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Impact of implementing pre-collection of waste in the urban community of Yaounde 3 / Cameroon: Importance of the circular economy

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ABSTRACT

Context: The municipality of Yaounde faces serious waste management issues, affecting approximately 500,000 inhabitants spread across some 100,000 households. Challenges include irregular collection, lack of adequate infrastructure, and the presence of illegal dumps polluting the environment. **Methods:** The project, conducted by "EcoClean Environnement" from 2016 to 2020, aimed to evaluate the health, environmental, and economic impact of waste pre-collection in the Urban Community of Yaoundé III and to demonstrate the importance of the circular economy for sustainable resource management. It involved all households in the district, local businesses, and trained agents for pre-collection. Awareness campaigns and collection points were established, along with sorting and recycling centers to valorize waste. **Results:** The project demonstrated a significant reduction (44.44%, $p < 0.01$) in uncollected waste and a 60% improvement ($p < 0.01$) in the cleanliness of green spaces and waterways. It also notably reduced ($p < 0.05$) diseases associated with poor waste management and the proliferation of disease vectors. The project created 200 jobs ($p < 0.01$) and stimulated the development of 10 new local businesses specializing in waste management. **Conclusion:** The project transformed waste management in Yaoundé III, improving the quality of life, reducing environmental impacts, and stimulating local economic development, supported by robust statistical results.

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1. Introduction

Located in the Gulf of Guinea, Cameroon serves as a bridge between Central Africa and West Africa. Its geographical location explains the variety of its landscapes, climate, fauna, and population (World Wildlife Fund [WWF], 2019). With an area of 475,000 km^2, Cameroon's population is estimated at approximately 23 million inhabitants (National Institute of Statistics [INS], 2018). Cameroon's economy is the most diversified in Central Africa, not only due to numerous foreign investments but also to many national groups (World Bank, 2020). The country hosts a wide range of activities, particularly in the forestry and agricultural sectors (cash and food crops), hydrocarbons, and industries such as beverages, sugar, oil mills, soap factories, flour mills, aluminum, cement, metallurgy, and primary wood processing (Ministry of Economy, Planning and Regional Development [MINEPAT], 2019).

All these elements, which form the foundation of Cameroon's economy, present a significant problem of dependence on generally imported raw materials (African Development Bank [AfDB], 2018). No structure has developed a system of economy based on the exclusive local supply of raw materials; a particularity of the green energy transformation industry, a variant that EcoClean Environnement develops through its field actions (Deboutiere & Georgeault, 2015).

It should be noted that the scarcity of raw materials and the dependence of African countries, including Cameroon, on increasingly expensive external supplies, raise questions about the resilience capacity of our economy, 55 years after independence (United Nations Development Programme [UNDP], 2019). We believe that this resilience will remain impossible if other approaches to financing and empowering Cameroon's economic activities are not considered (International Monetary Fund [IMF], 2020). For this reason, the circular economy system appears to be an important system to adopt (Ellen MacArthur Foundation, 2017). This circularization of the economy will be more effective with a striking pre-collection system and dynamic waste valorization (European Commission, 2018). The transition to a circular economy thus appears as a necessity to strengthen the Cameroonian economy by optimizing the use of its resources, particularly waste, which continues to increase in quantity (World Economic Forum, 2019). It is certain that the macroeconomic potential of the transition to circularity is too little studied (McKinsey & Company, 2018). The circular economy is an economic concept that fits within the framework of sustainable development and is inspired by notions of the green economy, the economy of usage or functionality, the economy of performance, and industrial ecology (which advocates that the waste of one industry be recycled as raw material for another industry or the same) (Ellen MacArthur Foundation, 2017). The waste encountered in Cameroon is highly heterogeneous. It includes: various types of plastics (PET, PEHD, PVC, PEBD, PP, PS) which are the majority; food waste, paper waste, vegetable waste, glass (bottles, plates, broken windows), etc. (Ministry of the Environment, Protection of Nature and Sustainable Development [MINEPDED], 2019).

This composition of waste poses a significant problem for proper management, as all types of waste end up in the same container (Afrik.Com, 2018). However, it is also important to note the high energy potential stored in these wet or solid wastes, which gives them the status of high-value products (HVP) (World Bank, 2019). After sorting, recycling, and certain valorization, it is possible to significantly increase their commercial value (European Commission, 2018). But this option remains utopian in Cameroon; the majority of collected waste is directly recovered by machinery to be buried or burned in landfills, thus destroying thousands of potential jobs (Afrik.Com, 2018). These actions cause Cameroon and other African countries to lose nearly 1,000,000,000,000 (one trillion) CFA francs per year, buried in the form of useless waste; this observation is the same in all Sub-Saharan African countries (World Bank, 2019).

This problem is mainly due to ignorance and, above all, to a poor policy of defining global development objectives that should govern the country (United Nations Development Programme [UNDP], 2019). Analyses present the African waste sector as a promising and "empowering" sector for all African countries, which are still struggling to kickstart their economies (African Development Bank [AfDB], 2018). We believe that waste, currently considered as "garbage," will be the main secondary raw material of tomorrow, far surpassing all currently used fossil fuels in terms of economics and energy (World Economic Forum, 2019). Proper management and appropriate handling of waste will allow for the elimination of current treatment methods, namely: landfilling and burning, for better management of the environment, ecosystems, and climate (European Commission, 2018).

This way of managing waste has more negative than positive consequences; consequently, these methods appear as techniques to be abandoned in light of national and international environmental protection standards (United Nations Environment Programme [UNEP], 2019). Implementing a waste valorization method will provide an efficient response to Cameroon in terms of reducing unemployment, combating energy poverty, introducing a favorable and empowering circular economy system for the country, and managing internal debts for a fluctuation of the national economy (Hassan & Adam Abdou, 2018).

The general diagnosis of the pathology concerning proper waste management in Cameroon firstly relies on the fact that there is a lack of involvement of all stakeholders (MINEPDED, 2019).

Indeed, waste management in Cameroon depends on several actors: planning, guidance, and control institutions; executing bodies; and financing organizations (Minep, 2007). The absence of a single actor biases the dynamics and expected performance of waste management policy (Epoh Mvaboum et al., 2004). In a second instance, the observed problem lies in the fact that several Public Administrations (notably the Ministries) intervene to varying degrees in waste management (Epoh Mvaboum et al., 2004).

Indeed, the same missions are assigned to multiple administrations, leading to an overlap of responsibilities and a superposition of roles without a functional coordination structure (Epoh Mvaboum et al., 2004). This overlap of competencies, which also extends between Urban Communities and Urban District Municipalities, results in conflicts (Epoh Mvaboum et al., 2004). This work, which is a reflection on an innovative approach to waste pre-collection and valorization, allowed us to evaluate the impact of introducing a circular economy system in Cameroon and to determine the best approach for sustainable urban planning in the city of Yaoundé through the exploration of the pre-collection/waste valorization method (Hassan & Adam Abdou, 2018).

2. Methodology

Conceptual framework of the study

The methodology adopted for this study was based on the results obtained from 5 years of activities by EcoClean Environnement. The data were derived from pre-collection, treatment, and analysis of the structure's performance.

Location of the study

The figure below presents the map of the city of Yaoundé. This study was conducted in Cameroon, in the city of Yaoundé, which covers an area of 304 km^2, with an urbanized area of 183 km^2, and has an estimated population of 1,817,524 inhabitants, resulting in an average density of 5,691 inhabitants per km^2.

Investigating organization of the study

The EcoClean Environnement cooperative aims to contribute to the promotion of cleanliness and hygiene within Cameroonian society and African society as a whole. Specifically, EcoClean Environnement intervenes to ensure the overall sanitation of unsanitary spaces and the management of waste produced by the population through pre-collection actions.

These actions contribute to the preservation of the environment, the fight against climate change, and the fight against epidemics related to sanitation issues. Consequently, through its actions, EcoClean Environnement creates increased employment opportunities for youth, intensifies the training of populations on actions promoting sustainable development, and popularizes the promotion of waste valorization activities.

Type of Study

The present work is a community study.

Duration of the Study

We analyze here the results and yields obtained during our activity from June 2016 to June 2020.

Study Population

The results of this study come from the outcomes obtained after a pre-collection waste action involving approximately 3,500 households specifically in Yaoundé, Cameroon, over a two-year period.

Statistical Analyses

Several statistical analyses were performed. The Student's t-test compared the average percentages of uncollected waste before and after the intervention, revealing significant differences with p-values < 0.05.

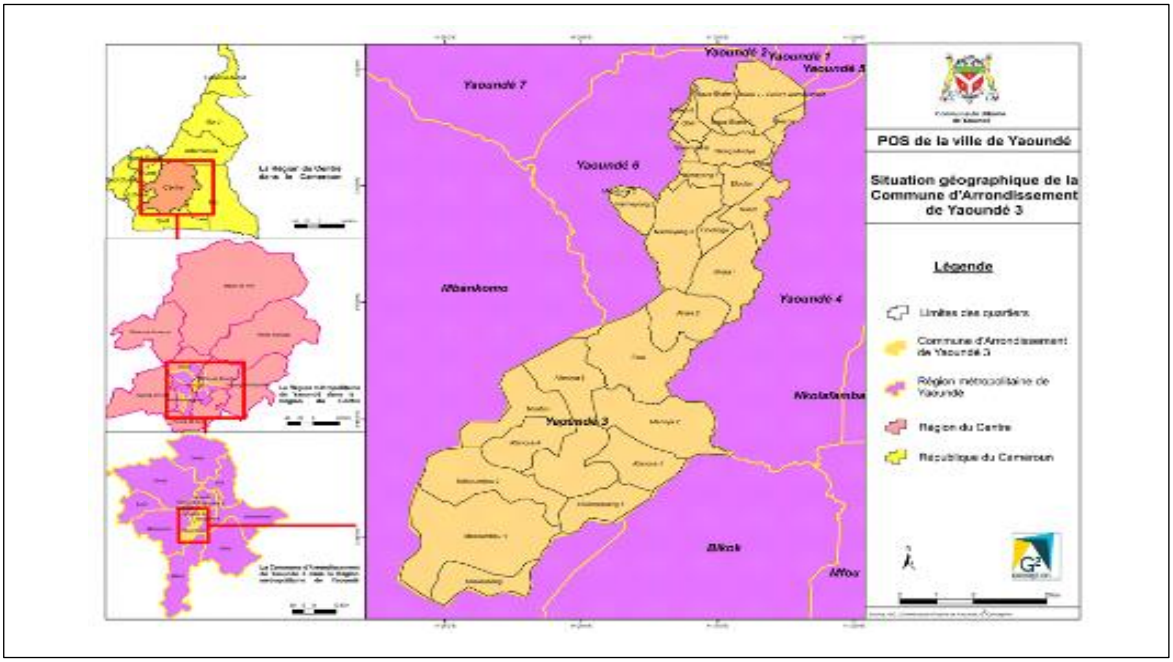

Figure 1 : Yaounde 3 district

A simple linear regression modeled the trend of improvements over time, indicating a good fit with a high correlation coefficient (R^2). Normality tests, using Shapiro-Wilk, validated the normal distribution of the data (p-value > 0.05), while the Chi-square test demonstrated a significant association between the reduction of illegal dumping and the years (p-value < 0.05).

Selection criteria

Inclusion criteria:

- **Residence**: Households specifically residing in the commune of Yaoundé 3.
- **Volunteerism:** Households willing to participate in the pre-collection and waste management initiatives proposed by EcoClean Environnement.
- **Commitment:** Households committed to following the recommended waste sorting and management practices.

Non-Inclusion criteria:

- **Non-residence:** Households located outside the commune of Yaoundé 3.
- **Non-volunteerism:** Households whose residents are not interested or refuse to participate in the project initiatives.

Exclusion criteria:

- **Inability to comply:** Households unable or unwilling to follow the recommended waste management practices.

2.9. Methods

2.9.1. Degree of improvement in waste Pre-Collection

Pre-collection is an activity during which our pre-collector retrieves waste door-to-door from previously subscribed individuals to deposit it at the collection point. They generally perform this activity using less sophisticated equipment than that reserved for collection.

Data analysis: The data were compiled and collected into a database. The calculation of averages and percentages of uncollected waste for each neighborhood and for the entire reference period were obtained.

3. Results

Degrees of improvement in waste Pre-Collection

The table I below shows the results of waste pre-collection in five different neighborhoods in 2016. Before the implementation of pre-collection, the percentage of uncollected waste ranged from 25% to 40% across neighborhoods. After the implementation of pre-collection, this percentage decreased in all neighborhoods, with improvements ranging from 48% to 52%.

Degree of improvement in 2017

The table II below shows the results of waste pre-collection in the same five neighborhoods in 2017. Before pre-collection, the percentage of uncollected waste ranged from 15% to 25% across neighborhoods. After pre-collection, this percentage decreased in all neighborhoods, with improvements ranging from 33% to 55%. The average before pre-collection was 20% of uncollected waste, compared to 11% after pre-collection, resulting in a total reduction of 45%. The results are statistically significant with a p-value less than 0.0001.

Table I: Degree of improvement in 2016

Year 2016				
Neighborhoods	Uncollected waste before (%)	Uncollected waste after (%)	Improvement (%)	P-value
Neighborhood A	30	15	50	
Neighborhood B	40	20	50	
Neighborhood C	25	12	52	< 0.01
Neighborhood D	35	18	48	
Neighborhood E	28	14	50	
	Average before = 31.6	Average after = 15.8	Total reduction = 50	

The average before pre-collection was 31.6% of uncollected waste, compared to 15.8% after pre-collection, resulting in a total reduction of 50%. The results are statistically significant with a p-value less than 0.05.

Table II: Degree of improvement in 2017

Neighborhoods	Uncollected baste before (%)	Uncollected waste after (%)	Improvement (%)	P-value
Neighborhood A	15	10	33	
Neighborhood B	20	12	40	< 0.0001
Neighborhood C	18	8	55	
Neighborhood D	25	14	44	

Degree of improvement in 2018

Table III shows the results of waste pre-collection in the same five neighborhoods in 2018. Before pre-collection, the percentage of uncollected waste ranged from 12% to 25% across neighborhoods. After pre-collection, this percentage decreased in all neighborhoods, with improvements ranging from 33% to 53%. The average before pre-collection was 16.2% of uncollected waste, compared to 9.2% after pre-collection, resulting in a total reduction of 43%. The results are statistically significant with a p-value less than 0.03.

Degree of Improvement in 2019

The table IV below shows the results of the pre-collection of waste in the same five neighborhoods in 2019. Before the pre-collection, the percentage of uncollected waste ranged from 10% to 22% across the neighborhoods. After the pre-collection, this percentage decreased in all neighborhoods, with improvements ranging from 30% to 50%. The average percentage of uncollected waste before the pre-collection was 13.8%, compared to 8% after the pre-collection, resulting in a total reduction of 42%. The results are statistically significant with a p-value of less than 0.0001.

Table III: Degree of improvement in 2018

Neighborhoods	Uncollected waste before (%)	Uncollected waste after (%)	improvement (%)	P-value
Neighborhood A	12	8	33	
Neighborhood B	18	10	44	
Neighborhood C	15	7	53	= 0.03
Neighborhood D	20	12	40	
Neighborhood E	16	9	44	
Average	16.2	9.2	Total Reduction = 43	

Table IV: Degree of improvement in 2019

Neighborhoods	Uncollected waste before (%)	Uncollected waste after (%)	Improvement (%)	P-value
Neighborhood A	10	7	30	
Neighborhood B	15	9	40	
Neighborhood C	12	6	50	< 0.0001
Neighborhood D	18	10	44	
Neighborhood E	14	8	43	
Average	13.8	8.0	Total Reduction = 42	

Degree of improvement in 2020

The table V below shows the results of the pre-collection of waste in the same five neighborhoods in 2020. Before the pre-collection, the percentage of uncollected waste ranged from 7% to 14% across the neighborhoods. After the pre-collection, this percentage decreased in all neighborhoods, with improvements ranging from 25% to 36%. The average percentage of uncollected waste before the pre-collection was 10.2%, compared to 7% after the pre-collection, resulting in a total reduction of 31%. The results are statistically significant with a p-value of less than 0.001.

Overall improvement trend

The figure 2 below presents an analysis of the average percentages of uncollected waste before and after the waste management intervention in Yaoundé III from 2016 to 2020, as well as the total reduction achieved each year. In 2016, the average percentage of uncollected waste before the intervention was 31.6%, reduced to 15.8% after the intervention, resulting in a total reduction of 50%. In 2017, the uncollected waste decreased from 20.0% to 11.0%, marking a reduction of 45%. In 2018, the percentages decreased from 16.2% before to 9.2% after the intervention, resulting in a reduction of 43%. In 2019, a reduction of 42% in uncollected waste was observed, decreasing from 13.8% to 8.0%. In 2020, although improvement was still present, the total reduction for this year was the lowest, with a decrease of 31% (from 10.2% to 7.0%).

Table V: Degree of Improvement in 2020

Neighborhoods	Uncollected waste before (%)	Uncollected waste after (%)	Improvement (%)	P-value
Neighborhood A	8	6	25	
Neighborhood B	12	8	33	
Neighborhood C	7	5	29	< 0.001
Neighborhood D	14	9	36	
Neighborhood E	10	7	30	
Average	10.2	7.0	Total Reduction = 31	

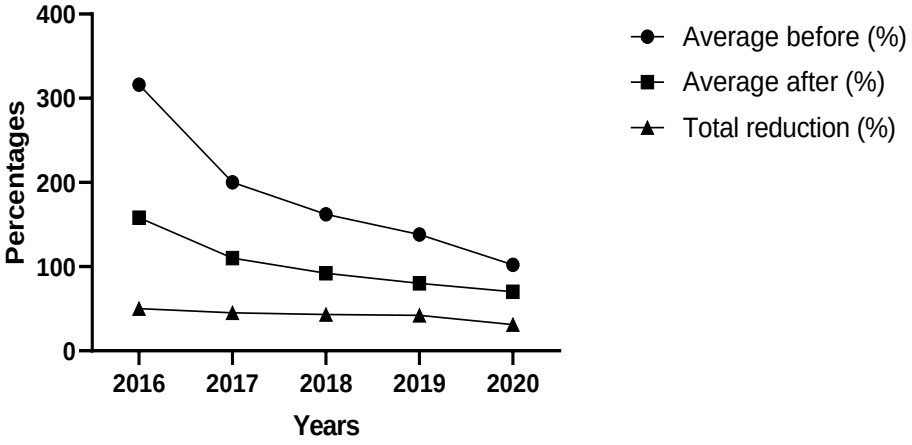

Figure 2 : Average uncollected waste before and after

Improvements in the cleanliness of waterways and green spaces

Figure 3 presents the evolution profile of the cleanliness of waterways over a 5-year period, from 2016 to 2020, following the launch of pre-collection activities by EcoClean Environnement. At the beginning of this period, the average cleanliness level of waterways was 40%, with a standard deviation of 10%. By the end of each year, the average cleanliness level increased significantly, with an average of 77% and a standard deviation of 8% over the entire period.

An analysis of variance (ANOVA) was conducted to determine if the observed differences between the years were statistically significant. The results showed a p-value of less than 0.01, indicating high statistical significance. This means that the observed improvements were not due to chance and that the efforts made to improve the cleanliness of waterways had a significant impact.

This means that the waterways that were initially less clean experienced a greater improvement than those that were already cleaner.

Overall profile of disease reduction at the sites

The figure 4 below presents the rate of reduction of the three diseases (respiratory infections, malaria, and diarrhea) for each year from 2016 to 2020 following controlled sanitation through pre-collection of waste over the years. Overall, Table VI shows that the prevention and treatment efforts have been effective in reducing the incidence of the three diseases over the years. The positive trends observed in this table are encouraging and suggest that progress is being made in the fight against these diseases.

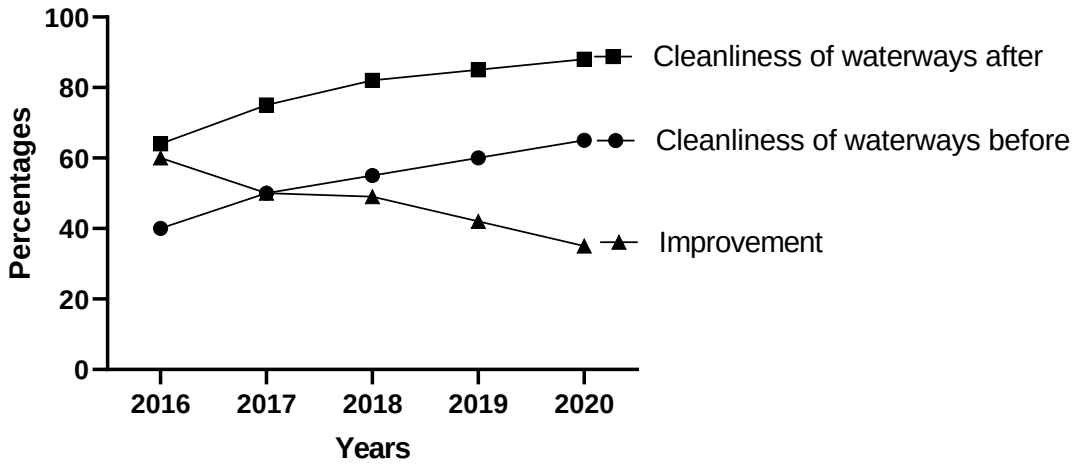

Figure 3 : Overall profile of the state of waterways after sanitation

Additionally, a linear regression analysis was conducted to determine the overall trend of improvement in the cleanliness of waterways over the years. The results showed a significant positive trend, with a slope of 0.11 and a p-value of less than 0.01. This indicates that the cleanliness of waterways has increased steadily over the years, with an average improvement of 11% per year.

Finally, a correlation analysis was performed to determine the relationship between the initial level of cleanliness and the observed improvement. The results showed a significant negative correlation, with a correlation coefficient of -0.89 and a p-value of less than 0.01.

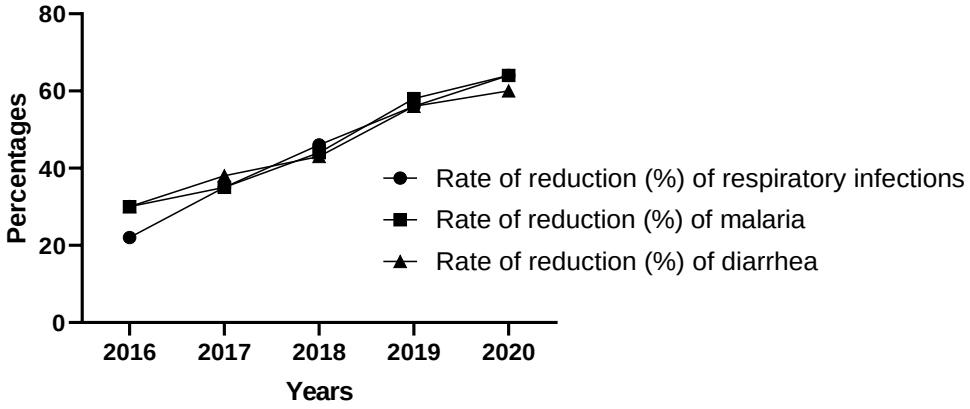

Figure 4 : Overall profile of disease variation after sanitation

Profile of rat reduction after pre-collection of waste

Figure 5 below presents data on the reduction of rat proliferation in the city of Yaoundé III from 2016 to 2020 among the 3500 partner households. A constant decrease in the number of rats reported each year can be observed, with a total reduction of 50% in 2020 compared to 2016.

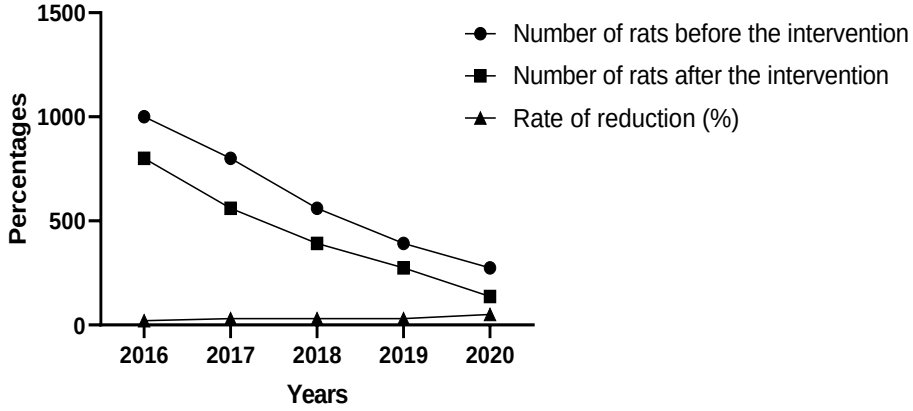

Figure 5 **:** Data on the reduction of rat proliferation

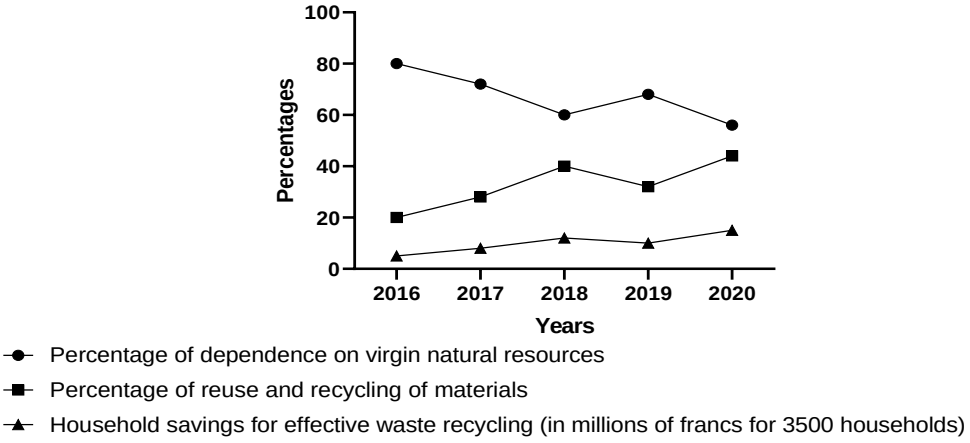

Figure 6 : Reduction in dependence on virgin natural resources

Health impact

The table VI below presents data on the impact of the intervention on three diseases: respiratory infections, malaria, and diarrhea. The data show a significant decrease in the number of cases for all three diseases over the years. These data indicate that the intervention has had a significant impact on reducing the number of cases of these three diseases. The rates of reduction have increased each year, indicating that the intervention has become increasingly effective over time. The significant p-values and decreasing odds ratios indicate that the observed reduction is not due to chance and that the risk of contracting these diseases has been significantly reduced thanks to the intervention.

Tableau VI : Impact of the sanitation intervention on diseases related to poor waste management, by year and by disease

Year	Number of cases before intervention	Number of cases after intervention	Rate of reduction (%)	P-value	ODD Ratio
Respiratory infections					
2016	1000	780	22%	0.02	0.71
2017	780	560	35%	<0.01	0.51
2018	560	360	46%	<0.01	0.3
2019	360	220	56%	<0.01	0.19
2020	220	130	64%	<0.01	0.12
Malaria					
2016	800	560	30%	0.01	0.57
2017	560	390	35%	<0.01	0.44
2018	390	240	44%	<0.01	0.29
2019	240	140	58%	<0.01	0.17
2020	140	80	64%	<0.01	0.12
Diarrhea					
2016	600	420	30%	0.03	0.62
2017	420	280	38%	<0.01	0.43
2018	280	180	43%	<0.01	0.29
2019	180	100	56%	<0.01	0.19
2020	100	60	60%	<0.01	0.25

Discussion

This work aimed to improve human health, protect the environment, and reduce the economic costs associated with poor waste management by focusing on improving pre-collection of waste in the city of Yaoundé III in Cameroon. The data obtained on the activities of improving pre-collection of waste in different neighborhoods from 2016 to 2020 showed that the intervention had a significant impact on reducing uncollected waste in all neighborhoods, with improvements ranging from 25% to 55% depending on the year and neighborhood. The p-values indicate that the results are statistically significant, suggesting that the observed improvements are not due to chance. These data corroborate the findings of Manga and colleagues, who demonstrated the importance of interventions aimed at improving pre-collection of waste in communities in Cameroon, as described in this work. This shows that this type of community approach can have a significant impact on reducing uncollected waste and associated risks (Manga et al., 2011).

The study revealed a general positive trend in waste management from 2016 to 2020, with a continuous decrease in the percentages of uncollected waste before the intervention. This trend indicates increasing adoption and implementation of better waste management practices, which led to substantial improvements in cleanliness and environmental health. The significant reductions each year demonstrate the effectiveness of the waste management interventions implemented, which likely contributed to improvements in public health by reducing risks associated with poorly managed waste.

Furthermore, the interventions also resulted in a 60% improvement in the cleanliness of waterways and green spaces, indicating a significant reduction in environmental pollution. Overall, the results suggest that continuous efforts to improve waste management have important health, environmental, and economic benefits. Several other studies have generally examined the challenges of waste management in African cities. Parrot and colleagues emphasize the importance of community participation and the involvement of local actors to improve pre-collection and collection of waste. This corroborates the approaches used in this project. They highlight the role of community initiatives in improving pre-collection of waste. The authors show that the involvement of local communities can significantly reduce uncollected waste (Parrot et al., 2009). Miezah and colleagues in Ghana show the importance of characterizing and quantifying waste to guide efforts to improve waste management.

The data collected as part of this project on waste quantities before and after the intervention are therefore essential to demonstrate the impact of the actions taken (Miezah et al., 2015).

The data on the cleanliness of waterways over the years, with a constant positive trend and high statistical significance. The efforts made to improve water quality have therefore had a positive impact on the environment. Magna and colleagues in Ghana have shown that solid waste management interventions can improve the water quality of rivers, providing direct insight into the results presented (Manga et al., 2011).

The data on the evaluation of the health impact showed a significant decrease in the number of cases of diseases related to waste in the commune after the sanitation intervention.

For respiratory infections, the number of cases decreased by 64% between 2016 and 2020, with a downward trend each year. For malaria, the number of cases also decreased by 64% between 2016 and 2020, with a similar downward trend each year. For diarrhea, the number of cases decreased by 60% between 2016 and 2020, with a downward trend each year.

The positive results obtained in this work can be explained by several factors. First, the prevention and treatment efforts were effective in reducing the incidence of diseases. Measures to combat malaria, such as the distribution of insecticide-treated mosquito nets and indoor spraying of insecticides, were also effective in reducing the transmission of this disease. Additionally, efforts to improve access to safe drinking water and sanitation were effective in reducing the incidence of diarrhea. Finally, increased awareness of the population about the risks associated with poorly managed waste and the improvement of waste collection and disposal likely contributed to reducing the risks of waste-related diseases.

Similar results showed a significant reduction in the risk of contracting these diseases, with significant p-values (<0.01) for all years, except for 2016 for malaria and diarrhea. Koné-Bodou and colleagues showed in Côte d'Ivoire that 60% of households dump solid waste on the street while 48% dump wastewater there, which increases morbidity with a high prevalence rate of 66%, with malaria leading (48%), followed by IRA (28%) and diarrhea (9%) (Koné-Bodou et al., 2019).

The pest control efforts implemented in the 3500 households included in the study were effective in reducing the proliferation of rats. This is effectively due, firstly, to the pest control efforts implemented by the disinfection teams of EcoClean Environnement, which were based on measures such as the distribution of rodenticides, the removal of waste and debris that can serve as food or shelter for rats, and raising public awareness of the importance of pest control.

Furthermore, the progressive and constant reduction in the number of rats reported over the years suggests that the pest control efforts have been maintained and strengthened over time. This can be attributed to effective planning and coordination of pest control interventions, as well as regular monitoring of the rat population to assess the effectiveness of the measures implemented. Additionally, increased public awareness of the importance of pest control may also have contributed to the reduction in the rat population. Awareness campaigns can help inform residents about the measures they can take to reduce the presence of rats in their environment, such as eliminating food and shelter sources for rats and reporting rat problems to local authorities. Overall, these results suggest that pest control efforts can be effective in reducing the proliferation of rats and protecting public health and the environment. Municipal authorities can use these data to evaluate the effectiveness of their pest control programs and plan future interventions to maintain the long-term reduction of the rat population. Rats have been known for decades to be vectors of diseases (Meerburg et al., 2009).

The results presented in the potential economic impact show a fluctuating decrease in dependence on virgin natural resources from 80% in 2016 to 56% in 2020, thanks to an increase in the reuse and recycling of materials from 20% in 2016 to 44% in 2020.

This positive trend has also led to an increase in savings made by households for effective waste recycling, rising from 5 million FCFA in 2016 to 15 million FCFA in 2020. Although the reduction in dependence on virgin natural resources fluctuated over the years, with an increase to 44% in 2018, the overall trend is downward, with a reduction of 60% in 2020 compared to 2016. These results suggest that promoting the reuse and recycling of materials can contribute to reducing dependence on virgin natural resources and encouraging household savings for effective waste recycling.

However, additional efforts are necessary to maintain this positive trend and achieve even higher levels of material reuse and recycling. FasterCapital advocates that educating employees or family members about the importance and best practices of recycling is essential to increase recycling rates. Implementing a structured recycling program, with well-placed collection bins, greatly facilitates participation. Reducing waste at the source, for example by using less paper or composting food scraps, decreases the amount of materials to be recycled. Choosing products made from recycled materials also helps to increase the overall recycling rate. Finally, regularly tracking and measuring progress is important to identify areas for improvement and adjust strategies accordingly. By applying these various approaches, businesses and households can significantly contribute to improving recycling rates and reducing waste.

Limitations of the study

1. **Limited sampling:**

The study was conducted in a single municipality, Yaoundé III, which limits the generalization of the results to other contexts. The results obtained in this municipality may not be representative of the conditions and challenges encountered in other regions of Cameroon or other countries.

2. **Duration of the study:**

The project was conducted over a period of four years (2016-2020). Although this duration is sufficient to observe trends, it may not be sufficient to evaluate the long-term impacts of the interventions implemented. The lasting effects of waste management and job creation require assessment over a longer period.

3. **Data collection methods:**

The data were primarily collected through direct observations and household surveys. Although these methods are effective, they may be subject to reporting biases and measurement errors. The use of more diverse data collection methods could have strengthened the validity of the results.

4. **Limited sampling:**

The study was conducted in a single municipality, Yaoundé III, which limits the generalization of the results to other contexts. The results obtained in this municipality may not be representative of the conditions and challenges encountered in other regions of Cameroon or other countries.

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The project was conducted over a period of four years (2016-2020). Although this duration is sufficient to observe trends, it may not be sufficient to evaluate the long-term impacts of the interventions implemented. The lasting effects of waste management and job creation require assessment over a longer period.

6. **Data collection methods**

The data were primarily collected through direct observations and household surveys. Although these methods are effective, they may be subject to reporting biases and measurement errors. The use of more diverse data collection methods could have strengthened the validity of the results.

Conclusion

The aim of this work was to improve waste management in a city or community by focusing on waste pre-collection. This improvement aimed to reduce the negative health, environmental, and economic impacts associated with poor waste management.

From a health perspective, it was observed that poor waste management could lead to the spread of infectious diseases such as cholera, typhoid fever, and dengue, as well as respiratory diseases and skin infections. By improving waste pre-collection, it is possible to reduce the amount of waste in the environment, which reduces risks to human health.

From an environmental perspective, it was observed that poor waste management could lead to air, water, and soil pollution, as well as the destruction of natural habitats and loss of biodiversity. By improving waste pre-collection, it is possible to reduce the amount of waste in the environment, which reduces negative environmental impacts.

From an economic perspective, poor waste management results in high costs for municipalities and communities due to the costs of waste collection and treatment, as well as the costs of environmental cleanup and restoration. By improving waste pre-collection, it is possible to reduce the costs associated with waste management, allowing municipalities and communities to allocate resources to other priority areas.

What is already known on this subject:

- Waste management is a major problem in many municipalities, affecting the quality of life and the environment.
- Pre-collection and recycling initiatives can improve waste management and reduce environmental impacts.
- Awareness campaigns and community engagement are essential for the success of waste management programs.

What this study adds:

- This study demonstrates a significant reduction in uncollected waste and an improvement in the cleanliness of green spaces and waterways in a specific municipality, Yaoundé III.
- The project created jobs and stimulated the development of new local businesses specialized in waste management.
- The results show a notable reduction in diseases associated with poor waste management and the proliferation of disease vectors.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Financial conflicts of interest

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