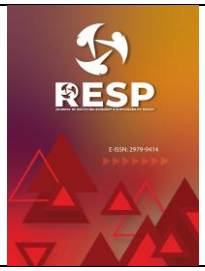

RESP

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Environmental and Economic Benefits of Recycling Wastepaper: In Case of Ethiopia

Atık Kağıdın Geri Dönüşümünün Çevresel ve Ekonomik Faydaları: Etiyopya Örneği

Natea Abdo [a,*] & Desissa Yadeta Muleta [b]

[a] Manufacturing Industry Development Institute, Addis Ababa, Ethiopia
ORCID: 0000-0001-5513-4418 0000-0002-7524-6588
[a] Dr., Manufacturing Industry Development Institute, Addis Ababa, Ethiopia
ORCID: 0000-0002-7524-6588

ANAHTAR KELİMELER

Katık Kağıt
Kağıt Pulp
Atık Kağıt Geri Dönüşümü
Katı Atık

ÖZ

Kâğıt üretimi, kökeni Antik Mısır'a uzanan ve teknolojik ilerlemelere rağmen önemini koruyan bir alandır; şehirleşme, nüfus artışı ve sanayileşme nedeniyle küresel talep kişi başı yaklaşık 60 kg'a ulaşmıştır. Odun temelli hammaddelere bağımlılık, ormansızlaşma, enerji kullanımı ve sera gazı emisyonlarını artırırken, geri dönüşüm döngüsel ekonomiyi desteklemekte ve çevresel baskıları azaltmaktadır; dünya genelinde her yıl yaklaşık 225 milyon ton atık kâğıt geri dönüştürülmektedir. Buna karşılık Etiyopya'da kişi başı tüketim 2 kg'ın altındadır ve yetersiz atık toplama ile geri dönüşüm sistemleri nedeniyle ülke büyük ölçüde ithal hamura bağımlıdır; yıllık 200.000 tonun üzerinde atık kâğıt üretilmesine rağmen sadece %5'i geri dönüştürülmekte ve dokuz geri dönüşüm tesisi atıl kalmaktadır. 2013–2024 dönemini (özellikle 2019–2024) kapsayan literatür incelemesi, atık kâğıt geri dönüşümünün artırılmasının emisyonları düşürebileceğini, enerji ve su tasarrufu sağlayabileceğini, Addis Ababa'daki çöp sahalarına olan baskıyı azaltabileceğini, istihdam yaratabileceğini ve döviz tasarrufu sağlayabileceğini göstermekte; ayrıca özellikle üretici sorumluluğunun genişletilmesi (EPR) alanındaki politika eksikliklerinin giderilmesi gerektiğini vurgulamakta ve Etiyopya'nın kâğıt sektörünün küresel sürdürülebilirlik uygulamalarıyla uyumlu hale gelmesi için bu adımların zorunlu olduğunu belirtmektedir.

KEYWORDS

Waste Paper
Paper Pulp
Waste Paper Recycling
Solid Waste

ABSTRACT

Papermaking, rooted in ancient Egypt, remains essential despite technological advances, with global demand rising to about 60 kg per capita due to urbanization, population growth, and industrialization. Reliance on wood-based raw materials drives deforestation, energy use, and greenhouse gas emissions, whereas recycling supports the circular economy and reduces environmental pressures; globally, around 225 million tons of wastepaper are recycled each year. Ethiopia, however, consumes less than 2 kg per capita and depends heavily on imported pulp because of weak waste collection and recycling systems; although generating over 200,000 tons of paper waste annually, the country recycles only about 5%, leaving its nine recycling plants underutilized. A literature review (2013–2024, with emphasis on 2019–2024) shows that increasing wastepaper recycling could lower emissions, save energy and water, reduce landfill pressures in Addis Ababa, create jobs, and save foreign exchange, while highlighting major policy gaps—particularly the absence of extended producer responsibility (EPR)—that must be addressed to align Ethiopia's paper sector with global sustainability practices.

1. Introduction

Papyrus, which was first used as a writing surface in ancient Egypt circa 3000 B.C., is still the basis for contemporary papermaking techniques (Rullifank et al., 2020). Modern paper is made by mixing pulp, mostly cellulose fibers, with different chemicals that affect its chemical and physical characteristics. The whiteness and quality of paper products are improved by additional chemical treatments like bleaching (Ozola et al., 2019).

Population growth, urbanization, and industrialization have

* *Sorumlu yazar/Corresponding author*.
e-posta: *nateaabdo8@gmail.com*

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all significantly increased the demand for paper worldwide, making it an essential part of social, economic, and environmental development. Throughout history, the development of civilizations and social structures has been impacted by the production and consumption of pulp and paper (Abd El-Sayed et al., 2020). Even with the introduction of digital technologies, the average person uses 60 kg of paper per year worldwide, with notable regional differences: 7 kg in Africa, 265 kg in the US, and 40 kg in densely populated Asia (Humagain et al., 2020).Paper is one of the most widely used materials in the world because it can be found in a variety of products, such as books, magazines, stationery, cardboard, commercial printing, and packaging (Awogbemi et al., 2022; Ma et al., 2021).

In both developed and developing nations, wood continues to be the most common raw material used to make pulp (Boadu et al., 2020). However, the need for cleaner production technologies has arisen due to environmental concerns and limited natural resources. In order to benefit ecosystems and industrial profitability, these strategies seek to maximize industrial output while minimizing environmental effects, lowering the cost of resource extraction, and increasing overall resource efficiency (Adane Haile et al., 2021). Around 406 million tons of paper and paperboard are produced annually worldwide, which includes 225 million tons of recycled paper, 176 million tons of wood pulp, and 12 million tons of other fiber pulp. The paper industry already uses more than 10% of the world's annual wood production (Małachowska et al., 2020). The demand for forest products is predicted to increase due to population growth and economic expansion, which will also increase competition for raw materials in the pulp and paper industry.

There are many opportunities to replace virgin wood fibers with waste and non-woody fibers, such as waste paper (Abd El-Sayed et al., 2020). Waste paper, which is defined as paper that is thrown away after use, makes up a sizable amount of recyclable material and roughly 10% of municipal solid waste (Tamiru & Abirham, 2022). Office paper, newspapers, cardboard, and paper sludge are among the sources; these materials can all be recycled to make new paper goods or used in different ways (de Oliveira et al., 2023).

By lowering reliance on virgin wood, minimizing environmental effects, conserving forest resources, saving energy, reducing pollution, lowering unemployment, and improving raw material efficiency, recycling waste paper is consistent with the principles of the circular economy (Agrawal et al., 2021; Ma et al., 2021). It encourages the shift to a more sustainable economic framework from the linear "extract-consume-dispose" model (Lorang et al., 2021). Deforestation, greenhouse gas emissions, and climate change have all been exacerbated by the overuse of wood in the paper industry (Worku et al., 2023).

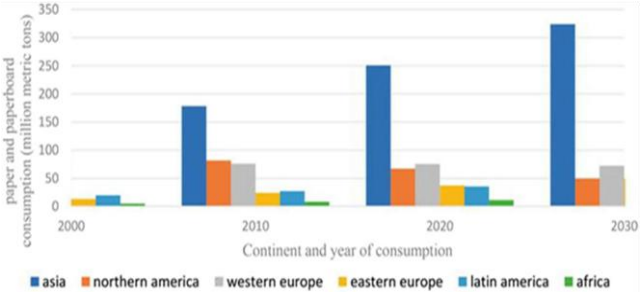
The situation is especially dire in Ethiopia. Despite consuming less than 2 kg of paper annually per person, every year Ethiopia imports raw materials valued at over $100 million USD for the paper industry to meet domestic demand(Global Business Network (GBN) 2020). Only about 5% of the more than 200,000 tons of paper produced annually by municipal solid waste is recycled locally.(Impact 2023)0. Due to ineffective waste collection systems, low public awareness, and a lack of policy support, the majority of Ethiopia's nine paper recycling industries are underutilized. This emphasizes how urgently structured collection systems, formalization of the unorganized sector, and expansion of recycling infrastructure are needed to promote the growth of sustainable industries.

This article examines the economic and environmental advantages of recycling waste paper, concentrating on Ethiopia and contrasting local customs with international patterns. With a focus on studies released between 2019 and 2024, a literature review covering publications from 2013 to 2024 was carried out using databases like Google Scholar and national reports. Relevance and data quality were taken into consideration when choosing reputable reports and peer-reviewed articles. In order to better understand cleaner production technologies and circular economy strategies, the review looks at production trends, consumption patterns, the environmental impact of paper production, and the financial potential of recycling.

2. Trends of World Pulp and Paper Manufacturing

Over the past few decades, the world's pulp and paper industry has experienced tremendous change due to population growth, technological advancements, and rising demand for sanitary, printing, and packaging goods. Plant materials are mechanically or chemically processed to create pulp, the fibrous structural element of paper (Małachowska et al., 2020). Hardwood and softwood together make up almost 90% of the raw materials used to produce pulp worldwide, but non-wood sources like agricultural waste are becoming more and more popular because they are easy to pulp, have good fiber qualities, and have a smaller environmental impact (Nagarajaganesh et al., 2022; Román et al., 2022).

Figure 1. Global Trend in Paper Consumption



Source: (Nagara jaganesh et al. 2022)

Ethiopia's population growth, urbanization, growing educational system, and growing use of packaging materials are all contributing to the country's rapidly increasing demand for pulp and paper products. Every year, the nation imports raw materials valued at about USD 100 million for the paper industry (GBN, 2020). Annual pulp imports between 2009 and 2016 varied between 82,000 and 154,000 tons (Megra et al., 2022), and the amount of paper and paper products coming into the nation has been rising by 12.6% annually (Tamiru & Abirham, 2022). Furthermore, Ethiopia imported 1,572 tons of scrap paper annually on average between 2015 and 2019 to augment domestic recycling inputs (Simret Girma 2022).Nine waste-paper recycling facilities with a combined annual production capacity of 114,710 tons are currently in the country; however, because of irregular and inadequate waste-paper supply, capacity utilization averages only 20%. In large urban centers, particularly Addis Ababa, informal networks known locally as "Korales" are the main source of waste-paper recovery, collecting a large portion of the recyclable material (GBN, 2020). Ethiopia's low recycling rate and reliance on imported raw materials have made better collection systems and domestic pulp substitutes more urgently needed.

Innovative initiatives to promote sustainable materials and lessen dependency on virgin pulp have recently surfaced. While businesses like Kirtas create environmentally friendly packaging from recycled paper, startups like Zafree have started producing pulp from banana leftovers and other agricultural waste(Hariram, Mekha, and Suganthan 2023). These changes show that Ethiopia's paper industry is increasingly moving toward resource-efficient production and circular economy strategies.

3. Trends Waste Paper Recycling Trends: Global and Ethiopian Context

Reducing reliance on virgin raw materials and minimizing the waste of potentially valuable materials are two important goals of recycling. In keeping with the well-known 4Rs—Reduce, Reuse, Recycle, and Recover—it entails the methodical gathering, sorting, and conversion of waste materials into new, reusable products. One of the most valuable recyclable resources is waste paper, which can be remanufactured into new, useful materials (Majeed et al., 2021). Newspapers, magazines, cardboard, office paper, and other paper goods produced on a daily basis by homes, businesses, and institutions fall under this category (Agrawal et al., 2021).

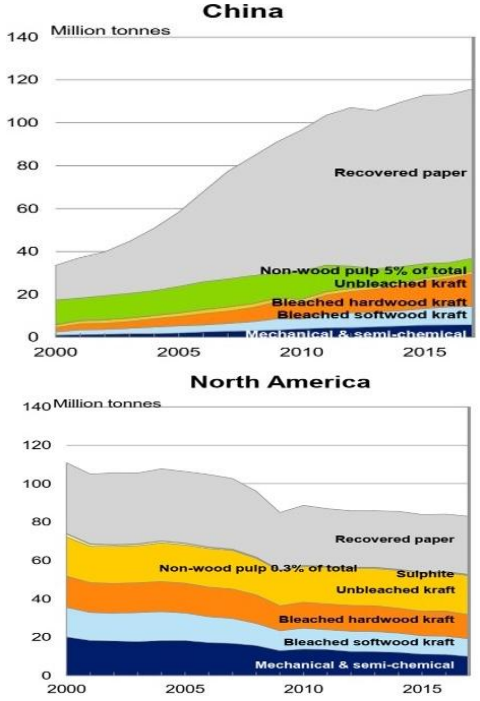
Paper accounted for roughly 17% of the world's solid waste generation, which reached 2.02 billion tons in 2016 and is expected to increase to 2.59 billion tons by 2030 and 3.4 billion tons by 2050 (Awogbemi et al., 2022). North America recycles 68% of its paper, Asia 53.9%, Latin America 47.2%, Africa 35.2%, Japan 80%, and Europe 72.3–73.3% (Yang et al., 2020; de Oliveira et al., 2023). In 2021, 1.15 million tons of paper and packaging were recycled in South Africa alone, representing a 66% recovery rate (Godfrey, 2021). While materials like glossy, waxed, or carbon paper are still difficult to recycle and have little commercial value, recycled paper is mostly used in office paper, tissue products, and packaging (Liu et al., 2020).

Ethiopia, on the other hand, performs noticeably worse in recycling even though waste generation is increasing. Every year, the nation generates 2.2 to 7 million tons of waste in urban areas and 0.6 to 1.8 million tons in rural areas (Teshome, 2020). Only around 5% of all waste is reused, frequently through unsafe and informal methods, despite the fact that per capita waste generation varies from 0.17 to 0.48 kg per day in urban areas and 0.11 to 0.35 kg per day in rural areas (Teshome, 2020). Ethiopia's waste paper recycling rate is only about 5%, far lower than Kenya's 15%, and over 200,000 tons of paper and cardboard are burned, dumped, or thrown out in the open annually (GBN, 2020).

However, recent Addis Ababa data shows signs of improvement. The city produced about 587,000 tons of solid waste in the fiscal year 2023–2024, of which 67,510 tons were recycled. Thanks to financial incentives like subsidies for collected recyclables, the recovery rate for paper and cardboard reached 11.5% (Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH 2023)). However, manufacturers' access to high-quality recycled fiber is still hampered by fragmented collection systems and limited industrial recycling capacity (GBN, 2020).

Global trends show that recycling waste paper has both economic and environmental benefits, but Ethiopia's recycling industry is still in its infancy. This underscores the need for better infrastructure, better collection methods, and supportive policy frameworks to improve resource recovery.

Figure 2. IMFA Presentation 2019



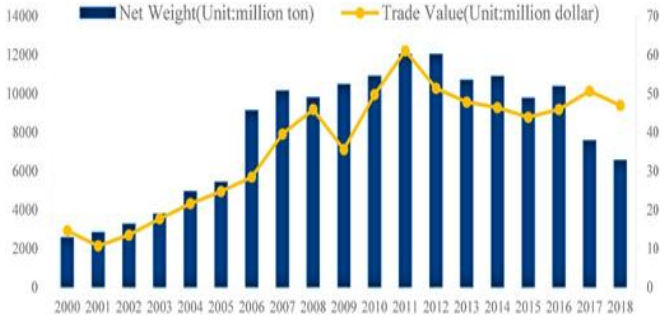
Source: (GBN) 2020)

4. Waste Paper Recycling Process

Paper recycling is one of the most well-established waste material recycling strategies, and its rates are steadily increasing as a result of economic and environmental initiatives (Defalque et al., 2021). Gathering, sorting, shredding, pulping with chemicals and hot water, bleaching to get rid of ink, and then creating new paper goods are the usual steps in the process (Kumar et al., 2020; Defalque et al., 2021). Research conducted in Ethiopia has demonstrated that recycled paper retains its high quality with little physical or chemical deterioration of fiber structures when processed appropriately (Tutus, 2021). Important physical and chemical characteristics of recycled fibers, such as bulk, moisture content, grammage, Kappa number, and water absorption, are mainly unaffected, allowing for efficient repurposing in the manufacturing of paper (Tutus, 2021). In an effort to lessen its dependency on imported virgin wood pulp, Ethiopia is also investigating the use of pulps derived from agricultural residues to supplement waste paper recycling.

5. Economic Benefits of Waste Paper Recycling

Through the creation of long-term employment opportunities, resource efficiency, and support for a circular economy, the collection and recycling of waste paper significantly benefits society (Ma et al., 2021). Recycling used paper improves the use of post-consumer materials, lessens reliance on virgin pulp, and conserves forest resources. Millions of tons of waste paper are produced annually worldwide; urbanization, increased literacy, and industrial development have all contributed to this trend. Paper recycling is now a crucial part of the global circular economy as a result. As waste paper's economic significance grows, the global trade in this product has grown dramatically since the beginning of the twenty-first century, from USD 2,136.5 million in 2001 to USD 12,204.3 million in 2018 (Xu et al., 2021). (Fig. 3).



Source: Xu et al. 2021

Figure 3. Annual Weight and Value of Global Waste Paper Trade from 2000 to 2018

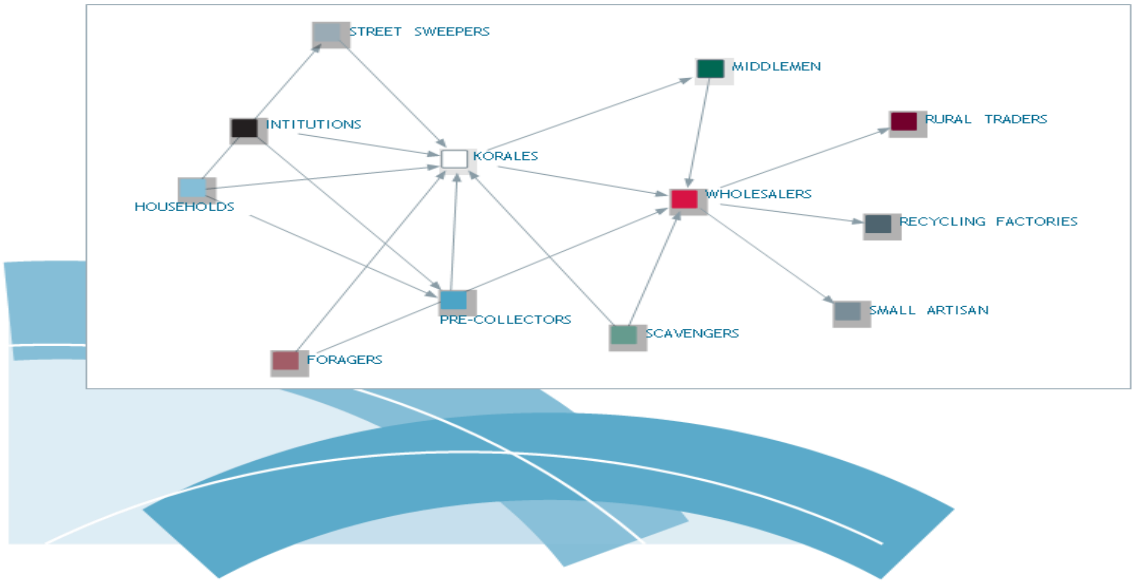
Cellulosic fibers, which must be blended with virgin fibers during the papermaking process because they lose strength and length with each cycle, are impacted by recycling paper. However, fibers are usually reusable three to eight times. Around 59.7% of paper worldwide was recycled in 2020; the highest percentages were found in Europe (73.3%), North America (68%), Asia (53.9%), Latin America (47.2%), and Africa (35.2%) (de Oliveira et al., 2023). Materials that can be remanufactured into new paper products are referred to as recyclable waste paper. Label stickers, papers with plastic coatings or waxes, and carbon paper are examples of non-recyclable waste that cannot be processed and, as a result, have little to no economic value (M. Liu et al., 2020).

Recycling used paper has financial benefits in addition to environmental ones. Due to its lower energy and chemical requirements, secondary pulp is usually less expensive to produce than wood pulp (Tutus, 2021). Additionally, it gives the paper industry a substitute raw material, making it less susceptible to changes in the market (Yılmaz et al., 2021). Additionally, recycling waste paper into building materials, biofuels, paper products, and other materials is economical, ensures appropriate waste management, fosters sanitation, and helps protect the climate (Awogbemi, Von Kallon, & Bello, 2022). Recycling has a wide range of social and economic benefits, including lowering resource use, energy consumption, waste production, and environmental pollution while prolonging the lifecycle of materials (Manandhar et al., 2022).

The recycling industry is still in its infancy in Ethiopia, a developing nation with a very low per capita paper consumption of less than 2 kg as opposed to the global average of 55 kg (GBN, 2020). To meet domestic pulp demand, the nation imported 1,572.4 tons of scrap paper annually on average between 2015 and 2019 (Simret Girma 2022). Due to the lack of a systematic collection system and the scarcity of high-quality waste paper, Ethiopia's nine formal waste paper recycling industries, which have a combined design capacity of 114,710 tons/year, only operate at about 20% of their full potential(Simret Girma 2022). The informal sector, which includes both individual collectors and community-based "Korales," is primarily responsible for managing the collection of recyclable waste (GBN, 2020).

In Ethiopia, recycling paper not only promotes environmental sustainability but also generates jobs in the fields of processing, sorting, and collection. Thousands of people make their living in the formal and informal sectors, and as recycling rates rise, there is even more room for job creation(Mcmillan and Zeufack 2022). Ethiopia can lessen its dependency on imported raw materials and preserve economic value domestically by using recycled paper, which will help create a more resilient and circular economy (GBN, 2020; Ma et al., 2021).

Figure 4. Waste Material Exchange Network Among Informal Actors in Addis Ababa



Source: (GBN) 2020)

6. Environmental Benefits of Waste Paper Recycling

Recycling waste has long been a major global environmental concern. Environmental sustainability has emerged as a major concern as countries work toward sustainable development, tackling issues like pollution, ecosystem degradation, climate change, and the depletion of natural resources (Haile Gelebo et al., 2021). Global paper consumption is still increasing despite the quick development of electronic media and digital communication. Significant environmental risks, such as deforestation, pollution emissions, and landfill overcrowding, are brought on by this rising demand. Paper recycling has therefore become a pressing worldwide issue (Liu et al., 2021).

In light of climate change, energy conservation and lowering greenhouse gas (GHG) emissions have drawn a lot of attention. The paper industry is one of the manufacturing sectors with the highest energy consumption and greenhouse gas emissions (Girma et al., 2021). When compared to other waste management techniques, recycling waste paper is thought to be a significant way to reduce carbon emissions (Shang et al., 2021).

Recycling paper has several advantages for the environment. Recycling saves landfill space for non-recyclable waste, lowers GHG emissions, conserves natural resources, and uses less energy (Shang et al., 2021). One ton of recycled paper can, on average, save 24–28 trees (12 m tall with a diameter of 15–20 cm), stop 36 tons of CO_2 and 267 kg of other pollutants from being released, save about 4,100 kWh of electricity, 1,750 liters of fuel oil, 38.8 tons of water, and save 3–4 m^3 of landfill space (Gupta et al., 2021). Paper and its waste can be recycled and biodegraded. Because 35% of the trees that are felled are used to make paper, the 400% increase in paper consumption over the past 40 years has contributed to deforestation.Recycling reduces the amount of heavy metals like Pb and Cd that are released during open burning or landfilling, as well as harmful gases like CO, SO_2, NOx, VOCs, ozone-depleting CO_2, and methane (Ozola et al., 2019; Agrawal et al., 2021).

When compared to the production of virgin pulp, the use of recycled fibers in Ethiopian papermaking can drastically cut carbon emissions and energy consumption by almost 50%)(MOHAMMED 2024). Recycling paper also lessens the need for landfills and deforestation, which addresses environmental risks related to burning or disposing of waste (Ozola et al., 2019; Agrawal et al., 2021). Additionally, incorporating agricultural waste—such as cotton, sugarcane, and banana stalks—into the paper recycling process improves sustainability and harmonizes Ethiopia's pulp and paper industry with the principles of the global circular economy (Sustainability MEA, 2023).All things considered, recycling paper is an important way to lessen the effects on the environment, conserve resources, and advance sustainable development in Ethiopia and around the world.

7. Conclusion

Ethiopia's paper consumption is still very low, at less than 2 kg per person annually, but the country imports more than USD 100 million worth of pulp and paper annually, while more than 200,000 tons of wastepaper are generated annually in municipal solid waste streams, of which only about 5% is recycled. This imbalance between high import dependency and low recycling performance emphasizes the urgent need for a national shift toward a circular paper economy. Recycling wastepaper offers significant environmental benefits and strong economic potential globally, but it is even more critical in the Ethiopian context,

as this review shows.

Ethiopia has significant unrealized potential in the environmental and economic aspects of recycling waste paper, according to the study's findings. Recycling waste paper can help the environment by lowering carbon emissions linked to the production of virgin pulp, saving a substantial amount of energy and water, and lessening the strain on forest resources. Research consistently demonstrates that one ton of recycled paper can prevent significant landfill usage and water pollution, save 4,100 kWh of energy, save about 36 tons of CO_2 equivalent emissions, and save about 24 to 28 mature trees. These advantages are immediately applicable in Ethiopia, where urban waste accumulation, land degradation, and deforestation are significant environmental issues. The review also emphasizes how replacing virgin wood pulp with recycled fibers, and possibly with pulp made from agricultural residue, can cut energy consumption and emissions by almost 50%, supporting Ethiopia's environmental sustainability and climate resilience objectives.

Economically speaking, the results highlight how recycling waste paper can lessen Ethiopia's dependency on imported raw materials, preserving foreign exchange and enhancing domestic production capabilities. Due to an irregular and inadequate supply of high-quality wastepaper, Ethiopia currently has nine wastepaper-based recycling industries with a combined yearly capacity of 114,710 tons, but these facilities only operate at around 20% of their full potential. Stable inputs for industry and long-term revenue opportunities can be created by fortifying the collection network, especially through the integration of the informal sector, which includes "Korales," who are essential to resource recovery. Experiences from other countries demonstrate that recycling sectors are labor-intensive and have the potential to create a significant number of formal and informal jobs throughout the value chain. Increased recycling rates in Ethiopia would lead to the creation of jobs in the transportation, processing, manufacturing, waste collection, and sorting industries, which would help to reduce poverty and promote inclusive urban development.

The study also finds that institutional and policy gaps, in addition to inadequate collection systems, are impeding Ethiopia's recycling industry. The sector's poor performance is caused by a number of factors, including a lack of Extended Producer Responsibility (EPR), insufficient incentives for recycling industries, shaky market connections, and low public awareness. The results indicate that formalizing the informal waste collection system, implementing EPR frameworks, and offering financial and technical assistance to recycling businesses could all greatly increase the wastepaper value chain's sustainability and efficiency. In the Ethiopian context, such reforms are both feasible and effective because, according to lessons learned from international best practices, coordinated policies can raise recycling rates from below 10% to above 50% in just ten years.

Furthermore, there is a significant chance to diversify the sources of raw materials thanks to creative methods that are being developed in Ethiopia, such as the production of pulp from cereal straws, banana stems, and other agricultural waste. This is in line with global trends toward resource-efficient production and bio-based materials. Ethiopia might create a hybrid pulp system that lessens its impact on the environment, lowers production costs, and strengthens ties between the rural and industrial sectors by combining recycled fibers with agricultural residues.

All things considered, the study's findings unequivocally show that increasing wastepaper recycling is a viable and strategic course for Ethiopia. In terms of the environment, it will lessen the pressure on urban landfills, greenhouse gas emissions, and deforestation. In terms of the economy, it will boost industrial competitiveness, save foreign exchange, and generate good jobs. Socially, it will promote livelihood opportunities in both the formal and informal sectors and enhance urban sanitation. Enhancing wastepaper recycling is therefore a comprehensive development strategy that is in line with Ethiopia's long-term economic and environmental priorities rather than just being an environmental intervention.

Coordinated efforts are required if Ethiopia is to reap these benefits. This entails developing clear policy frameworks, integrating informal collectors, enhancing recycling technologies, improving waste collection infrastructure, and increasing public awareness of waste sorting at the source. To further support evidence-based policy decisions, future research should concentrate on quantifying the potential for job creation, economic value recovery, and carbon savings using local data.

The results of this review conclude that recycling waste paper offers Ethiopia significant economic and environmental advantages. Ethiopia can turn wastepaper from an underutilized waste stream into a valuable economic resource by implementing a circular economy strategy and making investments in an efficient recycling system. This change has the potential to greatly improve sustainability, lessen reliance on imports, and make a significant contribution to the nation's green development agenda.

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