low-income are the most affected by excess waste and its corresponding climate impacts.

Waste is a climate justice issue because it does affect other social, economic, and environmental issues. The underlying greenhouse gas emissions from waste collection, transportation, sorting, recycling, landfill systems, and incineration also contribute to waste management being a climate justice issue. Composting, waste banks, circular economies, and even more solutions all have the potential to help combat greenhouse gas emissions from the waste sector and thus the climate crisis.

Landfills producing contaminated water runoff causes environmental harm to neighboring and downriver agriculture soil and social harm to the health of individuals and local communities. Carbon sequestration benefits agricultural soil issues and the climate crisis simultaneously. Organic and chemical soil composition is improved by carbon being drawn from

the atmosphere and stored in the soil. Communities can further improve this process by composting. Composting reduces the amount of greenhouse gases that organic material would have emitted if it had alternatively gone to a landfill. Reducing waste sent to a landfill comes full circle as a positive feedback loop that then reduces the amount of contaminated runoff affecting soil. Waste coming full circle contributes towards creating a circular economy. Community based composting solutions are small enough to start easily and quickly, but large enough to make a difference on more than an individual level. Community scale composting has more potential to work and make contributions towards a circular economy. By composting together, communities also avoid third-party businesses that might be looking to come in just to make a profit.

The disposable fashion industry relies on linear economic models that create tons of waste, advances climate change, and causes socio-economic problems. From production to waste management, fast fashion pollutes the environment massively and disrupts local communities socially and economically. More than half of globally produced fibres are polyester, a by-product of petroleum. Cotton, the second most commonly used fibre, and polyester both are entirely recyclable, but only a minuscule amount actually gets recycled. The rest ends up in landfills or incinerated. Unfortunately, textile production is very energy and resource intensive. Current markets operate under a linear economy, but many are transitioning to circular models. Due to circularity, many consumers tend to donate their pre-loved garments. Most of these waste garments end up in second-hand markets or landfills in the Global South. Waste banks are an innovative and community-centric waste management solution that attempts to reduce the overall dependency on virgin materials in the fashion industry. It also creates financial opportunities for low-income earners and operates as a sustainable and environmentally friendly waste management solution that promotes the 3Rs (Reduce, Reuse and Recycle). This body of work

closely examines the integration of waste banks into fashion supply chains, moreover, the challenges and practical implications of operating waste banks by drawing insights from case studies of textile waste banks from around the globe.

Technology integration in waste management presents a big opportunity to drive the transition to a circular economy and climate justice in underserved communities. Through the technology section, we dive deeper into the complex waste management issues that technology can alleviate. From the sorting at the source, hard-to-recycle materials segregation, ineffective composting to limited awareness on brands or producers' materiality and externalities, we provide a technological approach on each issue and the relevant impact it can create while advancing to the circular economy.

The technologies we underpinned are classified in the Fourth Industrial Revolution known for their ability to bring efficiency, velocity, scope, and systems impact in different areas. We explore the role of Artificial Intelligence in enabling monitoring of the compost moisture content and enable real-time decision making. The ability of the Internet of Things (IoT) in automating waste sorting at the source, Big Data in estimating the precise bin or waste bank placements around the cities, as well as Blockchain in providing transparency in product origin, producer accountability, and traceability of waste materials in the value chain.

To reinforce the application of the technologies, we provide different case studies where AI, Blockchain, IoT, and Big data are being applied, driving the transition to a circular economy in a climate justice lens. In Rwanda, 10 solar-powered smart waste collection stations were installed in 10 public markets. The IoT system is driven to facilitate the IoT technology for real-time monitoring of composting of 100 tons of waste generated daily from each station. In India, Artificial Intelligence is being used in waste sorting automation providing better quality

sorting in a fraction of time, as compared to human sorting. In Haiti, Blockchain technology is tapped on to provide immutability and transparency to prevent fraudulent and corrupt practices in the plastic value chain.

We leverage different sources to establish linkages between climate justice and circular economy in different multidimensional aspects between; compost & climate mitigation, Waste Bank & equal access-affordable waste collection services, and resource traceability & corporate accountability.

Part 1:

Introduction

1.1 Importance of Topic

Waste management solutions and the climate crisis are interlinked. Poorly managed waste is responsible for greenhouse gases (GHG) and Chloro-Fluoro-Carbon emissions.[1] Organic waste directly contributes to climate change because decomposition emits GHGs carbon dioxide and methane.

Waste can be classified by type based on origin and composition. Types of waste include municipal, industrial, hazardous, and agricultural waste.[2] Municipal waste comes from households and service-related industries. Manufacturing and mining result in industrial waste. Hazardous waste includes toxic and reactive waste from power plants, but also waste from healthcare sectors. Agricultural activities, such as crop production and livestock farming, produce agricultural waste. These differing types of waste are made up of varying waste components. Waste can be defined by physical, chemical, and biological components.[3] Physical features determine how waste can be disposed of. Chemical makeup indicates the combustibility of waste. Biological composition determines biodegradability of waste.

Inorganic waste is often incinerated which releases GHGs.[4] Both production and waste management processes must be taken into account while evaluating impacts on the environment

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[1] Anselm E O Eneh and Stephen N Oluigbo, "Mitigating the Impact of Climate Change through Waste Recycling," *Research Journal of Environmental and Earth Sciences* 4 (August 20, 2012): 6.
[2] Richard C. Porter, *The Economics of Waste* (Washington, DC: Routledge, 2010).
[3] Geoffrey Jones and Shelly Xu, "Can Fabric Waste Become Fashion's Resource?," Forbes, June 21, 2021, https://www.forbes.com/sites/hbsworkingknowledge/2021/06/21/can-fabric-waste-become-fashions-resource/; Porter, *The Economics of Waste*; Adama Onyanta, "Cities, Municipal Solid Waste Management, and Climate Change: Perspectives from the South," *Geography Compass* 10, no. 12 (2016): 499–513, https://doi.org/10.1111/gec3.12299.
[4] "Pacific Year of Climate Change 2009 Fact Sheet Waste & Climate Change," Pacific Year of Climate Change 2009, July 2009, 2.

and contributions to global warming. Processes of waste management include, but are not limited to, transportation, treatment, intermediate stations, and landfills dumping or incineration. Each of these stages contributes to GHG emissions.[5] Poorly managed waste contributes to almost 5% of global GHG emissions.[6]

According to the US EPA, landfills are the third largest methane producer.[7] Biodigestion and other approaches to waste management can reduce GHG emissions. For example, composting in India is diverting green waste from incineration to avoid GHG emissions.[8]

Solid waste generation is affected by a number of factors such as economic development, level of industrialization, public habits, and local climate. Disposable income and urbanization greatly impact individual consumption, and they positively correlate with waste generation. There is a stark difference in the consumption patterns between those in rural areas and people in urban areas. Those in urban areas produce significantly larger amounts of waste.[9] High-income countries generate 34% of the world's waste despite accounting for only 16% of the world's population. In contrast, low income countries (accounting for 9% of world's population) generate just 5% of global waste.[10]

The US accumulated 250 million tons of waste in 2011, more than half of which was green waste. However, 87 million tons of green waste were also diverted from landfills.[11] Diverting green waste does not mean that no GHG emissions are associated with its

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[5] UNEP, "Waste and Climate Change: Global Trends and Strategy Framework," 2009, 71.
[6] Silpa Kaza et al., *What a Waste 2.0 : A Global Snapshot of Solid Waste Management to 2050* (Washington, DC: The World Bank, 2018).
[7] OAR US EPA, "Climate Change," Collections and Lists, August 12, 2013, https://www.epa.gov/climate-change.
[8] Sonia Dias, Lucia Fernandez, and Federico Parra, "Waste Pickers | WIEGO," WEIGO, accessed August 23, 2021, https://www.wiego.org/informal-economy/occupational-groups/waste-pickers.
[9] Dan Hoornweg and Perinaz Bhada-Tata, "What a Waste: A Global Review of Solid Waste Management," *Urban Dev Ser Knowl Pap* 15 (January 1, 2012): 87–88.
[10] Kaza et al., *What a Waste 2.0 : A Global Snapshot of Solid Waste Management to 2050*.
[11] OMS US EPA, "Land, Waste, and Cleanup Topics," Collections and Lists, November 15, 2016, https://www.epa.gov/environmental-topics/land-waste-and-cleanup-topics.

management. If individuals can compost in their own community, for example in their own backyard or at a community garden, then GHG emissions from waste transportation and landfills are reduced. This is not impossible, even in large cities. Improved domestic waste management in cities has the potential to be highly efficient.[12] If a successful composting system can be set up effectively in New York, it can be implemented anywhere.[13] Unfortunately, a large number of residents in dense cities do not have local composting options, so this is where municipal composting programs would be most effective. Composting facilities located downtown would reduce GHG emissions associated with transportation distance. Composting in the EU is more advanced and growing faster. Copenhagen has been diverting green waste from landfills since the 1990s. While others have not yet started composting programs, some Eastern European countries have proven that young composting programs can be extraordinarily successful.[14]

The question of reparations is important to address in a global context because colonialism has led to exploitative production systems and unjust climate impacts.[15] This colonialism is visible in many ways. The British government has time and again claimed to be a "global leader in tackling plastic pollution" but has been exporting its pollution and dumping waste in Turkey, Malaysia, and Poland.[16] In 2019, Sri Lanka sent back 240 containers of hazardous waste to the UK, sent as "materials for recycling."[17]

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[12] Dave Levitan, "Recycling's 'Final Frontier': The Composting of Food Waste," Yale E360, August 8, 2013, https://e360.yale.edu/features/recyclings_final_frontier_the_composting_of_food_waste.
[13] Levitan.
[14] Levitan.
[15] Kristina Douglass and Jago Cooper, "Archaeology, Environmental Justice, and Climate Change on Islands of the Caribbean and Southwestern Indian Ocean," *Proceedings of the National Academy of Sciences* 117, no. 15 (April 14, 2020): 8254–62, https://doi.org/10.1073/pnas.1914211117.
[16] Kathryn Snowdon, "UK Plastic Waste Being Dumped and Burned in Turkey, Says Greenpeace," *BBC News*, May 17, 2021, sec. UK, https://www.bbc.com/news/uk-57139474.
[17] "Explained: Why Sri Lanka Is Sending Back Waste to the United Kingdom," *The Indian Express* (blog), November 6, 2020, https://indianexpress.com/article/explained/explained-why-sri-lanka-is-sending-back-waste-to-the-uk-6912941/.

In these less financially developed parts of the world, waste-picking or ‘scavenging’ as it is known in some places, is a common informal waste management system.[18] Waste pickers form the backbone of waste management in many countries by collecting and sorting waste for a living.[19] Waste picking represents "50-100%" of waste management in "most cities of developing countries.”[20] Waste pickers are responsible for Brazil's "92% of aluminum and 80% of cardboard recycled."[21] Waste pickers contribute significantly to the economies, the environment, and social health without much recognition or protection.[22] Economic, environmental, and social factors are called the triple bottom line.[23] Balancing the triple bottom line is essential for progressing towards and achieving sustainability. Economically, waste-picking is a livelihood that can provide at least some support for individuals and/or their families.[24] At the core of their economic woes is the right to the productive inputs that they use for their livelihoods, in this case, waste.[25] They have no ownership of waste management infrastructures and are constantly threatened by the risks of privatisation of the sector. This lack of access to waste as a commodity threatens their livelihood.[26] Environmentally, diverting recycling from incineration is one of the

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[18] Costas Velis, “Waste Pickers in Global South: Informal Recycling Sector in a Circular Economy Era,” *Waste Management & Research* 35, no. 4 (April 1, 2017): 329–31, https://doi.org/10.1177/0734242X17702024.
[19] Dias, Fernandez, and Parra, “Waste Pickers | WIEGO.”
[20] Anne Scheinberg, David Wilson, and Ljiljana Rodic-Wiersma, *Solid Waste Management in the World’s Cities, UN-HABITAT*, 2010, https://www.researchgate.net/publication/48199927_Solid_Waste_Management_in_the_World's_Cities_UN-HABITAT.
[21] Dias, Fernandez, and Parra, “Waste Pickers | WIEGO.”
[22] Martin Medina, “The Informal Recycling Sector in Developing Countries,” *Gridlines* 44 (October 2008): 4; Dias, Fernandez, and Parra, “Waste Pickers | WIEGO”; “Waste & Gender: Rethinking Relations for Empowerment | WIEGO,” accessed August 23, 2021, https://www.wiego.org/waste-gender-rethinking-relations-empowerment; “The Occupational Health of Waste Pickers in Pune: KKPKP and SWaCH Members Push for Health Rights,” March 2014, 23.
[23] Martin, “Climate Justice,” *United Nations Sustainable Development* (blog), May 31, 2019, https://www.un.org/sustainabledevelopment/blog/2019/05/climate-justice/.
[24] Dias, Fernandez, and Parra, “Waste Pickers | WIEGO.”
[25] V Kalyan Shankar and Rohini Sahni, “Waste Pickers and the ‘Right to Waste’ in an Indian City,” *Economic and Political Weekly* 53, no. 48 (June 5, 2015): 7–8.
[26] “First Global Strategic Workshop of Waste Pickers: Inclusive Solid Waste Management,” 2012, 21.

most efficient ways of avoiding GHG emissions.[27] For example, waste material is upcycled in Belo Hoizonte, Brazil, Nakuru, Kenya, and Los Angeles, United States and sold back to artists in local communities.[28] Waste picking is connected to multiple social issues, including gender income inequality. In Asia, many children are involved in waste picking.[29] About 1 percent of the Indian population is believed to be a waste picker population. Most Indian waste pickers also belong to the lowest caste (essentially outcastes) in the Brahamnical caste hierarchy[30] i.e. are Dalit.[31] Similarly to all occupations, women waste pickers have lower incomes than their male counterparts.[32]

Another social issue that waste picking is connected to is health. Community health benefits at the expense of the wellbeing and health of individual waste pickers. These health concerns are introduced into the homes of waste pickers when they have nowhere else to sort, placing all family members at risk. Waste pickers are often not considered in legislation. Instead, they have been assaulted and arrested for pursuing their livelihoods. Not being seen as a legitimate actor in waste processing and included in the lawmaking process means that health risks are further marginalized due to inadequate or exclusionary health care.

Brazil's government demonstrates that subsidizing and supporting waste pickers results in higher recycling rates and increased income for waste pickers.[33] This is especially true when compared to alternative jobs available to laborers in Brazil. Alternatively, working in cooperatives means that waste pickers can organize to formalize their work and the terms and

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[27] Dias, Fernandez, and Parra, "Waste Pickers | WIEGO."
[28] Dr Jim Bowyer, Kathryn Fernholz, and Alison Lindburg, "Urban Tree Utilization and Why It Matters," *Dovetail Partners, Inc.*, January 23, 2008, 10; Dias, Fernandez, and Parra, "Waste Pickers | WIEGO."
[29] "First Global Strategic Workshop of Waste Pickers: Inclusive Solid Waste Management."
[30] "What Is India's Caste System?," *BBC News*, June 19, 2019, sec. India, https://www.bbc.com/news/world-asia-india-35650616.
[31] "The Occupational Health of Waste Pickers in Pune: KKPKP and SWaCH Members Push for Health Rights."
[32] "Waste & Gender: Rethinking Relations for Empowerment | WIEGO."
[33] Sonia M Dias, "Statistics on Waste Pickers in Brazil," May 2011, 3.

conditions of their employment. For example, many organized waste pickers have access to uniforms that simultaneously save their personal clothes and increase their self esteem.[34] Waste pickers contribute significantly to the economies, the environment, and social health, but are often harmed economically and socially without support from governments or cooperatives.[35]

Circular economies can help economies grow and reduce their carbon footprint simultaneously.[36] Waste picking has proven to be an essential part in circular economies in the Global South.[37] Circular economies do not only concern themselves with waste disposal and management, their scope also extends to re-production and recycling of waste into useful products.[38] The Circular economy model has been adopted in many EU countries that are "green conscious." The EU itself produces about 1.3 billion tonnes of waste annually. Of this, 700 millions tonnes is agricultural waste.[39] There are dire impacts for communities and the environment if such waste is improperly managed. Promoting circular economies and improved waste management has economic value and is urgently required if we are to tackle climate change by reducing a significant portion of GHG emissions.

1.2 Statement of Topic

Waste management solutions range from large scale waste collection, transportation, sorting, recycling, disposal, and landfill systems to waste pickers taking care of their communities. The robustness of a waste management system does not necessarily equate to its effectiveness. The more robust a waste management system is, the more the individual workers

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[34] Medina, "The Informal Recycling Sector in Developing Countries."
[35] Dias, Fernandez, and Parra, "Waste Pickers | WIEGO."
[36] Iain Robertson, "The Leading Circular Economy Nations," May 21, 2017, https://www.innovatorsmag.com/the-leading-circular-economy-nations/.
[37] Velis, "Waste Pickers in Global South."
[38] Ružica Lončarić, Tihana Sudarić, and Sanja Jelić Milković, "Circular Economy and Agricultural Waste Management in Croatia," 2021, 787–803, https://www.researchgate.net/publication/352679367_Circular_economy_and_agricultural_waste_management_in_Croatia.
[39] Levitan, "Recycling's 'Final Frontier.'"

are supported.[40] Tech-enabled composting, waste banks, and sustainable textile management are all methods that can be used together to work towards circular economies. Circular economies can help economies grow and reduce their carbon footprint simultaneously.

[40] Dias, Fernandez, and Parra, “Waste Pickers | WIEGO.”

Part 2:

Methodology

This section describes the methodology used to conduct this systematic literature review on the corresponding research title. This study is a process that enabled the collection of relevant evidence on the pertaining topic that meets the pre-specified eligibility criteria and provided an answer to the formulated research questions, as shown below.[41]

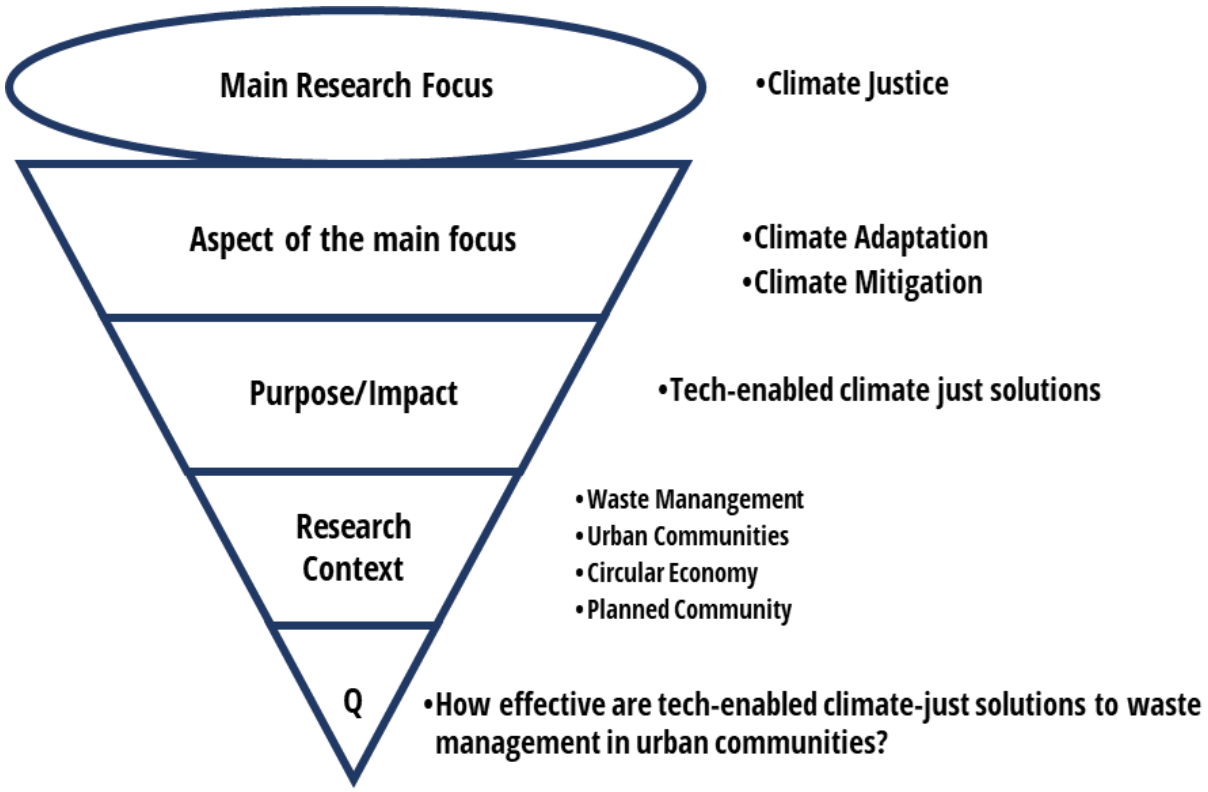

Figure 1: Ice Cream Cone Model.[42]

After establishing the research question, the study moved towards the following steps to develop the systematic review.

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[41] Angela Boland, Gemma Cherry, and Rumona Dickson, *Doing a Systematic Review: A Student's Guide* (United Kingdom: SAGE Publications, 2017).

[42] Simon Brownhill, Talash Ungarova, and Aiman Bipazhanova, "'Jumping the First Hurdle': Framing Action Research Questions Using the Ice Cream Cone Model," *Methodological Innovations* 10, no. 3 (July 1, 2017): 2059799117741407, https://doi.org/10.1177/2059799117741407.

Figure 2: Method for conducting systematic literature review.[43]

The first step was to search. This step included defining key searching terms and types of databases. The authors initially relied upon only academic repositories such as ResearchGate, ScienceDirect and Emerald Insight to define keywords and extract literature related to the research question.[44]

As per Mengist, Soromessa and Legese (2020), after establishing the key definitions the study expanded its search and initiated a quality assessment criterion to include and exclude literature based on key parameters such as published date to be before 2011, alignment with the research context, and regional focus in terms of urban communities.[45]

The study thereafter synthesized, categorised, and coded the articles according to the defined variables and research contexts as illustrated by Figure 1. The study relied on appraisal parameters and recorded the information authors obtained from the literature.[46] To reduce the opportunity for bias, the literature synthesis was defined and piloted in a manner suitable for answering the review questions.[47] Thereby, the study established Sustainable Development Goals 1,2,3,5,11,12,13 and 17 as metrics to measure the effectiveness of climate-just solutions.

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[43] Wondimagegn Mengist, Teshome Soromessa, and Gudina Legese, "Method for Conducting Systematic Literature Review and Meta-Analysis for Environmental Science Research," *MethodsX* 7 (January 1, 2020): 8, https://doi.org/10.1016/j.mex.2019.100777.
[44] Brownhill, Ungarova, and Bipazhanova, "'Jumping the First Hurdle.'"
[45] Mengist, Soromessa, and Legese, "Method for Conducting Systematic Literature Review and Meta-Analysis for Environmental Science Research."
[46] Boland, Cherry, and Dickson, *Doing a Systematic Review*.
[47] Mengist, Soromessa, and Legese, "Method for Conducting Systematic Literature Review and Meta-Analysis for Environmental Science Research."

Analysis narrated the findings and their practical implications to finally reach the conclusion. The main challenge that arose was the restriction in length imposed as well as the strong emphasis to use language that favours ease of comprehension with the use of visuals.[48]

Part 3:

Composting

Poor waste management has been detrimental to our soil, specifically agricultural soil.[49] Runoff from landfills causes soil to be less fertile.[50] Food grown in such soil is often filled with the same chemicals found in the growing medium. This affects not only those who eat this food, but communities whose economy is based on agriculture. These communities are unable to profit if the soil is not bearing food or if the food is inedible.[51]

We can acknowledge that climate change is expedited by carbon emissions. Effective carbon capture technology is a necessity in this fight. *Sciences et avenir*, the French science magazine, wrote that soil is a vital location for carbon storage because it helps the climate crisis and agricultural issues.[52] Plants convert carbon into organic compounds through photosynthesis.[53] Given this, we believe that soil can be used as a carbon capture method. However, carbon cannot be stored in soil forever. Carbon is attached to organic matter as energy storage for organisms before eventually going back into the hydrosphere or atmosphere as carbon dioxide.[54]

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[48] Boland, Cherry, and Dickson, *Doing a Systematic Review*.
[49] Seth Denizen, "Thinking Through Soil," Thinking Through Soil, 2020, https://thinkingthroughsoil.studio/.
[50] Denizen.
[51] Denizen.
[52] Colombe Henrion, "Le compost, une prévention contre les maladies alimentaires ?," Sciences et Avenir, April 12, 2021, https://www.sciencesetavenir.fr/nature-environnement/agriculture/compost-et-cultures-de-couverture-une-prevention-contre-les-maladies-alimentaires_153356.
[53] Henrion.
[54] Henrion.

As such, we've identified two targets within agricultural soil that require creative solutions and where waste management can play a key role: wastewater negatively affecting soil and soil being used as a carbon capture technology. Our solution is for rural communities to create composting infrastructure. By doing so, communities can reduce waste sent to landfills, store carbon within soil, and create a circular economy.

Waste banks can divert some waste traditionally sent to landfills. However, a portion of the waste sent to landfills is compostable. By reducing the amount of waste in landfills, we can reduce the amount of runoff affecting soil. Lower income communities that are unjustly zoned near landfills are affected by landfill runoff.[55]

It is important to consider how composting infrastructure can be ineffective. In Mumbai, India, tax rebates were offered to encourage citizens to compost. However, this did not result in increased composting efforts.

We believe composting is an effective solution to capture carbon, mitigate the effects of landfill runoff, and manage waste while providing agricultural communities an additional revenue stream. When used with our recommendations, composting can create a circular economy, closing the loop on production materials usually forgotten. While this paper focused on rural communities, this solution can be taken by any community that can afford to do so. Composting infrastructure on a small scale is relatively inexpensive to start and requires little management effort. Effective composting needs resources, but communities should be empowered to create the infrastructure they will need. Focusing on what goes into compost systems, the compost's carbon and nitrogen levels, and the proximity of composting centers to communities will give this solution the best chance of success. Communities that can afford to do so should create composting management teams, the size of which depends on the size of the

[55] Denizen, "Thinking Through Soil."

center itself. Communities that cannot afford to create composting divisions should put pressure on their current waste management partners to incorporate such infrastructure. They should be expected to do so swiftly.

While individual citizens can create personal composts where they have the space, they may lose the ability to sell the resulting material. The individual will also be required to allocate more resources to manage this waste stream. For this reason, we do not recommend individuals creating composting infrastructure. Communities can gather together more resources than the individual and can control their own economy. It is also not recommended that a third-party create such infrastructure for profit, as they will often ignore the needs of the community for their bottom line.

However, power lies with the individual. People can put pressure on factories and companies to produce waste that can either contribute to waste banks or be composted. They can request companies that have contributed to the deterioration of the soil to invest in the management or development of composting infrastructure. Groups like LA Compost can assist individuals in demanding required changes.[56] Forming collectives within the community to address these issues is also recommended.

[56] "LA Compost," LA Compost, accessed August 25, 2021, https://www.lacompost.org.

Part 4:

Fashion and Waste Banks

Around the world, one out of every three people does not have access to clean water.[57] Meanwhile, to make a cotton t-shirt it takes freshwater that is enough for a person to drink for two and a half years.[58] Waterways are polluted because of the extensive use of chemicals in the textile manufacturing process. Faroque and South (2021) noted that the majority of the rivers and waterways close to industrial zones are populated by garment factories that pollute high concentration levels of toxic heavy metals.[59] Islam and Mostafa (2019) pointed out that water pollution happens due to discharge of untreated textile dye effluents.[60]

Many academics have investigated and found the production of waste has detrimental consequences on aquaculture, agriculture, ecology, the environment, and public health. As per Textile Exchange (2020), polyester accounts for more than half of globally produced fibres.[61] Uren (2021) notes that polyester made using petroleum can be completely recyclable at the end of its life, still, only fourteen percent of polyester gets recycled.[62] According to Pulse Report (2017), four-fifths of post-consumer clothing waste ends up in landfills or incinerators and

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[57] WHO, "1 in 3 People Globally Do Not Have Access to Safe Drinking Water – UNICEF, WHO," June 18, 2019, https://www.who.int/news/item/18-06-2019-1-in-3-people-globally-do-not-have-access-to-safe-drinking-water-unicef-who.

[58] Better Cotton Initiative, "Cotton's Water Footprint: How One T-Shirt Makes A Huge Impact On The Environment," *Better Cotton Initiative* (blog), January 27, 2013, https://bettercotton.org/about-bci/cottons-water-footprint-how-one-t-shirt-makes-a-huge-impact-on-the-environment/.

[59] Muhammad Farooque et al., "Circular Supply Chain Management: A Definition and Structured Literature Review," *Journal of Cleaner Production* 228 (April 1, 2019): 80, https://doi.org/10.1016/j.jclepro.2019.04.303.

[60] MR Islam and M. G. Mostafa, "Textile Dyeing Effluents and Environment Concerns - A Review," *Journal of Environmental Science and Natural Resources* 11 (October 1, 2019): 131–44, https://doi.org/10.3329/jesnr.v11i1-2.43380.

[61] Textile Exchange, "2020 Preferred Fiber and Materials Market Report (PFMR) Released! - Textile Exchange," June 29, 2020, https://textileexchange.org/2020-preferred-fiber-and-materials-market-report-pfmr-released-2/.

[62] Ashlee Uren, "Material Guide: How Sustainable Is Polyester?," Good On You, May 13, 2021, https://goodonyou.eco/how-sustainable-is-polyester/.

one-third of material ends up as waste due to inadequacies in the fashion supply chain.[63] Pulse Report (2018) estimated that less than one percent of all clothing materials gets repurposed or recycled into new garments.[64]

[63] Jonas Eder-Hansen et al., "Pulse of The Fashion Industry 2017," 2017, 134.
[64] Morten Lehmann et al., "Pulse of The Fashion Industry 2018," 2018, 119.

The model below illustrates the linear supply chain of fashion.

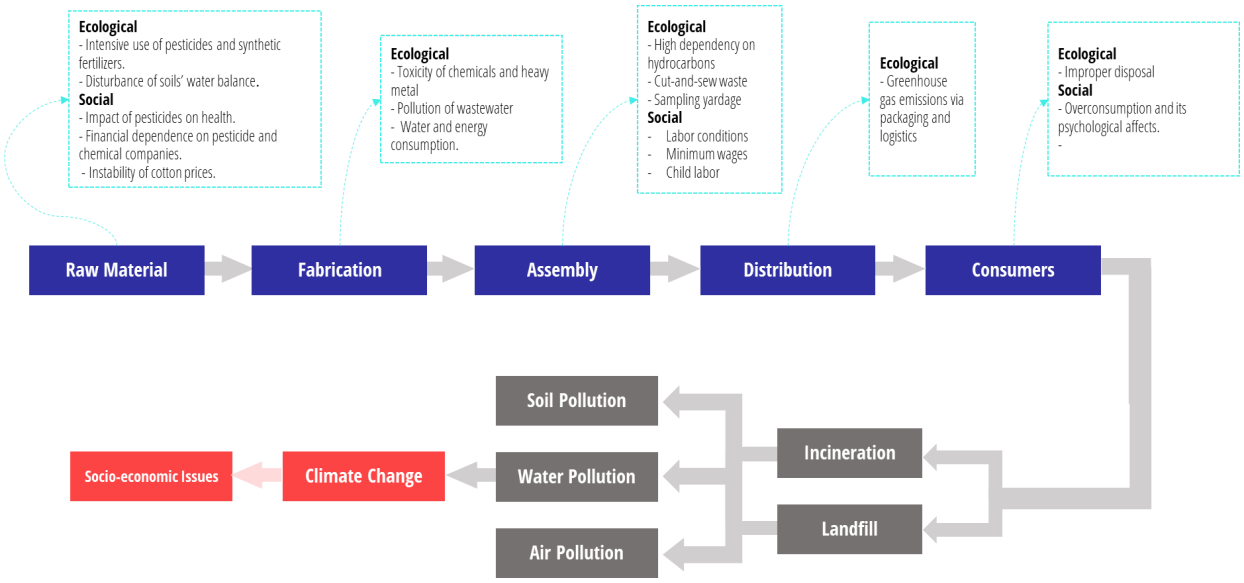

Figure 4: Linear Supply Chain of Fashion and Textile Industry.[65]

Regardless of whether raw materials are acquired from plants, animals, or crude oil, textile production is energy-intensive and pollutant-intensive.[66] Academics and industry leaders are working on various methods to innovate and fulfil sustainability standards in textile and garment manufacturing to promote an overall circular economy. These methods include but are not limited to recycling, zero-waste design, deconstruction, biodegradability, inclusive design, and organic cellulosic fibres.[67]

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[65] Farooque et al., "Circular Supply Chain Management"; Thomas K. Dasaklis and Costas P. Pappis, "Supply Chain Management in View of Climate Change: An Overview of Possible Impacts and the Road Ahead," *Journal of Industrial Engineering and Management* 6, no. 4 (October 29, 2013): 1139–61, https://doi.org/10.3926/jiem.883; Jisoo Oh and Bongju Jeong, "Profit Analysis and Supply Chain Planning Model for Closed-Loop Supply Chain in Fashion Industry," *Sustainability* 6, no. 12 (December 2014): 9027–56, https://doi.org/10.3390/su6129027.

[66] Laura Navone et al., "Closing the Textile Loop: Enzymatic Fibre Separation and Recycling of Wool/Polyester Fabric Blends," *Waste Management* 102 (February 2020): 149–60, https://doi.org/10.1016/j.wasman.2019.10.026.

[67] Antonella Patti, Gianluca Cicala, and Domenico Acierno, "Eco-Sustainability of the Textile Production: Waste Recovery and Current Recycling in the Composites World," *Polymers* 13, no. 1 (December 30, 2020): 134, https://doi.org/10.3390/polym13010134.

Spišáková, Mésároš and Mandičák (2021) emphasise that all waste management techniques should be audited for their carbon footprints and impacts on stakeholders.[68] Textile and garment waste management needs to be streamlined and integrated into other management techniques.[69] One popular garment disposal option is to donate to local charity stores.[70]

Contrary to popular belief, garments donated through charities are creating more problems than solving any.[71] Due to the unmanageable influx of pre-loved clothes, charities are sometimes even compelled to bear financially on sifting through and disposing of these donated clothes, of which only a quarter is donated to the financially and socially ill-fated communities.[72] In addition, between 40 and 50 percent of second-hand clothing is shipped into problematic global second-hand clothing trade, where it floods textile markets of countries, such as Rwanda, Pakistan, Haiti, and Uganda, while the rest ends up in local landfills or incinerators.[73] To add to the growing list of issues, these countries have far worse waste management systems and poor infrastructure to upcycle or recycle large quantities of waste.[74]

There has been a long practice of recycling textiles due to their scarcity throughout history. Some communities in South Asia would use them as lamp covers, carpets, rags, or process the garments and utilise the ash to make cosmetics, which is today known as

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[68] Marcela Spisakova, Peter Mesároš, and Tomáš Mandičák, "Construction Waste Audit in the Framework of Sustainable Waste Management in Construction Projects—Case Study," *Buildings* 11 (February 11, 2021): 61, https://doi.org/10.3390/buildings11020061.
[69] Navone et al., "Closing the Textile Loop."
[70] Alison Gwilt and Timo Rissanen, *Shaping Sustainable Fashion: Changing the Way We Make and Use Clothes* (London; Washington, DC: Earthscan, 2011), http://public.eblib.com/choice/publicfullrecord.aspx?p=982115.
[71] Joanna Psaros, "The Problem With Donating Your Clothes to Charity," Good On You, January 9, 2020, https://goodonyou.eco/the-problem-with-donating-your-clothes-to-charity/.
[72] Psaros.
[73] Textile Exchange, "2020 Preferred Fiber and Materials Market Report (PFMR) Released! - Textile Exchange."
[74] Syed Ali et al., "Improvement of Waste Management Practices in a Fast Expanding Sub-Megacity in Pakistan, on the Basis of Qualitative and Quantitative Indicators," *Waste Management* 85 (February 15, 2019): 253–63, https://doi.org/10.1016/j.wasman.2018.12.030; Joshua Babayemi et al., "Ensuring Sustainability in Plastics Use in Africa: Consumption, Waste Generation, and Projections," *Environmental Sciences Europe* 31 (September 28, 2019): 20, https://doi.org/10.1186/s12302-019-0254-5.

down-cycling.[75] Unfortunately, most people do not have the time or ability to fix or repair clothing and accessories.[76] Negatively changing consumer psychology has resulted in a culture of disposable fashion.

It is evident that an innovative and community-based solution is essential to battle the ecological impact as well as its ramifications on climate change.[77] To achieve environmental and social awareness, the community must be able to manage trash using several alternative waste management methods.[78] The establishment of waste banks can increase public awareness of the need to sort waste. As a result, the trash banks become sites for waste management where the community is involved. This is known as community-based waste management.[79] For community scale management, waste banks could be a hands-on experience of how environmental waste management can be done utilising the UNEP (2005) waste management hierarchy.[80]

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[75] Lucy Norris, *Recycling Indian Clothing: Global Contexts of Reuse and Value*, *Recycling Indian Clothing: Global Contexts of Reuse and Value* (Indiana, US: Indiana University Press, 2010), https://www.researchgate.net/publication/262818410_Recycling_Indian_Clothing_Global_Contexts_of_Reuse_and_Value.
[76] Norris.
[77] Dyah Wijayanti and Sri Suryani, "Waste Bank as Community-Based Environmental Governance: A Lesson Learned from Surabaya," *Procedia - Social and Behavioral Sciences* 184 (May 20, 2015): 171–79, https://doi.org/10.1016/j.sbspro.2015.05.077.
[78] Wijayanti and Suryani.
[79] Vita Ruliana, Roekmijati Soemantojo, and Donna Asteria, "Assessing a Community-Based Waste Separation Program through Examination of Correlations between Participation, Information Exposure, Environmental Knowledge, and Environmental Attitude," *ASEAN Journal of Community Engagement* 3 (July 31, 2019): 1–27, https://doi.org/10.7454/ajce.v3i1.120.
[80] United Nations Environment Programme, *Integrated Waste Management Scoreboard: A Tool to Measure Performance in Municipal Solid Waste Management* (The Hague, The Netherlands: United Nations Environment Program, 2005), http://www.unep.or.jp/Ietc/Publications/spc/IWM_scoreboard-binder.pdf.

When feasible, eliminating waste from production should always be considered first.[81] The overall objective of waste banks is to reduce overall dependence on virgin material.[82] When it comes to the second stage, reusing, the goal is to get the garment or textile back into the hands of another customer.[83] The third option, recycling, uses discarded objects to create new ones.[84] Waste can be upcycled or downcycled into items that serve the same or different purposes as when they were initially used.[85] Upcycling involves turning waste into high-value items that have a different function than the original usage. As discussed above, downcycling involves converting valuable products into lower-value ones.[86]

[81] Jibril Dan azimi Jibril et al., "3R s Critical Success Factor in Solid Waste Management System for Higher Educational Institutions," *Procedia - Social and Behavioral Sciences*, International Congress on Interdisciplinary Business and Social Sciences 2012 (ICIBSoS 2012), 65 (December 3, 2012): 626–31, https://doi.org/10.1016/j.sbspro.2012.11.175.
[82] Malgorzata Koszewska, "Circular Economy — Challenges for the Textile and Clothing Industry," *Autex Research Journal* 18 (July 19, 2018): 337–47, https://doi.org/10.1515/aut-2018-0023.
[83] Koszewska.
[84] Navone et al., "Closing the Textile Loop."
[85] Gwilt and Rissanen, *Shaping Sustainable Fashion*.
[86] Gwilt and Rissanen.

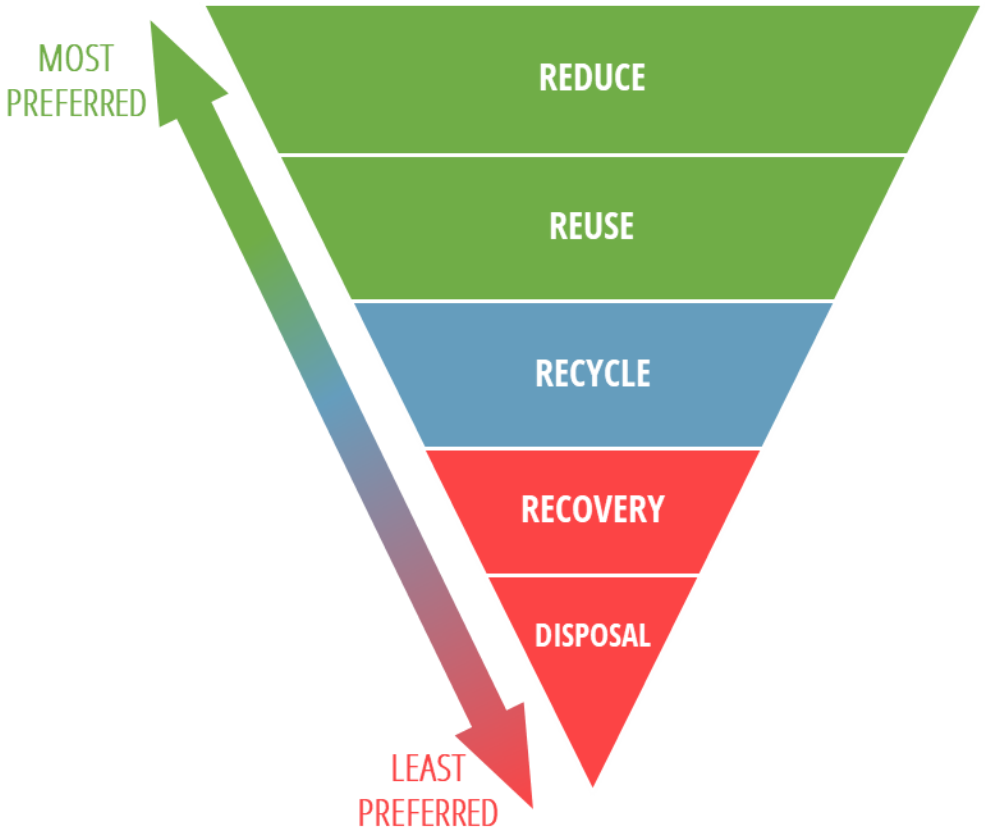

Figure 5: Waste Management Hierarchy.[87]

Trash banks work to create profits for their community, assuring long-term viability and reducing financial risk. Waste segregation is essential for sustainable waste management. Waste banks become consumers who can manage waste in their surrounding communities. It is the job of waste banks to simultaneously incentivise sustainable disposal, manage waste, and educate local communities.

By using waste banks to repurpose waste into a commercial commodity, the public's perception of waste may be changed in due process. To promote community knowledge of climate change and its impact, textile banks rely on consumers, as can be observed in textile

[87] United Nations Environment Programme, *Integrated Waste Management Scoreboard*.

bank activities. This demonstrates environmental consciousness, illustrated by the revised framework below.

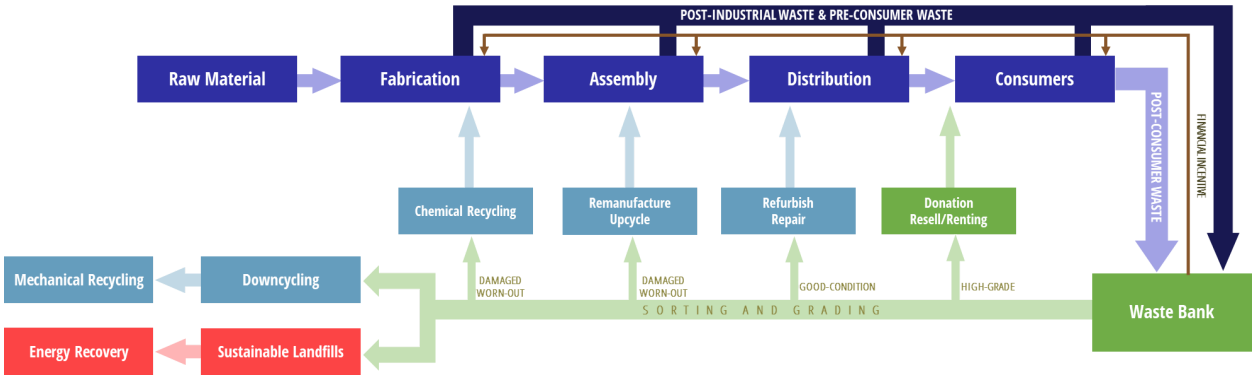

Figure 6: Waste Bank Integration to Fashion and Textile Supply Chain.[88]

Production, and disposal infrastructure along with garment construction, fibre composition, logos, emblems, and accessories play a role in the practical and economic viability of textile and clothing recycling.[89] Many modern trash problems stem from diversity between different types of waste.[90] As a result of this, waste banks depend on the local communities to

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[88] Vanessa Prieto-Sandoval, Carmen Jaca, and Marta Ormazabal, "Towards a Consensus on the Circular Economy," *Journal of Cleaner Production* 179 (April 1, 2018): 605–15, https://doi.org/10.1016/j.jclepro.2017.12.224; Alice Payne, "Open and Closed-Loop Recycling of Textile and Apparel Products," in *Handbook of Life Cycle Assessment (LCA) of Textiles and Clothing [1st Edition]*, ed. S. Muthu (United Kingdom: Woodhead Publishing, 2015), 103–23, http://store.elsevier.com/Handbook-of-Life-Cycle-Assessment-LCA-of-Textiles-and-Clothing/isbn-9780081001691/; Helena Dahlbo et al., "Increasing Textile Circulation—Consequences and Requirements," *Sustainable Production and Consumption*, Sustainable Utilisation of Waste, 9 (January 1, 2017): 44–57, https://doi.org/10.1016/j.spc.2016.06.005; Sarah Obser, "Transparency and Traceability in the Textile and Clothing Supply Chain" (2015), https://doi.org/10.13140/RG.2.2.16892.74883; Subramanian Senthilkannan Muthu, *Circular Economy in Textiles and Apparel: Processing, Manufacturing, and Design* (Woodhead Publishing, 2018), https://www.google.com/books/edition/Circular_Economy_in_Textiles_and_Apparel/Gap2DwAAQBAJ?hl=en&gbpv=0; Zhi-Hua Hu et al., "Sustainable Rent-Based Closed-Loop Supply Chain for Fashion Products," *Sustainability* 6 (October 16, 2014): 7063–88, https://doi.org/10.3390/su6107063; Farooque et al., "Circular Supply Chain Management."

[89] Sabine Weber, Jennifer Lynes, and Steven Young, "Fashion Interest as a Driver for Consumer Textile Waste Management: Reuse, Recycle or Disposal: Choice of Textile Waste Management," *International Journal of Consumer Studies* 41 (November 1, 2016): 207–15, https://doi.org/10.1111/ijcs.12328.

[90] Benjamin Piribauer and Andreas Bartl, "Textile Recycling Processes, State of the Art and Current Developments: A Mini Review," *Waste Management & Research* 37, no. 2 (February 1, 2019): 112–19, https://doi.org/10.1177/0734242X18819277.

collect waste. Based on the waste collected, the waste bank will give the donor a nominal amount for their efforts. This also acts as an incentive for consumers and manufacturers to dispose of their textile and cloth waste at the waste bank.[91] Waste banks sort and grade waste to select suitable processing.[92]

Waste banks depend on disposal as an option if they are unable to recycle or downcycle. During disposal, the focus is on energy recovery and its impact on the climate. The difficulty of recycling mixed textiles demonstrates that disposal and energy recovery are two stages that can be challenging to manage when.[93] Unregulated and illegal waste banks can have negative impacts on their local communities as they can advocate and practice unsustainable waste management procedures.[94]

4.1 Fashion and Waste Bank Practical Implications

Pradiko, Wahyuni and Ganiy (2021) carried out an investigation in Kasomalang Kulon Village to evaluate the aspects of knowledge, attitude and practice.[95] They found that knowledge sharing is a crucial part of a waste bank's ecosystem because knowledge, attitude, and motivation

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[91] Ida Marie Sandvik and Wendy Stubbs, "Circular Fashion Supply Chain through Textile-to-Textile Recycling," *Journal of Fashion Marketing and Management* 23, no. 3 (January 1, 2019): 366–81, https://doi.org/10.1108/JFMM-04-2018-0058.

[92] Hafizhul Khair, Indriyani Rachman, and Toru Matsumoto, "Analyzing Household Waste Generation and Its Composition to Expand the Solid Waste Bank Program in Indonesia: A Case Study of Medan City," *Journal of Material Cycles and Waste Management* 21 (February 11, 2019), https://doi.org/10.1007/s10163-019-00840-6.

[93] Diego Moya et al., "Municipal Solid Waste as a Valuable Renewable Energy Resource: A Worldwide Opportunity of Energy Recovery by Using Waste-To-Energy Technologies," *Energy Procedia*, Sustainability in Energy and Buildings 2017: Proceedings of the Ninth KES International Conference, Chania, Greece, 5-7 July 2017, 134 (October 1, 2017): 286–95, https://doi.org/10.1016/j.egypro.2017.09.618; Anna Palme et al., "Development of an Efficient Route for Combined Recycling of PET and Cotton from Mixed Fabrics," *Textiles and Clothing Sustainability* 3 (December 1, 2017): 9, https://doi.org/10.1186/s40689-017-0026-9.

[94] Chil Soon Kim and Ken Ri Kim, "Kim, Chill Soon, Ken Ri Kim, and Kyung Hee. 2016. 'A Case Study Comparing Textile Recycling Systems of Korea and The UK To Promote Sustainability'. Journal Of Textile and Apparel Technology and Management 10 (1).," *Journal of Textile and Apparel, Technology and Management* 10, no. 1 (2016): 11.

[95] Hary Pradiko, S Wahyuni, and W Ganiy, "Knowledge-Attitude-Practice Method Analysis as a Guide for Kasomalang Kulon Village Waste Bank Planning," *IOP Conference Series: Earth and Environmental Science* 737 (April 1, 2021): 6, https://doi.org/10.1088/1755-1315/737/1/012074.

have a positive correlation. Pradiko, Wahyuni and Ganiy (2021) recommended having a well-established channel to share knowledge with stakeholders when planning a waste bank.[96]

Wijatanthi and Suryani (2015) conducted research in Surabaya which showed that having a clear purpose, transparent administration, and involved community members results in a self-sustaining system that attracts new members and advocates.[97] In Gambo's (2018) study he uncovered that cloth banks in Kano State, Nigeria act as social welfare programs because they provide an alternative to working for factories or manufacturers.[98]

Norton, Cherrett and Waterson (2012) point out that Oxfam, a UK based non-profit textile bank depends on charity donations.[99] Like findings from Pradiko, Wahyuni and Ganiy (2021), Oxfam also depends on educating the public about the impact of textile waste with a strong emphasis on supply chain optimisation.[100] In another study of Oxfam, Cherrett et al. (2010) point out that Oxfam donates unwanted items to charity organisations to prevent them from ending up in landfills.[101] Additionally, Oxfam attempts to reduce its overall footprint by investing in green logistics.

In their comparative study of textile banks in the UK and Korea, Kim & Kim (2016) found that illegal textile collection and distribution is rampant in Korea.[102] Private organisations

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[96] Pradiko, Wahyuni, and Ganiy.
[97] Wijayanti and Suryani, "Waste Bank as Community-Based Environmental Governance."
[98] K.K. Musa Gambo, "Mosque Leadership and Management in Kano Metropolis: Case of Al-Furqan Mosque, Kano State, Nigeria," *International Journal of Islamic Marketing and Branding* 3, no. 3 (2018): 183, https://doi.org/10.1504/IJIMB.2018.095838.
[99] B. Norton, T. J. Cherrett, and B. Waterson, "Understanding the Explanatory Factors Leading to Variability in Charity Collection Bank Yields: Implications for Bank Placement and Logistics Strategy," 2012, https://eprints.soton.ac.uk/348583/.
[100] Pradiko, Wahyuni, and Ganiy, "Knowledge-Attitude-Practice Method Analysis as a Guide for Kasomalang Kulon Village Waste Bank Planning"; Norton, Cherrett, and Waterson, "Understanding the Explanatory Factors Leading to Variability in Charity Collection Bank Yields."
[101] Tom Cherrett et al., "Take-Back Mechanisms in the Charity Sector: A Case Study on Oxfam," accessed August 24, 2021, http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.408.4134&rep=rep1&type=pdf.
[102] Kim and Kim, "Kim, Chill Soon, Ken Ri Kim, and Kyung Hee. 2016. 'A Case Study Comparing Textile Recycling Systems of Korea and The UK To Promote Sustainability'. Journal Of Textile and Apparel Technology and Management 10 (1)."

hindering established regulations can have negative ramifications for waste separation and recycling crucial to waste banks. Kim & Kim (2016) also emphasised the need for effective regulations to avoid waste banks pivoting to global waste trade or shifting waste back to landfills.[103] Khair, Rachman and Matsumoto (2019) highlight the importance of the sanitation of waste before sorting and processing because unregulated and illegal waste banks pose a risk to public health.[104]

4.2 Fashion and Waste Bank Conclusion

When it comes to the social, economic, and environmental impacts of ultra-fast fashion and now real-time retail culture, the volume of textile waste has skyrocketed. Consumer education is needed to raise awareness of environmental problems and obligations as the volume of textile waste increases. International policy recognizing waste banks would reduce textile waste, save money, reduce energy consumption, decrease demand for natural resources, and promote the efficacy of recycling and reusing discarded textile goods.

It is crucial to empower community-based waste management that considers the cognitive capital of the public. For sustainable waste management, the social dimension of waste management via collaboration is essential because environmental and economic consequences of both textile production and waste management shift consumer attitude towards disposable fashion.

[103] Kim and Kim.
[104] Khair, Rachman, and Matsumoto, “Analyzing Household Waste Generation and Its Composition to Expand the Solid Waste Bank Program in Indonesia.”

Part 5:

Technology

Though it has been practised for centuries, waste management needs to evolve. Tapping into the latest technologies can make waste management more efficient, reliable, and productive by generating a valuable end-product, reducing emissions, and building a circular economy.

Economical and ecological impact integration of technology could catalyse circular economy and climate justice. For both developed and developing countries, it is a matter that may impede full resource recovery potential and health improvements.[105] For climate justice to be achieved, there is a need to rethink how we extract the natural resources and how we could potentially tap into waste as a resource in urban and rural settings.[106] Arguably, the finite resources that future generations will depend on should be conserved particularly since the means are available to develop circular economies and build more sustainable, non-wasteful, resource-efficient production and consumption cycles. In the climate justice context, we also take a look at a majority of households in developing countries that do not have access to reliable waste collection.

In low-income countries, over 90% of waste is often disposed of in unregulated dumps or openly burned. Compared to developed nations, residents in developing countries, especially the urban poor, are more severely impacted by unsustainably managed waste.[107] The disparity among

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[105] Colleen C. Naughton et al., "Can Sanitation Technology Play a Role in User Perceptions of Resource Recovery? An Evaluation of Composting Latrine Use in Developing World Communities in Panama," *Environmental Science & Technology* 52, no. 20 (October 16, 2018): 11803–12, https://doi.org/10.1021/acs.est.8b02431.

[106] Alan Murray, Keith Skene, and Kathryn Haynes, "The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context," *Journal of Business Ethics* 140, no. 3 (February 1, 2017): 369–80, https://doi.org/10.1007/s10551-015-2693-2.

[107] "Solid Waste Management," World Bank, September 23, 2019, https://www.worldbank.org/en/topic/urbandevelopment/brief/solid-waste-management.

those who receive waste collection ‘classified in basic services’ is another indicator of injustice that reveals how access to these basic services varies by income and economic status globally.

Technology	Application
Internet of Things	IoT-based waste management in automating waste sorting at the source, providing more efficiency in route optimization in waste collection.
Artificial Intelligence	AI-enabled composting in monitoring the moisture content and enabling real-time decision making.
Big Data	Big Data in estimating the precise bin/waste bank placements around the cities.
Blockchain	Blockchain is providing transparency in product origin, producer accountability as well as tracking waste materials throughout the value chain.

Figure 7: How different technologies and information management systems can be embedded in production processes to accelerate the circular economy and the potential for climate justice to be addressed.

5.1 Case Studies: Real-world application of advanced technologies in waste management

5.1.1 IoT-driven smart waste management in Rwanda

With different stakeholders, the government completed the installation of smart waste collection stations in 10 public markets across the three districts that make up Kigali. Powered with solar energy, the stations have smart garbage cans with a real-time monitoring system that uses sensors to alert collectors on garbage fill levels. The stations have dashboards where the information collected can be analyzed and displayed, as well as an end-to-end security system that includes video surveillance cameras and geographic information system (GIS) to identify the source of the data.[108]

Other than diverting 100 daily tons of waste generated in 10 public markets, the project is also leveraging the IoT technology for real-time compost monitoring. The resulting high-quality compost is being provided to farmers, the country's largest workforce. The Rwandan capital currently has a population of more than 1.6 million, which is expected to double by 2035. Waste management is becoming increasingly important. Adopting an effective management system now should enable the city to avoid a future crisis.[109]

5.1.2 AI-enabled waste segregation in India

With their proprietary algorithm 'ishitvAI,' an Indian-based company is leveraging computer vision to make sorting more efficient at different stages of the waste value chain. Ishitva currently offers a range of solutions including SUKA (AI-powered air sorting), YUTA, (AI-powered robotic sorting), Netra AI Vision system, which helps identify waste, and smart

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[108] Emmanuel Come Mugisha, "Kigali to Pilot 'Smart' Waste Management System | The New Times | Rwanda," The New Times, September 1, 2020, https://www.newtimes.co.rw/news/kigali-pilot-smart-waste-management-system.

[109] Ecofin Agency, "Rwanda: ICT Ministry Plans a Smart Waste Management System," Ecofin Agency, September 2020, https://www.ecofinagency.com/telecom/0409-41777-rwanda-ict-ministry-plans-a-smart-waste-management-system.

bins.[110] With ishitvAI, Ahmedabad-waste value chain actors have been able to achieve automated, high volume, and better quality sorting in a fraction of the time, compared to human sorting.

In India, an estimated 26,000 tonnes of plastic waste is being generated per day and over 10,000 tonnes of plastic waste is not being collected. Half of the country's plastic waste is generated in the five cities of Delhi, Mumbai, Bengaluru, Chennai and Kolkata. Maharashtra and Delhi are the leading MSW and plastic waste generating states respectively. Herein lies a big opportunity to use AI technology.[111]

5.1.3 Leveraging the blockchain to provide transparency in the plastic-value chain in Haiti

The Plastic Bank uses such blockchain rewards to incentivize individuals to become plastic waste collectors, particularly in developing countries. Their aim is to reduce the amount of plastic that ends up in the oceans. The gathered waste is brought to collection locations where the waste is weighed before a payment is made to the collector through a blockchain-based banking application. The immutability and transparency of blockchain prevents fraudulent and corrupt practices.

With over 30,000 registered members, the Plastic Bank has been able to stop over 28 million kilograms of plastic from going to the ocean. Plastic Bank's Social Plastic® ecosystems result in improved access to employment, education, services, and technology for developing communities across the globe.[112]

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[110] Shreya Ganguly, "This Ahmedabad-Based Startup Uses AI to Help India Effectively Recycle and Manage Waste," YourStory.com, May 25, 2020, https://yourstory.com/2020/05/ahmedabad-startup-ishitva-robotic-systems-recycle-waste/amp.
[111] Malvika Jain, "AI Opportunities in Waste Management," Invest India, January 19, 2021, https://www.investindia.gov.in/team-india-blogs/ai-opportunities-waste-management.
[112] "Plastic Bank Is #1 for Certified Environment & Social Impact," Plastic Bank, 2021, https://plasticbank.com/our-impact/.

Part 6

Conclusion

We establish a linkage between climate justice and circular economy in different multidimensional aspects:

6.1 Compost & climate mitigation

Through soil intake of organic materials, compost contributes to climate change mitigation. Composting improves soil's ability to pull more carbon dioxide out of the atmosphere, stabilize carbon storage, and increase plant growth.[113] Regarded as the largest waste stream in developing countries, bio-waste could be an efficient resource for more soil amendments, climate mitigation, and economic change.[114]

6.2 Waste Bank & equal access-affordable waste collection services

Lack of access to affordable and reliable waste collection services is an injustice in its own right. The right to sanitation entitles everyone to have physical and affordable access to sanitation.[115] For a majority of low-income households in unplanned settlements, the unavailability of waste collection results in constant water pollution and associated water-borne diseases. Waste banks provide a more robust way to tackle such injustice with more reliable and accessible waste collection services.

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[113] "Composting Waste Treatment: An Ecological Solution to Poverty and Climate Change | Haiti | UNFCCC," accessed August 24, 2021, https://unfccc.int/climate-action/momentum-for-change/planetary-health/composting-waste-treatment-an-ecological-solution-to-poverty-and-climate-change.

[114] Hiroshan Hettiarachchi, Jay N. Meegoda, and Sohyeon Ryu, "Organic Waste Buyback as a Viable Method to Enhance Sustainable Municipal Solid Waste Management in Developing Countries," *International Journal of Environmental Research and Public Health* 15, no. 11 (November 2018): 2483, https://doi.org/10.3390/ijerph15112483.

[115] UN-Water, "Human Rights to Water and Sanitization," *UN-Water* (blog), accessed August 24, 2021, https://www.unwater.org/water-facts/human-rights/.

6.3 Resource traceability & corporate accountability

Circular economies provide an integrated approach to keeping resources in use over the longest period of time. Companies that have not responded to externalities drive more climate emissions in various processes of their operations. In a circular economy, we can access the company's packaging system and reusability. Circular economies also present the opportunity to set up recycling systems to reduce waste dumping. Such accountability is needed to ensure that those who are responsible for emissions, pollution, and climate change take responsibility to address these externalities and mitigate them. Closing this loop on their production to reduce waste and emissions is a cornerstone in achieving climate justice.

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"Composting Waste Treatment: An Ecological Solution to Poverty and Climate Change | Haiti | UNFCCC." Accessed August 24, 2021. https://unfccc.int/climate-action/momentum-for-change/planetary-health/composting-waste-treatment-an-ecological-solution-to-poverty-and-climate-change.

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