



(RESEARCH ARTICLE)



THE CIRCULAR ECONOMY, A FACTOR OF TERRITORIAL DEVELOPMENT: AN ANALYSIS OF WASTE RECOVERY VALUE CHAINS IN KOUDOUGOU (BURKINA FASO)

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World Journal of Advanced Research and Reviews, 2026, 31(03), 1464–1473

Publication history: Received on 07 August 2026; revised on 19 September 2026; accepted on 21 September 2026

Article DOI: <https://doi.org/10.30574/wjarr.2026.31.3.2423>

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ABSTRACT

The circular economy model stands in contrast to the traditional linear model, which is based in part on the systematic disposal of waste in landfill, with its associated environmental impacts. Against a backdrop of dwindling natural resources and environmental crises, the circular economy paradigm is emerging as a catalyst for fostering and driving innovative practices that are environmentally friendly and promote sustainable development. This article aims to analyse the socio-economic opportunities arising from waste recovery in the medium-sized town of Koudougou. The methodology is based on a qualitative approach, combining literature review, direct observations and field surveys. The surveys enabled qualitative data to be collected from 39 stakeholders in the waste value chain between September 2023 and February 2024. The results reveal the emergence of informal waste recovery sectors through salvage, reuse, recycling and composting. Although these circular economy activities generate jobs and contribute to regional development, their potential remains hampered by a lack of regulation and support. Effective involvement by local authorities, through the structuring of these sectors and the training of stakeholders, is essential to ensure the long-term sustainability of this local circular economy.

Keywords: Circular economy; Waste management; Regional development; Koudougou; Burkina Faso

1 INTRODUCTION

The linear economic model, based on a unidirectional flow logic — "extract, produce, consume, dispose" — is increasingly being challenged in the face of worsening ecological crises and the depletion of natural resources [16]. This historically dominant paradigm simultaneously contributes to the depletion of raw materials, the uncontrolled growth of waste, and increasing pressure on ecosystems [6]. In this context, the circular economy appears as a structuring and sustainable alternative, based on the regeneration of natural systems, the circularity of material flows, and the closing of loops. This new paradigm calls for sober and responsible consumption of natural resources and energy while

minimizing associated waste [3]. It presents itself as an economic model capable of addressing the current challenges of the capitalist economic system. With this new paradigm, the aim is to do more with less [14]. Beyond its environmental benefits, the circular economy also offers economic opportunities by fostering innovation, job creation, and the development of new markets. Its principles therefore imply a holistic approach to waste management, covering the period from product design to end of life [8].

While the theoretical concept of the circular economy was formalized within the industrial and institutionalized contexts of Northern countries, its application in cities of the Global South, particularly in sub-Saharan Africa, follows distinctive trajectories [10]. Integrating circularity at the local scale makes it possible to valorize "local deposits," transforming an environmental nuisance into a territorial resource that generates non-relocatable added value [13]. In Burkina Faso, environmental management policies draw on principles of circularity such as reuse, repair, composting, and recycling of waste, even though current legislation does not explicitly mention the circular economy. As a result, dumpsite waste constitutes urban mines capable of promoting local development. This research explores the socio-economic opportunities generated by the implementation of the circular economy in Koudougou, from a territorial resilience perspective. Specifically, the aims are, first, to conduct a situational diagnosis of linear waste management, and second, to analyze the socio-economic opportunities of waste recovery value chains.

2 METHODOLOGY

The methodological approach adopted in this research is based on a state-of-the-art review of the topic and the use of qualitative data derived from semi-structured interviews. The state-of-the-art review consisted of an analysis of the scientific literature related to linear and circular solid waste management as addressed by various authors. Data collection took place between September 2023 and February 2024. The semi-structured interview guide was the primary tool used to collect this data. This data collection was also accompanied by direct observation. The analytical framework thus consisted of cross-referencing data collected from sixteen (16) waste traders identified through the snowball sampling technique, six (6) recyclers, six (6) composters, five (5) waste pickers, three (3) municipal technical service agents, and three (3) deconcentrated service agents. In total, thirty-nine (39) interviews were conducted. The choice of these interviewees was primarily motivated by their degree of involvement in linear and circular waste management. All interviews were recorded using a voice recorder, transcribed verbatim, and analyzed using the content analysis technique. Interviewees were assigned pseudonyms based on the initials of their first and last name(s) in order to ensure anonymity. In addition, GPS was used to geolocate recycling sites, composting sites, and waste trading sites within the municipal area. QGIS 3.34 software was used for mapping. The Figure 1 shows the location of the city of Koudougou.

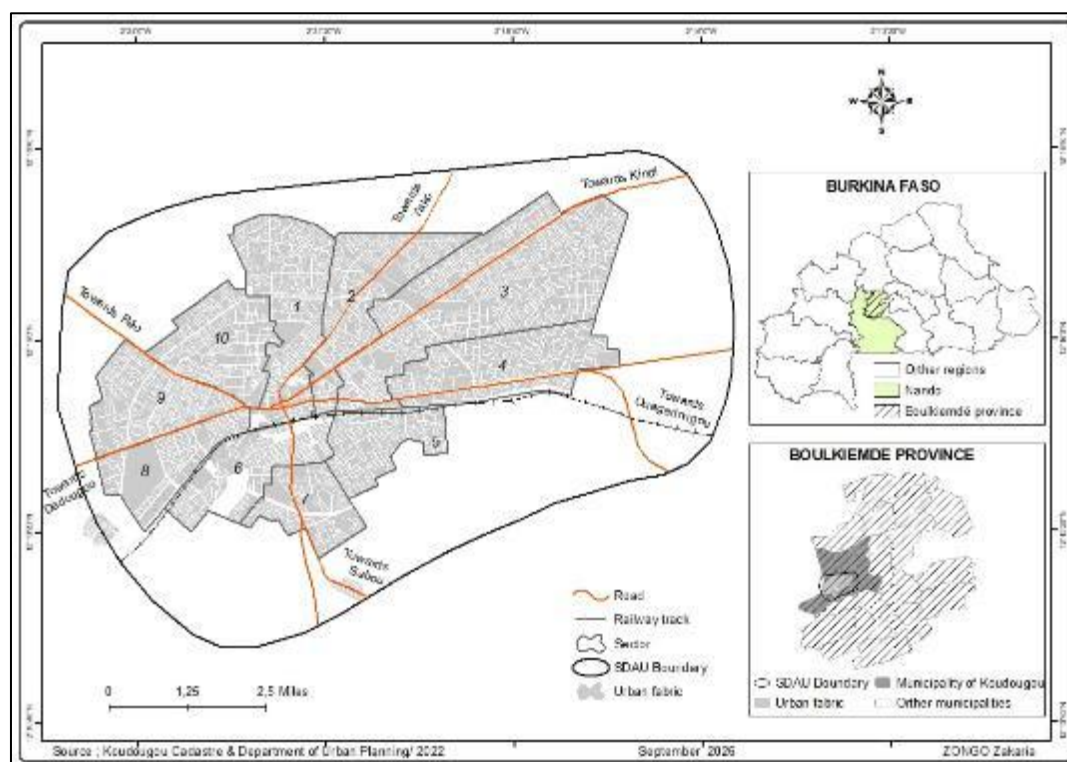


Figure 1: Location of the city of Koudougou

The research was conducted in the medium-sized city of Koudougou, located in the Nando region of Burkina Faso, between 2°21'51" West longitude and 12°15'3" North latitude. Its surface area is 720 km², with a population of 160,239 in 2022 [5; 9].

The city of Koudougou has 10 districts. It is located 100 km west of Ouagadougou and has been linked to the Burkinabè capital by rail since 1952 [5]. It is bordered to the west by the Commune of Reo, to the south by the Commune of Ramongo, to the southwest by the Commune of Ténado, to the east by the Commune of Nandiala, and to the north by the Communes of Imasgho and Soaw.

3 RESULTS

3.1 Diagnosis of linear waste management in Koudougou and environmental repercussions

The municipal solid waste management system in the city of Koudougou has historically relied on a classic linear model. Field investigations and direct observations reveal a model structured around pre-collection, collection, and disposal, with a breakdown occurring at various links in the chain. Indeed, the integrated waste management strategy struggles to keep pace with the city's rapid spatial expansion. The pre-collection service, which consists of removing waste from its point of generation to intermediate sites, is delegated to about ten community-based associations. This service suffers from a glaring lack of logistical equipment (drop-off sites, carts, tricycles) and sustainable funding. These shortcomings generate inequalities and a strong spatial injustice in access to sanitation. Indeed, the central districts (1, 2, and 4) and the commercial districts (8, 9, and 10) benefit from relatively regular removal of waste flows, given their accessibility and the solvency of the social groups residing there. In contrast, the peripheral districts (5, 6, 7) and informal settlements are excluded from official collection circuits, left to self-management. The inefficiency of public pre-collection has favored the proliferation of dumpsites within the municipal area. Figure 2 shows the current state of the municipal dumpsite.



Figure 2: The municipal dumpsite

Photograph credit: Zongo Zakaria, September 2023

Collection carried out by the town hall consists of transporting waste from intermediate sites to the final dumpsite, which remains unimproved. The department in charge of waste has one ordinary garbage truck of 18 m³ and about ten tricycles for transporting and disposing of waste. Public waste collection is not systematic. It is organized irregularly depending on the availability of the single garbage truck, which is also used by the road maintenance department. Beyond the shortage of logistical equipment, collection also suffers from a lack of qualified human resources and a budget deficit, as attested by one of the hygiene department officials:

"The department in charge of waste has two technicians and four support staff for collecting and transporting the city's waste. In addition to budgetary constraints, another bottleneck in the collection is the absence of a properly developed final dumpsite." (Interview with Mr. N D, hygiene-sanitation officer at the town hall, January 2024).

Since waste collection is irregular, the intermediate waste deposit sites are in a state of constant overflow, forcing pre-collectors to dump household waste in administrative reserves and undeveloped plots.

Uncollected waste can lead to environmental repercussions at several levels. Indeed, the most widespread disposal method at the household level remains open-air burning. The same applies to waste from intermediate sites. This practice releases toxic gases (dioxins, carbon dioxide) that contribute to the degradation of air quality in the urban environment. In addition, the accumulation of waste traps stagnant water, creating breeding sites that promote the proliferation of vectors (flies, mosquitoes, rodents, parasites, etc.) capable of transmitting diseases (malaria, dengue, cholera, typhoid fever). Finally, uncontrolled dumping directly threatens the local water table through leachate infiltration. This bleak diagnosis of linear management demonstrates the urgent need to shift toward circular management, in which waste is no longer perceived as a nuisance but as a resource — a secondary material that can be reintroduced into processing circuits.

3.2 Sorting and waste recovery, the first links in the circular economy

Sorting and recovering waste in dumpsites are activities practiced by a specific social category, namely vulnerable people. Also referred to as waste collectors or waste pickers, these individuals occupy the dumpsites throughout the day to recover recyclable materials. They play a key role in the waste management system in Koudougou. Waste pickers constitute the interface between the official waste management system and the informal and formal recycling sector. They collect various types of materials in wild dumpsites in order to reintroduce them into the local economy as secondary raw materials, as one respondent points out:

"We collect all sorts of objects abandoned in the environment: cans, vehicle wrecks, old batteries, zinc, bronze, aluminum, copper, buckets, jerry cans, bottle caps, plastics, etc. We resell them on site to waste traders and recyclers. The income allows us to take care of our families. I have been doing recovery work for five years now, and I believe there is no such thing as an inferior job. I know that plastic is recycled locally, and metal is transported to Ouagadougou to the CIM METAL factory to be processed." Interview with Mrs. O M, October 2023. Waste recovery feeds the trading sites for recyclable materials, as shown in figure 3.

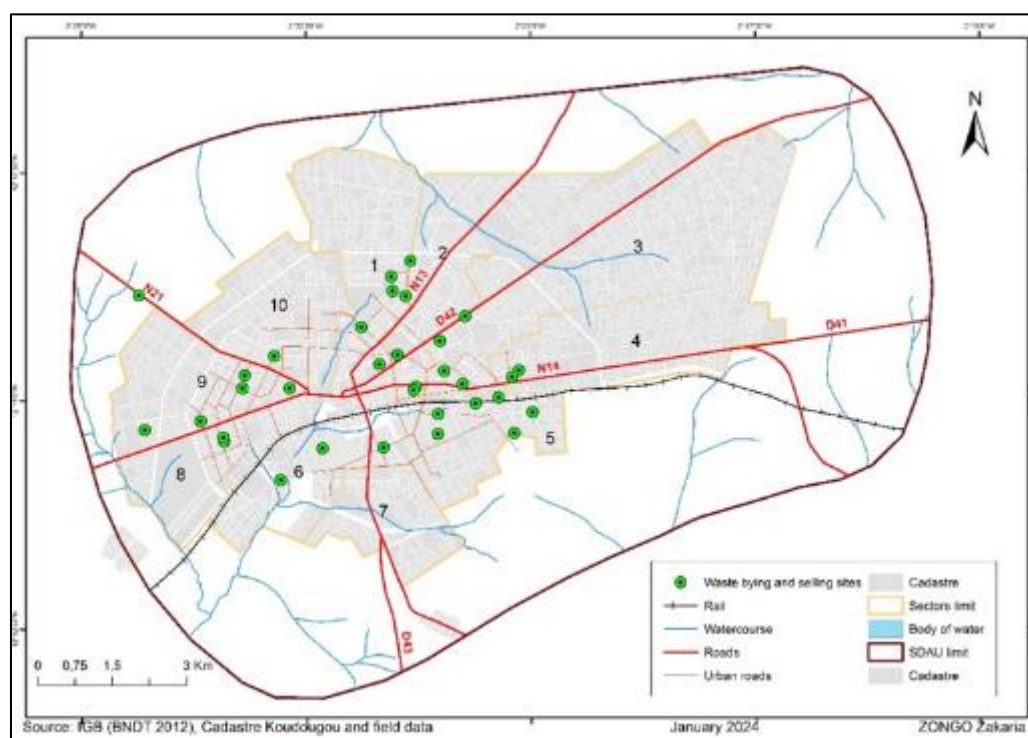


Figure 3: Spatial distribution of recovered waste trading sites

Sorting and recovery transform waste into marketable resources, structuring the local circular economy. The flows (intra-urban circuits for plastics, and transport to Ouagadougou for iron and other non-ferrous metals) reveal a hierarchical organization among collectors, intermediaries, wholesalers, and modern recyclers, generating income. The

circular economy presents a major opportunity for job creation through solid waste management. Its social significance is considerable, as it enables many people (children, young people, and the elderly) in the city of Koudougou to escape situations of precariousness and vulnerability by effectively integrating into the waste value chain.

The analysis of the map shows that all districts of the city are affected by the waste trading activity. In practice, these sites occupy undeveloped plots rented by traders at monthly rates ranging from 10,000 to 40,000 CFA francs. This is a rapidly expanding activity in the city. These traders act as intermediaries between waste pickers and wholesalers based in the capital, Ouagadougou, who in turn are partners of the CIM Metal factory and plastic recycling companies such as Faso Plast and Kady Plast.

Field investigations show that recovery activity permanently employs approximately eight hundred (800) people who make a living from it. The highest turnover is 40,145,600 CFA francs, held by one of the city's traders (Mr. Z A). These economic returns are reinvested in several areas, such as children's schooling, trade in various goods, the construction of shared housing, and the drilling of boreholes in informal settlements for water sales purposes. However, plastic waste undergoes only partial transformation and recycling at the local level, highlighting the ingenuity of local craftspeople.

3.3 Plastic waste recovery, an emerging sector in Koudougou

Recycling in Koudougou is an informal activity carried out by private actors and community-based associations involved in household waste pre-collection. The raw materials consist of non-biodegradable plastic waste abandoned in the environment. The recycling activity involves gathering this waste deposit in order to turn it into recycled raw material or finished products. These finished products constitute marketable goods that are reintroduced into the consumption cycle, within a perspective of sustainable development and environmental protection. They are valued by the local population for their resistance and durability. As a result, plastic recycling has significant economic and ecological reach in the city of Koudougou.

Plastic recovery is of major interest to the entire local community, given how bulky, unsightly, and harmful to the environment it is [19]. As for the recycling process, it begins with the collection of plastic bags of all colors (black, blue, white, etc.) from the street, households, businesses, and dumpsites. A kilogram is sold to recyclers for 75 CFA francs. The second step consists of manual sorting to obtain deposits by polymer family. The bags are then carefully washed and dried. Finally comes the melting stage. The viscous liquid is collected and poured into a semi-mechanized mixer, to which finely sifted sand with a fineness of 0.5 millimeters is added. The resulting paste is then placed in prefabricated wood-and-steel molds, previously coated with used motor oil to facilitate demolding. The process is carried out with great precision to avoid premature solidification. Once demolded, the products undergo finishing through polishing and painting. The figure 4 shows some products resulting from the recycling of soft plastic.



Figure 4: Various products made from plastic waste

Photograph credit: Zongo Zakaria, January 2024

Plastic waste recycling produces a wide range of finished products, including desk-benches, garden borders, and waste bins. These products are in high demand by the local population due to their durability and resistance. Beyond its

economic benefits, plastic recycling also remains a solution to the plastic hazard in Koudougou. Replicating such businesses at several locations across the city could help move toward the goal of zero plastic bags in the environment.

The marketing of recycled products serves as a springboard for improving the living conditions of those involved. Many pupils and students spend their free time in recycling workshops to learn, to serve as labor in production, or to help market finished products. This therefore represents a genuine opportunity that should be promoted for the benefit of a youth in search of employment.

"Beyond the taxes I pay, amounting to 20,000 CFA francs per year, I earn a net monthly profit of 200,000 CFA francs when the market is steady. My greatest wish is to be able to relocate the business to a plot of at least two (2) hectares, so that I can better train young people, for the great benefit of the Koudougou municipality," states one recycling business owner. (Interview with Mr. O S, January 2024).

The implementation of the circular economy in Koudougou is also reflected in the recycling of non-ferrous metals such as aluminum and copper.

3.4 Aluminum recycling, an activity of economic and social resilience

Recycling work involves a significant number of craftspeople in the city of Koudougou, with a form of specialization in each sub-sector. With regard to aluminum recovery, the activity puts the craftspeople in permanent contact with fire, which requires protective equipment: safety shoes, appropriate clothing, gloves, and face masks. The sources of raw material supply are scrap metal buying-and-selling sites, households, and mechanical garages. The process begins with melting the aluminum in a steel furnace heated to a high temperature. Before activating the system, craftspeople carefully prepare compacted molds using fine, damp sand, shaped according to the size of the pot or the form of the object to be made. The resulting viscous liquid is poured into the molds and immediately covered with a sand-clay mixture. The molds are then encased in wooden boxes and placed in a very humid location to facilitate cooling. The semi-finished product then goes through a stripping-and-polishing stage. Finally, once the finished product has been consolidated, cans are melted down and the liquid is poured over the pots or manufactured objects to give them extra shine. The figure 5 shows the manufacturing process for pots and other objects.



Figure 5: The artisanal process of aluminum recovery

Photograph credit: Zongo Zakaria, January 2024

These artisanal products are so highly valued by the local population that craftspeople sometimes struggle to meet customer demand. The finished product also travels within the sub-region, as attested by Mr. T S, one of the city's recyclers: "The finished products are resold locally, but also elsewhere. I regularly receive orders from Côte d'Ivoire, Togo, and Ghana." These remarks suggest that the products are of unmatched quality. Beyond job creation, aluminum recycling in Koudougou is a major economic sector, as illustrated by the following account:

"All the recyclers in the city learned the trade from me. I started this activity in 1983. Today, I recycle about 150 kg of aluminum per week and spend 500,000 CFA francs per month on raw material purchases. We pay 800 CFA francs per kg of aluminum. In terms of turnover, recycling earned me around 15 million CFA francs in 2023. I bought two plots of land and was able to build housing units for rent. Given how physically demanding the work is, young people no longer

want to learn it." Interview with Mr. S B, January 2024. The figure 6 shows the informal recycling sites in the city of Koudougou.

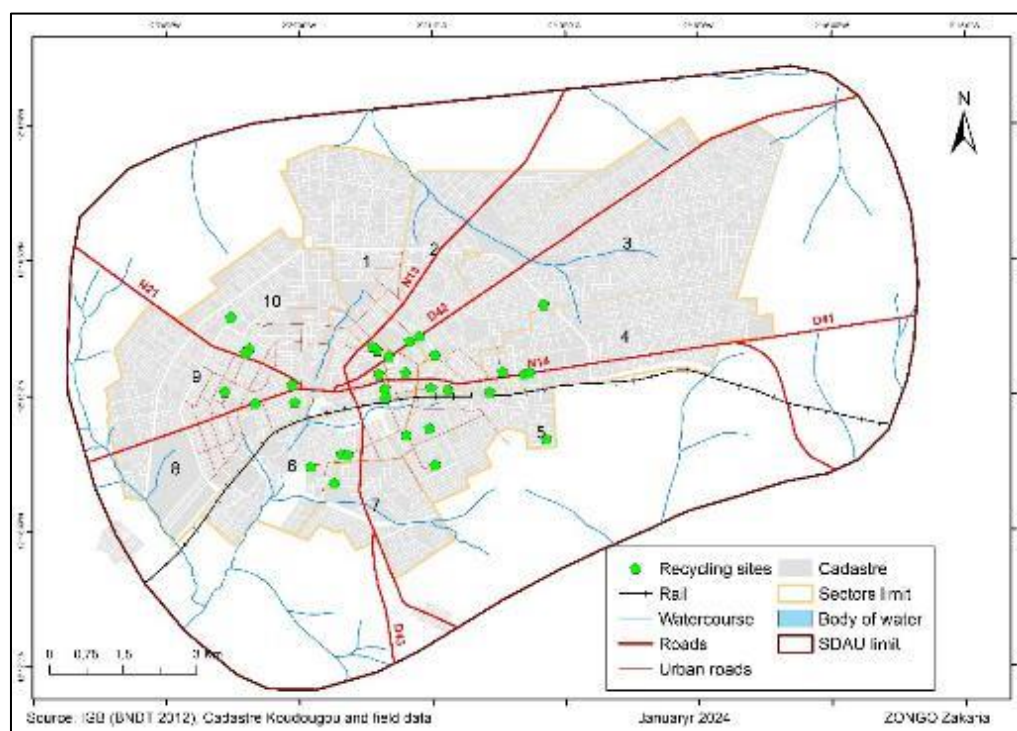


Figure 6: Spatial distribution of recycling sites

This figure shows the spatial distribution of informal waste recycling sites within the municipal area. Recycling covers both plastic waste and non-ferrous waste (the manufacturing of pots and similar products). The activity is genuinely widespread in the city of Koudougou and occupies a significant share of the youth. Recyclers are true environmental entrepreneurs. Nearly all districts of the city are involved in the activity. While some recyclers carry out the activity within their own compounds, others occupy undeveloped plots taken on rent.

From a social standpoint, the recycling process helps reduce the rate of depletable resource use, decreases the flow of waste released into the environment, and conserves natural resources for sustainable development. As a result, waste recovery through recycling reconciles consumers with their environment. The same holds true for organic waste recovery.

3.5 Organic waste recovery, an opportunity for peri-urban agriculture

In Koudougou, household solid waste, as well as commercial, industrial, and biomedical waste comparable to household refuse, offer opportunities for organic recovery. The fermentable fraction of municipal waste is estimated at 70.5% in the case of the city of Koudougou [4]. By recovering this waste, a ready alternative is found for reducing the substantial volume of waste requiring collection, while also helping to remedy the city's state of unsanitary conditions.

This means that composting provides farmers with a quality product at a reduced cost, which reveals its economic significance. Its large-scale implementation in the city of Koudougou offers a dual advantage: the elimination of organic waste and soil fertilization. For a Sahelian country such as Burkina Faso, implementing this circular economy sector makes it possible to effectively combat the harmful effects of chemical fertilizers on soils. Since compost is an organic fertilizer, its use can only improve agricultural yields. In the city of Koudougou, several actors are involved in composting. They are organized into a confederation together with actors from other regions, such as Guiriko and Bankuy. Moreover, composting is practiced in a traditional and informal manner (Figure 7) in the peripheral districts that still have available land for agricultural production.

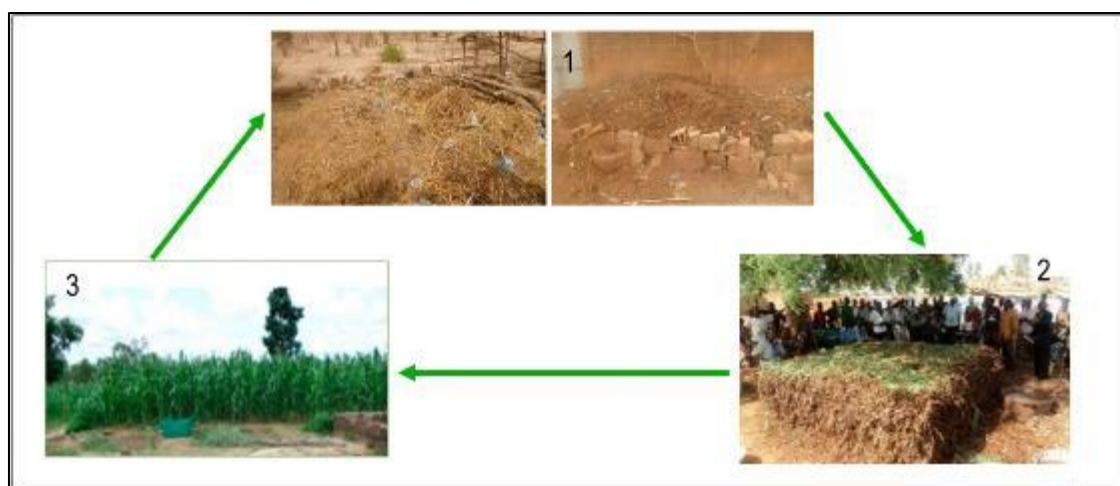


Figure 7: The composting process

Photograph credit: Zongo Zakaria, February 2024

This figure shows circular waste management using various residues: sweepings, ash, household waste, animal droppings, and straw (image 1). This heterogeneous mixture is generally contained in a pit and left exposed to open air (image 2). Wastewater from dishwashing and laundry is poured into it. Constant moisture and heat, combined with the action of microorganisms, promote the decomposition of the debris from the inside out. During composting, temperatures can rise to 50–60°C or even higher, reducing pathogens and breaking down the debris present in the biomass [18]. The resulting compost is used to fertilize fields (image 3) and prevent erosion. Admittedly, even well-processed compost cannot fully replace chemical fertilizer inputs, owing to certain elements such as nitrogen and urea [1], but it remains an organic component capable of improving soil biodiversity. Finally, compost is a truly important element in agricultural production systems, playing several roles, including water retention, protection, and fertilization. Thus, promoting the composting sub-sector represents an opportunity for farmers and horticulturists (market gardeners, gardeners, nursery operators). However, this requires genuine involvement by the municipal authority and deconcentrated services in organizing and training stakeholders to ensure greater professionalism.

4 DISCUSSION

This section compares solid waste management practices in the city of Koudougou with those of other localities, as well as their socio-economic impacts. The research showed that linear waste management in the city of Koudougou generally takes place in three main stages: pre-collection, collection, and disposal. However, there is a clear inefficiency in both the pre-collection system run by associations and the public collection system run by the town hall. This results in the overflow of authorized dumpsites and the proliferation of unauthorized dumpsites within the municipal area. This finding is consistent with that of several authors who have also shown that urban dynamics in developing countries generate an increased need for urban services, including waste management. [15] and [11] respectively identified shortcomings in household solid waste management in Ouahigouya (Burkina Faso) and Man (Côte d'Ivoire). They argue that this poor waste management, linked to a lack of coordination among stakeholders and a shortage of logistical equipment, leads to serious health and environmental consequences. The dispersal of untreated waste in the environment promotes the proliferation of disease vectors [2].

In the city of Koudougou, the implementation of the circular economy through recycling provides environmental, economic, and social benefits. This has also been demonstrated by [7], who showed that the circular economy presents numerous opportunities for the Abidjan district in Côte d'Ivoire. [17] also showed that waste recycling in cities of the Global South constitutes an opportunity for job creation and improved living conditions. Furthermore, [12] argues that in the circular economy, waste constitutes a raw material for certain economic, agricultural, artisanal, or industrial activities. Exploiting this resource base can have positive impacts across the entire waste management chain, allowing waste to be reconceived as marketable products with significant economic value.

5 CONCLUSION

This article helped to analyze the linear waste management system and the socio-economic opportunities generated by the implementation of circular economy principles. The shortcomings of linear waste management in the city of Koudougou create numerous problems for the population and generate negative externalities affecting the environment. The main constraints facing the waste sector are the shortage of qualified human resources, the lack of

administrative reserves for establishing dumpsites, and the insufficient logistical equipment and dedicated budget for the sector. Faced with these constraints, the municipality is attempting to find solutions. Waste collection carried out by municipal services is inefficient and results in only partial removal of waste from dumpsites. The quantities of solid waste temporarily removed remain lower than those generated by households and commercial infrastructure. This situation is at the root of the proliferation of unauthorized dumpsites within the municipal area. Circular economy practices have always existed in the city of Koudougou, but remain largely informal overall. They provide secondary resources for local and national businesses. Their implementation fosters socio-economic inclusion through the creation of circular jobs, while also promoting youth and women's entrepreneurship. However, the development of a final dumpsite that meets standards, along with support for stakeholders from local authorities, will enable better structuring and the establishment of circular economy sectors in Koudougou, moving toward an ecological and sustainable city.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Acknowledgments

Our thanks go to the actors involved in the urban management of Koudougou. We particularly thank the waste traders, recyclers, and composters of the city. Their contribution was invaluable in the collection of field data.

Disclosure of conflict of interest

There is no conflict of interest.

Statement of informed consent

Participation was voluntary and respondents provided informed consent prior to data collection.

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