

From Waste to Wealth: Exploring the Viability of Profitable Recycling Businesses in Developing Economies

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Abstract: This paper investigates the potential of establishing profitable recycling businesses in developing countries. Utilizing a literature review approach, we analyze the circular economy (CE) framework, recycling sector opportunities, and waste management strategies within these nations. While acknowledging the challenges associated with developing such industries, our analysis identifies potential avenues for success. To inform effective strategies and feasible solutions, we examine the growth patterns of the US recycling market and the

implementation of the circular economy in Africa. We posit that recycling can be a viable and profitable venture in developing countries, contingent upon the presence of specific enabling factors.

Keywords: circular economy (CE), recycling, developing countries, profitability, waste Management

1 Introduction

A waste crisis has emerged worldwide wherein billions of tons of waste are generated annually. Developing countries, in particular, grapple with insufficient or non-existent waste management systems, making waste management challenges more pronounced [1]. Recycling holds the potential to resolve this issue by minimizing waste and opening up economic opportunities. Yet, the establishment of profitable recycling industries in developing countries is hindered by inadequate infrastructure, limited financing, and unsupportive regulatory and policy structures. Additionally, it is worth investigating the possibility of public-private collaborations to encourage financially successful recycling businesses and the effects of such industries on society and the environment in emerging economies.

The purpose of this study is to find out how the recycling business can work in developing countries as an activity that can bring profit and, at the same time, have a positive effect on the environment such as waste, pollution, and CO₂ reduction. It is a well-known fact that recycling has been a successful activity in a number of developed countries. Yet, it is unclear which sectors of the recycling business are more profitable, especially considering the fact that developed and developing countries have different conditions under which recycling activities are conducted.

Exploring the most profitable recycling sector that can have a beneficial long-term impact in developing countries, as well as the challenges and opportunities that it may face in those areas will be under scrutiny. Many stakeholders such as governments, investors, and a variety of businesses might find this research beneficial to find new business opportunities as well as support the field of sustainability. That is why the aim of this research is to analyze recycling business models covering all its sectors, to perceive the potential opportunities and to comprehend the intricacies of a recycling business in developing countries in order to explore its possible profitability and its sustainability effect.

The research objectives will include the exploration of the recycling activities at current levels in developing countries, the analysis of possible obstacles to establishing a recycling business in developing countries, the evaluation of recycling models in developed countries and their profitability, the detection of long-term benefits recycling activities pose on the environment, the discovery of developing countries laws and regulations, the exploration of the advantages for

developing countries in terms of social and economic fields [2], and the provisions of possible profitable recycling business sectors for developing nature.

After the research and data collection methods a literature review will be presented. The Results section will include the detailed analysis and discussion of the present situation regarding the recycling sector in the selected developing countries and the paper closed with a discussion and conclusions sections.

2 Research Method and Data Collection

The research basically relies on secondary data and apart from the literature secondary data analysis is carried out. The literature review presents a comprehensive and in-depth literature review of available research addressing recycling as a profitable business in emerging and developing economies. Academic journals, prior research papers, and reports from organizations including the World Bank or the United Nations may fall under this category.

As primary research economic analysis is conducted focusing on the financial performance and profitability of recycling businesses in developing countries. This may include analyzing market demands for recycled products, recycling process costs, and the potential revenue streams that can be generated. Annual reports published by acknowledged companies and public datasets are used as source for analysis.

The primary research is conducted by the usage of secondary data. Developing countries are combined together in order to find out which recycling practices as well as practices of circular economy can bring profit and improve the environment in those specific regions. Due to the nature of the research which aims to find out the situation in a number of countries and touches a variety of sectors and businesses to which is hard to gain access to, it would be very costly and time-consuming to collect data. The most suitable method was the usage of secondary data which is obtained from such sources as books, journal articles, research papers, and governmental reports. These sources can provide a broad spectrum of information to answer the main questions of the research.

We will mainly rely on and utilize sources for the literature review in which we will choose carefully and thoroughly while paying attention to selecting the most relevant, credible, and up-to-date sources that highlight and gives insights on matters related to our topic such as circular economy using as outlined by [3], [4], recycling industries and waste management in developing countries while comparing these practices with some developed countries such as the United States of America. The selection criteria for these sources relies mostly on published academic articles and journals, books written by prominent researchers, and reports

published by well-known and relevant institutes such as World Bank and World Economic Forum with the intention to validate and prove the reported data.

3 Literature Review

Global waste management is critical to sustainable development, yet it is often overlooked in development theory and global education. Sub-Saharan Africa is expected to experience the largest increase in waste generation, and the region is already facing a growing waste management crisis [1]. The main conclusion of the dissertation by Thorleifsson [1] is that there are fundamental industry barriers that companies have limited ability to influence, but they urgently need to overcome them [1]. The industry is fragmented; many small actors are acting alone and several industrial synergies.

A roadmap for sustainable waste management in developing countries can be found in the book by Hossain et al. [5]. An experienced team of sustainability researchers provides a brief overview of modern waste management practices that serve as a guide for waste management professionals [5]. Along with flow charts and problem examples, the authors provide readers with the information they need to support decision-making by country, city size, population, waste generation, type, geographic location, etc. The book begins with an overview of modern waste management practices, including waste generation, collection, recycling, composting, recycling, and waste disposal.

The book “Waste Management Practices in Developing Countries” edited by Godfrey [6] provides information on waste management practices in developing countries, as well as the application of research and innovation to find suitable solutions to improve waste management [6]. Each chapter is selected with a focus on the accumulation of organic waste, a major waste stream in developing countries. Some chapters deal with waste mismanagement practices as well [7].

Based on the International Workshop on Controlled Life-Cycle of Polymeric Materials held in Stockholm, Sweden, the work by Albertsson and Huang [8] offers detailed discussions of degradable polymers and the recycling of plastic materials – analyzing important current topics such as renewable resources, degradation and test methods, processing and products, environmental issues, future materials, and global governmental policies [8].

The background and strategy paper published by the United Nations Industrial Development Organization (UNIDO) [9] proposes that the development of industrial and post-consumer waste recycling facilities would be an ideal starting point for the UNIDO to consolidate and expand its activities in the area of the

circular economy [9]. The research outlines a broad policy framework that provides some guidance on how this goal can be achieved [9]. Unfortunately, the development of the recycling market has largely neglected in recent decades. For example, the US, like many other countries, has become dependent on China and other countries for the final markets for materials. US since recyclers recognized the profitability of selling low quality products to the Chinese market, which the abundant and tolerant Chinese markets could absorb. Therefore, the growth of single-stream recycling developed in the United States which (with higher pollution rates) together with the relatively low oil and natural gas prices (crushing virgin plastic resin prices), and reduced U.S. production of many materials have all contributed to lower demand for recycling in the US domestic markets [10].

Recycling plastics into new materials is a vital step in addressing the problems presented by plastic waste since it may greatly reduce the quantity of waste that ends up in the environment [11]. Plastic waste is difficult to decompose in the environment and will endure a very long period in landfills and the ecosystem [12]. Through the implementation of plastic recycling techniques, plastic items may still be produced and consumed while producing less garbage that will harm the environment and land up in landfills. A significant portion (about 40%) of the plastics used globally are consumed by packaging. Annual global use of plastic packaging materials is over 78 million tons. Just 14% of plastic packaging gets recycled globally, with the remaining 40% being dumped in landfills, 32% leaking into the environment, and 14% being burned and/or utilized for energy recovery [13]. The global non-fiber recycling rate increased steadily between 1990 and 2014 at a rate of 0.7% per year, whereas the global non-fiber incineration rate rose by an average of 0.7% per year between 1980 and 2014. If these trends continue as it is estimated, by 2050 the global combustion rate will reach 50% and the global recycling rate will reach 44%, resulting in a decrease in the global waste rate of non-fiber plastics from 58% in 2014 to 6% [14].

3.1 The Circular Economy

This research claims that circular economy (CE) is practiced much less in developing countries compared to developed nations. Ahmed et al. [15] in their work aim to explore the circular economy model in a developing country, in Bangladesh to pursue a higher level of sustainability in the region. This work attempts to portray possible challenges as well as prospects of the CE being practiced in Bangladesh using qualitative and quantitative data. Despite the prospects, CE stays not widely practiced in the region. The study also tries to reveal the existing barriers in Bangladesh that prevent CE from being widely practiced [15].

In the work by Murphy and Resonfield [16] a collection of articles is presented that attempts to demonstrate how to move from theory to practice regardless of CE. The traditional approach to the life cycle of goods is also compared to the CE's approach to the life cycle. It is also discussed how CE could be profitable not only in

developed nations but also in developing countries. Customers' new demand for durable goods is discussed as well. Different sectors are considered and possible models are offered for those particular sectors [16].

In the WEF report [17], the work of the ACEA (the African Circular Economy Alliance) is discussed. The mission of this alliance is to deliver economic growth, to create jobs as well as to contribute to sustaining the environment. The sectors chosen by the ACEA (food systems, packaging, the built environment, electronics, fashion, and textile) are the most important to the region due to their high circularity potential as well as economic significance [17].

The circular economy is a model of production and consumption that involves sharing, renting, reusing, repairing, refurbishing, and recycling pre-existing materials and commodities to form a closed-loop system that reduces waste and keeps resources in use for as long as is practical. A circular economy aims to diverge from the traditional linear economy, which is predicated on resource extraction, consumption, and final waste disposal. In a circular economy, resources are not discarded since goods are made to have several lifecycles [18]. Recycling is a crucial part of the circular economy since it entails gathering, classifying, and processing garbage to make new products, which cuts down on the use of raw materials and waste [19].

The circular economy seeks to establish a sustainable system that minimizes waste, uses resources effectively, and safeguards the environment. In 2022, it was predicted that the entire global income from transactions involving the circular economy, which includes the categories of used, rented, and refurbished items, would be over 339 billion dollars. By 2026, this is expected to more than double [20].

Based on the literature review the following research questions were formulated:

RQ1: Which sectors of the recycling activities could be the most profitable in the developing countries?

RQ2: What are the possible obstacles to establishing recycling businesses in the developing nations?

RQ3: What are the social and economic advantages of recycling practices in developing nations?

4 Results

In order to be able to compare the recycling possibilities and the profitability potential in the recycling business in developing countries the performance in the USA is analyzed in detail.

4.1. Waste Management and Recycling in the US

In the USA the Municipal Solid Waste (MSW) production totaled 292.4 million tons in 2018, up by around 23.7 million from 2017. Compared to 1990 and 2017 MSW grew by 40.37% and 8.82% respectively. The per capita daily MSW figure was 4.9 pounds per person in 2018 up by 8.89% from 2017 [21]. Figure 1 displays MSW generation between 1960 and 2018 in the USA, which shows that paper and paperboard generation grew exponentially till around 2005 when a radical drop can be detected.

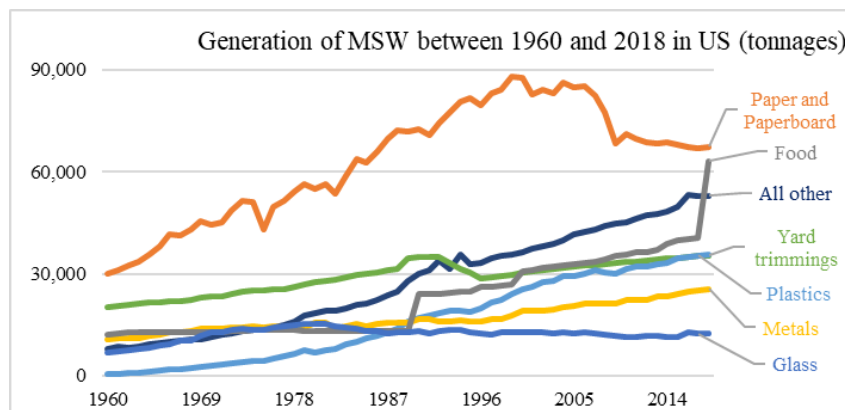


Figure 1

Municipal waste generation in the US between 1960 and 2018

There was an inflexion point in the middle of the 1980s in glass waste generation and from those years glass waste generation is continuously decreasing. The production of plastic products in 2018 was 35.7 million tons or 12.2 percent of total production. From 2010 to 2018, this increased by 4.3 million tons, and it was mostly driven by the categories of durable goods, containers, and packaging.

On the other hand, food waste generation sharply grew from 2017 to 2018, which should be taken into consideration in the future. Plastic waste generation has been continuously increasing from 1960, which also call for attention since plastic recycling has been one of the major issues in the last decade. From 8.2% of generation in 1990 to 12.2% of generation in 2018, plastics generation has increased. Over the previous eight years, the generation of plastics as a percentage of overall generation has ranged from 12.2 to 13.2 percent [21].

Figure 2 displays the distribution of MSW generated in 2000 and 2018. In 2000 paper and paperboard production made up the largest share of MSW (36.18%), which decreased to 23.05% by 2018. On the other hand, the share of food waste, metal waste and even plastics waste increased, there was a significant increase in food waste generation from 12.66% in 2000 to 21.59% in 2018, which means a 105.64% increase in 18 years.

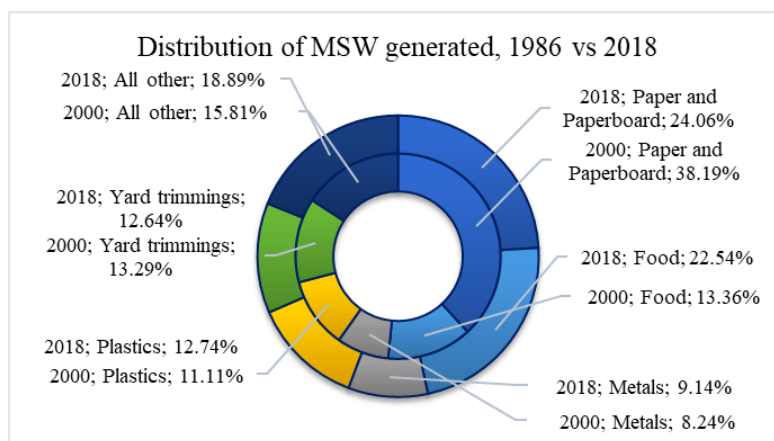


Figure 2

Total MSW generated by material in 2000 and 2018 based on [21] (developed by authors)

Paper and paperboard products made up the largest amount of all the materials in MSW, accounting for 23.05% of total output in 2018 (Figure 1). Less paper and paperboard were produced between 2000 and 2018, down from 87.7 million tons to 67.4 million tons, down by 23.2%. Newspaper production has decreased since 2000, and this trend is expected to persist, primarily due to increased news digitization but also in part due to smaller pages. Office-type (high-grade) paper output has dropped as well, at least in part as a result of procedures including an increasing dependence on electronic report filing [21].

The generated waste is managed in different ways in the US. Apart from recycling the waste is combusted with or without energy recovery, it is used for landfill, or it is composted. In 2018 out of the municipal waste generated 69.1 million tons were recycled, which is a bit more than 25% of the waste generated (26.36%). Figure 3 shows, however, that the recycling amount as well as the share of recycling have both increased since 1960 till the end of the last decade. There was large drop in the generated waste and its share, and while waste generation seems to increase since then, the share of recycling could not recover till 2018.

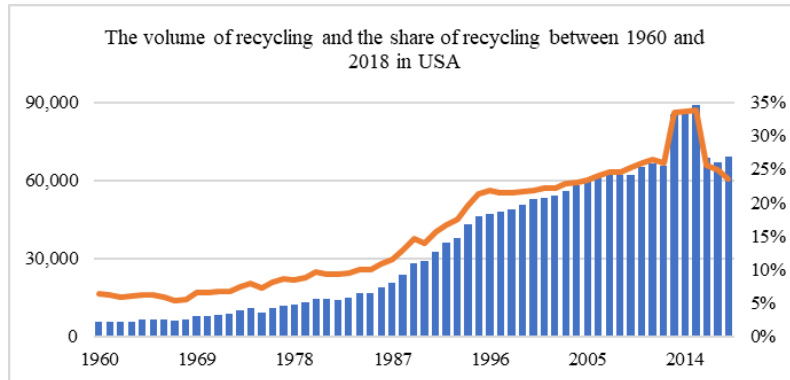


Figure 3
Volume and share of recycling from 1960 to 2018

Looking at the distribution of recycling by material and comparing 2000 and 2018 it can be seen that paper recycling dropped from 70.85% share to 66.54%, which is a significant drop, however, if the share of paper waste production is considered, which has significantly dropped from 2000, it is still the most popular and used type of recycling (Figure 4).

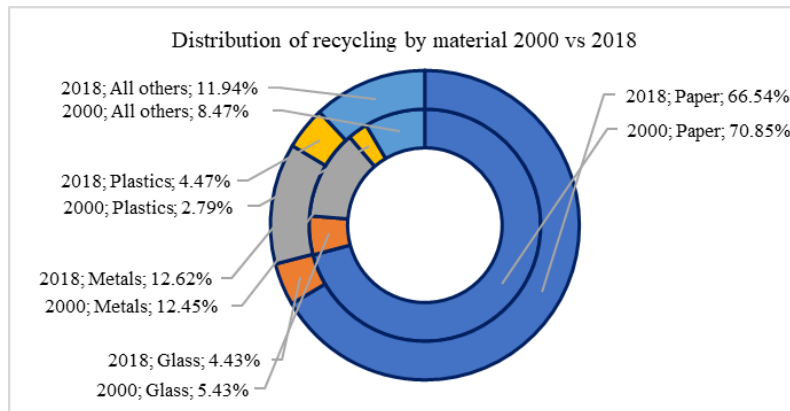


Figure 4
Recycling of Municipal Solid Waste

Moreover, 69 million tons of MSW were recycled in total, with paper and paperboard making up around 67 percent of that total. Glass, plastic, and wood made up between 4 and 5 percent, while metals made up roughly 13 percent.

There was a significant but relatively still very low share of recycling of plastics, the share of glass and metal recycling stagnated while other material recycling increased from 8.74% to 11.94% from 2000 to 2019.

Analyzing the historical time series data of the volume of recycled material an S curve can be detected for each type of material between 1960 and 2018. Figure 5 display the volume of recycled material between 1960 and 2018, the volume of paper recycling is on the right axis, while the others are on the left axis, due to a large difference between paper recycling and all the other material recycling.

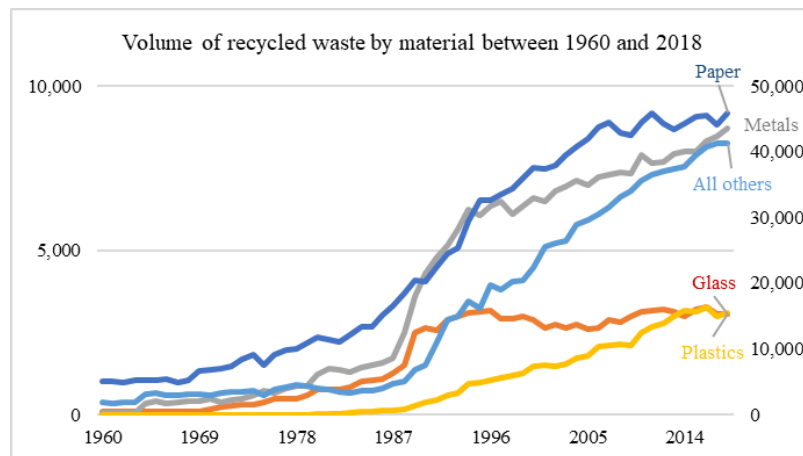


Figure 5
Volume of recycled waste by material 1960-2018

The rapid growth of recycling till 1990 turned into a lower growth, depicting a turning point in 1990. Since then the growth of recycling slowed down and signaling saturation in certain fields. As the volume of paper waste generation continuously decreasing it is expected that the volume of recycling will slowly decrease. A similar phenomenon should be detected in plastics recycling as the generation of plastics waste is expected to decrease resulting saturation even if the volume of recycling is increasing. Next to paper recycling metal recycling shows an accelerated growth in the last thirty years. Glass recycling, however, has been stagnating since 1990s, in which area a continuous increase should be expected [22].

Corrugated boxes (32.1 million tons) and mixed nondurable paper products (8.8 million tons), newspapers/mechanical papers (3.3 million tons), lead-acid batteries (2.9 million tons), major appliances (3.1 million tons), wood packaging (3.1 million tons), glass containers (3 million tons), tires (2.6 million tons), mixed paper containers and packaging (1.8 million tons), and a few consumer electronics were the most recycled products and materials in 2018 [21]. These items made up the majority of the MSW recycling in 2018, 90% overall.

4.2 Average Price index of recycled materials

When analyzing profitability considering the prices of the secondary material market is a must. Figure 6 presents indicators of the average prices of recyclables in the European Union (EU), considering the secondary price materials. The indicator aims to present relevant data and provide a broader overview of the secondary material market. Secondary materials are waste materials that are recycled and can be used in manufacturing processes, instead of alongside 'virgin' raw materials [23].

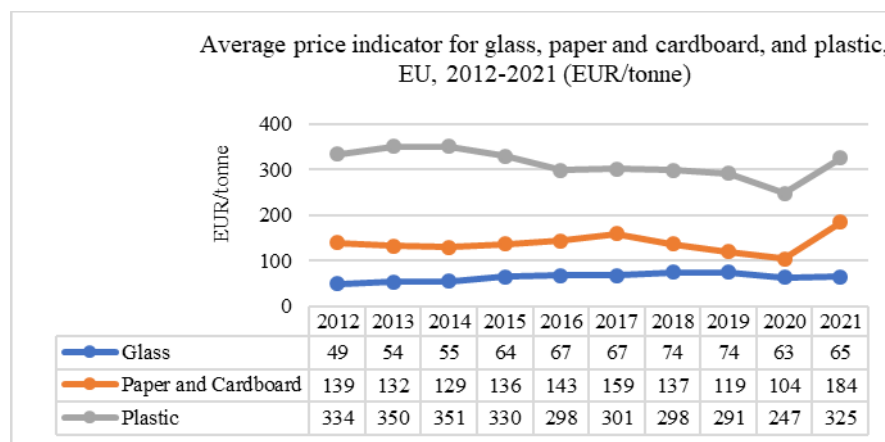


Figure 6

Average price indicator 2012-2021 (EUR/ton)

In the case of glass prices, after continuously increased they peaked in May 2018 (86 EUR/tonne) and July 2018 (84 EUR/tonne) in the observed period between 2015 and 2021. In 2019 the price remained stable between 57 and 82 euros per tonne, while it slightly dropped in 2020 and 2021. In 2021 the average price indicator could increase to a yearly 64.06 EUR/tonne after the January low price of 59 EUR/tonne [23].

Regarding paper, after a five-year stagnation from 2016 the average yearly price could reach a peak of 157 euros per tonne in 2017, but it was followed by a steeper decrease in the average yearly price to quickly to 137 euros in 2018, 118 euros in 2019, and 104 euros in 2020. The turning point was in 2020 when the average price rose to 184 euros per tonne in 2021. After the COVID-19 epidemic, there was a considerable rise in prices, hitting its peak for the whole time of 213 EUR/tonne in November 2021 [23].

The plastics market seems to have performed worse regarding the average price compared to the glass and the paper secondary market as after a peak in 2013 and 2014 (350 EUR/tonnes and 351 EUR/tonnes respectively) a considerable average price decrease can be detected till 2020. For plastics, the average price dropped to

298 EUR/tonne in 2016, then climbed during the next two years to 301 EUR/tonne in 2017, and then decreased for the following three years to under 300 EUR/ton again. The average price dropped sharply to 247 EUR/tonne in 2020, however a sharp increase can be seen in 2021 reaching a high of 325 EUR/tonne. Price growth in 2021 was significant, rising from 245 EUR/tonne in January to a high of 400 EUR/tonne in December [23].

4.3 Costs of recycling of materials

A second factor that determines the profitability of the recycling market is the size of costs. After presenting the MSW generated, recycled, and the purchasing price, the next stage will determine the cost of recycling for each sector.

Aluminum costs between \$0.65 and \$1.07 per pound (\$1300 and \$2140 per tonne), copper costs between \$2.13 and \$2.43 per pound (\$4260 and \$4860 per tonne), stainless steel costs between \$0.32 and \$1.64 per pound (\$640 and \$3280 per tonne), and brass costs between \$1.59 and \$1.76 per pound (3180\$ and \$3520 per tonne). These are the rates for recycled scrap metals [24].

Recycling just does not work as well as well-meaning recyclers would think because of expensive and time-consuming recycling processes, according to a former regional administrator for the Environmental Protection Agency (EPA) and current president of Beyond Plastics, a national organization. The countrywide plastic recycling rate is only 8.5 percent. [25]. Recycling is more cost-effective than trash collection and disposal due to the fact that the cost of a successful curb-side recycling program is between \$50 and \$150 per ton, but the cost of garbage collection and disposal ranges between \$70 and \$200 per ton. Recycling programs also help the environment [26]. There is a chance that recycling programs will turn a profit, but only if transportation, sorting, and processing costs are kept under this amount per ton of the typical mix of recyclables collected by a homeowner, which is estimated to be worth about \$125 per ton when the recycled materials are sold to manufacturers.

Depending on the area, the kind of glass, and the recycling procedure, many factors affect the average cost of recycling glass. The long-term financial gain comes from using recycled glass, which lowers costs for glass container producers, and benefits the environment [27]. 'The end market for recycled glass is mostly domestic, typically located within 300 miles of its end markets' [28, p. 1], and 81 percent of US recycling systems feature glass alternatives for residents, according to the Glass Packaging Institute [28]. While typical glass recycling rates in Europe and several US states with bottle deposit laws are closer to 70%, the country's rate has been stuck at about 33% for many years. More than 1.1 million people are employed by the glass recycling business, which has a gross annual income of \$236 billion. However, the profitability of recycling glass might vary depending on the type of glass recycled and the market demand [29].

Depending on the region, the sort of paper, and the recycling procedure, a business's typical recycling cost varies. Business owners should examine the rates at their local recycling facilities to see what they might be able to collect, according to howtostartanllc.com [30], which states that recycling facilities establish the rates that paper recycling firms collect. The facility has different payment rates for different types of materials. Newspapers are paid at a rate of \$50 per ton, cardboard at a rate of \$75 per ton, and high-grade office paper at a rate of \$2,120 per ton as examples [30]. For a paper recycling firm, the smallest initial expenses are \$62 and the maximum start-up costs are \$38,061 [31]. Recycled paper currently costs, on average, 59.47 cents per pound nationwide [32].

4.4 Profitability of recycling

Based on the data presented regarding the amount of waste generated and recycled, as we also explored the prices and costs of recycling waste the net of each recycling sector is needed to explore the profitability of each sector in order to determine which recycling sector is the most profitable.

Depending on the category of plastic, the recycling procedure, and the market demand, different polymers have different net profits. According to maycointernational.com [33], 500,000 pounds of plastic waste may provide a profit of \$100,000 if we assume a median scrap price of \$0.20 per pound. Recycling sales to consumers like plastic manufacturers generated \$339,395, exceeding their annual projections by \$13,395 [33]. But it may be difficult to make money from recycling plastics, especially if the materials are not properly classified and treated [34]. The market for recycled plastics was estimated to be worth USD 47.60 billion in 2022, and from 2023 to 2030, it is anticipated to increase at a compound annual growth rate (CAGR) of 4.9% [35].

The nature of metal, the recycling procedure, and the market demand all affect the net profit of recycling metal. Due to the increased value of metals, scrap metal recycling facilities have the potential to increase their profitability, according to upperinc.com [34]. According to the International Centre for Trade and Sustainable Development (ICTSD), scrap vehicle metal may bring in between \$65 and \$115 per ton, while appliances can bring in \$0.15 per pound [36]. The cost and value of recycled scrap metal varies depending on the metal. Aluminum for instance, costs between \$0.65 and \$1.07 per pound, copper costs between \$2.13 and \$2.43 per pound, stainless steel costs between \$0.32 and \$1.64 per pound, and brass costs between \$1.59 and \$1.76 per pound [24]. However, recycling scrap metal is a powerful economic stimulant. In the US, the metal recycling business produced over \$64 billion in 2020 and recovered nonferrous metals worth \$40 billion, including aluminum, and lead.

The type of paper, the recycling procedure, and the market demand all affect the net profit of recycling paper. The primary source of income for paper recycling, according to thesmallrich.com [37], is the availability of the primary raw material

(scrap paper), which is relatively inexpensive, and the final goods produced from this source are often sold for a high price, providing a healthy profit margin for the producer [30]. Starting a paper recycling business is a lucrative venture that offers its owners significant profits. One may easily make Rupees (INR) 10–15,000 per day which is approximately equivalent to 133\$ to 200\$ (USD) in the recycling industry [38].

The form of glass, the recycling procedure, and the market demand all have an impact on the net profit of recycling glass. According to alliedmarketresearch.com the worldwide recycled glass market is expected to expand to \$5,544.9 million by 2025, while it is increasing by a compound annual growth rate of 5.7% from 2020 to 2025 [39]. In 2017, the market was predicted to be worth \$3,529.2 million. More than 1.1 million people work in the glass recycling sector, which has annual gross sales of \$236 billion [29]. Employing recycled glass is cost-effective in the long run, lowers costs for glass container makers, and is good for the environment because glass can be recycled endlessly and it is 100% recyclable.

Numerous contributing elements, including location, the type of recycled materials, and the market demand, can have a significant impact on how profitable a newly founded recycling firm is. Nevertheless, after examining the volume of MSW produced, recycled, and their costs

In summary, the scrap metal industry appears to be the most profitable as we examined the recycling costs and net profits of each sector using the secondary data gathered. Business owners in developing nations should perform market research to analyze all the aspects before deciding which industry sector is more profitable for that particular place and conditions because many factors might affect profitability.

4.5 Possible obstacles of recycling

For the PESTEL analysis in this research paper, we chose Brazil, Ethiopia, and Indonesia in order to fully examine the difficulties that recycling companies in various developing countries confront. This rigorous selection ensures a thorough examination of the geographic, economic, cultural, regulatory, and environmental elements that influence recycling challenges. It includes Southeast Asia, East Africa, and South America. With their unique cultural origins and ranging from the economic element of growing markets (Brazil and Indonesia) to a low-income economy (Ethiopia), these selected nations provide a thorough grasp of the numerous obstacles in waste management. The study is further deepened by differences in regulations and particular environmental concerns, such as the biodiversity of Brazil and the deforestation problems in Indonesia. All things considered; these nations provide a comprehensive viewpoint on the difficulties faced by recycling companies in emerging countries.

4.5.1 Political obstacles

According to Trading Economics, Indonesia's Corruption Index was 34 points out of 100 (0 very corrupt and 100 clean) in 2022 [40]. There is a lack of government support to organize recycling processes in the country. The infrastructure for recycling is poorly organized and the mostly informal sector is involved in recycling [41]. Brazil's Corruption Index was 38 points out of 100 [42]. Regarding recycling, there is no support at governmental level, no money is invested in the recycling infrastructure by the government [43]. Ethiopia's Corruption Index was also 38 points out of 100 in 2022 [44]. There is political instability in Ethiopia [45] and there is no sufficient infrastructure for waste collection and management. Furthermore, there is lack of governmental initiatives, while a high level of bureaucracy exists [46].

4.5.2 Economic obstacles

Indonesia has high barriers for investors and it is hard to attract foreign direct investment, which makes Indonesia's economic growth slower [47]. A major issue with getting foreign capital is that there is a lot of paperwork and intellectual property isn't protected well enough. This tough situation not only makes it harder for foreign business to happen, but it also makes it harder to protect intellectual property. Businesses that use e-commerce sites also have to pay extra taxes, which makes doing business even more difficult. This heavy governmental load makes foreign investors less likely to spend and limits businesses' ability to grow in this situation. The lack of satisfying infrastructure and ineffective supply management chain for recycling lead to cost increase in the recycling sector [48]. There is also lack of investment in Brazil, therefore not enough financial resources are invested in recycling. Poorly organized logistics increases transportation costs in Brazil. [49], which leads to the absence of modern technologies. Modern technologies are presented in non-sufficient numbers. The separation processes of waste are not well defined thus waste collection is a difficult and expensive process [43]. The political instability in Ethiopia affects economic inadequate distribution of funding to the recycling industry, which is a significant problem, mostly due to poor organization of financial management and planning. The insufficient financial resources in this field are further worsened by the absence of government-level cost restrictions. This scenario not only interferes with the ability to effectively plan finances, but also adds to the difficulties encountered by the recycling industry in obtaining the required funds for its operations and projects [46].

4.5.3 Social obstacles

There is no demand for recycled products in Indonesia because there is a lack of awareness and there are some misconceptions. The culture and attitude do not show great support towards recycling processes. Households do not show a willingness to take part in recycling processes [50]. People's level of awareness of recycling processes and their importance stay low in Brazil, not enough attention is paid to

informal waste pickers, even though they play a significant role in recycling processes. Furthermore, not enough support or training is provided for waste workers in Brazil [43]. Even in Ethiopia attitude and awareness stay a problem. Even though, awareness has been increased in the country, the attitude has stayed unchanged. No emotions are attached to the recycling processes and there is no will to pay for recycling services. People whose work is related to recycling in Ethiopia get low social status, and waste workers are not paid enough [46].

4.5.4 Technological obstacles

Limited availability of advanced recycling technologies, outdated waste management systems, and the need for investment in modern recycling equipment and processes can pose technological barriers. There are challenges related to infrastructure development and the digital divide in developing countries [51], [52], [53].

The recycling technology available in Brazil may not be as advanced as in other countries, and importing such technology can be expensive [54]. Limited access to technology and technical expertise could also be an issue. The country has experienced significant political changes and reforms in recent years. The Brazilian Information Technology market (IT) was valued at \$46.2 billion and is expected to grow 8.2% in 2022, according to a report [55].

Most production sites have grinders to process the production offcut into reusable re-granulate that is utilized for production and mostly exported to gain foreign currency. The main reason for this is the technology gap, which prevents the pre-treated feedstock (e.g. PET-flakes, paper pulp) to be processed into raw materials that can be used in production [56]. Getahun Mekuria, Ethiopia's minister of innovation and technology, points out that services account for 65% of global GDP – far more than agriculture or manufacturing [57].

4.5.5 Environmental obstacles

Indonesia is grappling with significant plastic waste pollution, particularly in coastal areas. Managing and recycling plastic waste can be complex due to the diverse range of plastic types and contamination levels. Addressing the plastic waste issue and establishing effective recycling practices are crucial for a sustainable recycling business. One of the waste management strategies is waste recycling, an alternative for the reutilization of recoverable portions of resources, especially in times of higher consumption of goods and services [58].

The inappropriate disposal of waste is a serious problem faced by the Brazilian society today. The dumps attract pickers who scavenge material and survive selling this material to the recycling industry. This form of work promotes the recycling industry in the state of Rio de Janeiro and throughout the country. About 60% of recycled plastic is collected from dumps by pickers. But, it is verified that the

recycling industry cannot be based on recyclable material collection by human beings in dumps [59].

On average, every citizen in Addis Ababa, Ethiopia's capital, is estimated to generate about 51 kg of waste per year. About half of that waste is organic, which includes predominantly food waste. About 7.92 kg, or 15.5% of the total waste generated, is plastic. Higher-income people typically use (and throw away) more plastic than their lower-income peers, with the former also using more different types of plastic [60].

4.5.6 Legal obstacles

The involvement of producers in the waste management circle is pertinent to ensure a progressive step towards the efforts of embracing all sectors to extend and intensify the works of waste management in Indonesia [61]. Their roles are regulated through the Ministry of Environment and Forestry of the Republic of Indonesia Regulation Number 75 Year 2019 on the Roadmap of Waste Reduction by Producers [62].

Understanding and complying with waste management regulations, permits, and licenses are necessary for operating a recycling business in Brazil. The establishment and operation of a recycling business may require obtaining permits and licenses from relevant authorities. These permits and licenses may vary depending on the location, scale, and nature of the recycling operations. It is important to comply with the necessary legal requirements and obtain the required permits and licenses [63, p. 12].

The major environmental body in Ethiopia is the Environmental Protection Authority (EPA). The EPA is responsible for federal-level environmental protection by formulating the national environmental policy [64]. The government issues environmental proclamations that are aimed at various sectors of the environment (land, biodiversity, etc.).

In summary, the PESTEL analysis has identified several external factors that affect the recycling industry in Indonesia. Political factors such as government regulations impact waste management practices, while economic factors such as growing consumption patterns impact waste generation rates. Social factors such as changing attitudes towards waste and urbanization influence the amount and types of waste generated. Technological advancements will continue to influence recycling practices. Environmental factors such as climate change are significant drivers for the industry. Legal factors related to the enforcement of waste management regulations pose a challenge. This analysis highlights that the recycling industry in Indonesia is vulnerable to external factors, but there are opportunities for growth and innovation to meet the demands of the industry. To be successful in this market, the industry must adapt to changing external conditions, and take advantage of government support and technological advancements.

Recycling has gained attention significantly in the past decade due to the positive impact it offers in the areas of the environment, economic growth, and society as a whole. Effective recycling programs can help the earth and the economies of both Brazil and Ethiopia, which are both growing countries. With its wide range of plants and animals and growing cities, Brazil can benefit from recycling programs that cut down on waste, protect natural resources, and help local businesses. Even though there is not a lot of information specifically about Brazil, the general benefits of recycling suggest that tailored methods could have good results. Similarly, recycling is very important in Ethiopia, where sustainable development is a top priority. It helps create jobs, protect the environment, and make towns better and healthier. Even though there is not a lot of information available about Ethiopia, the country's drive to environmentally friendly methods fits well with the possible benefits of recycling. Setting up recycling programs in Ethiopia could help the economy grow and protect the earth at the same time. Recycling allows us to reduce the amount of waste we transport to landfills, preserve natural resources, and use fewer resources. Additionally, recycling can boost the local economy and generate work opportunities.

5 Discussion

Recycling has obtained significant attention in developing countries as a promising and sustainable business opportunity, offering both economic and environmental benefits [65]. If applied effectively, recycling initiatives and programs can generate job opportunities, create income from waste, and play a big role in reducing greenhouse gas emissions [66]. This can help empower local communities and promote local economic growth, by providing sustainable livelihoods and a way out of poverty. In addition, recycling plays a crucial role in supporting environmental challenges by minimizing waste in landfill and protecting natural resources.

5.1 Environmental concerns

Our environment benefits greatly from recycling. We make the world healthier for present and future generations by recycling our waste [67]. Regarding natural resource conservation, recycling lessens the need to remove resources like minerals, water, and lumber for new products. The most recent EPA study states that municipal solid waste recycling and composting prevented the emission of nearly 193 million metric tons of carbon dioxide, in comparison with 2018 [21] thus reducing the burden on the world climate. Recycling helps to preserve energy, for instance, recycling 10 plastic bottles can result in energy savings sufficient to run a laptop for over 25 hours. Finally related to waste and pollution reduction, recycling helps to divert garbage from landfills and incinerators, which lessens the adverse impacts of emissions and pollution.

5.2 Economic benefits

Key findings on the economic advantages of the recycling industry in 2020 were published by the EPA in an update to the National Recycling Economic Information (REI) Study. This report discusses the number of jobs, incomes, and tax receipts related to recycling. The study found that in a single year, recycling and reuse activities supported 681,000 jobs, \$37.8 billion in wages, and \$5.5 billion in tax revenue across the US [68]. This translates into 1.17 job opportunities, \$65.23 in paychecks, and \$9.42 in tax income for every 1,000 tons of recycled materials.

5.3 Social and Community benefits

Typically situated in underdeveloped regions of the country, waste management facilities have the potential to negatively impact human health, asset values, aesthetic and recreational values, and land productivity. In many areas, recycling offers a healthier and more sustainable alternative [67].

Given the environmental, economic, and social advantages of recycling that have been established in developed countries that have large economies, such as the United States, it makes reasonable sense to assume that the same benefits could be employed as well in developing countries. By minimizing the amount of waste dumped in landfills and the need to mine new raw materials from nature, recycling may considerably help the environment [69]. Recycling can additionally boost the economy by reducing waste management expenses and creating jobs in the recycling industry. In addition, recycling can improve social conditions by reducing pollution and promoting a cleaner, healthier living environment for communities [70]. Recycling may have various benefits and challenges in developing countries compared to large economies but we could not do a proper comparison due to the lack of accessible data for developing countries, although generally recycling offers universally beneficial advantages. Developing countries must develop and implement effective recycling systems to take advantage of the numerous advantages that recycling may offer [71].

Moving forward, researchers and stakeholders must focus on realistic and feasible strategies that can successfully establish community-based recycling programs in developing countries. In addition, understanding the economic weight and cost of different recycled materials is vital in prioritizing recycling efforts and maximizing profitability. To facilitate comprehensive analysis and meaningful comparisons between developed and developing countries, it is essential for recycling companies and governmental entities to make profitability data freely accessible. This open access to data empowers future researchers to assess and compare profitability levels, providing valuable insights into the economic aspects of recycling.

By emphasizing practical strategies and considering the economic viability of recycled materials, we can make informed decisions to promote sustainable recycling practices. Recycling companies' and governmental entities' release of

profitability data fosters transparency, collaboration, and knowledge sharing among researchers, policymakers, investors, and entrepreneurs. Together, through these collaborative efforts, we can drive positive changes and advancements in the recycling sector within developing countries and on a global scale.

In order to guarantee the financial viability of recycling in countries such as Brazil, Indonesia, and Ethiopia, it is crucial to take into account important criteria such as the nature of the materials being recycled, the expenses related to operations, the market rates for recovered products, and the progress made in the recycling sector. For instance, Brazil may harness the economic opportunities presented by recycling organic trash derived from its rich biodiversity, while Indonesia could focus on capitalizing on the valuable plastic recycling sector. In Ethiopia, it is essential to synchronize recycling programs with sustainable development objectives. Government incentives, technology developments, and honest sharing of profitability data are crucial elements for promoting a profitable recycling industry in developing countries, which in turn leads to favorable economic, environmental, and social results.

Conclusions

The study we conducted revealed discoveries, namely on the profitability of recycling materials, especially metal. This was determined by doing a comprehensive examination of available literature. Nevertheless, it is crucial to recognize a notable obstacle: the scarcity of data about the recycling sector and its financial potential in poor countries. As a result of this constraint, our findings are mostly based on observations made in industrialized nations, highlighting the need for further data to thoroughly examine and provide treatments within the study.

Also, some similar features were found in developing countries (Brazil, Indonesia, Ethiopia) by means of the PESTEL analysis. Those are the lack of the governmental support, the lack of proper infrastructure for recycling practices and no proper attitude from the locals which would be helpful for recycling practices being promoted more.

There were certain limitations during the research due to the fact that there were no sufficient data about developing countries. Probably it happened due to the fact that recycling practices are not widely used in developing nations and there is not enough governmental support, therefore no data published. Also, there were no sufficient data about developed nations. Since recycling is an important topic and all nations should cooperate to establish the best possible practices in all regions and countries, we think such data should be publicly available for everyone for free and it should not require any financial contributions.

This research showed that recycling can bring environmental, social and economic benefits. It could be beneficial for governments and different businesses which are seeking for profitable business opportunities.

Future researchers can consider the implementation process of recycling technologies and obstacles which this process can entail. Since attitude was a problem in the developing countries which we chose, it would be interesting how the right attitude could be shaped and how the government can play a role in this process.

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