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Access to Carbon Credits in the Waste Sector: What Opportunity for Municipalities in Cameroon?

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ABSTRACT

Household solid waste management is a major concern for cities in developing countries. In Cameroon, an increase in the quantity of waste produced is associated with increased urban population. Within the context of decentralization, municipalities have been given the competence to manage waste, but challenges abound. This work seeks to demonstrate that municipal solid waste management via composting provides financial gains from the carbon credit. A mixed methods approach was used to collect secondary and primary data, and a participatory observation was used to evaluate the quantity of methane sequestrated during composting. Results show that with an estimated population of about 132916 inhabitants in 2023, Dschang produces 27514.9 tons of waste annually. However, only 32% of this waste is collected and 55.21% of the waste collected is valorized through composting. Between 2017 and 2023, the project activities produced 2472 tons of CO_2 equivalence and prevented the emission of 17,989 tons of CO_2, as the baseline scenario for the same period had predicted emissions of 20461 tons of methane. With this, Dschang municipality benefited from carbon credits amounting to 150,000 euros between 2019 and 2023. However, numerous material, organizational and regulatory constraints hinder the smooth running of the activity and threaten its sustainability. Resolving these difficulties is essential and requires the reorganization of the waste management system, more flexible and less rigorous policies in the carbon market.

INTRODUCTION

Waste production is increasing rapidly in urban areas and management challenges remain a major concern. According to the World Bank, (2018), the annual production of municipal waste already exceeds 2 billion tons per year. Several studies (Sharholy *et al*., 2007; Ahmed & Ali, 2006; Diabagate, 2009) are unanimous on the fact that rapid urbanization, the increase in living standards and population growth are closely linked to waste production. This has led to an explosive increase in the amount of waste and accelerated global warming through methane emissions. The recent World Bank report (2018) shows that the increase in the quantity of waste produced in the world is increasing rapidly and It is estimated at more than 70% by 2050 and will be multiplied by three in sub-Saharan Africa with more than 516 million tons compared to 174tons today. Greenhouse gas emission from waste significantly contributes to climate change. With 1.6 billion tons of carbon equivalent produced per year (5% of greenhouse gas emissions), the collection and treatment of waste is becoming an important factor in the fight against global warming. If mitigation measures are not put in place, this figure could reach 2.6 billion tons in 2050, further aggravating the current situation. These emissions largely come from methane (CH4) released by the decomposition of garbage in landfills.

In Sub-Saharan Africa, landfills only receive on average 30 to 40% of waste (Ngangué, 2012; Koledzi, 2011). This situation is caused by inadequate material, technological, legal and political framework that governs the waste management sector. The fraction of waste which dominates, however, consists of fermentable waste which can be recovered by composting (Topanou, 2012). In the cities of Central Africa, more particularly in Cameroon, the fermentable fraction contained in waste varies between 50 and 65% (Ngnikam *et al*., 2017; Sagne, 2021). This is a great potential as compositing provides opportunities to gain access to carbon credits and boast the effectiveness of municipal solid waste management systems. Through a public-private partnership set up to alleviate the financial difficulties faced by municipalities in developing countries, carbon reduction or sequestration projects can have access to carbon credits (Benrabia, 2003; Gbinlo, 2010). Carbon financing becomes an economic tool in the fight against climate change (Albérola, 2011; Boutti, 2013) as the carbon market encourages different agents to set up emissions reduction activities, especially in developing countries (Han, 2024).

The carbon market or greenhouse gas emissions trading system is a public policy tool for reducing gas emissions into the atmosphere (mainly carbon dioxide) responsible for climate change. It began from the Rio Earth Summit in 1992, which led to the adoption by 196 countries of the United Nations Framework Convention on Climate Change (UNFCCC), then to the establishment of the Protocol of Kyoto. This protocol is an international agreement signed on December 11, 1997 during COP 3 in Kyoto as an additional protocol and binding application to the 1992 climate convention. It came into force in 2005 with the objective of reducing responsible GHG

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emissions. This led to the putting in place of the largest emissions trading market though it only concerned industrialized countries.

In 2005, the States began negotiations for a new agreement which would also take into account developing countries in preparation for the expiry of the Kyoto protocol. This project culminated in COP 15 in Copenhagen in 2009, which set a temperature stabilization objective of 2% by 2050. The Kyoto Protocol expires in 2012 and its objectives seem generally achieved (despite the fact that the United States did not ratify it and Canada had withdrawn), but in the absence of an international agreement on climate, the industrialized countries decided to extend it beyond 2012. This is how in 2012, in Doha, a new Conference of the Parties (COP18) was held during which the rules for the second commitment period of the Kyoto Protocol (2013-2020) were defined.

It is in this context that COP 21 was held in Paris, from November 30 to December 11, 2015, which resulted in the adoption of a global agreement to combat climate change on December 12, 2015. With this new agreement, emitting GHGs above a certain threshold is now penalized and has a cost. Conversely, emitters capable of remaining below this threshold hold a differential value and have access to financial benefits. With this, the good news was the putting in place of benefits from emissions reductions. This was the origin of the carbon credits. Carbon is used because carbon dioxide is the main greenhouse and since then, it could be traded in the carbon market. Besides making money from composted waste, the idea of repurposing garbage as a resource has drawn much attention in light of growing concerns about sustainable development and environmental management. Saifullah *et al.*, (2024) explore the intriguing idea of using waste materials as a practical and ecological replacement for construction materials and also carefully evaluate the technical, environmental and financial viability of incorporating various waste products, like household waste paper and waste glass into different construction application. This economic value of waste has made scavenging a livelihood activity in some towns of developing countries though environmental and health concerns are on the rise.

Reducing greenhouse gas emissions into the atmosphere is important in mitigating global warming (Fapong, 2017). In the agricultural sector, carbon assessment represents 14% of greenhouse gas emissions (Foucherot *et al.*, 2011). The Ecological Footprint, the Carbon Balance Sheet or even the Life Cycle Analysis (LCA) is the tools par excellence for carbon assessment (Marchand, 2013; Aissani *et al.*, 2012; Sagne, 2021). In Gambia, life cycle analysis has made it possible to reduce 20% and 22% of the country's total municipal solid waste footprint (Jassey *et al.*, 2023). Unfortunately, climate policies are perceived by developing countries as an additional constraint on their development process (Mathy, 2004) with participation only taking place through the clean development mechanism (Kleiche, 2006). In relation this perception, Mahamane *et al.*, (2023) established a direct correlation between carbondioxide emission reduction and poverty in developing countries. Their work revealed that poor countries can not develop their economies if developed countries limit their industrial development with concepts such as the clean mechanism that limits energy consumption and development initiatives. Developing countries contribute very little in global green house gas emission and Sarker *et al.*, (2021) revealed the progress of developing countries away from poverty require investing in industries that will emit gases and pollute the environment. This work has a different perspective and shades light on existing opportunities for municipalities in Cameroon as potential beneficiaries from the carbon credits.

As part of the national waste management strategy implemented in Cameroon and compliance with sustainable development goals, the Dschang municipality has established since the mid-2000s, with the help of national and international partners, a waste management and recovery system with access to carbon finance and which integrates the participation of all local stakeholders. Since then, composting took a central stage in the waste management with construction and operationalization of two composting platforms. Non- the -less, there has been a number of drawbacks. For instance, waste is not sorted at source and in most cases; it arrives the composting platforms at an advanced state of degradation thus reducing the compost quality and credit potential (Moye *et al.*, 2024). As such, this work aims to show how carbon sequestrated during the composting process can fetch money from the carbon market. It has policy implications as it is imperative to take stock of the difficulties that hamper composting activity and impact carbon financing in developing countries. It has an introduction, presentation of the study area and the methodology for data collection and processing. Results demonstrate the contribution of composting in the management of household solid waste, the carbon evaluation process and carbon credits obtained and finally the difficulties that hinder the composting activity and by extension access to the carbon market.

MATERIALS AND METHODS

Presentation of the study area

Located between latitudes 5° 25' and 5° 30' North and between longitudes 10°30' and 10° 50' East of the Green Wich Meridian, Dschang is the headquarter of the Menoua Division. Geographcally, it falls within the Western Highlands of Cameroon, precisely on the South-Eastern slope of the Bamboutos Mountains. Dschang is located 46 km from the regional capital Bafoussam (Figure 1). With an average altitude of 1400m above the sea level, the dominant climate is the high altitude tropical type, characterized by a rainy season which extends from mid-March to mid-November and a dry season extending from mid- November to mid-March. Precipitation is decreasing with an annual average of 1872.3 mm in

1997 compared to 1654.2 mm in 2005. Altitudinal variations have put in place three agro-ecological zones (low, medium and high altitude) with strong agricultural potential (Dschang Council, 2019). According to data from the General Population and Housing Census (RGPH) of 2005, the municipality has a total of 120,207 inhabitants. That is, 63,838 inhabitants in the urban area and 56,369 inhabitants in the rural area.

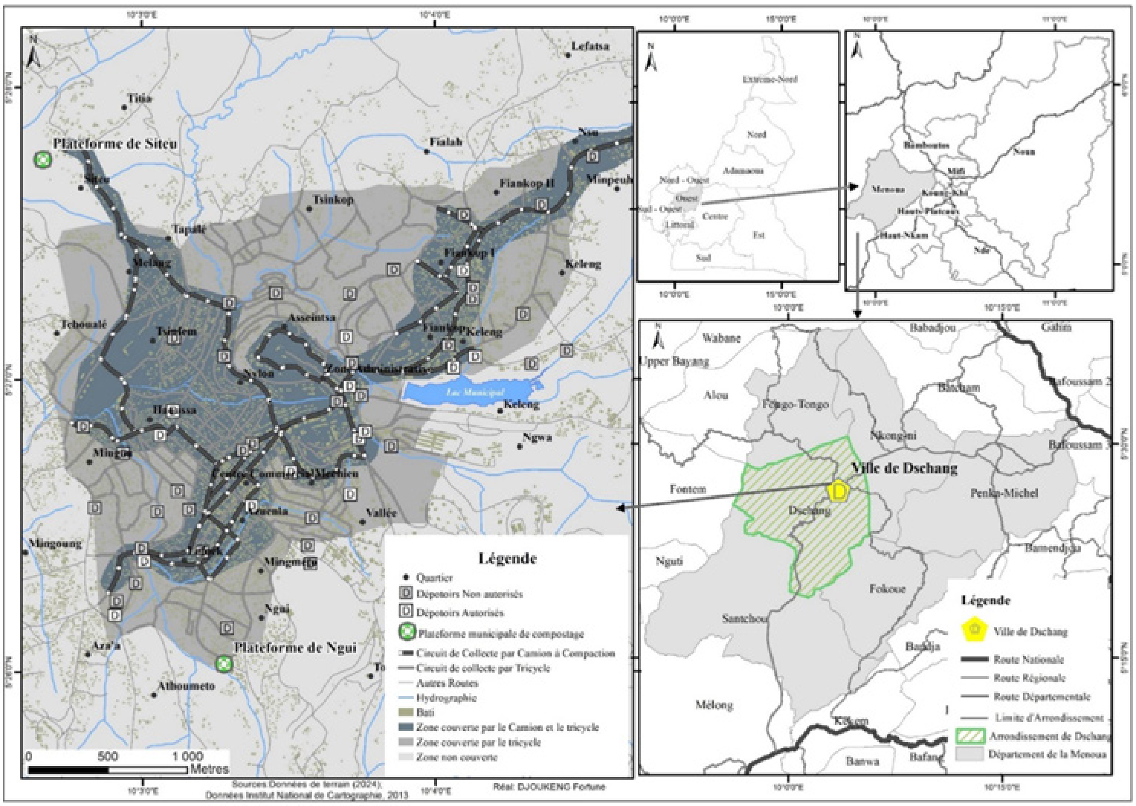

Figure 1: Localization of the study zone

Figure 1 shows two systems of waste management which do not follow the same circuit. Pre-collection is carried out by private organizations in partnership with the municipality, especially in the inaccessible neighborhoods with the use of tricycles. Collection takes place along the main streets of the town by compaction trucks. There are authorized dumpsites, but the population has created unauthorized garbage dumping sites throughout the city. Waste collected is transported to the composting sites for the production of compost. The Siteu composting platform located at a high altitude is only accessible by compaction trucks and dump trucks while tricycles transport fresh waste to the Ngui composting platform.

Data collection and analysis

Secondary and primary sources were used to collect data for this work. Secondary data was obtained from reports, archives and online articles. Primary data collection was done through a participatory observation during internships carried out at the municipality composting platforms and at ERA Cameroon, an NGO works with the municipality in the composting project. Structured questionnaires were administered to 41 purposively selected actors within the waste management chain and four(4) interviews carried out with major stakeholders such as the head of the Municipal Waste Management Agency and agents of ERA Cameroon in charge of the valorization of the carbon credits produced during the composting process.

Data collected was treated quantitatively and qualitatively. Questionnaires were coded and treated in SPSS while interviews were transcribed, coded and analyzed according to contents and themes using the Atlas.Ti software. For carbon evaluation, parameters for calculating emission reductions during the composting process were employed, permitting the estimation of avoided emissions to be sold in the carbon market. The formula for calculating avoided emissions is that of AMS-III.F "Avoidance of methane emissions through controlled biological treatment of biomass" of the United Nations Framework Convention on Climate Change which stipulates that, to obtain avoided emissions, we proceed by calculating the difference between emissions of the project and those of the reference scenario. The reference scenario is that which prevails in a situation where there is no waste treatment and the project emissions represent those which take place during the project activity.

The AMS-III.F methodology is the most suitable for calculating reduced emissions with regard to projects for the valorization of solid waste into compost on a small scale (-60,000 tCO_2eq / year), on a medium scale and on a large scale. It incorporates measures to avoid emitting methane into the atmosphere, whether from biomass or organic matter found in anaerobic conditions.

To calculate the emissions of the situation without the Composting operation, the formula is as follows:

$$BE_Y = BE_{CH4SWDSY} + BE_{WWY} + BE_{CH4manurey} - MD_y * GWP_{CH4} \quad (1)$$

Where:

BE_Y= baseline emissions for year y; $BE_{CH4SWDSY}$= Yearly methane emissions from solid waste; BE_{WWY}= BE from waste water co-composted (BE from composted waste water); $BE_{CH4manurey}$=BE from manure composted (BE from composted manure); MD_Y= methane that would have to be composted and combusted to comply with regulation. GWP_{CH4} is the global warming potential for CH4 = 23 (the global warming potential of CH4 is 23)

During the composting process, there are very small amounts of greenhouse gas emissions. These emissions are monitored and their values used to calculate project emissions. The formula for calculating project emissions is:

$$PE_Y = PE_{Y,power} + PE_{Y,comp} + PE_{Y,runoff} + PE_{Y,res\ waste} \quad (2)$$

Where:

PE_Y = project emissions year y; $PE_{Y,\ power}$ = emissions due to electricity; $PE_{Y,comp}$ = emissions linked to the composting process; $PE_{Y,\ runoff}$ = emissions due to leachate; $PE_{Y,\ reswaste}$ = emissions linked to anaerobic storage of compost. Waste treatment through composting in Dschang focuses on the fraction of CH4 emissions avoided, so the formula becomes;

$$BE_Y = BE_{CH4SWDSy} \quad (3)$$

Where,

$$BE_{CH4WDSy} = \Phi \times (1-f) \times GWP_{CH4} \times (1-o_x) \times (16/12) \times F \times DOC_f \times MCF \times \sum_{x=1}^{y} \sum_j W_{j.k} \times DOC_j \times e^{-kj(y-x)} \times (1-e_{-kj}) \quad (4)$$

From this formula, we understand that the reductions in CH4 for waste composted in year X do not only apply in year X, but also in future years. More explicitly, it must be understood that the emission reductions in later years are the results of the waste treatment carried out in the beginning. For this reason and for a better understanding of the immediate benefits of composting activity on GHG emissions in Dschang, we adopted this formula while reducing all year round emissions for landfilling.

$$W_{jx} = W_x \times p_{jx} \quad (5)$$

W_j= quantity of treated waste "j" monitored, DOC_f = Degradable Organic Carbon: default value; Kj= waste degradation rate j by default; W_{jx}= quantity of waste "j" treated in year x; W_x: total quantity of waste treated; P_{jx} = average fraction of waste "j" in waste of year X; DOCj: fraction of degradable organic carbon (weight), in waste type per day and Kj is the waste degradation rate.

Regarding the calculation of project emissions during the composting process, reference is made to greenhouse gas emissions (in very small quantities) but whose values are monitored and used to calculate project emissions. They include;

Emissions due to electricity consumption

$$PE_{Y,power} = \sum jEC \times EF \times (1+TDL) \quad (6)$$

Where;

EC=quantity of electricity used in the year; EF=default emissions factor of 1.3; (1 + TDL)= network loss by default which is 20%

Emissions linked to the composting process

$$PE_{Y,comp} = Q_y \times EF_{comp} \times GPW_{CH4} \quad (7)$$

Given that the methodology is conservative, it is estimated that there are few emissions where: Qy=quantity of waste treated; EFcomp = default emissions factor which is 4% and=GWP_{CH4}, which is 23. In the case where the oxygen is monitored and is greater than 8% with 90% confidence and 10% error, then PEy,comp = 0

Emissions linked to leaching (PEy, runoff)

$$PE_{Y,runoff} = Q_{y,www,runoff} \times COD_{y,www,runoff} \times B_{o,ww} \times MCF_{ww,treat} \times UF_b \times GWP_{CH4} PE_{y,runoff} = 0 \quad (8)$$

These emissions were not considered because composting on both sites is done in a shed and therefore the leachate effect is null.

Emissions linked to anaerobic storage of compost PEy, reswaste

$$PE_y = PE_{y,power} + PE_{y,comp} \quad (9)$$

In the case of Dschang, compost is stored aerobically so PEy, reswaste = 0

RESULTS AND DISCUSSION

The contribution of composting in the municipal solid waste management system

The population of Dschang municipality has evolved over time, increasing from 30,000 inhabitants in 1952 to about 132,916 inhabitants in 2023. It is important to note that the waste production capacity of a city depends on its population and as such, quantities of waste produced by the city's populations have evolved in line with its population growth. With the establishment of a composting activity in the mid-2000s, a Municipal Waste Management Agency was created in 2015. Within this agency is the service responsible for pre-collection and collection of waste. In the year 2023, the population was estimated at 27,514 tons with an average per capita waste production capacity of 0.65kg/day. However, the waste management service collected only 32% of the waste produced by the city's population. A comparison between the quantities of waste collected and those treated (Table 1) gives us the contribution of composting in waste management.

Table 1 shows that quantities of waste collected in Dschang have increased significant since the inception of the composting project in 2015. The change from about 4000 tons in 2015 to 14000 in 2022 is remarkable but there was drop to about 9000tons in 2023. Interviews revealed that the drop was caused by technical challenges that made waste collection ineffective. This implied a corresponding increase in waste treated from 500tons in 2015 to about 5000tons in 2023. Despite the steady increase in quantities treated, there are fluctuations in the rate of treatment. It varies in relation to the waste collection rate. This treatment rate is highest in 2018, where it represents 66.55% of the quantity of waste collected but trends have been falling with 2022 representing only 28.64% but in 2023 it went up to 55.21%. These fluctuations in quantities treated have implications on the carbon credit potential of the municipality.

Table 1: Quantity of waste collected and treated on the platforms between 2015 and 2023

Years	Total quantities of waste collected (tons)	Total quantities of waste composted	Rate of treatment by composting (%)
2015	3909,04	1130	28,91
2016	4 996,90	1695,1	33,92
2017	5800,53	3487,57	60,13
2018	5633,35	3411,11	60,55
2019	5342,10	2187,31	40,94
2020	11282,67	3012,48	26,70
2021	13267,19	4 450,05	33,54
2022	13817,14	3 956,90	28,64
2023	8939,5	4 935,21	55,21

Composting as an alternative method for municipal solid waste treatment

Composting is a method of stabilizing and treating biodegradable organic waste using the natural process of decomposition of organic matter in the presence of oxygen. An increase in temperature for several weeks, reflecting the activity of a large number of microorganisms, produces a stable final product called compost (Figure 2).

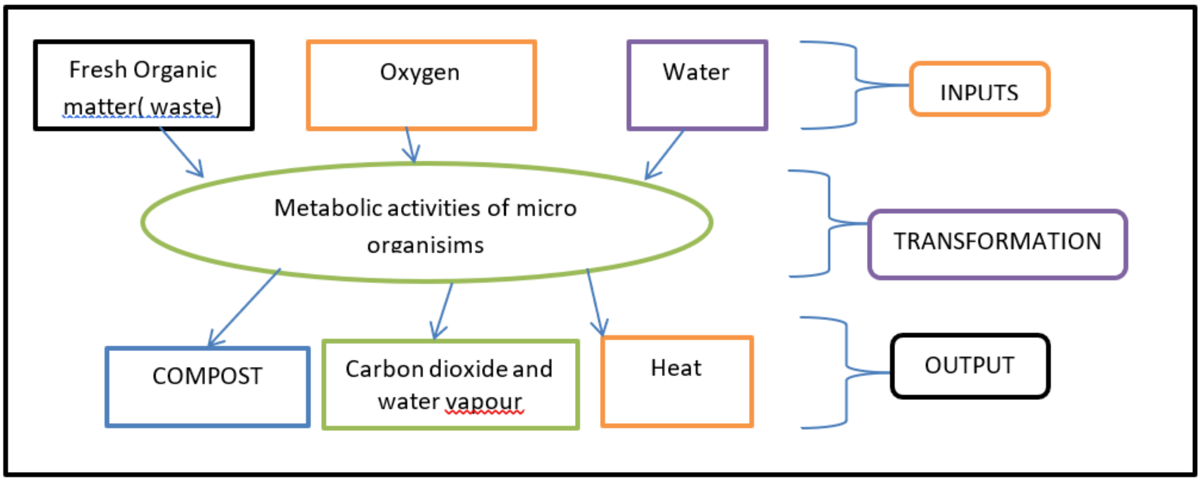

Figure 2: Organic Waste composting system

Figure 2 shows the inputs, processes and output from the composting process. The process begins when waste reaches the composting platforms at Ngui and Siteu. It involves a number of activities (Figure 3). The first stage is the sorting of non-biodegradable components of the waste using the handpicking method on sorting tables (Photo A). The compostable waste is the place in heaps and fermentation begins (Photo B). The fermentation is done under aerobic conditions to avoid the production of methane. After a month of fermentation, there is sharp rise in temperatures due to action of micro-organisms. Temperature remains generally high during the first month and decrease gradually. During this phase, the humidity level of the heap is checked and if it is too dry, it is watered (photo D). The heap must not be too dry or too wet.

A dry heap may stop the activity of the microorganisms while too much water produces a blackish liquid called leachate which is toxic. Watering is therefore monitored carefully. As decomposition is going on, heaps are constantly turned (Photo C). During this phase, the waste that makes up the heap is unidentifiable and a reduction in temperature is observed (below 40 °C). This is the second month of fermentation and it lasts for a month and a half. Throughout this phase, the decomposition of the waste continues and the organic materials undergo biological and chemical stabilization. After 3 and a half to 4 months, waste is completely decomposed. A final turning is carried out to dry it completely and larger particles are removed through sieving (Photo E). The dry compost is then packaged into bags and sold to local farmers (Photo F). During these processes, data is collected for calculation of project emission reductions.

Carbon evaluation during composting processes

This process begins with a project design document. When drafting this document, estimates are made of the emissions that would normally take place in a situation without a composting project. These emissions are still called baseline emissions and are different from project

Photo A: Waste sorting on tables

Photo B: Formation of heaps

Photo C: Turning of heaps

Photo D: Watering and temperature control

Photo E: Drying and Sieving of compost

Photo F: Packaging of compost

Figure 3: Composting processes at the municipal composting platforms

emissions. During the composting activities, a carbon monitoring of certain key parameters on the different composting platforms was carried out. In Dschang, these parameters are used in the calculation of project emissions by ERA Cameroun and the verification of reduced emissions ensured by a designated operational entity. After calculating project emissions, they are compared to those of the baseline to obtain the reduced emissions (figure 4). During the year 2023, 2873 tons of emissions were avoided from baseline emissions estimated at 3334 tons. This shows a reduction of 86%.

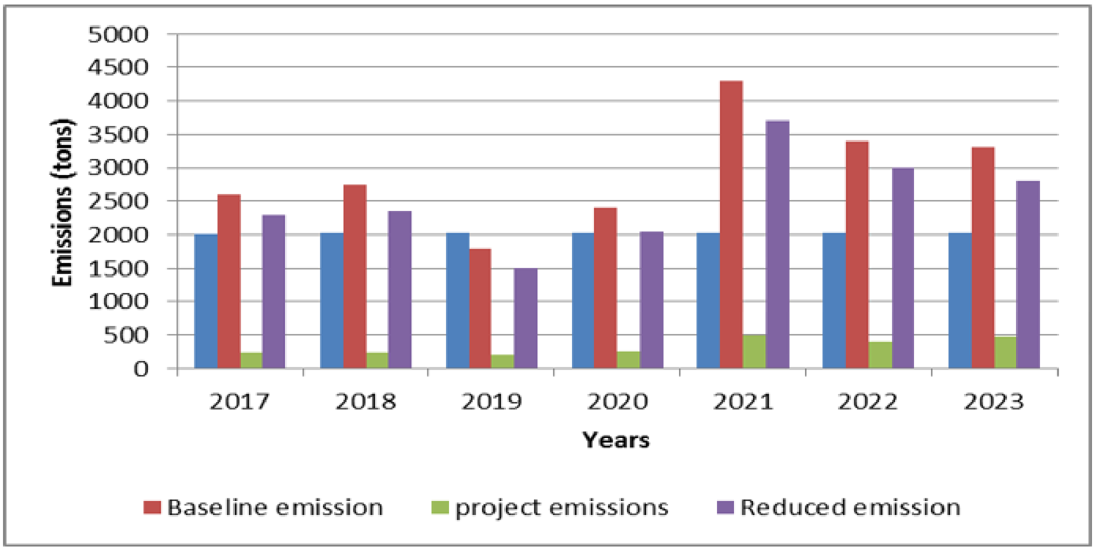

Figure 4: Emissions calculated during the composting processes

Figure 4 shows the baseline emissions and emissions reduced by the Dschang City Composting Project. It is clear that the project avoided each year more than 90% of CH4 emissions that would have occurred in the absence of a composting project. The city's waste would have produced 20461 tons of carbon equivalence between 2017 and 2023. Thanks to the composting of its waste, 17989 tons of CO_2 eq were avoided. This corresponds to 87% of the emissions that would have occurred without the project. It is important to note that during the composting process, small quantities of other GHGs are emitted especially CO_2. Between 2017 and 2023, 2472 tons of CO_2 were emitted from composting activities such as electricity consumption and storage of compost.

Accessing carbon credits from certified reduced emission

To access the carbon market, developing countries must not only set up a project to sequester or avoid greenhouse gas emissions but they are conditioned to draft a carbon file to be submitted to Gold Standard, an institution that regulates the voluntary market resulting from the Clean Development Mechanism (CDM) to which the project is registered. This is the first condition to obtain certification for emission reduction and possibility of selling them. The procedure begins with the elaboration of a project design document that is submitted to a designated operational entity for validation after monitoring project activities in the field. Registration is then done and it corresponds to the formal acceptance of the carbon project by the CDM executive board. This is a prerequisite for the verification, certification and marketing processes of credits relating to the project activities.

It is important to note that carbon financing is additional financing allocated to decentralized local communities in developing countries to enable them to cover part of the costs related to the management of their waste. In Dschang, the NGO ERA Cameroon is the local structure that handles the sale of certified emissions and the main buyer is the French foundation Good Planet. The Dschang municipality began receiving carbon credits in 2019 although the evaluation of emissions avoided by the composting project started in 2017. Delays observed in the reception of credits between 2017 and 2019 were attributed to administrative bottlenecks encountered during the drafting and validation of the project design document as revealed in the following excerpts captured during an interview with an agent of Era Cameroon;

"……drafting the project design documents and getting validation and certification of reduced emissions is a long and challenging task. That is why it took us more than two years to start benefiting from carbon credits… "(Interview, 2023).

However, the Dschang project unit benefited from remote support from the GEVALOR team (Sustainable management and recovery of waste and mineral raw materials), which gave them the opportunity to finalize the document by 2019. Thanks to their interventions, credits for the years 2017 and 2018 were then considered as a balance that was later paid to ERA Cameroon by Good Planet. From 2019 to 2023, there has been a steady increase in the amounts benefited by the project although with marked differences between the received and the expected amounts (figure 5).

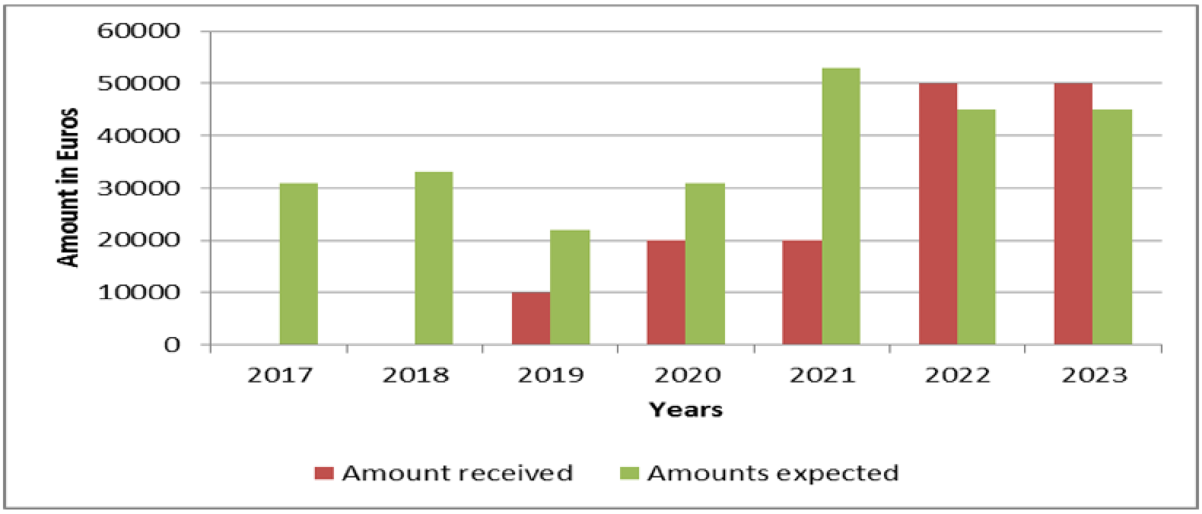

Figure 5: difference between the amount of carbon credits received and the expected amounts

Figure 5 shows that carbon credits obtained have evolved from 10,000 euros in 2019 to 50,000euros in 2023 but were below the expected credits except for 2022. However, in 2022 and 2023, the amounts received were more than the expected amounts. This is explained by the fact that even though emission reductions are only calculated for specific years, the carbon credits are paid throughout the entire period of the project's activities. Therefore, the greater the quantity of waste processed at the start of the project, the greater the carbon credits obtained over time. Between 2019 and 2023, the project has benefitted from credits amounting to 150,000 euros. However, before the implementation of a carbon monitoring system, the project already had other financial sources. These are the revenues from participatory pre-collection and from the sale of compost. Between 2016 and 2020, the total amount of money made by the pre-collection and collection service was 43,510,750 FCFA, while from 2015 to 2023, the revenue from compost sales amounted to 50,981,128 FCFA. Despite these financial gains, the project still encounters a number of challenges that limits its ability to make more money.

Challenges in accessing carbon credits by from composting activities

Waste collection and composting barriers

In Dschang municipality, only 32% of waste produced reaches the composting sites. This implies that 68% of waste produced is dumped illegally. From questionnaire survey, 67% of the population revealed that pre-collection and waste collection activities are not at its peak. The primary causes are mainly insufficient technological (23%), financial, material (41.2%) and human resources (7.8%). The poor state of roads (5%) was equally identified as a limited factor as it delayed waste supplies to the composting platforms. Interviews with head of waste collection unit revealed that the pre-collection and waste collection circuit does not cover the entire town due to limited materials and poor state of roads. He added

"…. There is only one compaction truck that plies only the main streets whereas dense residential quarters where waste is produced in large quantities are inaccessible. It is difficult and these people are forced to dump waste illegally…(Interview, 2023).

At the level of the composting platforms, challenges arise from the quality of waste treated. As revealed by the head of the composting unit;

"…due to delays in waste collection and transportation, waste sometimes arrive the composting platforms at a degrading state…waste that is produced after three days is not compostable because it will produce poor quality compost.." (Interview, 2023)

It should be noted that the greater the quantity of waste collected, the greater the quantity treated, as well as the quantity of emissions reduced and consequently the carbon credits.

The sale of certified reduced emissions through an intermediary

For projects developed in Cameroon as part of the Clean Development Mechanism to have access to the voluntary carbon market, they must go through an intermediary for the sale of their certified reduced emissions. There are in fact two sizes of project: small-scale projects that avoid less than 60,000 tons of carbon per year and large-scale projects that avoid more than 60,000 tons of carbon per year. To sell directly to the label that regulates the voluntary carbon market, it is indeed necessary to reduce a large amount of carbon per year. Each standard at the international level gives conditions to be met to deal directly with them. The Dschang project is a small-scale and must go through an intermediary to sell get access to the carbon market. The intermediary must be a project promoter, registered with the desired standard. With reduced emissions of 3334 tons of CO_2 equivalent, emissions are sold via Good Planet, a French association which helps small project leaders to sell their credits on the voluntary offset market. The latter buys the credits at a fixed price and later resells them to one of the labels which regulate the carbon market. It is important to note that the label with which the city's project is registered is the Gold Standard. Good Planet buys carbon credits from ERA at a fixed price of 15 euros per ton of CO_2eq and resells them on the market. During an interview to this effect, the representative of the NGO ERA Cameroon declared;

"…Gold Standard does not know ERA but Good Planet who has an account with him and is a promote…". (Interview, 2023)

This shows that if ERA had the possibility of dealing directly with the Gold Standard, ERA could sell its credits at a higher price and thus increase the revenue from the sale of carbon credits. More than 10% of carbon credits go to the intermediary organization.

Access to the carbon market conditioned by a certified of a project

To have access to the carbon market, it is necessary to set up a project whose aim is either to avoid emissions or to sequester emissions that have already occurred. Cameroon joined the UNFCCC in 1994 and is required to comply with decisions that were taken by the decision-makers at the 1992 Summit. The condition of setting up a project before having access to the carbon market is already in itself a hindrance for developing countries. These countries that do not contribute up to 4% of global emissions responsible for global warming have unstable financial conditions and limited know-how on the carbon certification projects. As such, there are individuals, companies and non-governmental organizations that carry out activities to reduce emissions and/or sequester gas emissions but cannot have access to carbon credits because they are outside the framework of a project. The processes of setting up a project or even a carbon file remains very little known and challenging as stipulated during an interview with the municipal agent;

"…the project existing for two years before we had access to credits due to challenges in mounting the project documents and the complication certification procedures. Dschang equally faced language problems as project documents were majorly in English.." (Interview, 2023)

Surveys conducted among workers in the waste sector showed that 92% of workers do not know how to set up a similar project while more than 90% of those surveyed have no knowledge on carbon financing. It therefore becomes crucial to set up initiatives that will provide resource persons in this area in order to address some of these challenges.

Discussion

Waste management through composting in developing country can provides direct or indirect access to carbon credits depending on the scale of the project. This study shows that the population of the city of Dschang estimated at 123,916 inhabitants in 2023 produced 27,514 tons of waste. The service responsible for pre-collection and collection recovered 32% of this waste and 55% of it was treated through composting. This shows a low collection rate that is similar with that in most towns in Sub Saharan Africa. According to a study conducted by Koledzi, (2011), the waste collection rate in Lomé, Togo is 35%. It is therefore evident that a greater proportion of waste produced is dumped illegally. Waste management in developing countries needs to be improved upon. To effectively handle solid waste management, it is crucial to adopt a comprehensive approach that combines sustainable practices, community engagement and efficient policy (Shahen, 2024). Waste is a resource and has been valorized by Dschang municipality through it composting project that initiated in 2015. As an income generating activity, it has yielded 50,981,128 FCFA from the sale of compost between 2015 and 2023. Through the monitoring of data collected in the field, the carbon footprint of the composting activity was carried out. Avoided emissions can be quantified through several different methods, namely life cycle analysis, ecological footprint and carbon footprint or greenhouse gas emission footprint (Aissani *et al*., 2012; Sagne, 2021). Through the AMS-III.F methodology of the United Nations Framework Convention on Climate Change, it was determined that in 2023, thanks to the said project, 2,873 tons of CO_2 equivalent were avoided from the baseline emissions previously estimated at 3,334 tons, given a reduction of 86%.

These reduced emissions are then sold on the voluntary offset market to cover part of the costs relating to waste management. According to Fapong (2017), access to the carbon market involves setting up a carbon file in 6 stages. This file must be validated by the chosen label. In the case of Dschang, the amount of carbon credits received by the composting project for the year 2017 was 10,000 euros and 50,000 euros in 2023.This is an important strategy in climate change mitigation. Albérola (2011) talks about the fight against climate change through economic instruments such as carbon finance, carbon taxation and regulation. The carbon credit is a market-based tool that encourages economic agents to implement carbon emission reduction activities as part of the fight against climate change (Wang, 2024). Total transactions from carbon credits represented 103 billion euros in 2009 and are today a central pillar in the financing of international climate policy (World Bank, 2018). Never the less, developing countries are not making maximum use of these financial benefits related to the carbon market. This work provides elements for understanding the current development of carbon credits within the waste sector. However, waste management projects in developing countries have not been transformed into economic projects. Dschang municipality was pioneer in Cameroon to transform its waste management project to an income generating activity through composting. Despite the success recorded, composting activities in the city face many difficulties including; insufficient technology (23%), financial and material limitations (41.2%) and inadequate human resources (7.8%) and poor state of roads (5%) which sometimes leads to the collection of waste already in the decomposition phase. These challenges are common in Sub Saharan African towns have limited municipality's abilities to expand their waste collection streams (Topanou, 2012; Ngahane *et al*, 2021; Moye *et al*., 2024). These challenges go beyond technical and financial limitations to policies. Within the context of decentralization, municipalities in Cameroon have been given all competences that can permit them manage their waste effectively (Moye *et al*., 2024). At the international level Mathy (2004) believes that developing countries see climate policies as a constraint to their developmental projects and therefore pay little attention to emission reduction projects. Equally, Fujiwara (2012) states that the limited size of future demand for compensations or credits, restrictions on the use of CDM credits in phase III of the European Union emissions trading system are the primary difficulties hindering the access of developing countries to the carbon market. These challenges need to be given particular attention in order to ameliorate access to carbon credits for effective climate change financing.

CONCLUSION

This work had as objective to assess the opportunities and challenges of municipalities in accessing carbon credits from the waste sector. Using the case study of Dschang municipality, mixed research methods were employed to collect qualitative and quantitative data. Findings revealed that the rate of waste production is 0.65kg/per/day which is slightly above that in other towns of Cameroon. To effectively manage this waste, the municipality in collaboration with partners such as ERA Cameroon set up a waste composting project in the mid-2000s that had the objective to transform municipal solid waste into compost. However, in 2023, only 32% of waste produced waste collected and transported to the composting platforms. These platforms have been able to transform 55% of waste collected into compost. In 2017, the municipality started a carbon evaluation project and according to emissions of the reference scenario, the city's waste would have produced 20461 tons of carbon equivalence between 2017 and 2023. Thanks to the composting of its waste, 17989 tons of CO_2 eq were avoided, representing 87% of the emissions that would have occurred without the project. It is important to note that during the composting process, small quantities of GAS are emitted, mainly CO_2. During this activity, 2472 tons of CO_2 were emitted between 2017 and 2023. This project began to receive carbon credits in 2019 after validation of the project design document, and between 2019 and 2023, the amount received was 150,000 euros. However, a lot of challenges have reduced the municipality's potential in reaping greater financial benefits from the waste management project. The inability to treat greater quantities of waste due to financial, technical and material inadequacies, the lengthy and complex certification procedures are some of the short comings identified. As such, it is important to set up an entity that represents Cameroon in particular and Africa in general on the carbon market to allow the establishment of a more flexible framework and less rigorous regulations regarding access to the carbon market for developing countries.

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