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ENVIRONMENTAL AND SOCIO-ECONOMIC IMPLICATIONS OF NON-BIODEGRADABLE SOLID WASTE VALUATION IN YAOUNDE III COUNCIL AREA, CENTER REGION OF CAMEROON

A dissertation submitted in partial fulfilment of the requirements for the award of the master's degree in geography defended on the 30th July 2024

Specialization: URBAN AND RURAL GEOGRAPHY

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Academic year 2023/2024

DEDICATION

This dissertation is wholeheartedly dedicated to with special regards to Mama Mbah Lydia and Doris Eposi for their support and to all the households who were involved during the major field survey.

I want to thank the Almighty God for security, provision, inspiration, good health and for the accomplishment of all this research study.

ACKNOWLEDGEMENTS

Special gratitude goes to the Pr ENCHAW Gabriel, the supervisor of this project who spared no effort in making this work a success and for painstakingly being there to ensure that I complete it.

My regards to Pr NGOUFFO Roger for the seminars on geographic research and Pr MOUPOU Moise for methods and tools for geographic research that helped this research. My special acknowledgment further go to my scientific educators Pr MEDIEBOU Chindji Rose, Dr NDI Roland, Pr NKWEMOH Clément, Pr TCHAWA Paul, Pr DEFO Louis, Dr WUCHU Cornelius, Dr NNOMENKO'O Eric, Dr BOUBA Dieudonné, Pr TCHINJANG Mesmin, Dr TENDE Renz, for their scientific teachings that ameliorated the work.

Special acknowledgements goes to Mr Hubert who wholeheartedly gave valuable field data contributing to the accomplishment of this work and to the Senior Biomedical technician Mr Durand Esigue, for their collaboration during interview at the Saint Michel Medical Center.

I equally acknowledge my friends and course mates who have been there throughout the course of this study including Marx Mbidzenyuy, Ashu Domonink, Robi Alex Essola , and Mbwemwa Audrey.

Special regards goes to Nshanji Desmond, Tanteh Vivian and Desiire Mungeh for all their valuable support and contribution to accomplishment of this study.

More acknowledgments goes to the waste recyclers and pickers who spared no effort in sharing their experiences that were of utmost importance for this study.

ABSTRACT

Deficient value addition non-biodegradable solid waste recyclables characterized by unauthorized dumping and open burning imposed environmental risks, and negative socio-economic externalities in Yaounde III council area. The objectives of this study seek to assess the environmental and socio-economic effects of non-valuation of non-biodegradable waste in Yaounde III council area.

The study was guided by three hypotheses and 50 effective respondents in Yaoundé III provided responses 15 questions. More data was collected through on-the-spot field observation. Hypothetic-deductive method by way of descriptive statistics consisting permitted the testing of the hypotheses by the used of mediating variables. Interviews were conducted with resource persons including waste pickers and secondary data from web based databanks were gleaned. Hence, valuable conclusions were drawn and propositions were made to remedy the problem of the non-valuation of non-biodegradable solid waste in Yaoundé III council area. The findings were presented in four chapters of the study.

Findings revealed that environmental degradation was characterised by soil contamination, surface and underground water pollution and atmospheric pollution. The social effects included 85 (51.8%) of the patients who were diagnosed with malaria and typhoid infections among which 69 (81%) were chronic cases meanwhile 16 (18%) cases were mild. Non-valuation led to missed economic opportunities including limited entrepreneurship and enterprise development, limited opportunity to create intermediary jobs and generate revenue.

Keywords: Implications, valuation, non-biodegradable, solid waste, socio-economic, environment, Yaounde III council area.

RESUME

Le manque de la valorisation des déchets solides non-biodégradable recyclables, caractérisé par les décharges non autorisé et l'incinération à ciel ouvert présente des risques environnementaux et les externalités socio-économiques zone du conseil municipale de Yaoundé III. Les objectives de cette étude consistait à évaluer les effets socio-économique et environnementale dans la zone de conseil de Yaoundé III.

L'étude a été guidée par trois hypothèses et 50 personnes interrogées à Yaoundé III ont répondu à 15 questions. D'autres données ont été collectées par le biais d'observations sur le terrain. La méthode hypothético-déductive par le biais de statistiques descriptives a permis de tester les hypothèses par l'utilisation de variables médiatrices. Des entretiens ont été menés avec des personnes ressources, dont des ramasseurs de déchets, et des données secondaires provenant de banques de données en ligne ont été consultées. Des conclusions précieuses ont donc été tirées et des propositions ont été faites pour remédier au problème de la non-valorisation des déchets non-biodégradable.

Les résultats ont révélé que la dégradation environnementale était caractérisé par la contamination des sols, la pollution des eaux de surface et souterraines et la pollution atmosphérique. Les effets sociaux comprennent 85 (51.8%) des patients diagnostiqués avec les infections paludismes et la typhoïdes parmi lesquels 69 (81%) étaient des cas sévère tandis que 16 (18%) étaient de cas simple. La non-valorisation a conduit à des opportunités économique manquées y compris un développement limites de l'entreprenariat et des entreprises. Une opportunité limités de créer les emplois et de générer des revenus.
Mots clés: Implications, valorisation, non-biodégradable, déchets solide, socio-économique, environnement, conseil municipal de Yaoundé III

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LIST OF ACRONYMS AND ABBREVIATIONS

BGR: Federal Institute of Geoscience and Natural resources of Germany

BUCREP: Bureau Central des Recensement et des Études de Population

CED: Centre de d'Information et de documentation sur l'environnement

DST: Department of Science and Technology

ELV: End of Live Vehicles

GHG: Green-House Gases

HDPE: High Density Polyethylene

HYSACAM: Hygiène et Salubrité du Cameroun

IARC: International Agency for Research on Cancer

INC: L'Institut National de Cartographie

INS: L'Institut National de la Statistique

IUCN: International Union for Conservation of Nature

ISWM: Integrated Sustainable Waste Management

KBA: Knowledge Based Authentication

MFR: Material recovery facility

MINHDU: Ministère de L'Habitat et du Développement Urbain

MINEPDED: Ministère de L'Environnement, de la Protection de la Nature et du Développement Durable

MSW: Municipal Solid Waste

NBSW: Non-biodegradable Solid Waste

NCD: Non-Communicable Diseases

NGO: Non-Governmental Organisation

ONACC: Observatoire National sur les Changements Climatiques

PET: Polyethylene Terephthalate

PM: Particulate Matter

POP: Persistent Organic Pollutants

PPE: Personal Protective Equipment

PWR: Public Waste Receptacle

SEI: Stockholm Environmental Institute

SME: Small and Medium Size Enterprises

SWMB: Solid Waste Management Behaviour

UNEP: Unites Nations Environmental Programme

VICAD: Ville du Cameroun en Développement

WHO: World Health Organisation

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GENERAL INTRODUCTION

Introduction

This study examines the extent of deficient valorisation of non-biodegradable solid waste and the effects it has on the environmental preservation as well as socio-economic viability of local inhabitants in Yaoundé III council area, Mfoundi division of the center region of Cameroon. There are several remarkable topics and their singificance in this study will be presented in the form of a background to the study (Ogolo, 1996).

0.1 Background to the study

About 600,000 tons of plastic waste is generated in Cameroon annually, only around 200,000 tons (20%) reaches the recycling stage after use (MINEPDED, 2023). According to MINEPDED (2023), about 1.5 million kg (1500 tons) is produced in annually with only 300,000 kg recycled with the remaining 1.2 million kg left un-recycled. An estimated 1,500 tons of waste is generated per day in Yaoundé and about 700t of household waste is currently collected per day per day (HYSACAM, 2022). The per capita daily production of non-biodegradable solid waste in Yaoundé ranged between 0.096 to 0.138 kg/HH/day and the main components include plastics, metals and glass. Furthermore, about 33% of the waste generated in Yaoundé was not collected by the waste management company and was dumped streams and canals (Ludovic, 2016).

Evaluating the value gains of treating non-biodegradable solid recyclable waste materials as an environmental and socio-economic resource is crucial in the paradigm shift from perceiving waste as a problem to viewing it as a resource. Valuation here refers to the organised sorting, collection, transfer, processing and conversion of plastic, metal, rubber and electronic waste as secondary resources for the production of other goods. The usage of this waste as a resource can have tremendous environmental and socio-economic potentials benefits.

Non-biodegradable solid waste is waste that cannot be decomposed and disintegrated by the biological action of microorganisms. This includes glass waste which last for about 1million years, plastic waste which last for 1000 years, ferrous and non-ferrous metals last 50-80 years and batteries last million years (UNEP, 2018).

Existing waste management methods employed to cope with the ever increasing waste generation has faced numerous setbacks. The advent of the influx of internally displaced persons from the North and South West regions that led to the increasing waste demographic boom and increased waste generation and rapid filling up of public waste bins added pressure on the existing waste management methods.

The state of waste management has seen the induction of private waste utility company TYCHLOF SARL waste collection services, which collects biodegradable solid waste materials. However, despites initiatives such as 'national clean city contest' and of the sub-divisional prefect of implement voluntary hygiene and sanitation 'jeudi-propre' the failure to institute a valorisation program for non-biodegradable solid waste recyclables is a major issue in the Yaoundé III council area.

The poor collection coverage coupled with lack of waste sorting schemes and proper collection, lack of adequate infrastructure, lack of discipline through uncontrolled dumping as well as open burning and weak implementation of the existing waste policies are indicative of the non-valuation which gave rise to environmental sustainability challenges and socio-economic externalities.

0.2 Statement of the problem

The predominance of waste dumps of non-biodegradable solid waste recyclable materials lacking valorisation as an environmental, social and economic resource by households is problematic. The waste lacks segregation prior to collection, into separate waste bins as well as the collection by para-public waste utility collection services do not have adequate equipment to separately collect waste. The traditional authorities and quarter heads are not included to supervise proper segregation, storage and collection of waste. Moreover the waste regulation do not ensure that waste is properly treated prior to storage, collection, transportation and disposal. The waste-recycling or absorption capacity of the environment is at times surpassed due to the huge quantity and variety of waste produced by households and leads to various forms of environmental pollution (Enchaw, 2018). As such, this pollutes the local environment seen in land deterioration, water pollution and atmospheric pollution due to pollutants from openly burnt waste (UNEP, 2015). Open burning and unauthorised dumping engenders negative externalities affecting social livelihood including blocked drainages which provokes plastic aggravated flash-flooding (Jane, 2023), public health challenge, disfigures the urban presentation as well as reduced crop production due to decreasing soil fertility. The absence of source sorting leads to higher cost of managing this waste is huge and this reduces the budget for innovation and limits opportunities for job creation and income generation. Lack of policy implementation and inclusion of stakeholders are equally aspects that had negative implication of sustainability in the Yaounde III council area.

Deficient value attachment to waste as an environmental resource results in environmental land degradation in Yaounde III council area. On the local environment, waste degrades the top soil through dumping and burning which blocks soil fissure, making the soil to become more compact. This reduces infiltration and interferes with the action of soil microorganisms. Dumping and burning plastics on water bodies speeds up decomposition of algae which produces a lot of CO_2 reducing the proportion of oxygen hence suffocating aquatic organisms. On the global environment, burning waste emits nefarious compounds into atmosphere in the form of green-house gaseous emissions. The gases releases from plastic and rubber waste burning include carbon monoxide, ethylene oxide, sulphur dioxide, nitrogen dioxide, and particulate matter 2.5. Burning electrical waste releases ozone. These ozone depleting gases are chemicals that contribute to increasing levels of tropospheric ozone layer that reduces plant yield, leads to stunted growth and plants may even die due to too much exposure to tropospheric ozone. The stratospheric ozone layer is destroyed by ozone depleting substances that react with ozone molecules (O_3), dissociating them into free oxygen atoms and oxygen molecules.

Limited of value addition to recyclables materials as a social resource impart social challenges on public health, aesthetic nuisance, as well plastic-aggravated flash flooding events and impoverishes farmlands in the study area. On farmlands, uncontrolled plastic disposal and burning entangles with the soil nutrient cycle and soil PH which reduces productivity of the staple maize food and cash crop. Loss of arable land hinders food security in the urban space as farmlands have been occupied with garbage. Mixed waste dumping is a source of visual pollution reducing the aesthetic attractiveness of the urban landscape while open burning increases waste-aggravated injuries to children as well it emits toxic fumes such as dioxins, furan that intoxicate the health residents. Furthermore mixed waste disposal creates breeding ground for pathogenic organisms such mosquitoes, flies, roaches and rodents that transmit malaria and dysentery. Disposing into drainages increases plastic aggravated flash flooding events through the blockage of drainage canals reducing runoff evacuation capacity.

Reduced of value attachment to waste as a secondary economic resource in value is an economic loss for job creation, income generation, management costs and sustainable innovation in the study area. Considering the high rate of unemployment of 7% is indicative of deficient waste valuation for economic benefits since waste is not used to create intermediary jobs which and earn income by households who generate these recyclable materials. In the event whereby of a household get infection from waste aggravated diseases, their ability to work is reduced along finances losses incurred for treatment. The lack of proper waste segregation, treatment and conversion action plan by the managing authority incur huge management costs since revenue is not generated from collected waste. There is lack of sustainable indigenous innovation as a result of non-valuation since waste material recyclables limited use as raw materials for producing economical goods and services. Non-valuation equally limits the sustainable innovation, enterprise development, entrepreneurship and limits the opportunity to alleviate poverty.

0.2.1 Research questions

General question

To what extent does the non-valuation of discarded plastic electronic, rubber and metal waste affect the environmental sustainability, social wellbeing and economic performance in the Yaounde III council area.

Specific questions

i. What are environmental impacts related to the non-valuation of non-biodegradable plastic, metal, glass electronic and rubber waste recyclables in the Yaoundé III council area?

ii. What are the social effects inherent to the non-valuation of non-biodegradable plastic, metal, glass rubber and electronic waste recyclables in the Yaoundé III council area?

iii. What are the economic implications associated to the non-valuation of plastic, metal, glass, rubber, and electronic and metals waste recyclables in the Yaoundé III council area?

0.2.2 Objectives of the study

General objective

The general objective is to investigate the ramifications associated to the non-valuation of non-biodegradable solid plastic bottles, polyethene bags, rubber tyres, metallic and electronic waste on environmental sustainability and socio-economic wellbeing in the Yaoundé III council area.

Specific objectives

i. To assess the impacts of the non-valuation of non-biodegradable solid plastic, rubber and electronic waste materials on environmental sustainability in the Yaoundé III council area.

ii. To investigate the effects of non-valuation of non-biodegradable plastic, metal, glass, rubber and electronic waste recyclables on social livelihood in Yaoundé III council area.

iii. To evaluate the influence of non-valuation of recyclable plastic, electronic metallic, rubber and electronic waste on economic wellbeing within the Yaoundé III council area.

0.2.3 Hypothesis

i. The non-valuation of non-biodegradable solid plastic, metal, glass, rubber and electronic recyclables impact the environment of the Yaoundé III council area.

ii. The non-valuation of non-biodegradable plastic, metal, glass, rubber and electronic waste recyclables affect social life in Yaoundé III council area.

iii. The non-valuation of non-biodegradable recyclable plastic bottles, rubber tyres, electronic materials and metallic waste influence the economy of the Yaoundé III council area.

0.3 Significance of the study

Valuable metal, rubber and electronic equipment waste materials is perceived as an urban problem by the generating households. Despite the numerous efforts to efficiently collect and dispose waste no empirical study have being conducted to find out why these current waste management approach failed through perceived environmental degradation and sustained socio-economic challenges. It is therefore important to determine value of waste as an environmental and socio-economic resource in the study area.

The findings of the study would therefore be useful to waste stakeholders including the local population to segregate waste prior to disposal. To policy designers to adopt inclusive regulations taking into account traditional authorities, quarter heads and in the collection chain. To policy executors to effective implementation of existing waste legislation as well as the technical aspects including adequate collection infrastructures for collection. These results would thus be of value to as it depicts recycling initiatives which can be adopted by households and other stakeholders in the waste resource management arena.

0.4 Scope and delimitation of the study

Thematic delimitation

The scope of this research takes into consideration the in-situ aspects of non-valuation of non-biodegradable solid waste as a resource in the environmental sustainability, social life and economic wellbeing in Yaounde III. The ex-situ aspects of the scope focuses on the effectiveness of adaption strategies, institutional challenges and waste governance.

Temporal delimitation

The rapid demographic boom characterised by rapid population increase caused by internal displacement of persons from north west and southwest with a corresponding increase in waste generation during the course of the previous decade increased the pressure on existing waste management services. In effect, he study ranges the year from 2012 to 2024 which witnessed an extensive generation of NBSW owing to demographic boom from natural increase and internal migration and failure to attach value necessitated a detail study of the resultant environmental footprints and socio-economic ramifications in Yaoundé III council area.

Spatial delimitation

The Yaounde III council area extends on a surface area of $67km^2$ and has a population of about 252,501. It shares boundaries with Yaoundé I to the North, North West by Yaoundé V, north east by Yaoundé II, to the south and southwest by Mbankomo, west by Yaoundé VI, to the east by the Yaoundé IV council area and to the southeast by Bikok. The Yaoundé III council area currently has 14 quarters. The area is located between longitude 11°26'80", 11 ° 31'20" East of the Greenwich meridian, and latitude 3° 43'70", and 3 ° 51'66'' North of the Equator.

The Yaoundé III council area was created by presidential decree N°87/1365 of 24th September 1987 that dwelled on the creation of the Yaoundé council areas (OSIDIMBEA, 2023). The decree was modified in 1993, when Yaoundé III was split into two parts, separating it from its western part and creating Yaoundé 6 in the process.

The special status of Yaoundé III council area was granted in 2019 as part of government's response to the crisis in the English-speaking region. Yaounde III is located in the southern part of the Yaoundé city. Yaounde III is also home to the Yaoundé municipal lake and as well as the 5th urban forest of the city.

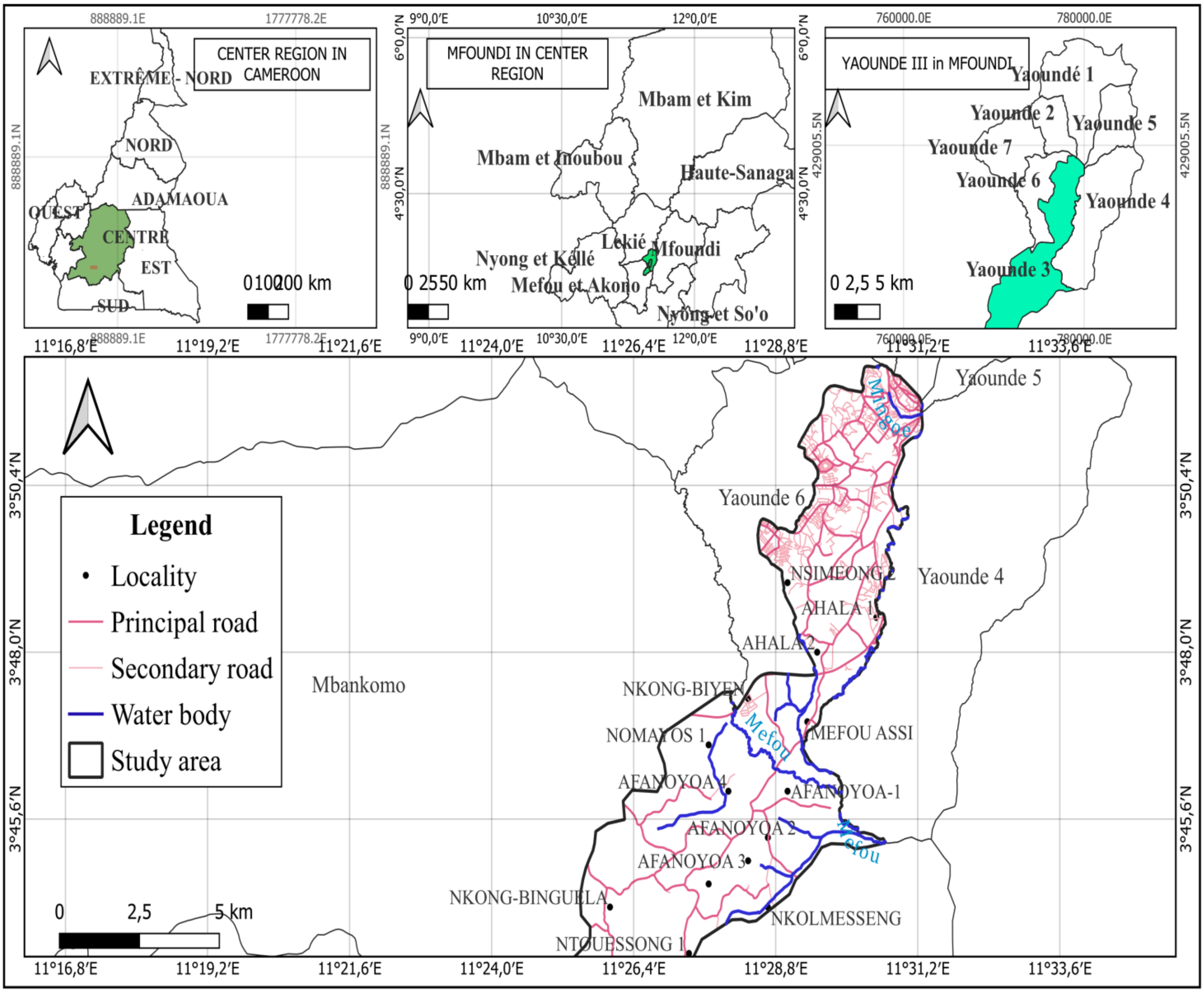


Figure 1: Location of Yaoundé III

Source: INC, realised by KONGNYU CHIFU MBAH, 2023

Yaoundé III council area is a part of the Mefou watershed, which drains the Cameroonian capital of Yaoundé in the humid tropical zone of the southern Cameroon low plateau. The climate of the area is of the equatorial type, with two rainy and dry seasons (Daouda Nsangou et al. 2022).

The average annual rainfall is about 1600mm and the average annual temperature is about 24°C. The hygrometric measurements of relative humidity and other gases in the atmosphere is 80% and this varies between 35 and 98%. The vegetation is the inter-tropical type with the predominance of the humid meridional forest (Wéthé. J. 1999; 2001).

The relief of the area is characterized by hills and valleys, with an average altitude of 701m above sea level. The geology of the area is mostly composed of gneisses, schist and granites.

The relief of the Yaoundé III council area (fig. 2) is particularly rugged with uneven terrain, with hollows interlocking watercourses and numerous plateau dissected by interpolated valleys. This municipality equally harbours valleys. The highest altitudes located in the Ngoaekelle, Mvolye and Nkol Nguie quarters.

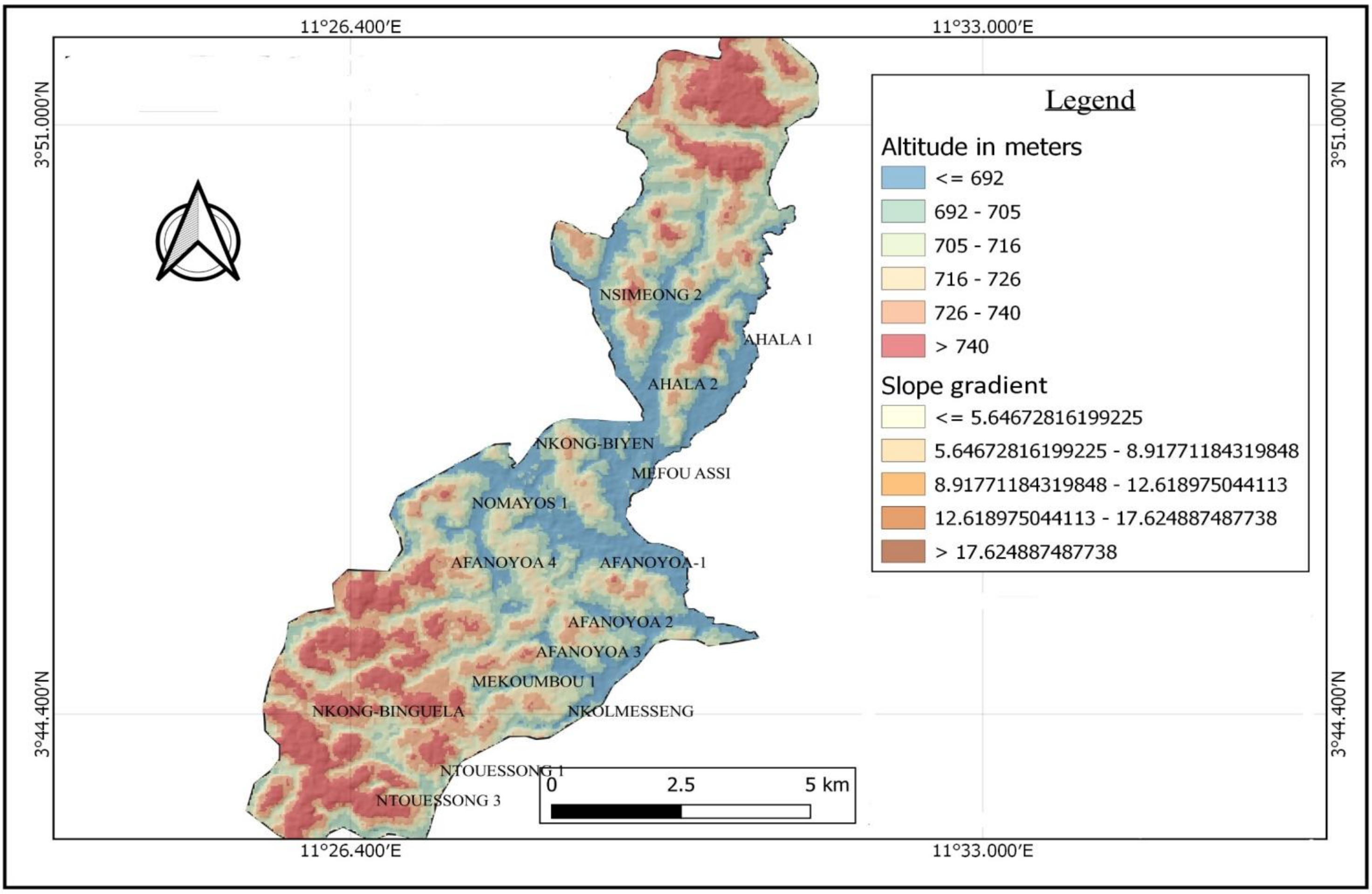


Figure 2: Relief of the study area

Source: INC, realised by KONGNYU CHIFU MBAH 2023

The relief of the area is characterized by hills and valleys, with an average altitude of 701m above sea level. The geology of the area is mostly composed of gneisses, schist and granites.

The relief of the Yaoundé III is particularly rugged with uneven terrain, with hollows interlocking watercourses and numerous plateau dissected by interpolated valleys. This municipality equally harbours valleys. The highest altitudes located in the Ngoaekelle, Mvolye and Nkol Nguie quarters.

0.5 Literature review

0.5.1 The state of solid waste management

Tchuikoua (2015), in studying urban practices and the management of household solid waste in Douala indicated that only citizens in precarious conditions neighbourhoods in Douala adopted practices to evacuate waste in the absence of modern and conventional ones. The study stated the poor domestic waste management practices led to environmental and sanitary health risks. Given the fact that domestic waste apart from recovery, can be transformed for the production of organic manure or biomass to produce renewable energy is a testament that effective opportunities exist towards sustainable development. However, these opportunities were valorised only to a lesser extent or were not valorised at all.

Ngambi (2008), studied the indicators and health consequences of water pollution in Yaounde. The author focused on the method of management and hygiene in the urban space. He emphasised on using tools and methods that could make the population change their behaviour, creating a judicial framework in order to formalise the circular economy, setting up a feedback committed that assists and surveys the population, communicate to facilitate dialogue among social actors, and to re-compensating actions that support waste valorisation.

Tchuikoua (2010), in studying solid waste management in Douala, Cameroon orients his view on orienting his analysis on recycling systems emphasized that collective selection of household waste in order to recover certain materials must not be considered as singular aspect. It should be an integrated program for managing waste associated with policies that target the reduction of the volume of waste and which valorises of sub-materials. The author equally mentioned that the action plan of HYSACAM was insufficient in dealing with increasing waste generation and this malfunction caused the used of popular unorthodox practices of waste management within the urban milieu leading to environmental risks. Moreover, the aspect of economic and energetic valorisation of waste was little or unknown to the inhabitants as well as the public authority. Furthermore, policies towards waste reduction could take into consideration the economy in general, duration of materials, as well as the new idea of materials. Considering the valorisation of sub-materials, existing systems could be divided into two major categories including mechanical sorting in which solid waste is separated into certain fractions, and the sorting at the source of certain materials after collection, their transportation and separate transformation to ensure materials reuse.

When studying household solid waste management and salubrity in the town of Kékem" (Nkeuh, 2022), underscored the fact that the existing household waste management system was insufficient for most of the households surveyed, as no recycling or recovery system or even a technical landfill centre has been set up. Thus, to get rid of waste, people dump it either in gullies, waterways, or on the side of the road, and some resort to incineration. As the sanitation systems are rudimentary, the image of the city is disfigured; the environment is degraded by atmospheric pollution and the health of the population is also degraded by the proliferation of flies and rodents, which are real vectors of diseases such as malaria, typhoid fever, diarrhoea, amoebiasis, and skin diseases. The author laid more emphasis on the investigating waste management as a problem without assessing waste as a social resource for aesthetic beautification which is a crucial aspect in our study.

Ludovic (2016), in the study of residential solid waste management in cities with developing economies) proposed that the composting and recycling of biodegradable and non-biodegradable solid waste respectively could mitigate negative ecological footprints while fostering the economic value of waste management in Yaoundé. This study suggested that increasing the number and positioning of garbage bin, collection and transportation systems and developing recycling and waste-to-energy facilities could enhance the efficiency and sustainability of waste management in Yaoundé (Innocent, 2016). The study was more focused on ecological as well as economic value gains of recycling and necessity of having a good management infrastructure without dealing with prior segregation of waste as a societal resource for waste for beautification and sustainable construction which is paramount in our study.

0.5.2 Waste management systems

Parrot (2009), in studying the determinants of domestic waste input use in urban agriculture lowland systems in Yaoundé said that the factors contributing to the adoption of recycled livestock wastes were the age of the farmers, the distance between the house and its crop field, the educational level of farmers and land size. Young farmers were more likely to adopt recycled livestock wastes, and short distances between houses and crop fields were more likely to contribute to the adoption of both recycled kitchen waste and recycled livestock wastes. The authors were more interested on organic domestic waste recycling that was used in crop fields. They did not consider the use of the plastic bottle for farming and gardening which as nurseries and their used for irrigation which is important in our study.

Sotamenou (2019), in studying the drivers of legal and illegal solid waste disposal from households in Yaoundé said the regulatory instruments were often limited, available resources were scarce and illegal waste disposal was the outcome. The authors further showed that investing in waste collection infrastructure offered great potential in improving waste disposal, particularly in combination with other measures such as removing illegal dumpsites, incorporating pre-collection and composting into institutional programs, raising awareness and increasing the level of compliance. The study looked at the factors of illegal waste disposal without incorporating the environmental and socio-economic valorisation of waste which is of prime value in our study.

Robert (2021), in studying solid waste management systems in Down beach, Tiko, South Waste region of Cameroon highlighted that the Tiko council administration investigated how solid waste was been managed by examining the types of waste, management schemes, challenges inherent to waste management and to provide solutions to mitigate these waste management challenges . The author paid little or no concern to the accumulation of waste generated and dumped in streams and open areas (Robert Mbah, 2021). This study was more concerned with management aspect of waste without taking into account the social and economic valuation of waste to mitigate these challenges.

Samuel (2022), in researching the status of household solid waste management and its associated factors in Fiche town, Ethiopia, mentioned unconventional modes of transport, waste dumping on road sides and water bodies, irregular waste picking programs, infrastructural constraints, financial constraints, lack of skill human resources and unregulated land-filling as the observed negative solid waste mal-practices. The study did not go beyond the factors of solid waste management to investigate waste valorisation as a social, economic and environmental as resource which is crucial in our study.

0.5.3 Environmental impacts

Ndabuf (2022), in studying domestic waste management and its effects on the environment of Yaoundé II, sort out to determine how increasing waste production surpassed the management capacity in Yaoundé II. Examinations of policies and institutional frame work governing waste management and evaluations of how domestic waste management had affected the environment of the study area were conducted. The study however failed to assess the environmental and socio-economic valuation of waste as a resource which is an important dimension in our study.

Lema (2021), in studying household waste management, examined waste disposal in order to dispose waste using new risk free and sustainable system in Bamenda and Buea cities of Cameroon. Mark et al. (2006) suggested that people be advised to separate organic waste from inorganic solid waste before depositing for collection to a compositing depot. The author was more interested on the waste management aspect of household waste disposal without laying emphasis on valuating waste as economic resource which is of prime interest in our study.

Rufis (2022), in studying the environmental impacts of second-generation biofuels production from agricultural residues in Cameroon. . This focused on the life cycle assessment method, in order to contribute to sustainable development with emphasis on environmentally concerned decision-making and appropriate choice of technologies. This laboratory-scale work was meant to serve as a reference for decision-making of pilot plants and then large-scale production of liquid and gaseous biofuels with the objective of promoting the development of a sustainable biomass-energy industry based on avocado seeds, cocoa pods and peanut shells through identification of critical factors. However, this study laid more emphasis on economic benefits of waste without evaluating the environmental and socio-economic aspects of waste valuation that is an important dimension for our study.

Abia (2019), in the article on environmental health concerns in Cameroon said that industrial chemical spills and disposal of industrial debris into water or open fields harmfully impacted the environment, particularly causing air, water and soil pollution. They indicated that the direct consequences of these bad practices were reflected through common diseases, and food intoxication and climate change. The challenges included environmental waste management, pollution, and the associated health implications that were the major concerns. The author said poor industrial as well as market waste management, poor town planning including poorly constructed houses and poor drainage systems contributed to the spread of diseases remained major concerns, leaving an unhealthy environment. The poor handling of pesticides and non-biodegradable plastics had negative impact on soil quality and thus reducing portions of farmlands and agricultural production. Human exposures to harmful chemicals, pesticides, pathogens present in the polluted environments, in foods, water, air, untreated waste at workplace or at home, were the causes of many environmental diseases. The study focused more on the health challenges of waste management without paying attention to the economic and institutional aspects of waste valorization to remedy these challenges which was assessed in our study.

Pravin (2012), in studying some major non-biodegradable solid wastes (NBSW) along Thane Creek of Mumbai, India, observed that the release of sewage, as well as dumping solid waste had succeeded in chocking the ecosystem. The observations indicated that plastics carry bags, milk/oil bags, plastic bottles and foot wares were the major non-biodegradable solid waste materials responsible for solid waste pollution. However the authors was more concerned with the negative environmental effects of plastic waste without paying attention to the plastic waste valuation that generate income and create jobs in our study

Buitrago (2023) in studying the geological perspective of plastic pollution focusing on geological record of plastic pollution with the widespread presence of radionuclide, organo-chlorine pesticides, PCB (polychlorinated biphenyl) and plastic production, highlighted that the cycle encompasses extraction, production, use, disposal, degradation, fragmentation, accumulation and lithification. The author equally pointed out the negative impacts of plastic pollution on the environment through photo-degradation, thermal stress and biodegradation. The author was more interested in studying plastic waste pollution without studying it social valuation for aesthetic beautification which is impoetant in our study.

Saimin (2021), on scientometric analysis and comprehensive review of plastic waste management strategies and their environmental impacts noticed that the existing management methods such as plastic waste dumping in landfills was not sustainable. The aim was to compare the benefits and drawbacks of all management strategies in order to recommend the most desirable ones. The study revealed that among the six plastic waste management techniques (landfills, recycling, pyrolysis, liquefaction, road construction and tar, and concrete production), road construction and tar and concrete production were the two most effective strategies due to significant benefits, such as decreased greenhouse gas emissions, and increased durability and sustainability manufactured materials roadways. Tis study pointed out that using landfills was the most undesirable strategy due to environmental and human health concerns while pyrolysis and liquefaction were favourable alongside the use of plastic waste for construction applications was recommended. The analysis was more focused on plastic waste management strategies without paying attention to plastic waste as social resource for beautifying the social landscape.

Sunita (2021), in reviewing the processes and prospects on valorizing solid waste for the production of valuable products via bio-routes dwelled on the fact that humanity was struggling against a major problem for a proper management of generated municipal solid waste. The collected waste causes natural issues like uncontrollable emission of greenhouse gases and others. The authors said that the increasing of waste generation surpassed the carrying capacity of dumpsites and therefore creating awareness in the society to use organic products like biofuels, bio fertilizers and biogas was very important. The study emphasized that biochemical processes such as composting, vermicomposting, anaerobic digestion, and landfilling played an important role in valorizing biomass and solid waste for production of biofuels, bio surfactants and biopolymer. However the study focused more on municipal solid waste management as a problem and failed to emphasize on the valuation of waste as a social resource for aesthetic beautification which is a bond of contention in our study.

0.5.4 Socio-economic effects

Songue (2023) studied the occurrence of bisphenol levels in sachet water, bagged whisky, crude palm oil and traditional alcoholic beverages in Cameroon. The authors said Bisphenols are known to be endocrine disruptors, are ubiquitous in the environment as well as in plastic materials such as those used in food packaging. This can lead to the contamination of food in contact with environmental products or plastic packaging. The study laid more emphasis on plastic packaging as an agent of pollution without studying the procession of plastic packaging into flakes for the production of other goods.

According Kaseva (1996), in researching on eco-friendly and income generating activity towards sustainable solid waste management in Dar es Salaam, Tanzania, stated that the ever increasing tonnage of waste due to the expansion of urban centres which could be solved through increased rate of collection, transportation and disposal costs was currently accepted as a sustainable approach to solid waste management. The study demonstrated the potentials of recycling in generating gainful employment which reduced the crime rate among the unemployed. The findings also emphasized on these recycling activities as a critical source of raw materials for small-scale businesses. The author was more focused on environmental and economic aspect of was waste management without focussing on the use of this waste as a social resource for aesthetic beautification which is an important aspect in our study.

Robin (2003), in the study of the economics of residential solid waste management in the United Kingdom said that a rapid number of cities and towns had already adopted the pay-as-you-dump system. Revenues collected from this system could be sufficient to finance community solid waste collection and disposal services. It was pointed out that neatly packed in uniform bags reduced collection costs and injuries as opposed to the nuisance of households that overstuffed bags with unsorted waste. The author laid was more interested in studying the waste income generation capacity of residential solid waste management without assessing the benefits of giving value to solid waste a social resource for aesthetic beautification which is an important dimension in our study.

0.5.5 Valorisation and policy

The United Nations Institute for Training and Research (UNITAR) in a 2022 report stated that, 62 million tons of electronic waste was generated equivalent to filling about 1.55 million 40-ton trucks. An amount of waste enough to create a line of trucks stretching all the way round the equator. According to the report there was a significant surge in e-waste, with an annual increase prediction of 2.6 million tons which could reach 82 million tons, a 33% rise from the 2022 level

The rate of electronic waste production was rapidly increasing currently five time faster than previously recorded according to the UN's fourth Global e-waste monitor (GEM) released on march 20, 2024. However, the report did not consider to evaluate the economic benefits of valorising electronic waste for enterprise creation and revenue generation which is an important dimension in our study.

Solange (2022), in studying energy recovery from end-of-life vehicle recycling in Cameroon made mention of the fact that the growth in the automotive industry over time has been coupled with the consumption of larger quantities of primary resources and the generation of more wastes. The authors stated that end-of-life vehicles (ELVs) were increasingly being treated not only as wastes, but also as an opportunity for resource recovery, with great potential to provide industry with valuable secondary raw materials. Another benefit of the recycling of ELVs was that the environmental pollution caused by untreated ELVs was reduced. Results added that the recycling of ELVs allowed a substantial amount of energy to be recovered. The study was more interested in assessing the environmental economic benefits of ELVs without assessing the social benefits giving value to ELVs through refurbishing car wheels and tyres as a social resource for aesthetic beautification.

Negasi (2022) wrote a research article on the combined effects of particle size and concrete manufactured with waste recycled glass. The investigation noted the depletion of natural resources has motivated construction industry sectors to look for partial or full replacement of aggregate and cement in concrete. This article said recycled glass was an alternate candidate for replacing mineral cement, fine aggregate and coarse aggregate. The durability of the concrete manufactured with crushed and ground glass improved with increasing replacement proportion while flexural strength decreased. Results presented in the article demonstrated that it was viable to replace cement, fine aggregate and coarse aggregate with an optimum of 10%, 15% and 20% of crushed and ground waste glass respectively and produce concrete with acceptable fresh, hardened and durable properties. The article was more interested in recycling glass waste without laying emphasis on recycling plastic waste for producing pavement blocks which created jobs and generates income.

Nivedha (2022) in the report in reporting the problem of solid disposal in vast landfills that was rising due to increasing population and has overwhelmed garbage collection services in Bangalor, India said that automated sorting technology was used to separate solid waste into biodegradable and non-biodegradable components. The sorting machine separated 200tons of dry (biodegradable) and wet (non-biodegradable) solid waste per day. The food waste was recycled into manure and biofuel and sold to farmers in the region mean while the plastic was shredded, sorted and recycled into furniture; tables, benches, desks, and shelves. The report was laying more emphasis on automation waste sorting process without taking into consideration the institutional aspects of waste sorting through the inclusion of local authorities for efficient collection.

Ugalmugale (2021), in the research article regarding the construction of bituminous roads in India using plastic waste said that the utilization of plastic waste in bituminous mixes enhances its properties and its strength, durability and life. According to the authors, it would be a solution for plastic waste disposal and various effects in pavement including potholes on the road as well as corrugation. The type of plastic waste used are polyethylene as well as polypropylene. The plastic waste could be used in road construction and the fields tests reduced the stress and proved that the plastic waste used after proper processing as an additive could enhance the life of the roads and bring solutions to environmental problems and cost efficient. The report based more on the utilization of plastic for road construction without considering its utilisation as a secondary economic resource for the production eco-friendly and cost-effective pavement slabs which generated revenue and created jobs.

Niran et al. (2019) in studying plastics and micro plastics as a threat to the environment said plastics are synthetic polymer compounds made from petrochemical sources as this compounds have a high molecular mass and plasticity alongside chemicals added to increase the performance and efficiency of the product. The authors further said that plastic sizes less than 5 mm are categorized as micro plastics and it is one of the greatest potential threat to marine environment for the world. Two types of micro plastics were identified, the first being primary, which are the by-products of particulate emission from industrial production as well as the release of plastic dust from plastic products. The second type, which are secondary micro plastics are larger particulate material. The authors further found that micro plastics eventually ended up in water bodies, travelling from rivers to seas or oceans. Micro plastics could act as a pollutant transport medium for toxic elements such as dichlorodiphenyltrichloroethane (DDT), an insecticide and hexa-chlorobenzene that ended up in the bodies of living organisms who consumed it. The author only focused of studying the eenvironmenal threats of plastic proliferation without studying the use of plastic bottles as eco-friendly resources for sustainable production.

Eike (2022), researched on the legal aspect of waste Management in Buea, Cameroon. The study proved that there existed well-stated laws for waste management in Cameroon and concluded that there is poor implementation of the existing laws from evidence of waste littering and uncontrolled burning. The author researched on the legal aspects of waste management without researching on the economic and social aspects of waste valorisation which created intermediary jobs, and generated income as well as beautified the social landscape which is important in our study.

0.5.6 Stakeholder inclusion

Farrah (2022), in the research article studying the effectiveness of stakeholders' involvement and solid waste management (SWM) in Mombasa, Kenya to determine stakeholders' wariness, engagement, commitment, capacity building on SWM. The article focused the importance of involving stakeholders in order to achieve effective SWM through strategic plans and policies. The authors said appropriate laws, regulation and enactment would be on track to reduce operational inefficiencies through stakeholder involvement in dealing with SWM issues. The article was more interested in the institutional aspects of waste management without reviewing the aspect of valorising waste as a social resource for aesthetic beautification which is important in our study.

Kurian (2006), in the research paper studying stakeholder participation for sustainable waste management emphasized that upgrading the coverage of waste management and services together with increasing their efficiency was a precondition for improving environmental quality in the cities of developing countries. The paper highlighted the fact that the participation of all the stakeholders such as the waste generators, waste processors and formal and informal agencies, NGO and financial institutions was a key factor for the sustainable waste management. The paper was more focused on the stakeholder involvement for sustainable waste management without giving prior review to valuating waste as an economic resource which created employment and generated income.

Summarily, these research works underscored the fact that the existing systems of solid waste management faced shortcomings from unconventional modes of transportation, dumping into water bodies as well as by the road sides, irregular picking and collection patterns, infrastructural and financial constraints and unregulated landfilling (Samuel, 2002 and Nkeuh 2022) underling that some residents resorted to uncontrolled incineration of waste. In this light, these dimensions of non-valorization resulted in environmental and human exposure to harmful chemicals from plastic waste pollution such as bisphenols. The review studied the use of advance technologies such as pyrolysis and liquefaction of plastic waste for road durable and sustainable construction and concrete production (Saiman, 2021 and Ugalmugale, 2021). However the aspects of waste valuation as a primary social resource for audible presentation of the urban landscape was not considered which is an important dimension in our study.

0.6 Theoretical and conceptual framework

0.6.1 Theoretical framework

We focused here on two theories. These include the theory of economic incentives propounded by David Martimort in 2001 and the theory of planned behaviour by Ajzen in 1991.

0.6.1.1 The economic incentives theory

The economic incentives theory propounded by David Martimort in 2001 is a subfield of environmental economics which studies how to measure the social costs and benefits of solid waste management and recycling and how to design policies and mechanisms which can encourage efficient and sustainable waste reduction and recovery.

The theory makes use of various methods and tools such as cost-benefit analysis, contingent valuation, hedonic pricing, as well as life cycle assessment. This is used to estimate the externalities, preference and trade-offs associated with different waste management options.

The theory equally analyzes how different types of incentives including taxes, subsidies, fees, deposits and refunds would influence the attitude of waste generators, collectors, processors as well as customers and how to optimize the incentive scheme to achieve the desired social and environmental outcomes.

The theory of economic incentives has some main challenges in terms of the non-biodegradable solid waste valuation including how to account for the uncertainty, heterogeneity, and dynamics of non-biodegradable solid waste generation, composition and their implications on waste management and recycling costs and benefit. How to incorporate the multi-dimensional aspects of non-biodegradable solid waste management and recycling performance such as environmental economics, social, technical as well as institutional aspects and how to balance the trade-offs among them. How to design and implement incentive mechanisms that are fair, transparent, feasible as well as enforceable and that could cope with the potential conflicts of interests.

The theory of economic incentives suggests that improving economic incentives such as subsidies for recycling industries or taxes on landfill disposal can encourage the proper valuation and management of non-biodegradable solid waste. The economic incentive theory plays a crucial role in shaping attitudes and encouraging sustainable waste management practices applied through four principles (land dumping taxes, deposit reform systems, green procurement initiative and tax incentives for green initiatives).

- Land dumping taxes:

Applying on dump lands disposal aligns with the economic incentives theory. Higher dump land taxes create a financial disincentive for businesses and individuals to dispose of waste on dump lands fostering them to seek alternative, more sustainable waste management options such as recycling. This aspect of the theory would applicable at the point where waste is being dumped. A minority of land dumps within Yaoundé III council have written notices on a board “interdit de deposer les odures ici” prohibiting households from illegally dumping their waste at the site, a warning often violated and contravened by the local inhabitants. There is need for the waste management authorities to impose craft, implement and monitor policies illegal such land dumping tax.

- Deposit-refund systems:

This is a new bottle and canned recycling system whereby when you buy a drink in a container with a Re-turn logo, you are charged a small refundable deposit which you can claim back by returning the empty container. By providing a financial incentive for returning items for recycling such as lead-acid batteries, tyres, electronics, beverage containers such as plastic bottles, tins, cans made from aluminium or steel. Drink containers of 150ml and 3 liters in size having the Re-turn logo can be returned can be returned once they are emptied, undamaged and in their original shape, with a readable barcode.

Subsidies for recycling industries.

- Green procurement policies:

Government and businesses can use their purchasing power to create economic incentives for sustainable practice. By favoring supplier who adhere to environmentally friendly packaging, they motivate a toward more sustainable production processes. When proactive policies are enforced including to purchasing and use of only biodegradable packaging, this would boost local market manufacturers of biodegradable packaging bags and account for import substitution of such non-biodegradable plastic packaging for a sustainable economy.

- Tax incentives for Green initiatives:

These incentives reduce the overall cost of implementing sustainable measures making it financially appealing for businesses to invest in environmentally responsible waste management. Tax incentives could be applied to businesses involved in transformation, recycling and processing of plastic bottles, and electronic waste within the study area to encourage the path to environmental preservation for a sustainable future.

Providing financial incentive such as subsidies to businesses involved in recycling and developing sustainable waste management technologies encourages the growth of thee industries. This approach stimulates the economic activity while promoting environmentally responsible practice. Private companies involved in waste recycling often use rudimentary techniques with emission of green-house gases.

0.6.1.2 The theory of planned behaviour and sustainable waste management behaviour: An adjustment theory.

The theory of planned behaviour was propounded by Ajzen in 1991. Based on the theory, a person’s intention guides their behaviour, which is then controlled by their attitude, subjective norm, and perceived behavioural control. The theory of planned behaviour describes the overall decision-making process of individual behaviour from the perspectives of information processing and the concept of expected value. With the development of the reasoned action theory, the TPB was created. Its fundamental components are attitude, subjective norms, and behavioural control, all of which can be used to anticipate behavioural intents and actions. The theory of planned behaviour is an effective theory that has been used extensively to explain a variety of personality behaviours, including pro-environmental behaviours like conserving energy, reduction, waste sorting, green purchasing, and low-carbon travel.

The behaviour of sustainable waste management is analysed using the 3R practises, such as “Reduce, Reuse, and Recycle”, which is also known as a waste management hierarchy. Additionally, the hierarchy of waste management is another name for the 3R method. Besides, claim that the adoption of 3R practises enabled SWMB strategies to be formed and aligned and to be divided into different categories, with a primary emphasis on the willingness of individuals to carry out waste management. In line with, this 3R practise is a very helpful activity that has been demonstrated to be able to impart countless benefits to society in terms of job vacancy availability, income production, and tax revenue. Reuse is the act of switching an item’s primary use from one application to another. Recycling is often described as a process that turns waste into new resources, but this approach not only achieves the recycling objective but also generates financial benefits.

The theory equally mentioned that residents must adopt profitable actions and practice less negatively impactful material consumption in order for their country to maintain its competitiveness in the economy, prosperity contribution, and environmental protection.

The 3Rs (reduce, reuse, recycle) practice is crucial in measuring waste management behaviour as it serves as the foundation for effectively managing waste and fostering a sustainable society that optimizes material cycles and resource utilization. The 3R approach highlights the significance of diminishing trash output, utilizing products again, and recycling resources to mitigate the environmental impact. Research has demonstrated that both habits and ideal circumstances have a substantial role in waste recycling behaviour, and additionally, habits have a positive and significant influence on 3R behaviour. Therefore, the assessment of 3R behaviour is essential in examining the efficiency of waste management strategies and promoting the effective utilisation of resources.

0.6.2 Conceptual framework

In this section, we examined four concepts. They include the integrated sustainable waste management model, valuation of non-biodegradable solid waste and concept of value chains.

0.6.2.1 Integrated sustainable waste management concept (ISWM)

Developing a waste management system is complex. According to the UNEP, 2018 experience suggests that, for a system to be sustainable in the long term, consideration needs to be given to the following aspects shown in (figure 3) below.

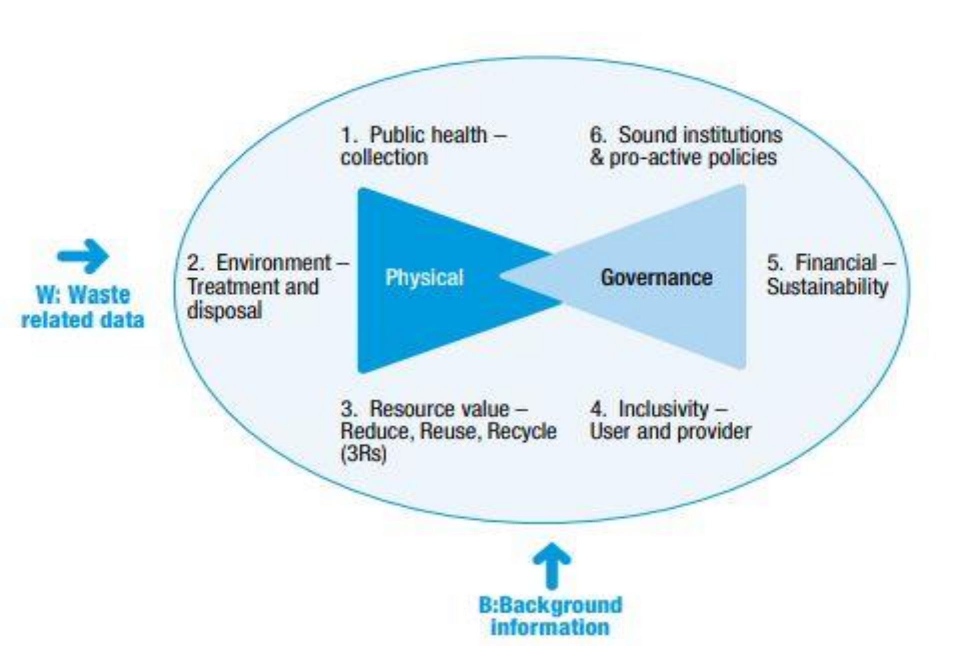


Figure 3: Integrated sustainable waste management concept

Source: UNEP, 2018

Figure 3 presents the concept of integrated sustainable solid waste management. The first triangle below comprises the three primary physical components (elements), These provide the necessary infrastructure for solid waste management: (1) Waste collection: driven primarily by public health, (2) Waste treatment and disposal: driven primarily by environmental protection, and (3) the 3Rs (reduce, reuse, recycle) driven by the resource value of the waste and more recently by 'closing the loop' in order to return both materials and nutrients to beneficial use (UNEP, 2015).

The second triangle focuses on the 'softer' aspects of ISWM – the governance strategies (4). Inclusivity of stakeholders: focusing in particular on service users and service providers, (5) Financial sustainability: requiring the system to be cost-effective, affordable and well financed; and (6) Sound institutions and proactive policies: including both the national policy framework and local institutions.

0.6.2.2 The concept of non-biodegradable solid waste valuation

The concept of non-biodegradable solid waste valuation (fig. 4) within this study is the extent of value attachment and addition to plastics, glass, rubber, waste, as well as metallic and electronic waste materials in the environmental domain, economic dimension, social aspect and governance including waste legislation and regulation and the implementation of policies. The other dimension of valuation is waste governance which assess the degree of enforcement of regulatory and policy framework.

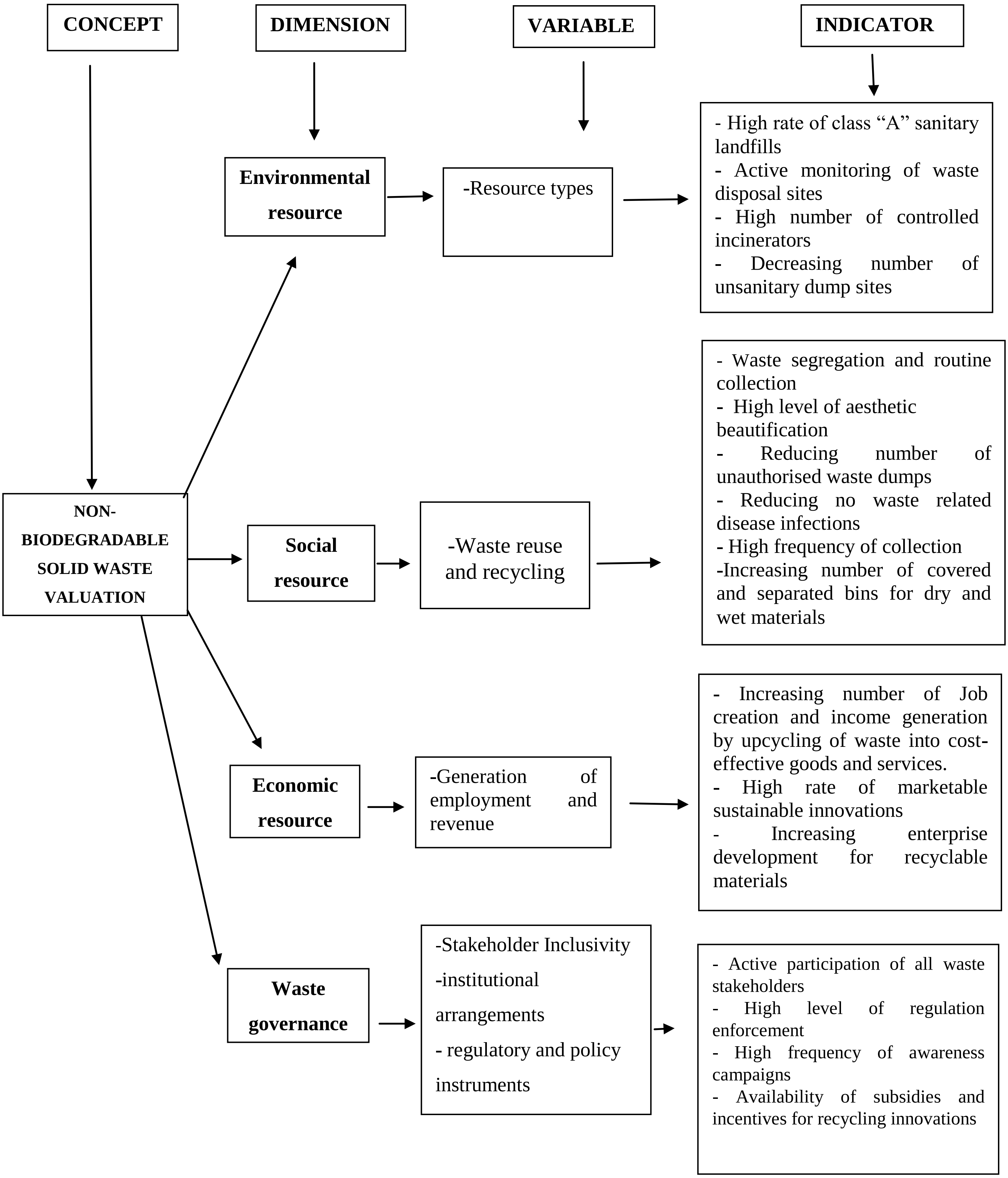


Figure 4: Conceptualization of non-biodegradable solid waste valuation

Source: KONGNYU CHIFU MBAH, 2023-2024

0.6.2.3 The concept of value chains

Value chains in this deals with value attachment process to plastic, metal and rubber recyclables through collection, storage, processing and converting into new products of higher quality and greater functionality. The modalities that account for value chains vary from one waste reduction, recovery, reuse, recycling, refurbishment, repurposing.

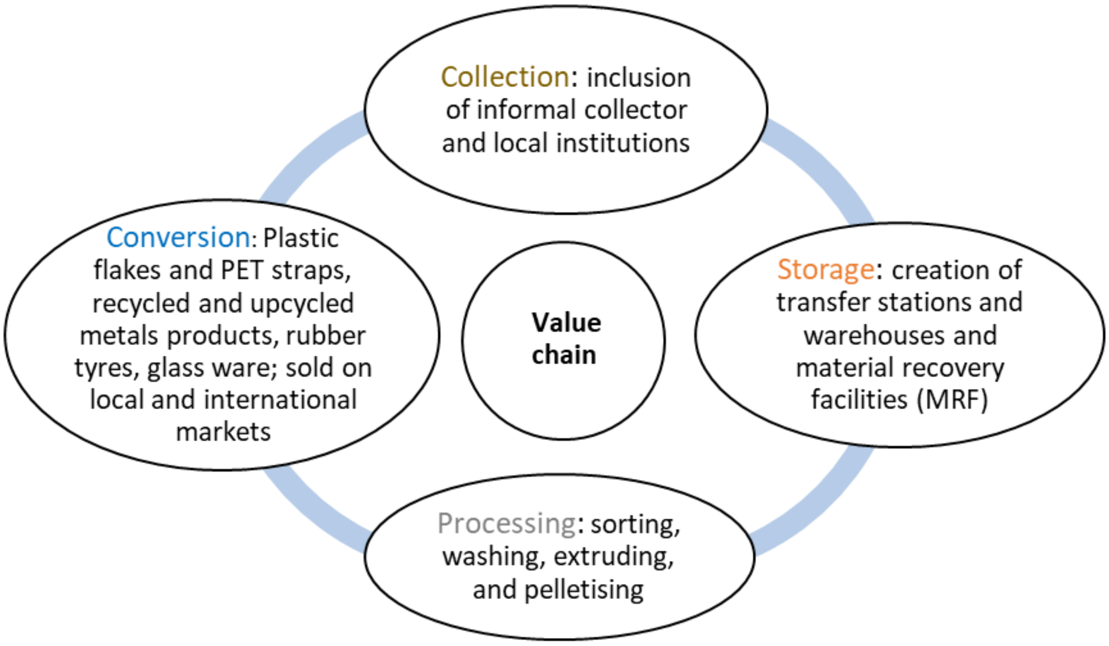


Figure 5: Value chains in unlocking economic opportunities

Source: KONGNYU CHIFU MBAH, 2024

0.6.2.4 The concept of circular economy

The concept of circular economy also referred to as circularity is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. Circular economy aims to tackle global challenges as climate change, biodiversity loss, waste, and pollution by emphasizing the design-based implementation of the three base principles of the model. The three principles required for the transformation to a circular economy are: eliminating waste and pollution, circulating products and materials, and the regeneration of nature. Circular economy is defined in contradistinction to the traditional linear economy. The idea and concepts of circular economy have been studied extensively in academia, business, and government over the past ten years. Circular economy has been gaining popularity since it helps to minimize emissions and consumption of raw materials, open up new market prospects and principally, increase the sustainability of consumption and improve resource efficiency. At a government level, Circular economy is viewed as means of combating global warming as well as a facilitator of long-term growth. Circular economy may geographically connect actors and resources to stop material loops at the regional level. In its core principle, the European Parliament defines circular economy as, "a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. In this way, the life cycle of products is extended.

0.6.2.5 The concept of waste hierarchy

Waste management hierarchy places waste management strategies in preferences of their prevention potential. The three R's (reduce, reuse and recycle) are crucial and remain the most important practice of most waste strategies. Waste hierarchy is a tool used in the evaluation of processes that protect the environment alongside resources and energy consumption from the most favorable to least favorable actions. Priorities are established based on sustainability and an integrated approach shown in the figure below. The stages of waste hierarchy from the most desired of the least wanted consist of waste prevention, minimization, reuse, recycling, energy recovery and disposal.

0.6.2.6 The concept of the environment

The environment refers to the sum total of natural resources in which man and all that which influence man his behaviour constitute the most important element. The environment includes all elements, factors and conditions that influence growth and development of living organisms. The three main dimensions of the environment make up the natural milieu or resources, the human milieu and all that which influence the behaviour of man where he lives.

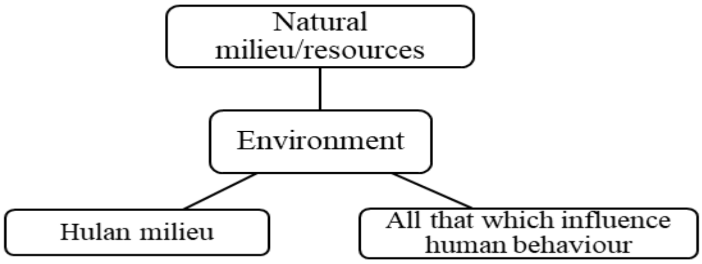


Figure 6: Conceptualization of the environment

Source: Enchaw Gabriel, 2014

The environment offers vital functions to human and every other species. These functions include a supply depot, living space and waste repository Dunlap and Catton Jr (2002). The manner in which non-biodegradable solid waste is managed has an impact on the environment function as a waste repository.

0.6.2.7 The concept of socio-economic implications

The concept of socio-economic implications refers to the consequences or effects of that arise from a particular action decision or situation on social and economic wellbeing of man. The concept studies how social factors intersect with economic activity. The concept of socio-economic implications is a critical concern in the waste management arena as population growth and urbanization has led to higher rates of waste management. To this, managing waste is of prime importance for government, regulatory agencies and pollution control departments (A. D. Sawant, Sujata Warrier and Geetanjali Pawar, 2021).

Socio-cultural factors including social norms and relations influence waste generation and disposal practices. Gender roles equally impact waste handling and recycling behaviour. Awareness and education play a role in waste reduction. Social implication of effective waste management has an impact on health and hygiene.

Economic considerations include proper waste management that reduces the budget needed for collection, transportation and treatment. Efficient waste collection, recycling and reuse contributes to balanced development. Proper waste resource utilization increased production, better distribution of goods and marketability. Economic implications include sustainable waste practices that contribute to a good standard of living and economic stability (A. D. Sawant, Sujata Warrier and Geetanjali Pawar, 2021).

0.6.2.8 The concept of reverse logistics

The concept of reverse logistics or reverse distribution is a stage in the supply chain in which products are returned from the point of sale to the manufacturer or distributor for recovery, repair, recycling or disposal. Reverse logistics has a major target to manage the flow of products, materials and resources from the final consumer to the origin of the supply chain in order to maximize their value and minimize their environmental impact.

The types of reverse logistics include green reverse logistics in which products go through a process of repair, recycling or disposal in an environmentally friendly way before being stored and sold. Another type is that of revers return logistics in which the products that return to the point of origin is put back into stock to be sold again without needing to go through any additional processes

Reverse logistics follows the functional process including collecting goods, sorting goods into categories, returning goods to warehouse after sorting whereby the routes of products returned to the warehouse is subsequently determined. It equally includes destruction of unserviceable products that have been classified as broken which thereafter deposited at appropriate points for disposal. Further reverse logistics integrates recovery, recycling and management of materials classified as reusable or recyclable to extend their useful cycle. Reverse logistics finally consists of administrative processes and follow-up of operations for due documentation (Mohammend Alnuwairan, 2024).

0.7 Methodology of the study

According to the classification system proposed by Barr (1960), it is possible to group data-gathering techniques and data-processing methods. A self-report descriptive survey will constitute the data-gathering method for this study while the data treatment method is be based on statistical empiricism for this study. Secondary data collection tools (articles, web bases sources, journals, documentary data and libraries) and primary data collection tools interviews, questionnaire, and field observation.

0.7.1 Method of secondary data collection

The collection of quantitative data from journals, online web resources articles largely constituted the secondary data collection method. The primary data collection data constituted pilot phase, field survey and interviews related to the effects of non-valorisation. Moreover, structures involved to the valorisation non-biodegradable solid waste and data on existing legislation regarding waste governing in Cameroon were equally exploited.

0.7.2 Method of primary data collection

0.7.2.1 Direct field observation

Direct field observation included the use of the eye for ocular observation. The degree to which households practised segregation, the practices of open burning and uncontrolled dumping the nature of waste storage use. A collection of photos were taken after these observations were made.

0.7.2.2 Interviews

Interviews were used to complement the secondary sources of data. This method was used to get first-hand data on from resource persons. The interviews involved those who recycled NBSW. The characterisation of the valorisation network and challenges inherent to the waste picking activity constituted one type of data as well as the level of effectiveness of adaptation strategies to non-valuation.

0.7.2.3 Administration of questionnaire

Typed manuscripts of the questionnaire were handed-out to the heads of selected households for responses. The questionnaire (appendix 2) covers three section. Section one was made to test the hypothesis that non-valuation of non-biodegradable solid waste impact the environment of Yaoundé III council area. This is in line with specific objective (1) of the study which was to assess the impacts of not valuating non-biodegradable solid waste on environmental sustainability in the study area.

The second part of the questionnaire, was made to test the hypothesis that non-valuation of non-biodegradable solid waste affect social livelihood in Yaoundé III council area. This is in line with specific objective (2) set out to the objective to investigate the social effects of non-valorisation of non-biodegradable solid waste in the study area.

Section (3) of the questionnaire was conceived to test the hypotheses that non-valuation of non-biodegradable solid waste influence economic wellbeing in Yaounde III council area. This is line with specific objective (3) in order to evaluate the influence of non-valuation of non-biodegradable solid waste on economic wellbeing in the study area.

0.7.2.4 Administrative clearance

The researcher was granted an attestation for research. The attestation was granted by the head o department and was used as a tool which augmented the credibility of field investigations.

0.7.3 Population of the study

The study area composed of some simple randomly selected neighbourhoods in the Yaoundé III council area. These neighbourhoods included Ahala, Efoulan, Melen, Ngoaekelle, Nsimeyong, Obobogo and Obili. They had a total population of 193,358 inhabitants and 35,816 households (BUCREP, 2010). These 7 neighbourhoods make up the study area.

No.	Quarter	Population	No. of households (HH)
1	Ahala	17858	3180
2	Efoulan	32240	5899
3	Melen	19255	5305
4	Ngoaekelle	27714	9051
5	Nsimeyong	62279	11591
6	Obobogo	16921	2937
7	Obili	17091	3752
	Total	**193358**	**35816**

Table 1: The population of the study area

Source: Adapted from INS & BUCREP, 2010 population and housing census HH=household

0.7.3.1 Sampling technique and Sample size

The hypothetic-deductive approach through systematic random sampling technique that was be used for this study will be the simple random sampling type. A sample size of 5% from every 78th household was selected from the targeted households who generated NBSW (table 2). Interviews were granted to some recyclable solid waste pickers. The sample size of 5% that was chosen for the study is justified by the fact that the population is in several hundreds of thousands and a sample size of 5% is convenient to handle (Nwana, 1982).

No.	Quarter	Household	sample size	Effective respondents	% of Effective respondents
1	Ahala	3180	10	8	80%
2	Efoulan	5899	10	6	60%
3	Melen	5305	10	7	70%
4	Ngoaekelle	9051	10	6	60%
5	Nsimeyong	11591	15	10	66.6%
6	Obobogo	2937	10	8	80%
7	Obili	3752	10	5	50%
	Total	**35816**	**75**	**50**	**66%**

Table 2: The households in the study area and effective respondents

Source: BUCREP, 2010, realised by KONGNYU CHIFU MBAH, 2023.

0.7.4 Research design

The research design employed hypothetic-deductive approach by way of descriptive statistics. As such one method was used to supplement the lapses of the other. The approach helped to better explain and understand the results of the other (Ndabuf, 2022). The mixed method is an approach to research that collects both quantitative and qualitative data and integrating the two form using different designs can involve philosophical and theoretical assumptions (Creswell, 2014). Mediating/intervening variables was used to measure constructs that stand in between the cause and effect variable.

- **Difficulties encountered**

The major field survey was characterised by some difficulties related to the limited availability of some households who were adamant to answer some questions and chose to remain silent due to trust issues. Another difficulty was encountered with regard to the interviews as some institution never called us back to conduct interviews despite of the requests we made for this purpose. Informal waste recyclers often restricted us from taking some photos thinking we were undercover council agents.

0.7.5 Operationalization of variables

Indicators for the relationship between independent variable (non-valuation) and the dependent variables (environmental and socio-economic effects) in the Yaoundé III is presented in the subsequent tables.

Hypothesis 1: The non-valuation of non-biodegradable solid plastic, metal, glass, electronic and rubber recyclables impact the environment of the Yaoundé III council area.			
Independent variable	**Indicators**	**Dependent variable**	**Indicators**
Non-valuation of non-biodegradable solid waste.	1. Number of waste dumpsites along water body 2. Number of points of uncontrolled disposal on land 3. Huge piles of unsorted waste along encroaching into the roadway 4. Uncollected and Overflowing waste in public waste receptacles 5. Unsorted waste during pre-collection by households 6. Mixed waste collection by itinerant truck 7. Limited number and distribution of recycling structures 8. Abundance of artificial dumpsites	Impact on the environment	1. Increasing risk of soil contamination 2. Percentage of polluted of water bodies 3. Increasing risk of habitat degradation 5. Temperature and precipitation anomalies and extreme weather 6. Increasing dump land usage

Table 3: Operationalization of variables for hypothesis one

Source: KONGNYU CHIFU MBAH, 2023

Hypothesis 2: The non-valorisation of plastic, metal, glass, rubber and electronic recyclables affect social life in Yaoundé III council area.			
Independent variable	**Indicators**	**Dependent variable**	**Indicators**
Non-valuation of non-biodegradable solid waste.	1. Number of waste dumpsites along water body 2. Number of points of uncontrolled disposal on land 3. Huge piles of unsorted waste along encroaching into the roadway 4. Uncollected and Overflowing waste in public waste receptacles 5. Unsorted waste during pre-collection by households 6. Mixed waste collection by itinerant truck 7. Limited number and distribution of recycling structures 8. Abundance of artificial dumpsites	Effect on social life	1. Aesthetic degradation and bad odours reducing 2. Increased risk of plastic-aggravated flash-flooding 4. Reduced soil fertility and low crop production 5. High number of waste related diseases infections. 6. Air pollution index

Table 4: Operationalization of variables for hypotheses two

Source: KONGNYU CHIFU MBAH, 2023

Hypothesis 3: The non-valuation of recyclable plastic, metal, glass, rubber, and electronic recyclables influence the economy of Yaoundé III council area.			
Independent variable	**Indicators**	**Dependent variable**	**Indicators**
Non-valuation of recyclable non-biodegradable solid waste	1. Number of waste dumpsites along water body 2. Number of points of uncontrolled disposal on land 3. Huge piles of unsorted waste along encroaching into the roadway 4. Uncollected and Overflowing waste in public waste receptacles 5. Unsorted waste during pre-collection by households 6. Mixed waste collection by itinerant truck 7. Limited number and distribution of recycling structures 8. Abundance of artificial dumpsites	Influence on economic wellbeing	1. Limited rate of sustainable innovations. 2. Limited rate of opportunities for job creation and income generation. 3. limited rate income and revenue generation. 5. limited rate of entrepreneurship and enterprise development 6. High cost of waste management

Table 5: Operationalization of variables for hypotheses three

Source: KONGNYU CHIFU MBAH, 2023

0.7.6 Data treatment and interpretation

The data collected from responses to the questionnaire and interview was processed using quantitative and qualitative analysis. Inferential statistics by way of correlation coefficient was used to test the degree correlation between non-valuation and environmental and socio-economic data sets. The results from data treatment was as presented was presented in tables for interpretation. Mobile software including Picasart was consulted in processing the photos collected using a GPS camera. The coordinate of surveyed dumpsites were imported into QGIS for spatial representation.

0.7.7 Dissertation chapter layout

This study encompasses the general introduction including the background to the study, the problem statement, research, questions, objectives, and hypotheses. The delimitations of the study, literature review as well as conceptual and theoretical framework and methodology constituted the general introduction.

The general introduction is then succeeded by Chapter one which dwells on the environmental dimension of non-valuation, chapter two which presents the economic implications of non-valuation of non-biodegradable solid waste and chapter three which showed the social ramification of not valorising waste in Yaounde III council area. Chapter four is constructed to present the effectiveness of adaptation strategies in the waste valorisation arena.

A synoptic table (table 6) was created in order to ameliorate the understanding of the study.

Theme	Research questions	Research objectives	Hypotheses	Methods	Layout of chapters
The environmental and socio-economic implication of non-biodegradable solid waste valuation in Yaounde III council area	What are environmental impacts related to the non-valuation of non-biodegradable plastic, metal, glass electronic and rubber waste recyclables in the Yaoundé III council area?	To assess the impacts of the non-valuation of non-biodegradable solid plastic, rubber and electronic waste materials on environmental sustainability in Yaoundé III council area.	The non-valuation of NBSW impact the environment of Yaounde III council area	Questionnaire Field Observation checklist Interviews	effect of the non-valuation of non-biodegradable solid waste on the environment of Yaounde III council area
	What are the social effects inherent to the non-valuation of non-biodegradable plastic, metal, glass rubber and electronic waste recyclables in the Yaoundé III council area?	To investigate the effects of non-valuation of non-biodegradable plastic, metal, glass, rubber and electronic waste recyclables on social livelihood in Yaoundé III council area.	The non-valuation of NBSW affect social life in the Yaounde III council area	Field observation Questionnaire Interviews Web based resources	influence of non-valorisation of non-biodegradable solid waste on social livelihood in Yaounde III council area

	What are the economic implications associated to the non-valuation of plastic, metal, glass, rubber, and electronic and metals waste recyclables in the Yaoundé III council area?	To evaluate the influence of non-valuation of recyclable plastic, electronic metallic, rubber and electronic waste on economic wellbeing within the Yaoundé III council area.	The non-valuation of NBSW influence the economy of Yaounde III council area	Documented archives Questionnaire interviews	Influences of non-valuation of non-biodegradable solid waste on the economy of Yaounde III council area

Table 6: Dissertation chapter layout

Source: KONGNYU CHIFU MBAH, 2023

CHAPTER 1

IMPACT OF NON-VALUATION OF NON-BIODEGRADABLE SOLID WASTE ON THE ENVIRONMENT OF YAOUNDÉ III COUCIL AREA

Introduction

The environmental function of the environment as a waste repository is challenged as the waste absorption and recycling capacity of the environment has been surpassed due to huge piles and variety of non-biodegradable solid waste as a result of non-valuation. The absence of value addition to non-biodegradable solid materials including plastics, metal, glass, rubber and electronic recyclables an environmental resource is characterised by the lack of environmental control in the incineration and disposal of waste can be perceived through uncontrolled dumping and open burning. The non-valuation of these waste materials as an environmental resource for ecological preservation engenders negatively footprints on the local environmental perceived through the prism of soil contamination, pollution of water bodies, increased dump land and deterioration of natural habitats which leads to loss of biodiversity and on the global environment through increasing atmospheric pollution and weather extremes from green-house gas emissions. The resultant environmental pollution is indicative of the deficient value addition to waste as a secondary environmental resource was presented below (table 7).

Quarter	**Effective respondents**	**% of Effective respondents**	**Environmental pollution**		
			Soil pollution	**Water pollution**	**Weather extremes**
Ahala	8	80%	8	3	2
Efoulan	6	60%	6	6	3
Melen	7	70%	7	3	2
Ngoaekelle	6	60%	6	5	3
Nsimeyong	10	66.6%	10	10	4
Obobogo	8	80%	8	7	4
Obili	5	50%	5	5	3
Total	**50**	**66%**	**50**	**39**	**21**

Table 7: Respondents' perception on environmental pollution

Source: Kongnyu Chifu, 2023

Table 7 shows that all the respondents attested to the environmental sustainability challenges of non-valuation in which soil deterioration (100%), followed by pollution of water resources (78%) and lastly weather extremes (42%). This proves that the study area primary suffers from land degradation water and atmospheric pollution as a result of waste pollution caused by non-valuation.

1.1 Soil contamination

The prevalence of mixed waste (food and dry recyclables) artificially disposed on land is associated with slow release and infiltration of soil pollutants such as micro-plastics from burnt polyethylene and leachate from food leftovers into the soil. The solidification of plastic film after cooling hardens up to pore soil pores. Blocked soil causes limits soil aeration hence limited the infiltration of runoff. The action of certain micro-organisms is disrupted due to uncontrolled disposal which equally engendered poorly aerated soils (photo 1).

Photo 1: Soil pollution through open dumping

Source: VICAD, 2023

Photo 1 show characteristic uncontrolled disposal of plastic bottles and plastic bags in a ditch. The waste can be seen sinking into the ground gradually which contaminates the soil due to their non-biodegradability. This leads to release of soil contaminants such as ethylene oxide that is harmful chemical secreted by disintegration of plastic bags into micro plastics, hence polluting the top soil with potentially leachate sip into underground soil layers.

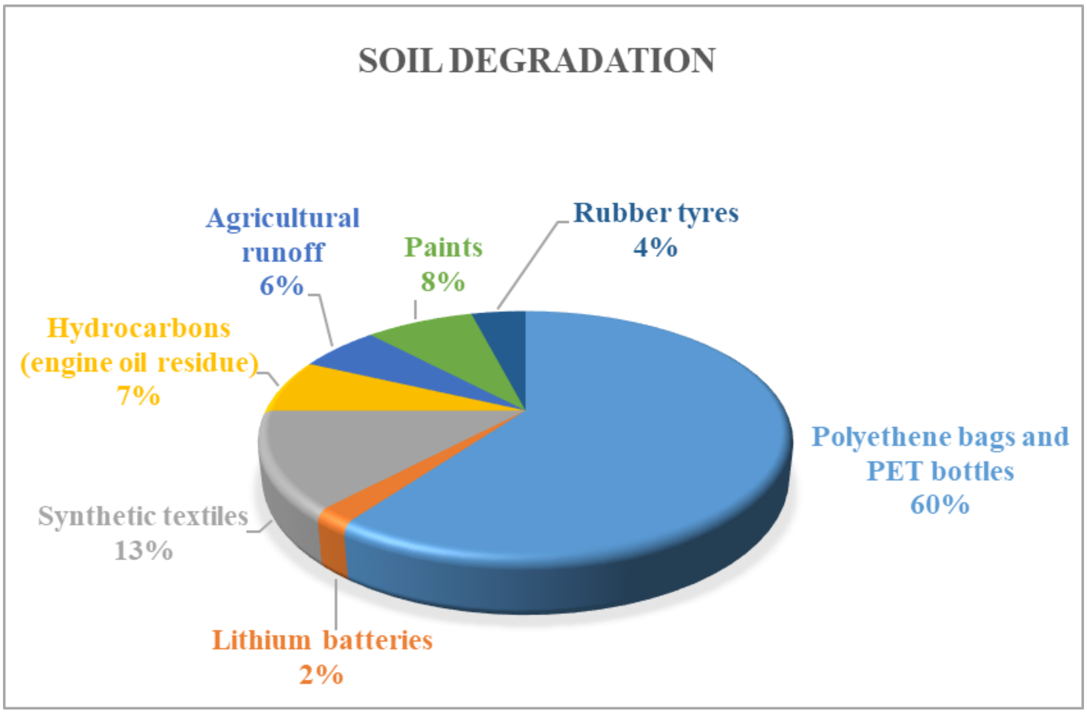


Figure 7: Sources of soil pollutants

Source: Kongnyu Chifu, 2024

Figure 7 is a presentation of the leading non-biodegradable waste streams causing soil contamination inherent to their non-valuation by either open dumping or uncontrolled dumping. The pollutants were composed of polyethene bags and PET plastic bottles (60%), followed by synthetic textiles (13), paints (8%), engine oil residue (7%), agricultural runoff (6%) and lithium batteries which made up 2% of the waste streams.

1.1.1 Level of heavy metals concentration in soils

A study by (Aboubakar et al. 2021), analysed soil samples from three garden sites in Yaounde. The median concentration of heavy metals (in mg/kg) were 259.0 for manganese, 111.2 for Cupper (Cu), 81.9 for Zinc (Zn), 54.6 for Chromium (Cr), 19.3 for Lead (Pb), 14.9 for Nikel (Ni) and 0.1 for Cadmium (Cd). All the median values were below their corresponding geochemical background except for Lead (Pb) (Celestin Defo et al., 2015).

1.1.2 Pollution indices

Single pollution indices indicated soil contamination with Lead (Pb). The Nemerow pollution index revealed that 60% of soil samples were at a high level of pollution. Based on potential ecological risk index, 16% of soil samples exposed to high levels of (Amina Aboubakar, Ahmed Douaik and Saoud El, 2021).

1.2 Pollution of water bodies

Over 70% of urban flowing water bodies in the council area are polluted from open dumping and burning (Jean Blaise, 2023). The spatial representation of artificial dumpsites along river Biyeme was realised (fig. 8).

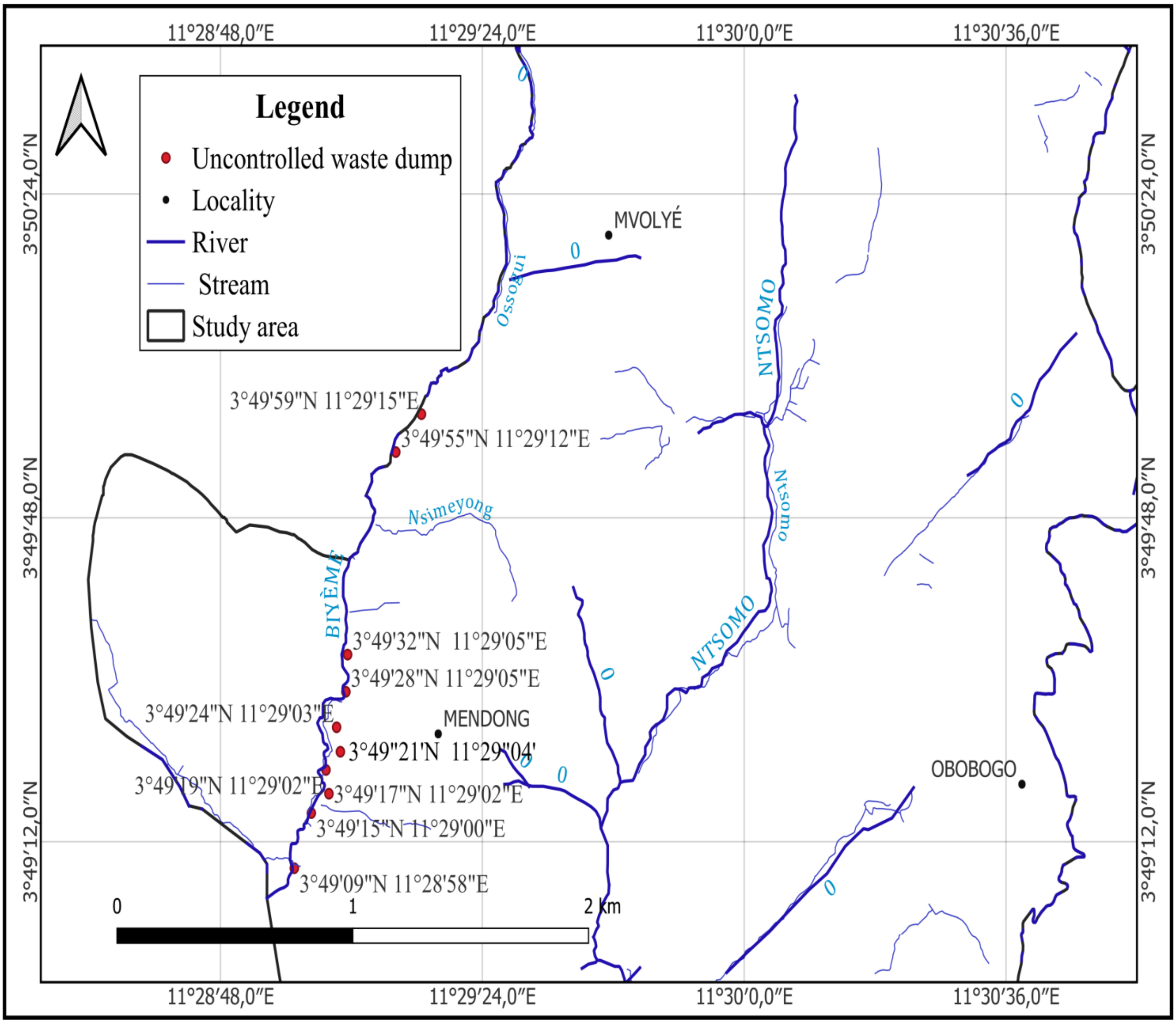


Figure 8: Spatial Location of dumpsites on river Biyeme

Source: Kongnyu Chifu, 2023

Figure 8 indicates the location of artificial dump sites along river Biyeme which was polluted with about ten garbage points as observed on the plate. This is indicative of of a serious threat to this water body due to eutrophication and resultant algal boom posing risks to aquatic life with the dominant waste being plastic materials.

1.2.1 Eutrophication of water bodies

Oxygen depletion is an indirect and insidious impact of water pollution. The reduction of oxygen levels due to contaminants such as plastic and rubber materials residue from domestic premises mixed with food waste, get transported by runoff and fosters algae bloom. When algae multiplies in large number and die (Enchaw, 2023), the process of decomposition produces a lot of carbon dioxide consuming huge amounts of oxygen. This creates 'dead zones' where fish and other aquatic organism suffocate due to the lack of oxygen which cause breeding difficulties (Chris Peacock, 2023) (Plates 1 and 2).

Plate 1: water pollution along river Biyeme

Source: Kongnyu Chifu, 2024

Plate 1 presents plastic pollution along the course of river Biyeme. The pollution which degrades the quality leading to discolouration of this water resource. The non-biodegradability of plastic waste (red arrow) on this river which depleted oxygen in the water created dead zones. These dead zones are indicated of water bubbles (black arrow) on the surface of the water body.

Plate 2: Dumping along river course

Source: Kongnyu Chifu, 2024

Plate 2 demonstrates the point of plastic waste disposal (black arrow) and flow of waste along the water body. The waste congests the water body favouring the eutrophication which fosters the development of algae (blue arrow). Plate 1 equally demonstrates the rubber tyre (red arrow) waste flowing along the water body which poses a serious threat to aquatic organisms.

1.2.2 Underground water pollution

Open dumping generate watery liquid 'Leachate' due to field capacity. This watery liquid slowly infiltrate through the soil layers into underground water polluting this water source. Leachate sipping into underground water alter the latter pH level. This favours the dissociation of minerals in the aquifer (water-bearing porous earth) to the water. This increases loss of water quality. The contamination spreads due to the nature of the aquifer (ferrasols: kaolinite and Fe oxides) which has good permeability. The excellent porosity of the reddish and yellow ferrasols does not restrict the movement of ions into underground water and is favourable to infiltration through its loose soil matrix.

Photo 2: Underground water risk by disposed materials on river Biyeme

Source: VICAD, 2015; adapted by Kongnyu Chifu, 2024

Photo 2 reveals the magnitude uncontrolled risk to underground water due to mixed disposal of engine oil residue (red arrow), tetra pak (black arrow), ferrous metal cans (), LDPE bags on river Biyeme. This indicates an environmental hazard since such materials are non-biodegradable for this water body and the receiving underground water below the surface as a result of leaching from magnitude of this constraint which occurred due to non-valuation of these materials for environmental conservation.

1.3 Atmospheric pollution and weather extremes

Typical emissions associated with open burning of plastic, electronic, rubber as well as metal waste include dioxins, polycyclic aromatic hydrocarbons and black carbon, which are highly toxic and powerful climate pollutants respectively (UNEP, 2015). Considering the release of various atmospheric pollutants, the climate change mitigation index for the study area was presented in table 8 below.

	Rank	Score (100)	10 year change
Climate change mitigation	**108**	**39.4**	**-4.3**
Ajusted emission growth rate for carbon dioxide	108	43.6	10.9
Ajusted emission growth rate for fluorine gases	86	7.7	-48.0
Ajusted emission growth rate for black carbon	168	28.6	-9.6
GHG growth rate adjusted by emission intensity	100	36.7	-1.9

Table 8: Climate change mitigation index for the study area

Source: Yale school for the environment; EPI, 2024

Burning plastic and electrical insulators releases green-house gases with far reaching adverse consequences on the weather. Green-house gaseous emissions from the activity open burning to reduce the volume of waste adversely affect micro climates with releases such as ozone gas (O_3) from electronic materials which are composites of plastic, rubber and metal components. The gases Mixed burning of non-biodegradable and biodegradable solid waste (cardboard, tetra pack) to reduce quantity is prevalent at along the road side was shown below (photo 3).

Photo 3: Open burning by the road side

Source: Kongnyu Chifu, 2023

Photo 3 above indicated open burning of mixed waste along a road side which emissions of toxic fumes. These fumes contain polluting gases including Nitrogen dioxide, sulphur dioxide, Particulate matter PM2.5 and PM10, carbon dioxide, as well as carbon monoxide as well as ethylene oxide and various organic compounds contributing to climate change.

The effect of open burning of mixed waste result in changing weather patterns characterized by temperature extremes concords to forecast for climatic parameters by the National Observatory for climate change (ONACC, 2023), which recorded that the months of September, October and November 2023 witnessed the hottest temperatures and highest rainfall in the study area. Characteristics of gaseous from their sources of non-valorisation contributing to these weather extremes are presented below (table 9).

Atmospheric pollutant	**Source of non-valorisation**	**Lifetime in the atmosphere**	**Major scale of impact**
- Ethylene oxide - Polychlorinated dibenzofurans (PCDFs: called dioxins and furans), - Hydrofluorocarbons (HFC) - Nitrogen oxides, sulphur dioxide, volatile organic compounds and (VOC), polycyclic organic matter (POMs)	Open burning of plastic bottles and nylon	15 years	Global impact
- Tropospheric Ozone (O_3)	Open burning of electronic insulators	Weeks	Local and regional impacts
- Copper, antimony	dumping of cathode ray televisions, speakers, phones, radios)	Weeks	Local impact
sulphur dioxide (SO_2), carbon monoxide (CO),	Open burning of rubber tyres	Days	Local and regional impact

Table 9: Short-lived climatic pollutants

Source: Adapted from UNEP, 2018; adapted by Kongnyu chifu, 2024

The weather extremes resulting from atmospheric pollution was increasingly characterised through temperature extremes perceived through extremely cold temperature at night day in the rainy season and extreme heat wave during the dry season. The scarcity of rainfall since the month of April 2024 was equally notice. This was attributed to El nino phenomenon with the threat of an impending decreased agricultural output as a result (ONACC, 2024).

1.3.1 Temperature and precipitation anomalies

Precipitation anomalies in the study area were perceived through the extension of the rainy season from August late into mid-December, 2023. This was supercede by a higher and drier temperatures recorded during the months of January, February, March, and mid-April of 2024. The weather during this period was characterised by abnormal heat during the day and night. The month May to June and July was characterised by minimal rainfall associated with constant drizzling and very cold day and night temperatures. The culmination of this abnormal seasonal variations was presented in the form a graph showing temperature and precipitation anomalies between 1980 and 2024 shown in figure 9 below.

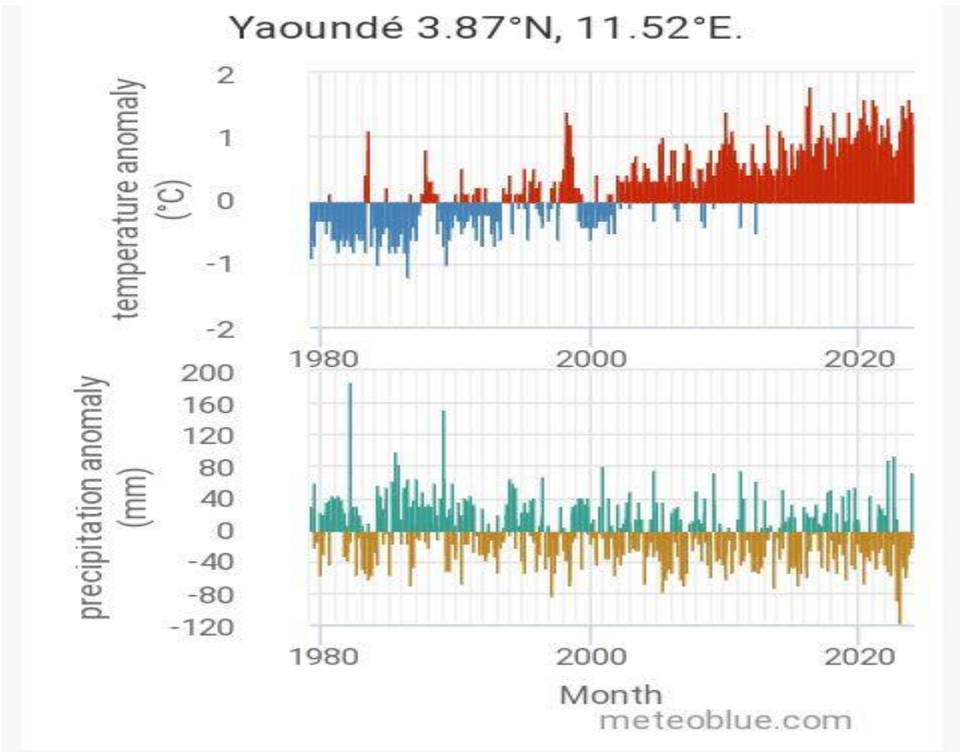


Figure 9: Real time temperature and precipitation anomalies for the study area

Source: https://www.meteoblue.com; 1980-2024

Real time data from meteoblue, the graph upper graph presents the temperature and precipitation anomaly for every month since 1979 up to now. The anomaly tells us by how much it was warmer or colder than the 30 year climate mean of 1980-2010. This implied that the months in red were warmer while the blue months were colder than normal. Some locations had increase of warmer months over the years reflecting the global warming association with climate change. This implies that the months in green were wetter while the months in brown were drier than normal.

The lower graph presents the precipitation anomaly for every month since 1979 up to 2024. The anomaly shows when a month had more or less precipitation than the 30 years climate mean of 1980-2010.

1.4 Increased dump land usage

The non-attachment of value to waste creates spontaneous pockets of unsanitary urban dump lands contributing to the overall use of landfill space and potential soil and water pollution. Low regards for environmental preservation by unscrupulous households who prefer to dump waste uncontrollably creates artificial and uncontrolled dump lands in the study area (plate 3). Only a small percentage of the plastic disposed by household each day is recycled (Netsol, 2022). Much of it ends up in dump lands where harmful compounds can leach into the soil and water. The characteristic nature of increased dump land usage was shown below (plate 3).

Plate 3: Artificial waste dump land

Source: Kongnyu Chifu, 2023

Photo 3 indicates the dumping of a bag of waste containing non-biodegradable materials including electronic waste casing (blue arrow), broken screen glass (A), polyethene bag (black arrow) and metal can (red arrow). This artificial waste disposal is a source for creation new uncontrolled waste dump lands which contribute to land degradation in the long run.

1.5 Increasing risk of Habitat degradation

The uncontrolled dumping and burning coupled with the lack of active enforcement of legislation and action plans for non-biodegradable solid waste contributes and amplifies the loss of biodiversity in Cameroon. Dumping waste in natural habitats such as wetland forests and wetlands disrupts the delicate ecosystems leading to the destruction of various plant and animal species. The loss of biodiversity does not only influence natural balance but also has negative externalities on the tourism industry which heavily relies on its natural landscape and unique wildlife (Jean, 2023).

Habitat fragmentation in an organism's referred environment whereby large and continuous habitat get divided into smaller, isolated patches of habitats causes species fragmentation and ecosystem decay (Fahrig L. 2003 and 2019) as a result of plastic pollution.. The current population trend of the *Ploceus bannnermani* (weaver bird) native to Cameroon, was reportedly decreasing associated with the continuous decline of mature individuals threatened by habitat loss (Bird Life International and IUCN, 2016).

Burning electronic waste contains toxic chemicals (e.g. heavy metals and polybutylene terephthalate PBT) and persistent organic pollutants (POPs), which are persistent in the environment, can travel long distances, and are likely to accumulate in fauna and flora and in the food chain (UN-Habitat, 2010). The index for biodiversity and habitat for the dimension of ecosystem vitality for the study area over the last decade scale was presented in table 10 below.

	Rank	Score (100)	10 year change
Ecosystem vitality	**103**	**48.1**	**3.4**
Biodiversity and habitat	**108**	**45.0**	**-1.3**
-Species protection	129	31	1.6
-Terrestrial biome protection (national weigh)	125	33.1	1.6
-Terrestrial protection (knowledge based authentication-KBA)	71	67.7	0.0
-Red list index	103	49.0	-0.9
-Species habitat index	138	0.0	-50.6
-Bioclimatic ecosystem resilience	101	44.9	-0.7

Table 10: Ecosystem vitality index for the study area

Source: Yale school for the environment and EPI, 2024

Moreover, habitat degradation as an effect to uncontrolled materials disposal is a threat to terrestrials and aquatic ecosystems and risk to the soil microorganism in the study area (plate 4).

Plate 4: Risk of degradation of terrestrial and fresh water ecosystems

Source: Kongnyu Chifu, 2024

Plate 4 presents the presence of non-biodegradable rubber tyre (black arrow) stagnated on river and polyethene terephthalate plastic bottles among plants (yellow arrow). The presence of these materials which not biodegradables hinders native plant growth and fosters the growth of obiquisite plants including the Solanum torvum species (white arrow). This is indicative of the impending risk of habitat degradation that may affect microorgasms, flora and fauna speicies in the area

The extended effects of habitat degradation on avifauna was the reduction of fitness for some bird species. The Passer domesticus (house sparrow) was a bird species which had been observed with difficulties related reduced fitness as shown below (photo 4).

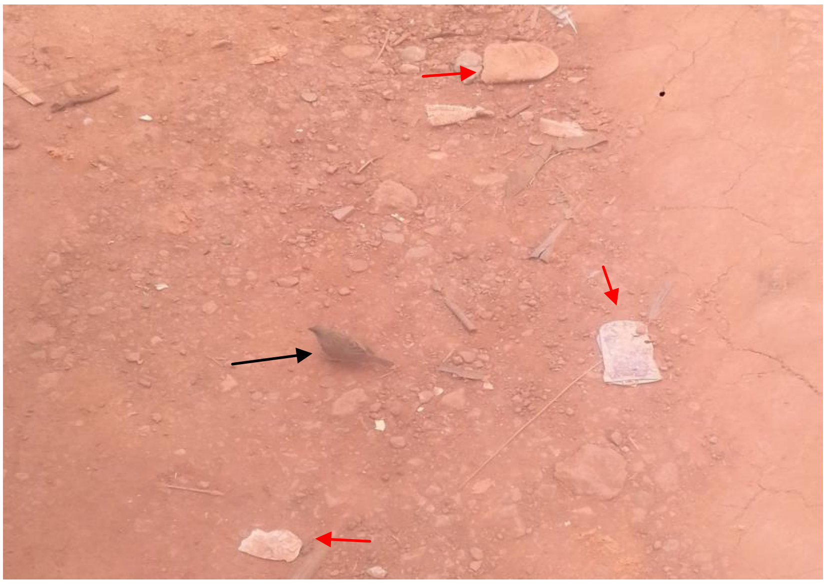


Photo 4: The Passer domesticus species with reduced fitness

Source: Kongnyu chifu, 2024

Photo 4 shows the presence of house sparrow (black arrow) in the urban environment littered with low density polyethylene plastic packaging (red arrow). The observation made was the fact that the bird did not flee upon approach which is an unusual behaviour and stayed grounded which an evidence of fitness difficulties which may be attributed to toxic fumes generated by open burning or by the presence of traces of plastic residue in its internal organs.

Conclusion

The non-valuation of plastics, rubber, glass as an environmental resource through open disposal and burning was found to have negative environmental footprint. These practices polluted the polluted water bodies such as river Biyeme suffocating aquatic organisms, contaminated the soil with substances including dioxins, lithium as well as polychlorinated biphyenyls. Climatic pollutants including GHG emissions such as CFCs, black carbon, O_3 and hydrogen gas affected local, regional and global climatic (UNEP, 2015). There was an increasing use of dumping land with the proliferation of plastic waste that increased the risk of soil pollution. What obtains from open burning and emission of toxic fumes was a risk of habitat degradation which reduced the fitness of the house sparrow bird species. The accumulation of non-biodegradable therefore negatively impacted the environment of Yaounde III council area. The next chapter focuses on the social effects inherent to non-valuation of non-biodegradable solid waste in the study area.

CHAPTER 2

EFFECT OF NON-VALUATION OF NON-BIODEGRADABLE SOLID WASTE ON SOCIAL LIFE IN YAOUNDE III COUCIL AREA

Introduction

Non-attachment of value to waste plastic, rubber, metal, and e-waste recyclable materials as a social resource in the economic domain as a social resource create creates social challenges in the study area. The preliminary absence of waste segregation prior to storage, collection and transportation and subsequent predominance of uncontrolled waste dumping in public waste receptacles (PWR) and burning is a testament of the lack of implementation of waste poor reduce, reuse and recycling. Unsegregated and uncollected waste by utility management services waste is usually disposed in unsanitary PWR, by the road side, into flowing water bodies and drainage systems. The roadside dumping of unsegregated is characterized by emission of noxious odours from mixed waste of putrescible and NBSW materials. Informal waste pickers openly burn electrical waste is burned for its precious metals and plastic, rubber and glass materials to reduce their volume. Burning waste in unregulated conditions emit toxic fumes including oxides of nitrogen, sulphur, carbon, as well as ozone, volatile organic compounds which are carcinogenic and respiratory issues to preganant women, infants and old age persons (UNEP, 2018) and indicative of poor air quality. Pathological health issues including, malaria, diarrhea as well as typhoid fever. Dumping plastic bottles recyclables into drainage canals causes plastic-aggravated flash-flood. The spatial distribution of unregulated dumpsites in Yaounde III waste was presented (fig. 10). Moreover, Piles of open dumps of these waste materials caused the loss of valuable land which could be utilized for urban agriculture.

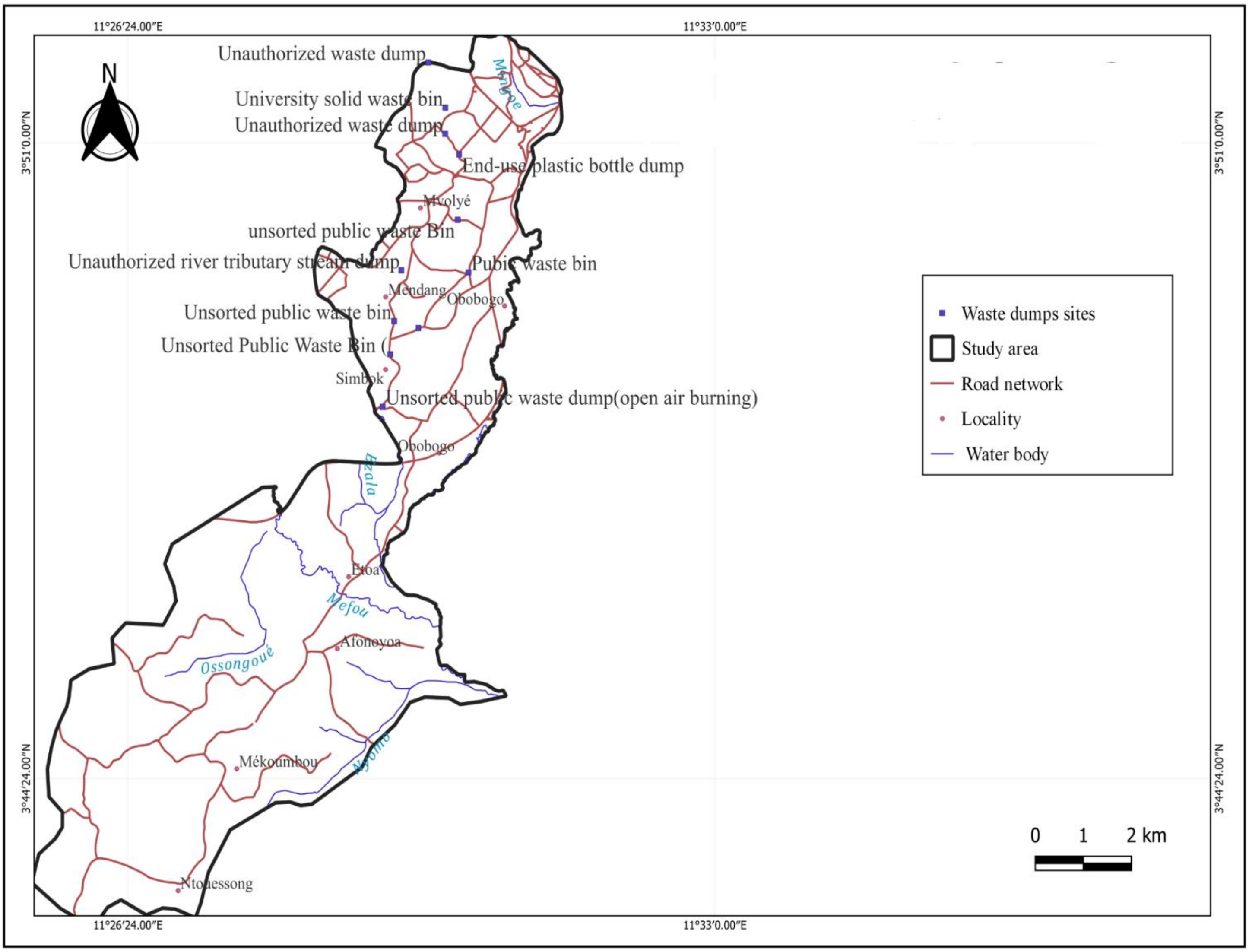


Figure 10: Spatial presentation of unsanitary dumpsites in the Yaounde III council area

Source: INC, realised by Kongnyu Chifu, 2023

Figure 10 spatially presents some sites which had been polluted with open dumping of non-biodegradable solid materials. The figure indicates ten unsanitary dumpsites located within the study area.

2.1 Health effects of non-valuation

Unregulated burning of plastic, glass, metals, electronic and rubber waste material releases toxic fumes and produce many pollutants. The pollutants with the most strong evidence for public health issues were carbon monoxide (CO), anthropogenic PM2.5, sulfur dioxide (SO_2), nitrogen dioxide (NO_2) presenting non-contact respiratory health difficulties such as coughs, influenza, rhinitis, to infants, pregnant women and elderly persons that can be caused by inhaling or ingesting even small amounts of these pollutants (WHO and SEI, 2023). Plastic openly dumped trap precipitation and impede passage for runoff creating pools of stagnant water which resulted parasitic infestations from mosquitoes, cockroaches and rodents including bacterial to malaria, and typhoid fever within households (table 11).

Quarter	**Effective respondents**	**% of Effective respondents**	**Infection**	
			contact	**Non-contact**
Ahala	5	71%	2	1
Efoulan	11	73%	9	5
Melen	3	42%	3	3
Ngoaekelle	6	54%	5	3
Nsimeyong	10	62%	9	6
Obobogo	11	84%	7	3
Obili	4	44%	4	2
Total	**50**	**64%**	**39**	**24**

Table 11: Contact and non-contact pathologies

Source: Kongnyu Chifu, 2023

Table 11 indicates that 78% of the respondents suffered with recurrent contact diseases (malaria and typhoid fever) mean while respondents that faced non-contact illnesses (respiratory infections) were about 24 (48%).

2.1.1 Air pollution index

The air pollution index for gotten from (UNEP and MINEPDED-CIDE, World air quality index, 2024), the air quality index indicates a moderate level of pollution (52) at which sensitive groups which may experience health effects in the Yaounde III council area. Members of sensitive groups including active children, and adults, people with underlying respiratory diseases such as asthma were advised to limit outdoor exposure. However, the general public was not likely to be affected. The main air pollutant that was revealed for the study area was PM 2.5 with a concentration of 16µg/cm^3 (MINEPDED-CIDE Yaounde air quality forecast, 2024).

Reports made public from a study on air quality in Yaounde indicated that air in the city contained so many pollutants with mainly particulate matter, PM2.5 which posed a threat to the health of inhabitants (Stockholm environmental institute, SEI and Ministry of environment and nature protection and sustainable development, MINEPDED, 2023). The findings from the study by (SEI and MINEPDED, 2023) study revealed that Yaounde's PM2.5 level was greater than the WHO recommended standard of 25 micrograms per cubic meter, $\mu g/m^3$. In November 2023, recording for 21 days in Yaounde indicated a PM level exceeding $35\mu g/m^3$ that was significantly above WHO standard. The findings further revealed that only five days in November 2023, met the WHO air quality standard. Findings from the study further showed pathologies including coughs, influenza, conjunctivitis and rhinits.

Outdoor air pollution from increasing waste dumping and open burning and the release of PM were classified as carcinogenic (WHO and IARC, 2013). The health concerns associated with PM $\leq$ 2.5 microns in diameter are of particularly relevant to health issues. associated with the release of PM2.25 and PM2.5 are capable of penetrating deep into the lungs while PM 2.0 can even enter the bloodstream resulting in non-communicable diseases (NCD) such as cardiovascular and respiratory diseases (WHO and IARC, 2013).

Open waste incineration creates harmful air substances including particulate matter which causes lung and heart. Heavy metals such as lead and mercury, which cause neurological diseases. Toxic chemicals releases such as polyfluoroalkyl substance and furan (C_4H_4O) which are carcinogenic and increase risk of birth defects (Daniel Rosenberg, 2021). The health issues, air quality index and related to toxic emissions inherent to open burning and dumping of NBSW was presented (table 12).

Toxic fumes emitted	**Air quality index (17.0)**	**Respiratory Pathologies**
PM2.5 ($35\mu g/m^3$)	14.6	Carcinogenic
Ozone, (O_3)	25.0	Conjunctivitis, endocrine disruptor
Nitrogen dioxide, (NO_2)	63.0	Coughs, conjunctivitis
Sulfur dioxide, (SO_2)	47.4	Rhinitis, Coughs influenza
Carbon monoxide, (CO)	38.7	Rhinitis, Coughs
Polyfluoroalkyl and Furans (C_4H_4O)	_	Birth defects

Table 12: Gaseous emission and associated health defects.

Source: WHO and IARC, 2013; UNEP, 2018; SEI and MINEPDED, 2023; and EPI, 2024.

2.1.2 Proliferation of parasitic insects and rodents

Informal and uncontrolled disposal without valuation of materials has influenced the societal wellbeing of the inhabitants negatively as rats, cockroaches, mosquitoes use the waste dumps as a harbour. These organisms are carriers of parasitic infections such as rats invade households causing uneasiness and disturbances. Residents reported that rats, mosquitoes and roaches disturbed their sleep at night by making unwanted noises and drilled holes into items containing food and were classified as *"real destroyers"*. Over 15% of residents disclosed to have been bitten by rats in their sleep or injured by their wanton movements and considered their prevalence as preoccupying. When rats bite food, they transmit harmful bacteria which are transmitted to humans when consumed.

Thirty five (70%) of residents reported to have been victims of *food poisoning* transmitted by *Salmonella* bacteria causing chronic diarrhoea and Salmonellosis after haven consumed food bitten by rats. An unhygienic mixed waste materials dump observed in the study area was subsequently presented (photo 5).

Photo 5: Unhygienic waste dump with food waste and dry recyclables

Source: VICAD, 2015

Photo 5, reveals the presence of plastic bottles (red arrow), polyethene bags (black arrow), aluminium cans (blue arrow) which are not able to undergo bio-degradability by microorganisms, mixed with food waste. The accumulation of this waste at this point prevents plant growth due to the saturation of non-biodegradable material. This waste accumulation lead to soil acidification and degradation of soil quality. Meanwhile, the food waste (yellow arrow) which is the biodegradable fraction undergoes aerobic decomposition with the release of the potent methane green-house gas.

2.1.3 Prevalence of parasitic diseases

Diseases including malaria, typhoid fever, diarrhea are additional effects of prevalent dumping and burning and as societal livelihood challenge of non-valuation. Disposed waste on the road side, open PWR, into drainage canals creates pockets of unsanity characterised by standing water (plate 5) which create ideal conditions favouring breeding grounds for parasitic organisms including mosquitoes, roaches, flies, rodents that scavenge on these open waste dumps (Nkeuh, 2022).

Plate 5: Uncollected waste in bin (A) and congested drainage canal (B)

Source: Kongnyu Chifu, 2024

Plate 5 presents the state of a public waste bin which has been uncollected for many days (B). The presence of waste overflow in these bins creates a safe harbour for mosquitoes, cockroaches, rodents as well as bad smell emanating from the bin. Plate 5 equally shows how informal waste disposal clogs a drainage (B) which prevents the flow of stream. The huge pile of plastic bottles slows flow of water leading to stagnation during the dry season. The stagnated water result in high prevalence of parasites especially the female anopheles mosquitoes transmit malaria infections to inhabitants in the neighbourhood. The malaria infection was associated with symptoms of typhoid fever constituting a public health malaise.

Data for recorded cases of and degree of severity for malaria and typhoid fever associated to open dumping and burning was collected from health institution and presented from the month of February to July, 2024 (table 13).

<table>
<tr><th colspan="2"></th><th>Feb</th><th>March</th><th>April</th><th>May</th><th>June</th><th>July</th><th>Total</th></tr>
<tr><td colspan="2">Total no. of registered patients at the hospital</td><td>28</td><td>31</td><td>29</td><td>25</td><td>23</td><td>28</td><td>164</td></tr>
<tr><td rowspan="3">Malaria and typhoid fever cases</td><td>Chronic</td><td>13</td><td>15</td><td>13</td><td>11</td><td>10</td><td>8</td><td>69</td></tr>
<tr><td>Mild</td><td>2</td><td>5</td><td>2</td><td>3</td><td>2</td><td>3</td><td>16</td></tr>
<tr><td>Raw scores</td><td>15</td><td>20</td><td>15</td><td>14</td><td>12</td><td>11</td><td>85</td></tr>
<tr><td colspan="2">% Total for malaria and typhoid cases</td><td>53%</td><td>64%</td><td>51%</td><td>56%</td><td>52%</td><td>39%</td><td>51.8%</td></tr>
</table>

Table 13: Recorded severity for cases of malaria and typhoid infections

Source: Saint Simon Medical Center, 2024

The data in table reveals that for the months of February to July of 2024, out of 164 number of patients received at the health center, 85 (51.8%) of the patients were diagnosed with malaria and typhoid infections among which 69 (81%) were chronic cases meanwhile 16 (18%) cases were mild. This magnitude indicated the high prevalence of malaria and typhoid infections among the local residents from huge and numerous mosquitoes breeding waste dumps.

2.1.4 Physical injuries

Reported findings (Nivedha, 2022) indicated that illegal solid waste burning led to physical injury particularly to vulnerable children playing on the streets who got inured from open burning such as from broken glass bottles and the risky practice was shown below (photo 3).

Photo 6: Burnt broken glass bottles

Source: Kongnyu Chifu, 2023

Photo 3 indicates the remains of charred and broken glass (black arrow) bottles after being openly incinerated. The exposure of the broken bottles remains presents a permanent risk to public who may get physically injured especially at night on passing along this street.

2.2 Ground water pollution

The quality of urban groundwater has been assessed based on 39 groundwater samples which were analyzed for a variety of microbiological and hydro-chemical parameters. Samples were taken at the end of dry season 2012 in five spatial clusters. The results obtained for 21 shallow dug wells, 14 springs and 4 production wells showed a considerable presence of fecal bacteria in the water. This shows the considerable risk to which the population, forced to use groundwater due to water cuts, is being exposed (INS and BGR, 2013).

The analysis of nitrate (NO_3) as a chemical parameters showed that 51 % of all groundwater samples exceed the WHO concentration limit of 50 mg/l NO_3. From the chemical quality perspective, this groundwater is not suitable for human consumption. This applies in particular to babies and children under five years of age. It adds to the outlined microbiological risk and aggravates morbidity. The chemical analysis of groundwater has shown a strong, systematic and direct impact of waste water discharge procedures on groundwater quality. This is exemplified in the spatial distribution of nitrogen, chloride, potassium and sodium concentrations in groundwater. High and extreme concentrations are found next to the upstream limits of human settlement (INS and BGR, 2013).

Almost 90 % of the households in the study area would consume treated potable water if the demand could be met. In the case of supply shortages of piped water, these households rely on stored reserves (54.7 %) or on bottled mineral water (10.2 %). Untreated water sources being used are production wells (5.7 %) but also springs (10.6 %) and shallow dug wells (12.8 %). The latter two are very unsafe from a hygienic perspective (INS and BGR, 2013).

The shortages of piped water are due to frequent temporary cuts by the water supplier CAMWATER which have become common in the City of Yaoundé last two years. Almost 69.0 % of Yaoundé households stated that they suffer from piped water cuts at least four times a month. These temporary and frequent water cuts force households to resort to shallow dug wells (35.9 %) or springs (5.6 %). Less than half of these shallow wells/springs can be considered « amended » (46.6 %) in a perceptible sense. Using water from these dug wells/springs carries a major risk of infection (INS and BGR, 2013).

2.3 Increasing risk of plastic-aggravated flash-flooding

The social culprits of aggravated flash-floods are households who fail to add value to waste as a social resource. During days of high intense rainfall characterised by large droplets, and fast paced downpour, the capacity of drainages to evacuate runoff is compromised due to disposed plastic which block the draining of runoff (plate 6).

Plate 6: flash flooding (A) and blocked drainage systems (B)

Source: Kongnyu Chifu, 2023

Plate 6 reveals the man point of plastic bottles saturating a gutter (B) which blocks the drainage of water. The blockage reduces the drainage capacity and forces water overflow during heavy rainfall which gives rise to plastic-aggravated flash-flooding (A).

2.4 Impoverishment of soils and reduced crop yield

Deficient added value to plastic and rubber waste of waste as a social resource reduces crop yield due to impoverished soil. Open dumping and burning which last for several months on arable land hardens upon cooling making the compact and less aerated. This reduces the activity of soil bacteria disrupting the nutrient cycle vital for crop growth. A case study was conducted for the corn plant and results showed that the corn seeds planted on soil which had been littered with varieties of non-biodegradable solid waste faced delayed germination and a majority of the planted grains did not germinate at all. The crop yield from the grains that germinated was relatively scanty in compared to grains that were planted on non-polluted soil. This is indicative of the fact that the nutrients cycle in the littered soil had been disrupted by openly dumped and burnt waste which prevent it from germination and stunted its growth (plate 7).

Plate 7: Scanty crop yield (A) and Healthy growth crop yields on unpolluted soil (B)

Source: Kongnyu Chifu, 2024

Plate 7 portrays how improper waste disposal reduces soil fertility resulting in mitigated growth of maize plant hence low crop yield (A) as opposed to the unpolluted farmland (B) shows healthy crop strands ensuring high output.

Reports indicated a perilous effect of burning on the production of maize (a staple cereal crop in Cameroon). This report stated that the 55 tons of maize annually produced was insufficient due to impoverishment of soils from bush fires as a clearing technique by the farmers (Le Messager, 2024).

2.5 Obnoxious odours and aesthetic pollution

Absence of waste reuse, refurbishment, repair and recycling into for societal embellishment of the study zone led to visual nuisance and obnoxious odours. Non-biodegradable valuation through uncontrollably disposed with mixed piles of abandoned garbage of material including plastic bags collectively dumped emitted bad odours upon putrefaction. The effects are felt through the eyesore of putrescible and non-degradable material that emit bad odour and spirogyra growth which cause eyesore. This form of social pollution of the urban landscape reduces the appeal of the zone as presented below (plate 8).

Plate 8: Aesthetic degradation in water body (A) and on land (B)

Source: Kongnyu Chifu, 2024

Plate 8 is an indicator of a congested PWR (B) which I a source of visual nuisance. The informal disposal of mixed waste in water ways results in a negative social presentation of the urban space (A) resulting in aesthetic pollution. Furthermore, non-valuation of plastic and rubber materials for social beautification led to the loss of aesthetic value and attractiveness of the urban landscape, which reduces the potential for tourism and recreation (Nkeng, 2019).

2.6 Loss of urban arable land

The proliferation of open dumpsites with the predominance of unvalued non-biodegradable solid waste material induces the loss of land for urban farming. When artificial pockets of dumping are created on farmlands in the urban space, where access to farmland is limited, the space for urban gardening is compromised as the land is lost to littered piles of plastic bags, plastic bottles, nylon, and rubber waste materials (Photo 7). The loss of arable land can affect ability to sustain food prodution as the inhabitants primary depend on farm outputs for their food provision. The loss of agricultural land and soil fertility due to waste dumping and burning affected crop yield and food security (Nkeng, 2019).

Photo 7: Loss of urban agricultural land

Source: KONGNYU CHIFU MBAH, 2023

Photo 7 reveals an arable plot of land occupied by variety of plastic waste. The occupation is indicative of the loss of this valuable which could serve the purpose for sustainable urban agriculture. The land is dominated low density polyethene (blue arrow), followed by polyethene terephthalate (white arrow), and high density polyethylene (black arrow).

Additional reports according to experts hold that there is need to handle issue of land availability and rejuvenate farms. Limited availability arable land minimised the potentials to produce in large quantities and boost agricultural productivity (Cameroon tribune, 2024).

Conclusion

The non-valuation of NBSW as a social resource for societal embellishment was proven to have far reaching effects on social life. Non-valorisation led to health issues such as respiratory disorders (coughs, influenza, rhinitis), conjunctivitis, birth defects, being carcinogenic from anthropogenic particulate matter PM2.5, nitrogen dioxide, sulphur dioxide, furans. Prvealence of open waste dumps which generated breeding grounds for mosuitoes transmitted typhoid and malaria fever to local inhabitants according to (Saint Michel Medical Center, 2024), in which out of 169 patients received, 85 were diagnosed with malaria and typhoid among which 59 cases were chronic as opposed to 16 which were simple or mild cases. The lack of valorisation through open incineration impoverished soils which reduced maize crop yield. The non-valuation also caused visual nuisance as and bad odours. Illegal dumping made inhabitants to lose arable land due reduced soil fertilty threatening food self-sufficiency for low income households. The waste dumping equally occasioned underground water pollution. The next section of the study focuses on economic repercussions of non-valuation in the study area.

CHAPTER 3

INFLUENCE OF NON-VALUATION OF NON-BIODEGRADABLE SOLID WASTE ON THE ECONOMY OF YAOUNDE III COUNCIL AREA

Introduction

The Yaounde III council area generates varied non-biodegradable solid waste resources including plastic bottles, rubber tyres, metals, electronics, glass, waste composites; but the council area is still view these resources as a problem. This because the council area lacks an enterprise economy to recycle these recyclable materials as an economic resource. Systemic absence of proper resource collection and washing separation,, fragmentation, and extrusion to in order to produce products that of higher quality and greater functionality gives rise to an economic peril. The economic peril is varied including limited sustainable innovation, adding to the financial burden of the local council administration. Non-valuation equally causes to the loss of economic opportunities such as of intermediate job creation and income generation from value addition. Youth unemployment stands at 7% (MINEPDED, 2023) indicative of the limited opportunities in the waste valorisation sector.

3.1 High waste management costs

The cost of managing unsorted waste is higher than the cost relative to managing waste that has been source sorted. Inefficient waste management failing to consider waste segregation can lead to higher costs for waste disposal, affecting council budgets. Waste management budgetary allocations for solid waste collection and disposal services annually cost XAF 1.8 billion (Nkeng et al., 2019) and waste management was yet to give way to resource management to be implemented within the framework of non-biodegradable solid waste valuation.

3.2 Limited sustainable innovation

Lack of emphasis on value addition relinquish innovation in non-biodegradable solid waste-resource valuation technologies limiting the development of more sustainable solutions in Yaounde III. Sustainable innovations of economic value such as pyrolysis and gasification and liquefaction of plastics for cost effective road and energy recovery are still lacking adoption and implementation in the action plan of waste as a resource management in Yaoundé III.

Furthermore, it was observed that the waste generation of plastic waste and collection by waste pickers had locomotion difficulties in transporting huge nets of collected plastic bottle as they often carried them on their backs over long distances before getting point of assembly. This was indicative of glaring absence of scrap metal upcycling into products of higher quality and greater functionality to ease the transportation process for economic efficiency (photo 8).

Photo 8: Household furniture (chairs) conceived out of rubber tyres

Source: Cynthia Wanchia, 2022

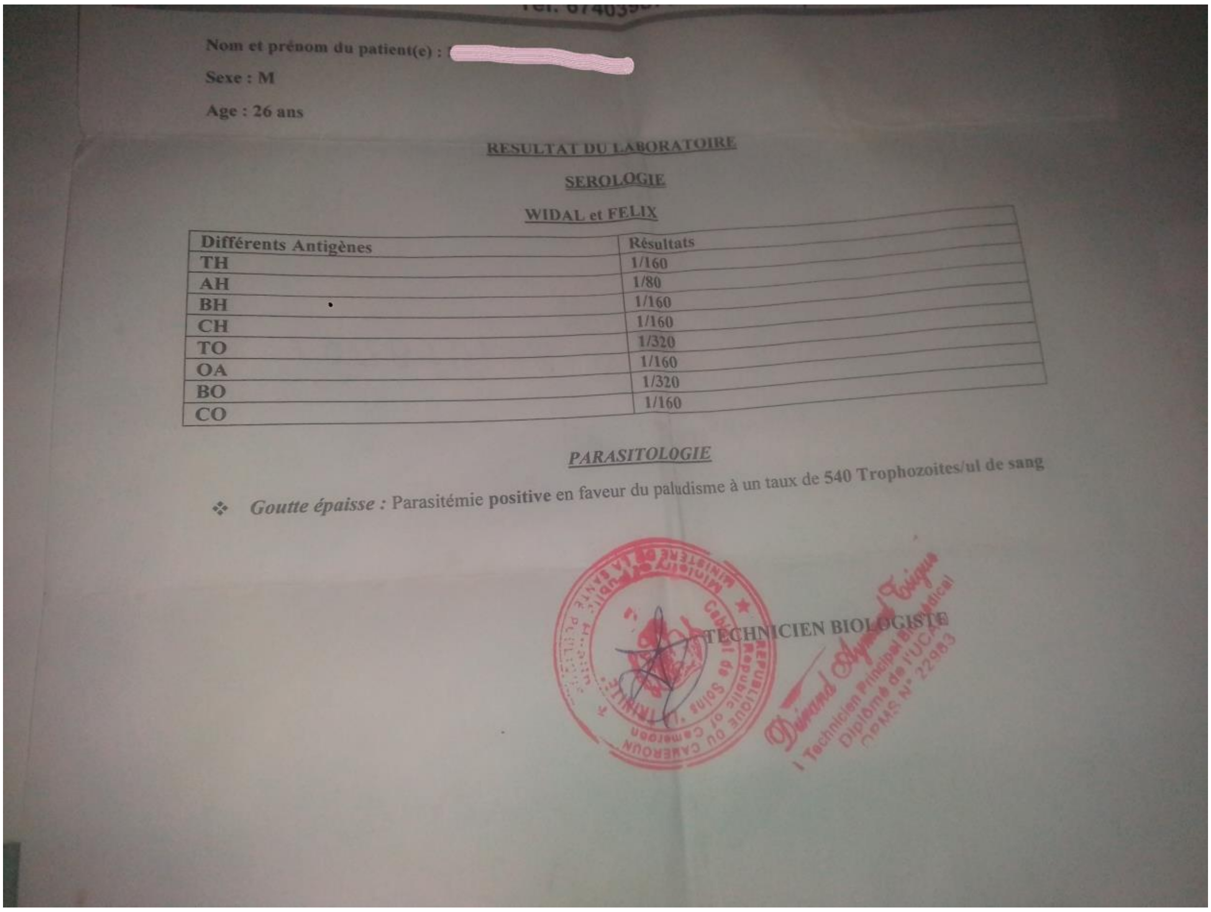
Photo 8 shows a living room equipped with audibly presentable chairs which have been made using rubber tyres. What obtains from this photo is the notion of sustainable creativity and innovation through value addition to used rubber tyre waste littering the environment. When such innovative ideas are adopted and conceived by local inhabitants, it could serve as a cost-effective approach by the designers and as such the commercialisation of such innovations could generate revenue and provide employment to local populations.

3.3 Missed economic opportunities

Non-valuation of plastic metal, rubber, and glass electronic recyclables as an economic resource has led to missed economic benefits in the study area. The absence of segregation at pre-collection and sorting at collection stage, recycling units, transfer stations, buyback centres and a proper valorisation action plan or resource management strategy and effective implementation of the 3Rs in valuing waste material recyclables undermines the potential economic benefits including employment creation and income generation (table 14). Household waste as a problem instead of seen it through the prism of waste and resource management by applying the principles of reduce, reuse, and recycle, which can save them the cost from purchasing new products.

3.3.1 The cost of inaction

Unvalued plastic bottles providing breeding ground for mosquitoes has negative economic externalities on household capacity to earn income. When the family head who provide for the household gets malaria and typhoid from mosquito bite and consumption of polluted water sources, their capacity to adequately work and earn income diminishes. The little savings of the family will be appealed to buy medication (Nkeuh, 2022).



Nom et prénom du patient(e) :

Sexe : M

Age : 26 ans

RESULTAT DU LABORATOIRE

SEROLOGIE

WIDAL et FELIX

Différents Antigènes	Résultats
TH	1/160
AH	1/80
BH	1/160
CH	1/160
TO	1/320
OA	1/160
BO	1/320
CO	1/160

PARASITOLOGIE

❖ *Goutte épaisse :* Parasitémie **positive** en faveur du paludisme à un taux de 540 Trophozoites/ul de sang

TECHNICIEN BIOLOGISTE

Photo 9: Laboratory test result for malaria

Source: Trinity Health Clinic, 2024

Photo 9 presents results of a patient who had fever and acute diarrheoa. The laboratory results indicates a positive test in favour malaria at a rate of *540*

Trophozoites/granule of blood. The proliferation of diseases constitute a financial burden for to treat these illnesses, as reported by the patient.

3.3.2 Influence on job creation

When value is not added to waste resource materials, this mitigates the intermediary job creation potentials for the very households who are the primary generators and hence caused lack of income generation. Meanwhile, giving priority to recycling does not only results in a net increase in employment, these new jobs are typically higher paid and the working conditions greatly improved relative to landfilling and incineration (DST 2014). The metallic and non-metallic waste recyclables collected by waste pickers are exported to different part of the country for transformation (plate 9).

Plate 9: Sorted HDPE containers and aluminium cans (A), end-of-life vehicle scrap metal (B), tin cans(C) and PET bottles (D)

Source: Kongnyu Chifu, 2023-2024

Plate 9 presents the activity of waste recovery by informal waste recyclers. The Photo shows a bail of washed high density polyethylene plastic toys (red arrow), aluminium cans (yellow arrow), end of live vehicle scrap brought by scrap van at a scrap metal weighing point from where it is loaded on push carts for storage in informal material warehouse. A collection of tin cans in a metal dish (white arrow) at a materials recovery site and a bail of recovered polyethylene terephthalate plastic bottles awaiting transportation.

These experiences from the Yaounde III council area suggests that exporting recyclables could create more jobs at the expense of local employment opportunities. Hence, more opportunities for recycling should be created within the study area rather than exporting recyclables to create more jobs and increase revenue generation.

3.3.3 Influence on poverty alleviation

Non-valuation causes decreasing income generation and job creation hence the opportunity to alleviate poverty as a result. Waste recyclable that is recycled, and upcycled can be marketed to generate revenue and used to remunerate household revenue. A study in Douala showed that involvement in resource recovery improved the socio-economic status of respondents (Alain, 2023). Most of the informal waste pickers got up in the wee hours of the mooring searching garbage piles to recover a variety of NBSW including rubber tyres, scrap metals, plastic bottles, sachet packaging as well as aluminium cans which are being sold to recycling companies in the city. At the time of the survey, most of waste pickers were paying monthly rent for their accommodation using the income generated from the sale of recovered materials. From the study it can be deduced that when informal waste pickers are up-skilled to add value to the material they collect, they can increase their earning potential through economical gardening practices (photo 10).

Photo 10: Vegetable gardening

Source: J2D-Afrique, 2018

Photo 6 shows the reuse of plastic bottles for organic gardening of celery plant. The recycled plastic bottles are economical to recover and heir used for gardening requires gardening space. The soil used to grow the plants are further enriched with animal droppings. This organic vegetables cultivation guaranteed "defacto food security" (Francois Nkonzou Takuété, 2018)

3.3.4 Effect on enterprise development

Micro, small- and medium-sized enterprises (SMEs) have an important role to play in waste-resource valuation. However, a major challenge to enterprise development is non-attachment of value to NBSW. The council authorities have not had an enterprise economy to develop these waste resources and have not created an environment that enables enterprises to enter the resource management industry and this limits the potential for enterprise development. When informal pickers are given appropriate assistance, this could be scaled-up and better managed at the neighbourhood level. Enterprise development has the potential to improve urban environments while simultaneously generating income opportunities and improved livelihoods for the household when upcycled. (Photo 11).

Photo 11: Recycled organic coal for cooking

Source: Steve Djeutchou and Luchells Feukeng, 2022

Photo 7 presents the fabricated totally organic cooking coal made out collected, sorted and recycled plastic and food materials from households. The eco-friendly coal is produced by the sold at 300 FCFA per kilo and has created many job and generated revenue out of this activity.

3.3.5 Influence on entrepreneurship

When the local inhabitants do not add value to various non-biodegradable solid waste material through upcycling into durable, it reduces entrepreneurship in the council area which cause the local population to miss out on the economic efficient of the NBSW-related upcycled products. The opportunities related to waste entrepreneurship are spread throughout the value chain to construct indigenous products of better quality and greater functionality, as well as the uptake of sustainable technological innovation (photo 12).

Photo 12: Recycled kitchen ware

Source: Kongnyu Chifu, 2024

Photo 7 reveals the practice of recovery of used and discarded kitchen ware that was repaired and refurbished into new gas plates (yellow arrow) as observed on the wood stand by metal recycler for commercialisation. The commercialisation of the refurbished kitchen ware is a created job opportunity that earns income to the recycler.

Conclusion

The variety of non-biodegradable and quantity of plastic bottles, ferrous and non-ferrous metals, rubber tyres and glass recyclables in Yaounde III lack proper valuation at the household level and waste collection services. The study area have not had an enterprise economy that develop these resources. There exist an absence of material segregation at the pre-collection and sorting during collection in the current of waste management action plan. This negatively impacted employment and income generation for the local populations in the study area. The economic cost of failing to upcycle and recycle waste into economic goods and services result in missed economic opportunities to create jobs that could generate income, alleviate relative poverty among low income earners, limited enterprise development and diminished entrepreneurship. Considering the negative externalities of not attaching value to non-biodegradable solid waste, this study was designed to further assess the effectiveness of adaptation strategies in mitigating the effects of non-valuation.

CHAPTER 4

ASSESSMENT OF ADAPTATION STRATEGIES TO NON-VALUATION OF NON-BIODEGRADABLE SOLID WASTE IN YAOUNDE III COUNCIL AREA

Introduction

This section focuses on evaluating the institutional framework of waste valuation including the systems of regulations and their level of implementation. The role of informal sector recycling, involvement of stake holders such as traditional authorities, quarter heads authorities, households, private organisations and creating awareness presented in this chapter. The nature of waste bins among low, middle and high class households waste assessed to determine whether waste sorting and separation was practices. Ministerial strategies by the Ministry of Urban development and action plans adopted to deal with effects poor waste management was evaluated. A classification of waste streams with their physio-chemical properties was assessed to better comprehend the materials and their appropriate applications. Emerging waste streams such as nano-materials and nano-particles, approach to managing health care risk waste by households was assessed.

4.1 Level of implementation of regulation

There is no basic legal law according to the current municipal solid waste management situation. The existing regulation includes Decree No. 2012/2809/PM, 2012. This decree states the conditions for sorting, collecting, storing, transporting, recovering, recycling, treating, and disposing of waste. Additionally, In 2012, a decision was issued banning the use of non-biodegradable plastic packaging of less than 60 microns, which came into force in April 2014. This policy instituted a ban on the use of non-biodegradable plastic bags. Almost eight years later, these plastic bags continue to be used as packaging in markets and unfortunately end up on the street after use. Eventually, they end up buried in the ground and in waterways. This process has been repeated over the years and contributes to the clogging of drains and other waterways in our cities, which leads to an increase in flooding experienced across the country in recent months (Greenpeace Africa, 2021).

4.1.1 Encroaching waste on the carriage way

These strategies nevertheless due to the lack of active implementation, the absence of valuation strategy accompanied by lack of discipline resulted in compromised success. Huge piles of uncollected waste in PWR that surpassed containment capacity and artificial dumps on bare land led to garbage overflows on the streets. The waste covers portion of roads and can slow down free road circulation of vehicles (photo 13).

Photo 13: Pile of uncollected mixed garbage covering the encroaching into the road

Source: Benji, 2024

Photo 13 presents a huge pile of waste on occupying almost half of this stretch of road. There was formally a waste bin but due to exponential waste production the waste bin became full very rapidly so the waste saturated the surrounding. The waste collection company decided to take back their PWR since the waste was overflowing.

A commuter explained that "*there is often waste landfill behind waste bins where waste can be discarded but nobody goes there to dispose of their garbage and prefer to discard on road to block circulation*", another road user stated that *"The odour from the garbage can kill, it nearly suffocated me*".

4.1.2 Issuing warnings

Local inhabitants often times take matters into their hands to personally dish out stern warning to unscrupulous residents that litter the council area with waste from their households (photo 14).

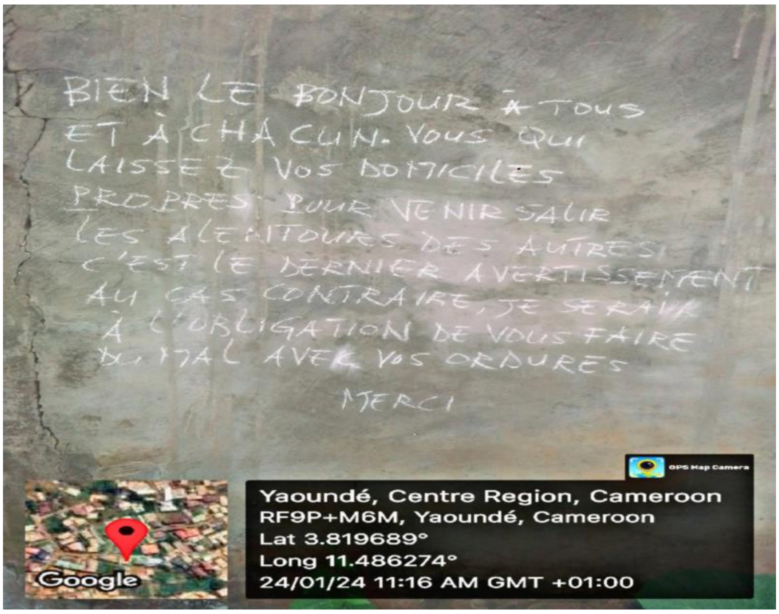


Photo 14: Warning by a resident

Source: Field work, 2024

The above on Photo 14 warning reads "Good morning to each and every one. Those of you who leave the environment of your household clean to go litter other household environments, this is the last warning, otherwise I will be happily compelled to harm you using your garbage".

4.1.3 Ministerial strategies

Strategies such as the yearly National clean city contest organized by the Ministry of Housing and Urban Development (MINDHU) uses key evaluation criteria. The inception of the contest in 2019 was initially named "Clean Quarter" before it was renamed in 2020 as the National Clean city contest. The evaluation criteria include street cleaning, the development and embellishment of public spaces, the fight against traffic jam of permanent or temporary roads, the removal of household waste and the eradication of illegal dumps.

Action plans including the "Operation punch, Yaounde without garbage" by the Minister of housing and urban development (Celestine Ketcha Courtes, 2024) noted that "the city of Yaounde is dirty. At everyplace we passed-by, there were heaps of garbage". The minister mobilised the solid waste utility collection companies, Hysacam and Thychlof to implement the operation. Furthermore the minister announced structural measures including the instructions for mayors to organise regular collection in the quarters. Furthermore a sensitization campaign was scheduled to be undertaken at the premises of the quarter heads to include them in sanitation management, especially during pre-collection of domestic waste, in dredging of drainages and street cleaning. The minister further emphasised on the fact that the participation of all stakeholders; from the authorities to the citizens, enterprises and quarter heads was vital to make clean and welcoming. This action plan from the ministry of Housing and Urban Development did not take into account the valuation strategies that supercede phases of pre-collection and deep hygiene which includes segregation and sorting by household and collection services respectively.

4.2 The role of informal sector recycling

The informal waste pickers collect valuable materials which active activity within the council area. The safety and security of informal waste pickers is also an issue, as many resort to sleeping on the streets at night to be close to the recyclable material, making them vulnerable to crime (Schenck et al. 2013). Informal waste pickers in the study are vulnerable to a wide range of chemical, biological and physical health risks posed by waste due to the lack of adequate personal protective equipment (PPE) (plate 10). These risks include wound infections from sharp objects, inhalation of dangerous gases, swallowing of dangerous and contaminated materials including condemned food, diseases like cholera, typhoid, diarrhoea, viral hepatitis and musculoskeletal injuries from manual lifting or sorting tasks (Phuka et al. 2003, Riungu 2003, Jerie 2016).

Plate 10: Informal scrap metal recyclers with inadequate PPE

Source: Kongnyu Chifu, 2024

Plate 10 presents the practice of informal waste recovery by individual waste pickers.

The table below enumerates the prices of recyclable material resources. Part (A) of the plate shows a scrap metal picker transporting collected recovers material from domestic premises. Part (B) of the plate shows the activity of folding end of life vehicles scrap into smaller chunks using an axe by an informal waste worker. The evident lack of personal protective equipment in carrying out this activity is a major challenged faced by these informal waste pickers.

4.2.1 Prices of recyclable materials

The prices for a quantified scrap iron, aluminium can, copper wires, plastic bottles were collected from itinerant waste pickers. These are standard prices for basic recyclate charged by itinerant waste pickers (table 14).

	Quantity of material	**Market value (FCFA)**
1	1kg of Scrap iron	100
2	1kg of aluminium	250-300
3	1kg Copper	2000
4	10 PET (1.5l) plastic bottles	100
5	1 net of PET plastic bottles	2000
6	1 metal wheel drum	1000
7	1 bale of aluminium can / HDPE plastic toys	30,000-40,000

Table 14: Price for scrap metal and plastic bottles

Source: Kongnyu Chifu, 2023

4.2.1 Level of source separation during formal collection

Waste that is generated from households lacks proper segregation of dry recyclables from and food waste. Added to this is the fact that existing waste management collection services do not sort waste during collection at residencies (plate 11). These is indicative of lack of segregation at pre-collection and absence of sorting during collection which slows down the recovery process due to extended time required to manually sort waste by informal waste pickers. Food and polyethylene bags mixed with dry recyclable during waste collection and storage is a source of contamination for machines at material recycling plants.

Plate 11: Absence of waste segregation (right) at household and sorting during collection itinerant waste management truck (left)

Source: Kongnyu Chifu, 2024

Plate 11 shows the lack of waste separation by households and utility collection services. This absence of sorting and separation is indicative of the limited awareness on the importance of sorting waste before and after collection by households and collection services.

4.2.2 State of recyclables storage facilities

Waste material collection and segregation by informal recyclers is inhibited by lack of adequate storage facilities (Photo 15). The nature of the storage environment for recyclable was not audible due to the absence of material warehouse in which waste could be stored and preserved from changing weather conditions.

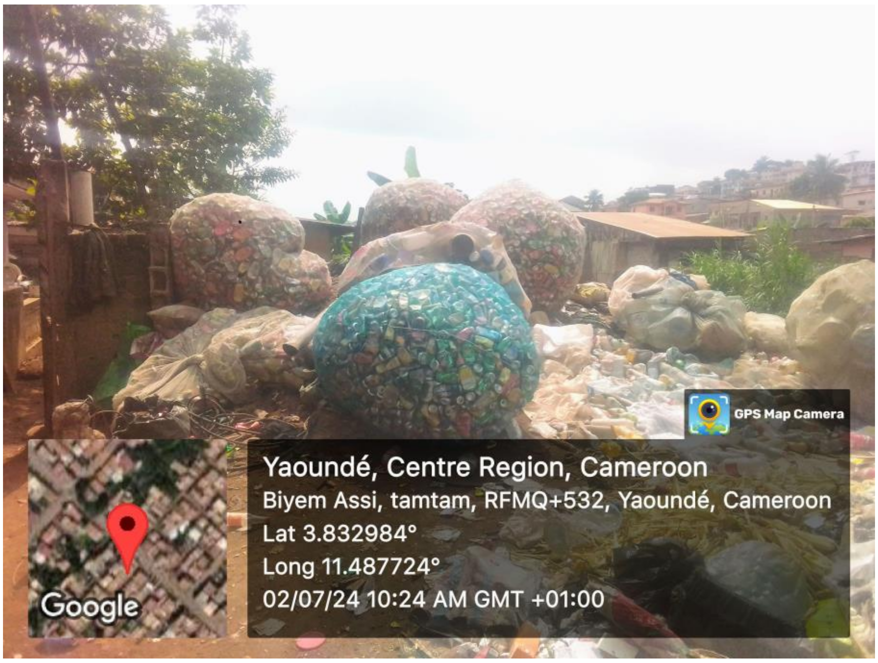


Photo 15: Poor waste storage facilities

Source: KONGNYU CHIFU, 2024

Photo 15 presents a informal waste storage site by informal waste recyclers. This is indicative of the limited storage warehouses and transfer stations where recovered materials can be securely stored.

Furthermore, interview with resource persons in the waste picking and recycling indicated that the waste was collected from individual garbage bin. The waste is first sorted before getting washed and packed into bales of net and stored awaiting to be purchases by private organisations in the recycling sector.

It was further made mention that these waste materials are the primary resource for recycling industries who do not have *Hevea b.* plantations. During recycling processing, plastic is crushed to obtain "*benamine powder*" considered as "gold/diamond" used as secondary inputs recycling industries. The powder is humidified used in the production of paint buckets, and pens.

Collected and sorted aluminium cans recyclables are melted during processing to produce other cans. The collected aluminium materials is the primary raw materials for non-ferrous can products.

Sorted rubber tyres materials during recycling are being washed, embalmed with mastic and engraved with imprints. The recycling or rubber tyres was carried out the informal waste recyclers.

Collected ferrous scrap metals are melted at thermally processed at 12000°C of heat. The molten metal is used to produce rails track for trains, concreting steel bars, and steel arms of weighing bridges.

4.3 Private recycling organisations

Some initiatives have been implemented to foster solid waste valuation in Yaoundé especially in the informal and suburban areas, where waste collection is less efficient and more expensive. Variety of association, NGOs and private structure involves in resource material recycling were spatially presented (fig. 11).

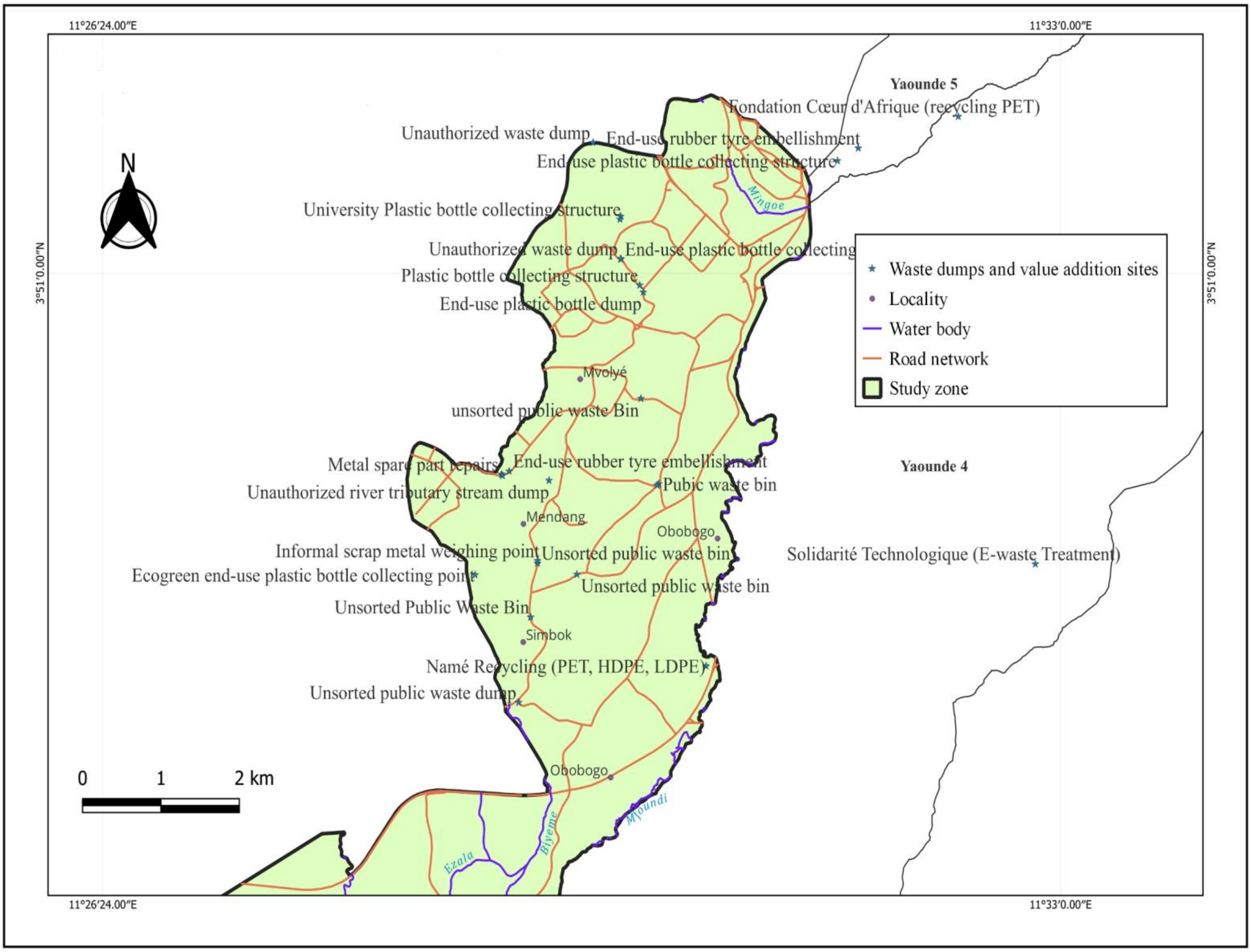


Figure 11: Spatial presentation of valorisation structures in Yaoundé

Source: INC, realised by KONGNYU CHIFU, 2023

Some of the NGOs involved in recycling sector were enunciated below. These organisations are involved in material valuation.

- The NGO AGRO-PME has developed a project called PAEPYS that aims to produce biogas and organic fertilizer from household and market waste for use as cooking gas and in agricultural applications.
- The NGO ACREST has installs mobile toilets in some neighbourhoods and uses the human waste to produce biogas and compost as well as to generate electricity for street lighting.
- The NGO GEVALOR has supported the creation of a network of micro enterprises that collect and sell recyclable materials to industries and crafts workshops.
- The NGO FONDATION COEUR D'AFRIQUE collects recycles end-use polyethylene terephthalate (PET) bottle into cost-effective and ecological friendly pavement slabs. This NGO has generated about 2500 direct and indirect for local population. The pavement blocks cost 3500/m² FCFA per meter square with thickness of 5cm as opposed the classical pavement blocks which costs higher that is 5000 FCFS/m².
- The NGO NAMÉ RECYCLING collects PET, low-density polyethylene (LDPE), high-density polyethylene (HDPE) through networks of informal collectors and businesses in Cameroon. Raw plastic is transformed into flakes and PET straps after being sorted, washed, extruded and pelletized. The PET straps and plastic flakes are sold on the local and international market to be used as recycled raw materials, closing the material loop.
- The NGO SOLIDARITÉ TEHCNOLOGIQUE practices controlled incineration of used batteries mitigating gaseous emissions. Electronic waste equipment is being repaired and refurbished into new products.
- The NGO THINK GREEN reuses plastic bottles as a secondary resource for the construction of building. The reuse use of plastics which is cost effective and sustainable.

The recycling practices of the NGO think Green by reusing plastic bottles to construct cost effective and sustainable construction was presented in (picture 16) below.

Photo 16: Sustainable construction

Source: Think Green (2023),

Photo 16 presents a all building constructed with the use of plastic bottles added to aggregate for eco-friendly building. The plastic bottles as observed were filled with sand used as a cheaper substitute as opposed to using concrete blocks which more expensive.

4.4 Household gardening

Giving value to non-biodegradable waste can reduce landfill pressure. This encourages recycling and proper disposal, reducing the amount of waste sent to landfills and this can help minimize soil and water pollution

Furthermore, conservation of resources required to produce new plastic bottles can be attained when they are recycle. Reusing plastic bottles (plate 12) for farming conserves natural environment was this reduces from pollution of illegal dumping.

Plate 12: Eco-gardening and farming

Source: KONGNYU CHIFU, 2023

Plate 12 presents crop nurseries by reusing a rubber tyre (yellow arrow) used for nursing a coconut tree, plastic bottle (black arrow) for nursing licks spices, and edible vegetable.

4.5 Creating awareness

Considering efforts harnessed to combat plastic pollution plastic made structure were created to create awareness on the necessity of recycling. These bottles were mounted on assembled structure made up of scrap steel which makes the area look presentable (Photo 17).

Photo 17: Plastic bottle receptacles on steel structures

Source: Bruno Ndonwie, 2017

Photo 17 presents giant steel structure having the shape of a bottle embellished with plastic bottles. This serves the purpose of creating awareness for more plastic recycling in order to avoid plastic pollution. Such a pieces of arts added to their ability to create awareness on sorting plastic waste materials is a source of artistic embelishment to the urban space.

4.6 Informal land recovery

Local inhabitants in an effort to recover land to setup their small scale enterprises have resorted to informal land recovery in the flood risk areas. The use of land prone to floods was a suboptimal option used by inhabitants with limited income and this engendered even more plastic and rubber waste littering (photo 18).

Photo 18: Informal land reclamation

Source: KONGNYU CHIFU, 2023

Photo 18 shows the practice of informal land reclamation and ensuing plastic bags (black arrow), plastic bottles (white arrow) and rubber tyres (yellow arrow) littering the surrounding and covering the soil. The saturation of this waste material obstructs the smooth passage and infiltration of water and this gives rise to floods during episodes of torrential rainfall. Littering equally constitute a source of environmental pollution.

4.7 Unsanitary Landfilling

Landfilling is the most common method employed to manage waste at by households and by municipal authorities. Waste materials are disposed of in unsanitary landfills which engenders pollution to the receiving soil and underground water. A study conducted reported that landfills that accumulate plastics do not act as final sinks for plastics but rather as a new source of micro-plastics. They suggested that these micro plastics undergo breakdown due to exposure to the ultraviolet light and the prevalent conditions in the landfill (He et al. 2019). They also reported that as landfills age, the process of mineralization of waste occurs which increases the leaching properties of the waste in the landfill (Paul et al. 2019) (photo 19).

Photo 19: landfill along the railway

Source: VICAD, 2022

Photo 19 indicates a landfill of accumulated waste plastic bags (white arrow), plastic bottles (black arrow), ferrous metal cans (blue arrow), synthtic polymer (red arrow) and organic food waste (yellow arrow). Landfills that approximately 20% of the global CH_4 quantity is obtained. Besides CH_4, there are gases released from these landfills that have high level of toxicity. It is possible that leachate can find its way through the underground water mainly via the flaws found on the liners. Constructing landfills may have an adverse influence in the life of fauna and flora.

The head of hygiene and sanitation department of Yaounde III council area in 2022 explained that "The unauthorized waste dumps are formed near water sources, or the waste is thrown into them leading to surface water and ground water pollution through leachates. In addition the gutters are completely locked because of the waste resulting from the activity of citizens who throw anything anywhere (Ndam Salifou et al., 2023) (Photo 20).

Photo 20: Waste saturation on a stream course

Source: Kongnyu Chifu, 2024

Photo 20 presents saturation of waste on a flowing stream including polypropylene cases (black arrow), PET (blue arrow), LDPE (yellow arrow) and food waste materials (red arrow). The surrounding households have dug wells to for water about 10meters from this waste point. This presents a health risk to the underground water for population who rely on these wells in close proximity to this dump site as well the fresh water aquatic life and microorganisms.

4.8 Nature of waste bins by household standard

The households in the study area are produces a variety waste with some waste more common from one household to the other. The nature of waste bins and materials content was considered and classified into high standing, middle standing and low standing. The waste collection materials included biodegradables plastic bags by high standing households, bamboo and HDPE recipient used by middle income households. Bothe the middle and high standing households showed prove of material segregation as opposed to low standing households that stored all their generated waste in the same recipient.

4.8.1 High standing residencies

The waste materials generated by wealthy households was stored in Plastic bags. The bags which were either transparent of not transparent were always closed and the surrounding environment was kept clean with a audible level of hygiene and sanitation (plate 13).

Plate 13: Waste pre-collection by wealthy households

Source: KONGNYU CHIFU, 2024

Plate 15 reveals the nature of storage in high standing residencies. Transparent bags are used to store organic food residue meanwhile black plastic are mean to collect non-biodegradable plastic bottles. This type of pre-collection is eases the work of waste pickers and recyclers as segregated waste is devoid of impurities which can contaminate recycling machines and are easily handled as opposed to mixed waste. The streets and surrounding are cleaned by this hygienic practice of waste segregation.

4.8.2 Middle standing households

The nature of waste storage used by middle income households was found to be made up of certain degree of waste separation of materials. The materials that was used for storage included both open and closed bags and container storages (plate 14).

Plate 14: storage recipients used in middle standing residencies

Source: KONGNYU CHIFU, 2023-2024

Plate 14 presents the a middle standing household storage bag made up of a transparent biodegradable plastic with carefully selected dry recyclable plastic bottles, plastic wraps and paper waste (A). The (B) part of the plate shows a variety of storage recipients including HDPE container (blue arrow), cardboard (yellow arrow), LDPE bags (white arrow) and woven bamboo storage (black arrow). Plate 16 (C) shows a polyvinyl chloride plastic made carpet in front of middle class household and plastic bag and carton of burnt leaves.

4.8.3 Low standing households

Low standing households were found to mix all waste types in the same sorage recipient. Deficient sorting lead to unhygienic state of the surrounding characterised by overflowing bins (photo 21).

Photo 21: Storage recipient in a low standing household

Source: KONGNYU CHIFU, 2024

Photo 21 indicates bags of HDPE in which organic food materials (yellow arrow), plastic bags (red arrow), plastic bottle (black arrow) littering the storage surroundings. The unhygienic nature of the storage serve as habitat for mosquitoes, flies and rodents infestation in nearby households.

4.8.4 Nature of bins at Local storage sites

Some neighborhoods in the study area had an organized system of collection and storage where specific location was allocated to where waste materials generated from nearby inhabitants were transported for storage, waiting for collection itinerant waste truck or recyclable materials pickers (photo 21).

Photo 21: local transfer station

Source: Kongnyu Chifu, 2024

Photo 21 presents a local transfer station consisting of plastic bags recipient (A) into which is collected plastic bottles (blue arrow) while the black plastic contained food and other biodegradable materials. Styro foam (B) and a glass bottle (black arrow) was seen separately from the rest of the storage collection. What obtains from this transfer station is that materials are kept in sealed bags that prevented methane gases were emissions and avoided the loitering of rodents, flies and mosquitoes.

4.9 Waste related conflicts of interest

The absence of an active monitoring lead to implementation of waste regulatio associated to lack of discipline has resulted in quarrels among households. Report indicated that unscrupulous individual transported trash from their homes to discard them at the behind buildings of other households (photo 22). A local inhabitant stated that "*I collect my waste at home and when the storage is full, I make use of the public waste bin to discard it, but others transport their waste to dispose them into this stream even during the dry season with limited amount of rainfall, which brings mosquitoes into the households*" .

Photo 22: Waste litter in a stream

Source: KONGNGYU CHIFU, 2024

Photo 22 is an indication of in-civism by wanton disposal on a stream by other residents behind a household's building. This practice has been the source of many disputes and quarrels between the owner of the building at the edge of the stream and nearby household who argue "*we don't have access to para-public utility collection services and we have no other option but dispose it here*".

To avoid conflicts, some residents only discard their waste at night without witness. This explains why some waste piles often increase daily without anyone who is responsible. Informal waste bins are created without their initiators being known and usually start with one piece of waste usually (small empty biscuit packets or clothes) before becoming a large pile of garbage such as the one in photo 15.

4.10 Waste collection rate and coverage

The huge quantity and variety of waste materials generated require regular collection and sufficient public waste recipients. Many quarters were found to lacking proper public waste receptacles (PWR). Where waste bins existed, they were so few that they became overwhelmed with waste that littered the surroundings (photo 23). The collection coverage was insufficient and the waste remained in these PWR, uncollected by for several days and weeks. The collection rate of waste from PWR was found to be infrequent and irregular. This provoked residents to seek alternative practices including illegal-uncontrolled dumping and open burning.

Photo 23: overflowing waste bin

Source: KONGNYU CHIFU, 2024

Photo 23 is a presentation of a waste bin at Obobogo neighbourhood which have gone uncolllected for several days. The size of the waste bin is small and has a small waste containment capacity. Garbage bins/receptacles are very limited, hence, instead of segregation, garbage are simply mixed in a receptacle. The prove being shown as it was rapidly filled and over congested with saturated plastic cardboard and organic materials which littered its environment.

The rate at which waste materials ware collected influences the level of hygiene. Some quarters resort to informal dumping with artifical waste dumping which is source of social disamenity and morbidity (table 15).

Collection interval	Frequency	%
Once every 2 weeks	7	14%
Once a month	14	28%
Once in morethan one month	18	36%
No service	11	22%

Table 15: Collection interval of PWR

Source: KONGNYU CHIFU, 2024

Table 15 inicates that the waste bin were collected once every after two weeks by as revealed by 7 (14%). Some residents attested that waste was collected only once a month 14 (28%), while some confirmed they only had access to collection services only once in morethan a month 18 (22%). Eleven (22%) of the households inidcated no having received any colllection service.

Inhabitants without access to collection services of the ititnerant waste van indicated it was thanks to the services of the ititnerant waste pickers and private recycling structures who helped alleviate the sitution. The poor roaad network of some quarters made the area inaccessible as reported by th para-public public utility collection services (plate 15).

Plate 15: Inaccessible nature of the road

Source: VICAD, 2023

Plate 15 shows poor roadntework in the study area whereby the road has been completely obstructed with uncintrolled waste littering (blue arrow). The poorly libkked reoad network does not permit for proper passage and manoeuver of large collection trucks making the area to be unserviced.

4.11 Local materials segregation strategies

The variety of non-biodegradable solid materials was attached some valuae by individuals in the informal sector valuation. The most commonly valorised recyclables include ferrous and non-ferrous metals as well as rubber tyres, and PET plastic bottles.

4.11.1 Scrap metal recovery

Individuals were found to be involved in materials, sorting, recovery, transportation to recycling strcutures or washed and reused as shown in (plate 16) below. Indivduals are involved in material revovery do it informally and their services are used by local inhabitants who come to sell their metal scrap or used electronic materials. The high density plastic are reoverd frrom waste bins and households (plate 16).

Plate 16: Waste sorting by informal sector recyclers

Source: KONGNYU CHIFU, 2023-2024

Plate 16 reveals the process of waste sorting at scrap metal weighing point (A) in which was found plastic bag (yellow arrow) containing used HDPE packaging (red arrow), high density steel (blue arrow), metal construction wires (black arrow), and metal can (white arrow). Informal waste pickers tranported materials used wheeled barrows to transport recovered aluminium window frames (grren arrow) and metal wires (black arrow). These materials were reused or sold to reycling firms which generated some income for the inidividuals and served as source of intermediary employment.

4.11.2 Recovery of plastic bottles

The practice of collecting plastic bottles was found to be increasingly be on the rise in the study area. This was proven through the numerous collection points for recovered PET plastic bottles in bales of nets (photo 24).

Photo 24: Recovered plastic by Eco-Green

Source: KONGNYU CHIFU, 2023

Photo 24 presents the activity of plastic collection which was adopted by local residents and reycling structure. The bale of plastic was collected by indivivdual waste pickers who had been informed about the eonomic benefits inherent to this activity. A plastic waste worker while loading a bale plastic bottles on a truck was overheard saying "*You need to start collecting plastic bottles from households, as yo can see it generates money*". This is indicative of the importance attached to plastic waste valaution for reveue generation and jod creation.

4.11.2 Re-using to rubber tyres

The most common methods used to recover rubber tyres was its resuse as support in steep sloping paths and transforming them into rubber made flower pots which was illustrated in (plate 17) below.

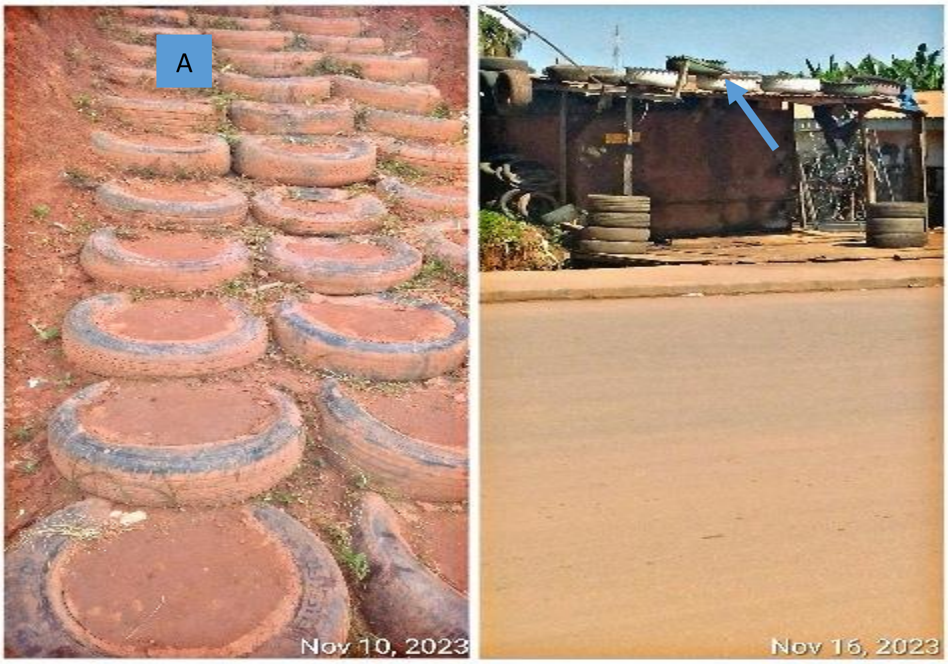


Plate 17: Valorisation of rubber tyres

Source: KONGNYU CHIFU, 2023

Plate 17 is an indication of the practice of the different methods used to attach value to rubber discarded tyre resource materials. Used tyres were design into beautiful flower pot (A) meanwhile recoverd damage tyres were sealed with washed, sealed with mastic and lined to be marketed for income generation. The tyres were used to improve the mobility in area with steep sloping footpaths which facilitated ascending and descending for residents (blue arrow).

4.12 Typology of non-biodegradable solid waste resources

A wide variety of Non-biodegradables solid waste resources was increasingly generated by households in the study area. These materials were made up of plastic, rubber, glass, non-ferrous metals as well as low and high carbon containing ferrous metals, health care risk waste, emerging waste such as nano-materials and particles paint and elctronical and electronic waste.

4.12.1 Plastic materials

The two major properties of plastics include thermosets that become permanently hard or solified when heated (bakelite, epoxies, phenoplast) and thermoplastic which softens when heated and harden when sooled and thus able to be moulded (high and low density polyethylene, polypropylene, polystyrene, and polyvinyl choride). Miscellaneous plastic materials inluding nylon, polycarbonate and acrylonitrile) constituted another type of plasstic waste materials (fig. 12).

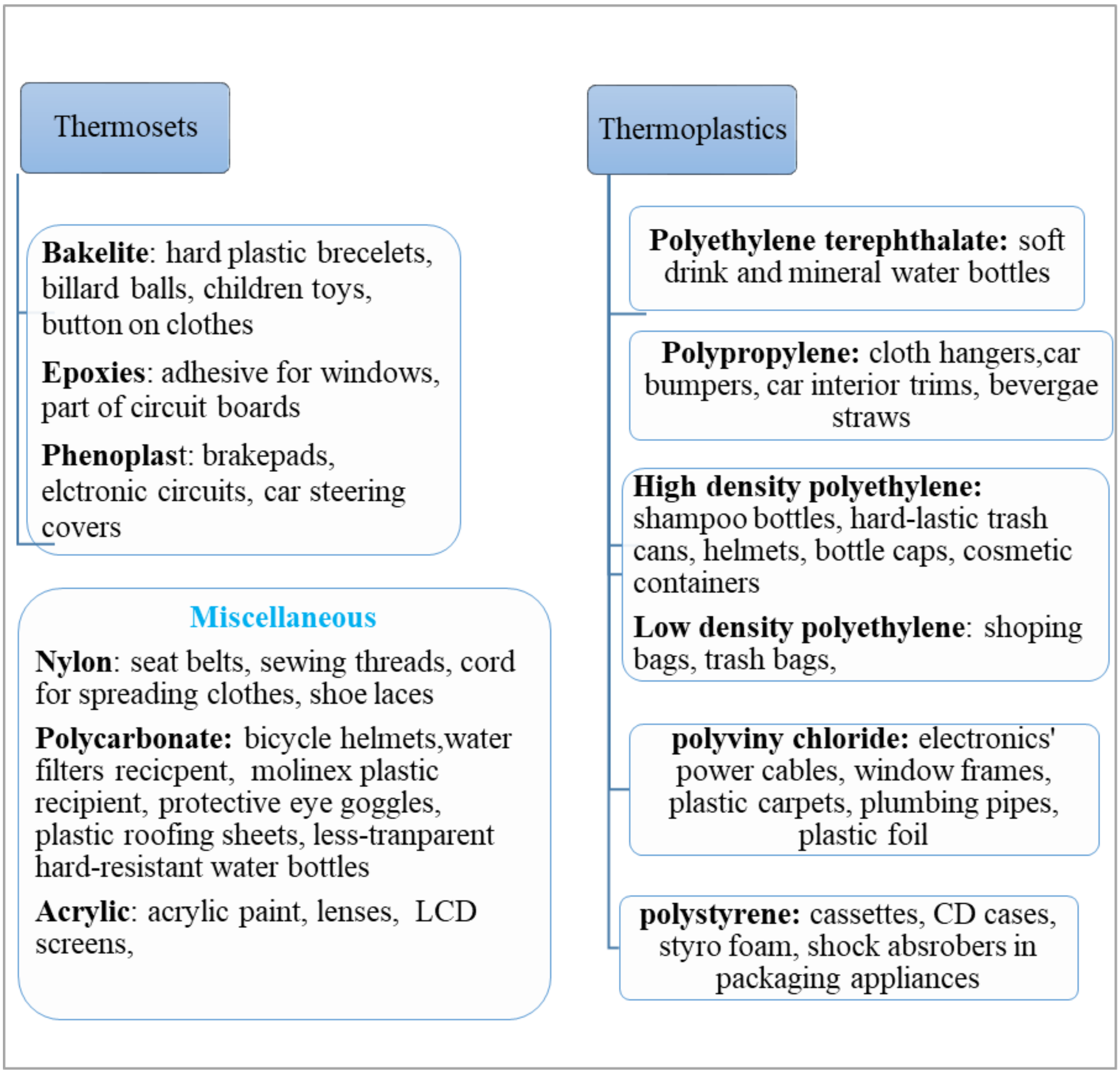


Figure 12: Categories of plastic waste

Source: International union of plastics classification (IUPAC), 2010; adapted by Kongnyu Chifu, 2024

The resin coded for plastics and their associated symnols was presented in (table 16) beow. The codes are the international recognised with their standard symbols symbols for the easy identification of seven classes of thermoplastic materials.

No.	Code	Symbol
1	Polyethylene terephthalate (PET)	01 PET
2	High-density polyethylene (HDPE)	02 PE-HD
3	Polyvinyl chloride (PVC)	03 PVC
4	Low density polyethylene	04 PE-LD
5	Polypropylene(PP)	05 PP
6	Polystyrene (PS)	06 PS
7	Miscellaneous	7 OTHER

Table 16: Resin codes and symbols for thermoplastic polymers

Source: IUPAC, 2010

4.12.2 Rubber waste materials

The main source of used and disposed of rubber waste were found to consist of vulcanised synthetic rubber tyres (photo 13: yellow arrow) from the automoative industry. Other domectic sources of rubber waste was found in textile cords, rubber shoes, rubber belts rubber gloves, rubber bans of used tapes, rubber pipes and elastic rubber bands.

4.12.3 Electronic waste materials

Electronics waste material were mostly found in a shattered state. Electronics such as tv sets were broken to extract the circuit boards after which their plastic casing and glass screens were irrationnaly disposed (plate 3A). Electronic waste materials in the study area included mostly batteries for remote control control composed of lithium, alkaline or nickel and those from small cell phones dispose after usage. Other openly disposed electronic and electrical equipment included used extensions and circuits (photo 25).

Photo 25: Elcteronic and electrical waste items

Source: Kongnyu Chifu, 2024

Photo 25 presents the types of e-waste generated inlcuding a circuit board (black arrow) and extsion with exposed sockets (blue arrow). The waste waste did not undergo an further treatment nor was it trasported to specialized facility and often ended up being openly incinerated or disposed in a mixed waste bin.

4.12.4 Glass watse materials

The inhabitants discarded glass materials mostly from used bottles into by either burning of dumping them uncontrollably. The bottles were used transparent or brown wine and whicky bottles (photo 6;black arrow).Other sources of glass materials included included used glass bulbs, shattered screen of from tv sets. Another type of glass waste was glass residue from glaziers loally termed "*glass man*" found at their jobsites as well as protective glass on smart phones termed "*android*" and smaller cell phones was a nother type of glass waste which was disposed after usage.

4.12.5 Composite waste materials

Waste composite were found among the huge uncontrolled waste dumps. The waste composites commonly kown as "tetra pak" originally in the form of a tetrahydron but now primarily in the form of a rectangular cuboid were made up of plasticized carton, internally lined with light aluminium plating (plate 2:black arrow).

4.12.6 Scrap metal waste materials

Scrap metal waste in the study area was mostly classified into ferrous and nonferrous metals. The ferous metal was further classified into low carbon, carbon and high carbon contaning metals (table 17).

Ferrous metals		**Non-ferous metals**
High carbon	**Low carbon**	Milk cans (Tin)
End of life vehicle parts	Metal wires	Roofing sheets (Zinc)
Door knobs and old bed frames	nails	Aluminium foil paper wrap
Stainless steel spoons, dishes	Copper wires	Alluminium door, window frames, rims of car wheels
Cast iron pots and pans		Beer and soda cans (Alluminium)
Magnets		Sardine cans (Alluminium)

Table 17: Typology of scrap metals in the study area

Source: Hubert, 2024; adapted by Kongnyu Chifu, 2024

4.12.7 Health care risk waste

Health care waste communually termed health care risk waste (HCRW) is another type of nonbiodegradable solid waste uncoverd in the study area. This waste was found dumped along side other on-biodegradable solid waste stream waste types in the quarters. Used health acre risk waste improperly discarded still contain chemical and biological residue which when spilled may impose health rsik to the local population and the surrounding environment (photo 26).

Photo 26: health care risk wastes

Source: Kongnyu, 2024

Photo 26 bring reveals various health care waste including a used syringe (light-blue), vials possibly containing medication or vaccine residue (white arrow), empty blister pack likely from medication tablets (yellow arrow), torn packaging that may have held medical supplies (red arrow), transparent plastic tube likely used for drip liquid medication (black arrow) and plastic bottles that like stored liquid medication (blue arrow) indicated by the presence of droplets.

This finding is supported by the World Health Organisation (WHO) reports that in Africa, infectious waste from health care activities is not adequately segregated, which increases the volume of infectious waste requiring special treatment and increases treatment costs. In the absence of proper treatment and safe disposal, this poses high risks to operators, the public, in particular children and other vulnerable groups, and the environment in general (WHO, 2010).

A common practice in many urban areas in Africa is the disposal of untreated HCRW along with MSW (OkotOkumu 2012). Health care risk waste is also illegally dumped in open areas owing to the lack of treatment infrastructure or lack of willingness to pay for safe treatment and disposal (Stinger 2011, Nwachukwu et al. 2013, Hangulu and Akintola 2017).

Poor HCRW management practices, including inappropriate or insufficient treatment technology, mean that untreated health care waste is often dumped in uncontrolled dumpsites, active with informal waste pickers. Health care risk waste is also illegally dumped in open areas owing to the lack of treatment infrastructure or lack of willingness to pay for safe treatment and disposal (Stinger 2011, Nwachukwu et al. 2013, Hangulu and Akintola 2017). HCRW management is of particular importance because of the dire and widespread impacts it can have if not managed properly.

The lack of sanitary landfills had led to the increased use of incinerators for HCRW. While it is estimated that there are more than 1,000 incinerators in Africa, many are reported to be inoperative or operating below standards. Some hospitals have re-built their incinerators a number of times owing to frequent break downs (Harhay et al. 2009, United Nations Developmental Program, 2009). The environmental and health impacts of improper incineration may cause irreparable damage. In 2005, the World Health organisation reported that incineration or the incineration of unsuitable materials, results in the release of persistent pollutants into the air, including dioxins and furans, which are human carcinogens with a wide range of adverse health effects.

4.12.8 Nano-materials and nano-particles

Nanotechnology is widely used in large and diverse industries that include computers, cellular phones, cosmetics, textiles and medicines. In many African countries, however, nano-materials and nano-particles are being disposed of together with conventional muncipal solid waste without any special segregation, precautions or treatment, despite inherent risks. While this may be owing to lack of awareness by communities and authorities, it raises the question of whether current waste treatment and disposal technology is appropriate for dealing with these waste streams, and what impacts these nano- and micro-wastes may have on human health and receiving environments during and/or after treatment (Organisation for

Economic Development and corperation, 2016). Failing to address nano-waste as a special constituent of the waste stream may have significantly adverse repercussions on human health and environment. There is a pressing need to raise awareness on these emerging waste streams, particularly in African countries that are often ill-equipped to deal with such wastes, as well as to introduce the infrastructure needed to identify and segregate nano- and micro-waste and provide the necessary training to mitigate and manage related risks

4.13 Controlled treatment of hazardous waste

Waste sources including mercury bulbs, battery waste are considered as inert waste which resuire specialized handling and recycling to mitigate human and environmenta risks. These inert or hazardous materials were found to be treated by association, "Solidarité Technologique" under monitoring and controlled conditions in specialised facilities.

4.13.1 Transformation of mercury containing bulbs

Mercury is a dangerous global pollutant used in a variety of human activities. Considered by the WHO to be of extreme concern to public health, mercury has toxic effects on the nervous, digestive and immune systems, lungs, kidneys, skin and eyes.

In order to reduce mercury pollution on a global scale, the Minamata Convention was adopted. The State of Cameroon, resolutely committed to the fight against pollution, signed the said Convention on 24 December 2014 in New York. This accession was confirmed by the ratification on 18 December 2018 by the Head of State following Law N°2018/017. The Minamata Convention obliges States Parties to take a set of measures, with the objective of eliminating mercury-containing products as well as mercury waste. According to WHO, among the 7 main products that contain mercury, 3 of them are listed in the category of electrical and electronic waste equipment including batteries, switches and relays inequipments as well as discharge lamps.

The three categories of lamps that contain mercury include straight fluorescent lamps (tubes), compact fluorescent lamps and High intensity discharge lamps. An indication of mercury containing bulbs could either be the "Hg" symbol on the bulb or the words "contains mercury" on the packaging or manual 'Solidarite technologique, 2022). It was noted that When these types of tubes or bulbs break, the mercury could be released, contaminating the environment and endangering the health of the user (Solidarite Technologique, 2022). The transformation process for mercury bulbs at the recycling plant was presented in (photo 27) below.

Photo 27: Treatment of mercury containing fluorescent lamps

Source: Solidarité Technologique, 2012; adapted by Kongnyu Chifu, 2024

Photo 19 indicates the worker with protective equipment (red arrow) handling a long tube (black arrow) into a fluorescent lamp crusher machinery (yellow arrow) used in the process of treating straight fluorescent mercury containing lamps in a cardboard (blue arrow) at the "Association Solidarité Technologique". The association worked in partnership with MINEPDED, and the Yaoundé City Council and were able to set up a line for shredding fluorescent tubes with a sulphur activated carbon filtration system. The workers reported that "*The mercury and glass silica dust, which is highly toxic to humans and the environment, is captured and filtered. The operator works in complete safety, without being exposed to mercury vapours and glass silica dust*".

4.13.2 Processing batteries and accumulators

According to figures from the General Association of Municipal Hygienists and Technicians (AGHTM) and the Organisation for Economic Co-operation and Development (OECD), each person uses an average of twelve batteries per year. These batteries and accumulators are used by households and professionals. Most of them contain substances that are hazardous to human health and the environment.

The nature of the waste depends on the compounds it contains: saline, alkaline, zinc, lithium, nickel/cadmium, lead and mercury which are compounds constituting a real danger for the environment. The company "Garage Marine Cameroon, GMC Sarl" practices industrial waste incineration with gas treatment to international standards. The waste is broken up, crushed and transferred to the incineration unit. During the incineration process, the various emission standards are monitored with a "*KIGAZ 700"* gas analyser for Carbon Monoxide (CO), Nitrogen Oxide (NOX), Sulphur Dioxide (SO_2), Carbon Dioxide (CO_2) and Oxygen (O_2) to control the quality of the gases emitted from the incineration process. The process of transforming batteries into less harmful residue under controlled incineration was shown below (photo 28).

Photo 28: Controlled Incineration of battery waste

Source: Solidarité Technologique, 2022

Photo 28 indicates depicts the process of controlled incineration of batteries and accumulators at Garage Marine Cameroon. This photo presents putting of battery shreds in incinerator (1), incineration of shredded materials (2) and residue from incineration (3).

4.13.3 Conditions for recycling electrical and electronic waste

In Cameroon, the problem of financing the treatment of these appliances, originally new or second-hand, remains. As of the year 2012, there was a law that in theory obligated any importer (with little or no local production) of electronic equipment to contract with a company authorised by the Ministry of the Environment for the collection and treatment of electronics and electrical materials, for each equipment that was to be imported. In reality, this competitive market for certificates was not reserved for active companies. The cost of this certificate was artificial and did not for instance, generate any income for an operational structure such as Solidarité Technologique. The resolution of such aberrations should have to been primarily legislative or regulatory (Solidarité Technologique, 2022).

Considering the role of the informal sector or locally termed "*attackers*", and the collection ecosystem two dimensions of the activity by the informal sector were highlighted.

Firstly, in terms of collection, the network of attackers was clearly a very effective organisational scheme for the upstream collection of household waste, with all the advantages associated with capturing the household deposit at source. It was proposed that the collection service should and could be implemented under the conditions that the electronic and electrical materials intact. Secondly, as for dismantling, this activity should be purely and simply prohibited and reserved for authorised operators according to Solidarité Technologique, 2022.

Regarding the financing of these activities, it was clear that, wherever respect for environmental commitments is required, the market for recoverable fractions cannot cover all the costs associated with the collection, dismantling and treatment of fractions. An eco-tax system was proposed be put in place and make operational the logic of taxing importers (or manufacturers) in Cameroon (Solidarité Technologique, 2022). An apercu of the varieties of electrical equipment was shown in (photo 29) below.

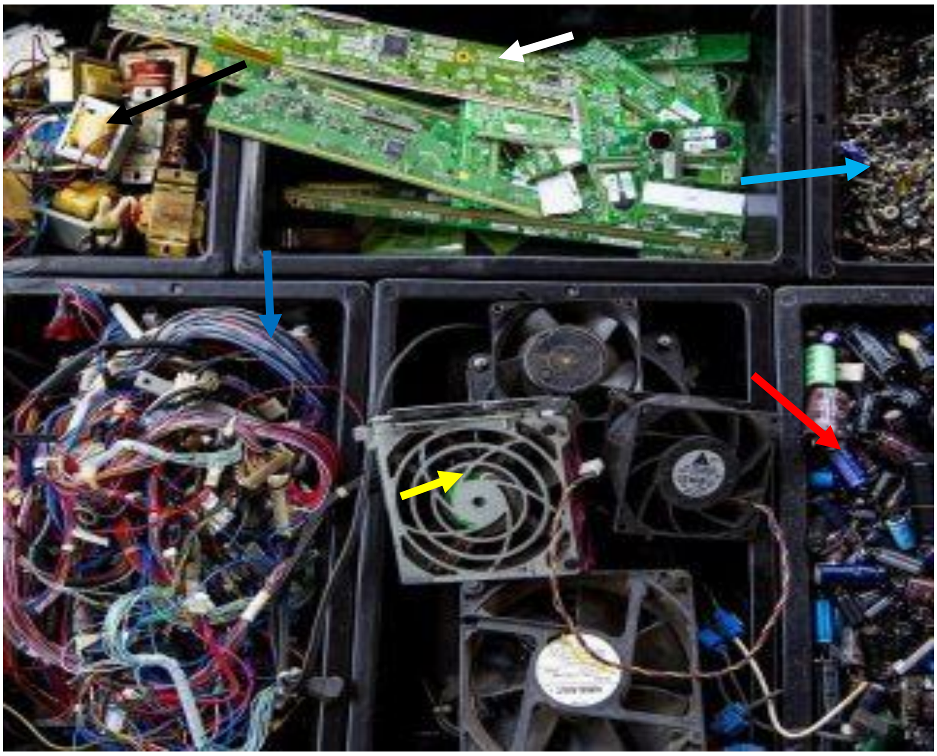


Photo 29: Recovered e-waste sample fraction

Source: Solidarité Technologique, 2022 ; adapted by Kongnyu Chifu, 2024

Photo 29 shows sampled fractions of e-waste including a recovered circuit board (white arrow), coloured wires bundled together (blue arrow), cooling fans (yellow arrow), capacitators and resistors (red arrow), electrochemical switches (relay) (green arrow) and light emitting diodes (light-blue-arrow).

4.13.1 Recycling used electronics

The actions of the young association Low Tech Lab Yaoundé was supported by Solidarité Technologique, which provided it with access to certain components from end-of-life e-waste equipment. The Low-Tech Lab associatin then used them to manufacture simple, inexpensive technologies that are accessible to all and easily repairable. Photo 29 brings to limelight the recycling of scrap electronic for producing street lights.

Plate 18: Producing street lights from electronic waste recyclables

Source: Solidarité Technologique, 2022, adapted by Kongnyu Chifu, 2023

Plate 18 presents the reuse of batteries (yellow arrow), solar panel (blue arrow), a pipe (red arrow) to production process of street solar lamps and an illuminated bulb . These recycling actions provided solar street lamps to poorly lit neighbourhoods or rural areas throughout Cameroon. This remarkable innovation that we encouraged, as it reduces the amount of electronic waste produced and encourages waste reuse (Solidarité Technologique, 2012).

4.14 Discarded paint

Used water based paints was another type of hazardous waste found to be unsanitarily discarded in an environmentally unsafe nature. The waste which is residual of painting works was disposed of in open storage bins (photo 30).

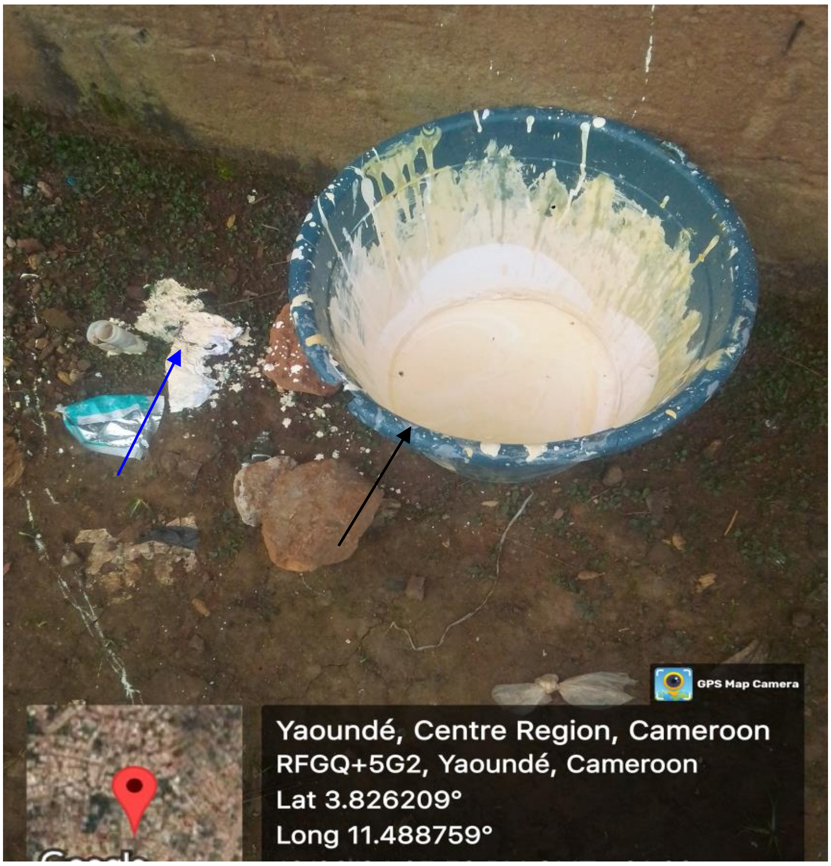


Photo 30: Disposed water-based paint

Source: Kongnyu Chifu, 2024

Photo 30 presents a buvket of used water based paint (black arrow) that was spilled on the ground (blue arrow). This exposure of paints to open air which causes solidification as observed on the soild imposes an impending risk to plants, animal life as well as microorganisms as the paint is classified as hazardous waste and therefore do not undergo biodegradation.

4.15 Waste management financing and urban laws

Decentralisation as a process of transferring competencies from the state to the local authorities is still at improving the frequency of waste removal and the standard of living of households. The decnetralisation policy is aimed at granting greater autonomy to public authrorities vis-à-vis the central government. The potential financial problems of this policy especially with regard to household waste management in the study area.

The household waste management sector suffers from serius lack of funding. As of 2021, the Minisry of Finance has allocated XAF 1,170,793,000 of the Cameroonian state budget while Yaounde city councils contributes about 1billion per year. But with the increasing demographic pressure and exponential urbanisation, this is largely insufficient to cover households management. To this, the need for more funding for household waste management was justified by low level financial contribution in the fae of growing waste generation of about 0.5 and 0.8 kg/day with an average of 0.62 per day (Salifou Ndam et al., 2023).

4.15.1 Complex legal instruments

The absence of a specific urban law governing non-biodegradable solid waste management corroborated by findings according to Ngnikam, Tanawa and Boukar (2016) who believe that Yaounde city council areas lack specific appropriate legal frameworks for household wase management.

Law No 96/12 of August 5, 1996 regarding the environmental management framework considers the "*polluter pays prinicple*" in Article 9. This provisions have not yet being enforced due to the absence of enforcement ordinances compelling polluters to pay for taxes related to their negative environmental impacts. Some of these laws are over 30 years old and further delays the relaunch of acivities, institutional and technical reorganisation. Without decrees enforcing the afforementioned laws, their real applications are limited regardless of the laws themselve (Salifou Ndam et al., 2023). Moreover, a Yaounde city council executive stated that "*some texts suffer from the lack of their application for instance, the polluter-pays principle, which is not very often respected and whose elaborated sanctions are not applied*".

Considering the role of the Yaounde III city council responsible for enforcing hygienic measures, sanitation, raising awareness among the local populations and collecting direct tax from households for waste removal, the lack of strictness and rigour in implementation these responsibilities was observed as shown on (plate 8B). The city council seems excessively indulgent, relaxed in the face of deviant practices of illegal dumping by the local populations. This indulgence on the part of the council authroirities was illustrated by "*Article R367, 369 and R370"* of the penal code which provide for a penalty fee ranging between XAF 200 to 3600 for anyone who contravenes legal decisions relating to household waste management such as illegally dumping waste in streets, waterways, open dump sites in neighbourhoods or openly incinerating waste (Salifou Ndam et al., 2023).

The behaviour of the city dwellers explain the level of application of waste management regulations. The interactions that individuals have with their living environment is equally dependent ont the standards imposed on them and the way they perceive, evaluate and represent the environment in which they live (interview with Nkodo, V; Coordinator of Coeur d'Afrique Fondation Roger Milla, CAFROMI, 2022) by (Ndam Salifou et al., 2023).

The failure to collect of delays in waste collection around domestic and commercial premises was explained by the frequent delays in apyment to the private companies in charge of waste collection and the lack o a budget to acquire the necessary equipment. Being constantly under budgetary pressure, the citys the city council authorites struggle to regularly remove waste and to effectively fight against the illegal waste dumps that multiplied in the Yaounde III council area. An anonymous interviewee stated that, "*The consequence of irregular waste removal was that waste from markets, industries, schools, and administration mixes in PWR and increases the financial burden on the council authorities*". To this, the lack of practical implementation of the orientation law on decentralization constitutes a signifacant sustainable development challenge in the study area (interview with Kayap, S; Deputy Head of the Hygiene and Sanitation Department of the Yaounde city council, 2022) by (Ndam et al., 2023).

As of the month of Spetember, 2022,The Yaounde city council distributed 35000 garbage to the local populations to fight figh against insalubrity in Yaounde. The sustainability of such actions was not guranteed due to the lack of organisation and corruption in various forms (Belomo Mvondo, 2014).

4.16 Waste superstitious beliefs

Socio-anthropological logic equally constitutes an explanatory parameter of the opaque household waste management in the study area. Analysis of social representations and different modes of waste treatment in West Africa reveals an ambigous relationship between societies and the waste they produce (Guitard Watelet, 2007). The analysis pointed out that the meaning individuals give to waste according to time and society particularly varies according to ecological material,economic, political context but equally acccording to social conditions, cultural and religious conceptions.

Some inbabitants believe that the observed piles of waste in public areas are the refuge of supernatural forces and sites of occult practices. Other residents believe that were interviewed also mentioned the place of ritual practices in maintaining and producing waste in the streets. HYSACAM officials explains the "identity logics and complex practices of the populations in waste management constitute a reality of the city. This finding is supported by researchers including Diabaté, Ngnikal and Tanawa who eblieve that withcraft has taken on unprecedented forms in contemporary africa in the waste management arena including child witches and ritual crimes.

Conclusion

The strategies for adapting to non-valuation of non-biodegradable solid waste include the setting up of waste actions such as the ‘Operation punch, Yaounde without waste’ meant to deep clean the city through dredging of drainage canals, involvement of the quarter heads at the pre-collection stage and remobilising waste collection services of HYSACAM an well as THYCHLOF, and the national clean city contest by MINDHU. Added to these are the existing regulation governing waste management waste such as the 2012 prime ministerial decree and 2014 ban on plastic waste was resulted in mitigated success as these policies lacked active enforcement, as sustained implementation, and equally due the absence of waste valuation plan waste recycling added to the lack of discipline from the local inhabitants, lack of segregation and absence of storage centers. The informal material recycling sector which who supported waste collection and sorting was challenged with lack of adequate infrastructure and PPE in carrying of this activity. Waste sorting and recycling was equally carried out by identified private NGOs in collaboration with informal waste pickers.

GENERAL CONCLUSION

❖ SUMMARY OF MAIN FINDINGS AND PROPOSITIONS

➢ Presentation and analysis of the results

This research work was carried out to inquire on the repercussions of repercussions of not adding value to plastic, metal, glass, rubber and electronic waste within the Yaounde III council area. The study was guided by three specific research questions, objective and three hypotheses.

The first specific research objectives were conceived to assess the environmental impacts of non-valuation of waste as an environmental resource. The second specific research objective was meant to investigate the ramifications of non-valuation of waste as a social resource on social life. The third specific research objective was crafted to evaluate the influence of non-valuation of waste as an economic resource on economic wellbeing of local inhabitants.

Chapter 1 focused on the environmental sustainability challenges inherent o non-valuation for environmental conservation. Chapter two dwelled on the societal challenges associated to not attaching value to waste as a social resource. Chapter three laid emphases on the economic losses concurrent to deficient valuating waste recyclable materials as an economic resource.

The methodology consisted of using the hypothetic-deductive approach to est the hypotheses. Data processing which responses from respondents to the questionnaire was interpreted by way of descriptive statistics. Out of the 75 households, 50 were able to effectively respond to the questionnaire giving a 60% response rate.

Research hypothesis 1: The non-valorisation of non-biodegradable solid plastic bottles, polyethylene bags, metals, electronic and used rubber waste recyclable impact the environment of Yaounde III council area.

Findings revealed that non-valuation characterised by heaps and varieties of non-biodegradable solid waste material showed to impact the environmental sustainability challenges in which all respondents (100%) said soil deterioration was the leading effect of uncontrolled disposal, followed by pollution of water resources (78%) and (42%) of respondents experience weather extremes (table 12). As of April 2024, the city of Yaounde in general had being experiencing scarcity of precipitation. This was accompanied by alternating heat in the dry season and cold extreme during the rainy season (ONACC, 2023).

Soil contamination resulted in the mineral deficiency for crops (Frank keith, 2002). Soils in Yaounde were at a high risk of pollution about 6% according to Celestin, 2015.

Finding according to Jean blaise, 2023 showed that 70of water bodies were polluted in the city of Yaounde.Water pollution as a result of open burning polluted surface water such as river Biyeme (fig). Water pollution enhances algae multiplication through eutrophication of water body. The decomposition of algae in large numbers depletes oxygen which can put the live of aquatic organism at risk of suffocation (Enchaw, 2023).

Contaminants from leachate sip into underground water through loose ferralitic soil matrix which could engender increased the risk on the environment-health nexus.

Atmospheric pollution from incineration emits green-house gases such as ethylene oxide, polycyclic organic matter, volatile organic compounds, oxides of carbon, nitrogen, sulphur having lasting effects ranging from days, weeks, months and years on local regional and global climates. These gaseous emissions contribute to global warming of earths troposphere resulting in stunted plant growth seasonal anomalies, temperature and precipitation anomalies (UNEP, 2015).

The uncontrolled waste dumping had negative impact on avifauna. The number of mature individuals in the population of the specie *Ploceus bannermani* (weaver bird) native to Cameroon, were declining according to Bird Life international and IUCN, 2016.

Research hypotheses 2: The non-valuation of non-biodegradable solid plastic bottles, rubber tires, electronic and metal waste recyclable affect the society of Yaoundé III council area.

Finding showed that open burning resulted in the health issues. Non-contact diseases such respiratory health challenges including coughs, influenza, rhinitis occurred due to the inhalation of toxic fumes during incineration. The major emissions included which included Nitrogen oxide, sulphur dioxide and particulate matter 2.5 endangered the health of vulnerable individuals including the old age persons, expectant mothers and infants (MINEPDED, 2023).

The above table indicated that

Contact health concerns due to proliferation of mosquitoes, rodents, roaches and flies 78% of the respondents duelled with recurrent contact diseases (malaria and typhoid fever) mean while respondents that faced non-contact illnesses (respiratory infections) were about 48% (table 12). A survey at Saint Simon health center revealed that out of 169 patients received between February and July, 2024, 85 (51.8%) of the patients were diagnosed with malaria and typhoid infections among which 69 (81%) were chronic cases meanwhile 16 (18%) cases were mild.

The uncontrolled disposal of glass waste and other burning waste material increased the risk of injury to children playing around these sites. Injury such as serious burns and death which may occur in severe cases as an effect of open incineration garbage Nivedha, 2022).

Low agricultural output for maize plant, a staple food and cash crop was shown to be associated to uncontrolled land disposal of waste on farmlands for several years. Dispose and burnt waste materials on farmland alter soil chemistry including soil PH, affected the activity soil bacteria affecting nutrient cycles (Nkeng, 2019). The low production of maize was attributed to bushfires as reported from (Le Messager, 2024). The loss of arable land to waste dump land induced limited access to land resulting in low agricultural output according to experts as reported by (Cameroon tribune, 2024). Reduced production negatively affected food security as a result.

Research hypotheses 3: The non-valuation of non-biodegradable solid plastic bottles, rubber tires, electronic and metal waste recyclable influence the economy of Yaoundé III council area.

Finding indicated that Non-valuation led to limited sustainable innovation as there was no upcycling of material recyclables into products of higher quality and greater functionality.

Added to this was the missed economic opportunities to create jobs that could be used for revenue generation. Missed opportunity alleviate absolute poverty through improvement of waste workers working conditions and get higher paid jobs. Another missed opportunity was the absence of enterprise development marked by the absence of an enterprise economy to develop waste recyclable material as an economic resource. The diminished of entrepreneurship by residents to recycle and refurbish waste into valuable products for economic wellbeing.

- **Perspectives and policy implications of the study**

Mediating causes of non-valuation included the absence of enforcing waste regulation, absence of a recycling policy in the management action plan. The non-participatory management strategy through supervision of traditional authorities was found to led to absence of segregation and as a result non-valuation.

Intermediate factors that caused non-valuation which resulted in in environmental ad socio-economic effects included; the lack of discipline from characterised by uncontrolled artificial dumpsites associated to absence of proper segregation at pre-collection, and sorting during collection by itinerant waste truck. This rendered the activity of informal recyclers difficult which resulted in retarding waste separation as well as contamination of recycling machines with foreign contaminants from mixed waste.

Intervening factors such as the lack of discipline and absence of material separation was deficiency of adequate infrastructure. This was perceived by inaudible nature of storage sites and lack of personal protective equipment for informal waste recyclers that increased the risk to biological chemical and physical threats including viral hepatitis, cholera, and musculo-skeletal injuries.

The present finding concurs with findings of an empirical study in the town of Kekem (Nkeuh, 2022), where household waste management system was insufficient for most of the households surveyed, as no recycling or recovery system or even a technical landfill centre has been set up. Dumping went rampant in drainages, waterways, or on the side of the road, and some resort to incineration to get rid of waste. As the sanitation systems were rudimentary, the image of the city was being disfigured; the environment was degraded by atmospheric pollution and the health of the population was also degraded by the proliferation of flies and rodents, which are real vectors of diseases such as malaria, typhoid fever, diarrhoea, amoebiasis, and skin diseases (scabies). It was showed that domestic waste was a secondary material containing limitless potentials. This waste could be valorised, recycled and reused. Valorisation could take the form of energy recovery (biogas production), artistic production (plastic recycling) or biological (composting).

➢ Recommendations

To the households

- Practice waste separation of dry recyclable material and food waste into separate waste bins. This eases the work by itinerant collection waste and informal waste pickers who can access source separated waste with ease.

To para-public collection services

There is need for more durable and taller covered PWR to prevent stray animals from scavenging on waste. The receptacles need to be colour-coded and labelled with clear rules on the collection schedule for biodegradable and non-biodegradable solid waste. Furthermore, there need to augment existing garbage trucks that are colour-coded for biodegradable and NBSW collection.

To the Council

- Regular organise sensitization campaign that create awareness through active collaboration among the households, waste pickers, NGOs and par-public collection services emphasising on non-biodegradable solid waste segregation, sorting, recycling and upcycling. Regular inspection and monitoring should be carried to households and business premises. This is important in order to ensure compliance and make projection on the seriousness of proper waste management and valuation efforts.
- Transport sorted materials to construct waste warehouses with different compartments for handling various recyclables. The waste should be transformed into pellets to be sold to companies which recycle them. Metal scrap can be assembled to produce indigenous products including carriage vehicles which can be commercialised to generated revenue. Non-reusable Electronic waste and plastic bags should be controllably incinerated by specialists. The recovered used electronic waste can be repaired and refurbished to be sold to the public. Recovered glass waste should be cleaned and sold to SOFAVINC and local markets to businesses which require this material for packaging. Can containers should be washed and sold to brewery industries who need them for packaging.
- Research on automated sorting systems that separates solid food waste from dry non-biodegradable recyclable in the waste management action plan. Research needs to be conducted on acquiring and investing on technologies including automated waste segregation machines that reduce health issues and the operation difficulties associated with manual sorting.
- Creatively design merit based system and formally institutional a community program aimed at recognizing households and business establishments with excellent record of compliance to waste valorisation.
- Concert on the rate of fines to be imposed on defaulters of proper waste disposal methods. What constitutes as a reasonable rate should be carefully determined through a participatory process.

To the ministerial department and policy regulators

- Ensure active participation of all actors and stakeholders in the waste valorisation arena including chiefs, quarter heads as well as business premises, educational and religious institutions.
- Adopt bottom-top approach to materials management in which the households practice compulsory segregation and para-public collection services segregate waste for further transformation.

➢ **Propositions for further research**

Further research within the framework of solid non-biodegradable solid waste is proposed on investigating the environmental sustainability challenges and recycling of tied to poor disposal of paint. Epoxy, acrylic and oil based paints and painting material which are often discarded into the environment after usage gets washed moves along soil matrix and water sources and dries up which result in significant ecological issues. Added to this are the beneficial opportunities of valorising such a waste needs further research.

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APPENDICES

➢ **<u>Appendix 1:</u> Research Attestation**

UNIVERSITE DE YAOUNDE I
UNIVERSITY OF YAOUNDE I

FACULTE DES ARTS, LETTRES ET SCIENCES HUMAINES

DEPARTEMENT DE GEOGRAPHIE
B.P 755 Yaoundé
Tél. 22 22 24 05

FACULTY OF ARTS, LETTERS AND SOCIAL SCIENCES

DEPARTMENT OF GEOGRAPHY
P.O BOX 755 Yaoundé
Tel. 22 22 24 05

ATTESTATION DE RECHERCHE

Je soussigné, **Pr. PAUL TCHAWA**

Chef du Département de Géographie, atteste que

Monsieur : **KONGNYU CHIFU MBAH**

Matricule : 18C118

Est inscrit(e) au cycle de : **MASTER** **(2022-2023)**
Spécialité : Marginalité, Stratégie de Développement et Mondialisation.

Et prépare une thèse sur le sujet : **ENVIRONMENTAL AND SOCIO-ECONOMIC IMPLICATIONS OF NON-BIODEGRADABLE SOLID WASTE IN YAOUNDE III URBAN COUNCIL.**

A cet égard, je prie toutes les personnes ressources et tous les organismes sollicités de lui réserver un bon accueil et de lui apporter toute l'aide nécessaire à la réussite de cette recherche dont la contribution à l'appui au développement ne fait pas de doute.

Fait à Yaoundé le 16 MAI 2023

LE CHEF DE DEPARTEMENT

Clement Anguh Nkwemoh
Associate Professor (M.C)
University of Yaoundé I

- **<u>Appendix 2</u>: RESEARCH QUESTIONNAIRE: SURVEY AT RESIDENCIES WITHIN YAOUNDÉ 3 COUNCIL AREA**

The current questionnaire is administered based on the requirements for geographic research entitled "environmental and socio-economic implications of non-biodegradable solid waste valuation in council area". Data collected will be used within the educational research only.

Please answer honestly to the different questions. Moreover, we assure you that all information collected here shall be treated in a strictly confidential manner.

Identification of Respondent

Q1	Gender: 1=Male 2=Female
Q2	What is the standing of your residence 1- high standing 2- average standing low standing
Q4	Economic activity: 1=Small businesses 2=employee 3=unemployed

Section A: The link between illegal dumping, open dumping and water pollution, air pollution and soil degradation

(1) How do you store your generated waste
a. collectively store in mixed bin b. segregate into dry and wet solid waste
(2) How does the non-valorisation of NBSW affect the environment?
a. Soil contamination b. Atmopheric pollution c. Water pollution
(3) How are you affected by the atmospheric pollution?
a= Extreme weather through temperature and rainfall anomalies b. flooding after heavy rainfall c.
(4) How does soil pollution affect your environment?
a= lower biodiversity of avifauna b. soil degradation c. surface water pollution
(5) To what extent is water pollution affecting environmental sustainability?
a. algal bloom cause suffocation of aquatic life b. eutrophication of water bodies

Section B: To investigate whether waste management services failed not incorporate valorisation system (source separation, frequent collection, inclusion of indigenous institutions) so as to reduce public health risks, and disfiguration of the social environment within the Yaoundé III council area.

(1) How does the itinerant truck collect your waste?
a. mixed collection b. sorts waste into recyclable and food waste during collection
(2) What is the level of monitoring at disposal sites?
a. Absolute b. relative c. absent
(3) How does non-valuation affect social wellbeing?
a. plastic aggravated flooding b. diseases c. bad odours d. loss of arable land e. lowers agricultural productivity
(4) What are the main disease of non-
a. malaria b. typhoid c. respiratory illnesses

(5) What are the most common respiratory illnesses
a. influenza b. cough c. rhinitis d. sinuses
(6) What are the main parasitic organism of non-valuation
a. flies b. rodents c. mosquitoes d. roaches

Section C: To investigate the influence of non-valuation of non-biodegradable solid waste on the economic wellbeing inhabitants within Yaoundé III.

(1) How does non-valuation influence the economic welleing?
a. diminishing entrepreneurship b. reduced sustainable innovation c. absence of entreprise economy
(2) what are the valorization infrastructure available?
a. recycling plant b. transfer stations c. covered and separate public waste bins d. dry materials and food waste separate collection-truck
(3) how far do you practice reduce reuse and recycle?
a. £Regular b. rarely c. never
(4) what institutions are involved in waste collection?
a. local chiefs b. quarter heads c. chef de bloc

Appendix 3:

DECREE N°2012/2809/PM OF SEPTEMBER 26, 2012 SETTING THE CONDITIONS FOR SORTING, COLLECTION, TRANSPORT, RECOVERY, RECYCLING, TREATMENT AND FINAL DISPOSAL OF WASTE

J? THE PRIME MINISTER, HEAD OF GOVERNMENT,

Mindful of the Constitution;

Mindful of law n°89/027 of December 29, 1989 relating to toxic and dangerous waste;

Mindful of law n°94/01 of January 20, 1994 governing forests, wildlife and fishing;

Mindful of law n°96/03 of January 4, 1996 relating to the framework law in the field of health;

Mindful of law n°96/12 of August 5, 1996 relating to the framework law relating to environmental management; Considering law n°96/117 of August 5, 1996 relating to standardization;

Mindful to law n°98/005 of April 14, 1998 relating to the water regime; Considering law n°98/015 of July 14, 1998 relating to establishments classified as dangerous, unhealthy or inconvenient;

Mindful of law n°2001/015 of July 23, 2001 governing the activity of the carrier router and transport auxiliary router; Considering law n°2003/003 of April 21, 2003 relating to phytosanitary protection;

Mindful of law n°2004/018 of July 22, 2004 setting the rules applicable to municipalities;

Mindful of framework law n°2011/012 of May 6, 2011 on consumer protection in Cameroon;

Mindful of Decree No. 92/89 of May 4, 1992 specifying the powers of the Prime Minister, modified and supplemented by Decree No. 95/145-bis of August 4, 1995;

Mindful of Decree No. 2011/408 of December 9, 2011 on the organization of the Government;

Mindful of Decree No. 2011/409 of December 9, 2011 appointing a Prime Minister, Head of government.

HEREBY DECREEDS AS FOLLOWS:

General provisions

Article 1

This decree sets out the conditions for sorting, collection, storage, transport, recovery, recycling, treatment and final disposal of waste.

For the purposes of this decree, the following definitions are:

Waste collection:

Any act of organized waste collection by any natural or legal person authorized for this purpose;

Controlled discharge:

Installation or site, meeting the regulatory characteristics and technical requirements where the waste is treated and permanently buried;

Final waste:

Any non-biodegradable and non-recoverable residue resulting from waste treated according to current technical and economic conditions;

Agricultural waste:

Any waste generated directly by agro-pastoral activities;

Waste assimilated to household waste:

Any waste originating from economic, commercial and artistic activities and which by its nature, composition and characteristics is similar to household waste;

Biodegradable waste:

Any waste that may undergo decomposition under the action of fungi and microorganisms present in the environment;

Industrial waste:

Any waste resulting from an industrial, agro-industrial, arts and crafts activity or a similar activity;

Inert waste:

Any non-flammable and non-biodegradable waste which does not produce a physical or chemical reaction and does not contain dangerous substances or elements generating

Medical and pharmaceutical waste:

Any waste resulting from diagnostic, monitoring and preventive, palliative or curative treatment activities in the fields of human or veterinary medicine and all waste resulting from the activities of public hospitals, clinics, scientific research establishments, analytical laboratories operating in these fields and all similar establishments;

Household waste:

Any waste from household activities;

Toxic and/or dangerous waste:

Any form of waste, which by its dangerous, toxic, reactive, corrosive, explosive, radioactive, flammable, biological or bacterial nature, constitutes a danger for humans and the ecological balance;

Final waste disposal:

Any incineration, treatment, controlled landfill or any similar process allowing waste to be stored or disposed of in accordance with conditions ensuring the prevention of risks to human health and the protection of the environment;

Exportation of waste:

Disposal of waste from the national territory to another country and subject to national and international laws and regulations in this matter;

Waste generators:

Any natural or legal person whose production, distribution, import or exploitation activity generates waste; Any natural or legal person whose production, distribution, import or exploitation activity generates waste;

Importation of waste:

Entry of waste from abroad or from free zones into the national territory subject to national and international laws and regulations in this area;

Trans-boundary movement of waste:

Any movement of waste from one State to another State or customs territory;

Waste pre-collection:

All operations organizing the evacuation of waste from the place of its production until it is taken over by the collection service of the municipality or any other authorized body:

Recovery:

Any operation to obtain physical waste by approved facilities with a view to their treatment, recycling and immediate elimination;

Recycling:

Direct reintroduction of equipment into its own production cycle as a total or partial replacement of a new raw material;

Waste storage:

Temporary deposit of waste in a facility authorized for this purpose; Temporary deposit of waste in a facility authorized for this purpose;

Waste treatment:

Any physical, thermal, chemical or biological operation leading to a change in the nature or composition of waste with a view to extracting the recyclable portion or reducing, under controlled conditions, the polluting potential, the volume and quantity of waste;

Transport of waste:

Transfer of waste from production sites to a storage, recycling, treatment or final disposal site within the national territory;

Sorting:

Systematic separation of waste according to different categories;

Waste recovery:

Any operation of recycling, reuse, recovery, use of waste as a source of energy or any other action aimed at obtaining raw materials or reusable products from the recovery of waste, in order to reduce or eliminate the negative impact of this waste on the environment.

Article 3:

(1) The provisions of this decree apply to the following categories of waste, as well as those in the annexes:

– household and similar waste;

– industrial, commercial and arts and crafts waste;

– hospital waste (medical and pharmaceutical);

– inert waste;

– agricultural waste.

(2) The following are excluded from the scope of this decree: radioactive waste, ship wrecks and all other maritime wrecks, gaseous effluents as well as discharges, direct or indirect deposits in surface water or groundwater except for discharges which are contained in closed containers, governed by specific texts.
(3) The conditions for collection, transport and treatment of liquid waste are set by an order of the Minister responsible for the Environment.

SORTING, COLLECTION, TRANSPORT AND STORAGE OF HOUSEHOLD AND SIMILAR WASTE

Article 4:

(1) Any household waste collection and storage activity is carried out by decentralized local authorities in liaison with the competent State services.
(2) The decentralized territorial authorities shall develop, in liaison with the competent State services, a municipal or inter-municipal plan for the management of household and similar waste which defines the operations of sorting, pre-collection, collection, transport, landfill, treatment, recovery and final disposal.

Article 5:

(1) The municipal or inter-communal plan takes into account the guidelines of the National Waste Management Strategy. It defines in particular:
– areas where municipalities or their groups are required to carry out sorting, collection, transport, recovery or final disposal of household and similar waste;
– the circuits, frequency and times of collection of this waste;
– waste collection arrangements;
– the frequency of cleaning operations per zone;
– areas where the transport and landfill of this waste is the responsibility of their generators.
(2) This plan is established for a renewable period of five (5) years and approved by decision of the Minister responsible for the environment.

Article 6:

(1) Any holder of household and similar waste is required to comply with the municipal or inter-communal plan referred to in paragraph 2 of article 4 above and to use the system for managing this waste put in place by the municipalities and their groups or by operators.
(2) Decentralized local authorities or operators must bear the expenses relating to sorting, collection, transport, controlled landfill, recovery, final elimination of household and

similar waste as well as expenses monitoring the cleanliness of areas where this service is provided directly by the generators of this waste.

COLLECTION, TRANSPORT AND STORAGE OF BIODEGRADABLE INERT AND AGRICULTURAL WASTE

Article 7:

(1)Subject to the provisions of Article 26 below, inert waste and biodegradable agricultural waste must be deposited by their generators or by persons authorized to manage them in the places and disposal facilities designated for this purpose by decentralized territorial authorities.

(2)This waste can also be used to recover, treat or eliminate other categories of waste, with the exception of hazardous waste.

(3)Other non-biodegradable agro-pastoral waste is treated or eliminated by approved facilities.

COLLECTION, TRANSPORT AND STORAGE OF INDUSTRIAL WASTE (TOXIC AND/OR DANGEROUS)

Article 8:

(1)Industrial waste (toxic and/or dangerous) may only be collected, transported or stored with a view to its final disposal by any natural or legal person approved by the administration in charge of the environment.

(2)The specific conditions for collection, transport and treatment of industrial waste (toxic and/or dangerous) are set by order of the Minister responsible for the environment.

Article 9:

The collection, transport and storage of industrial waste (toxic and/or dangerous) are subject to obtaining an environmental permit issued by the administration in charge of the environment.

Article 10:

The transport of industrial waste (toxic and/or dangerous) is accompanied by a waste traceability manifest issued by the administration in charge of the environment.

Article 11:

Any generator, collector, transporter or destroyer of industrial waste (toxic and/or dangerous) shall keep a register in which he records the type, nature, quantity, hazard characteristics and origin of the hazardous waste he has produced, collected, stored, transported, recovered or disposed of. This register is subject to control by the administration in charge of the environment.

SORTING, COLLECTION, TRANSPORT AND STORAGE OF MEDICAL AND PHARMACEUTICAL WASTE

Article 12:

(1) Medical and pharmaceutical waste is subject to specific management aimed at avoiding any harm to human health and the environment.

(2) However, certain types of waste generated by healthcare establishments are assimilated to household waste provided that this waste is sorted beforehand and is not contaminated by hazardous waste.

(3) The specific conditions for sorting, collection, transport, storage and final disposal of medical and pharmaceutical waste are set by order of the Minister responsible for the environment

Article 13:

(1) The administration in charge of public health shall develop, in liaison with the competent administrations, a medical and pharmaceutical waste management plan which defines the operations of sorting, pre-collection, collection, transport, treatment and final disposal of this waste.

(2) This plan, established for a renewable period of five (5) years, is approved by joint order of the Ministers responsible for the environment, public health and breeding, fisheries and animal industries.

Article 14:

(1) The collection and transport of medical and pharmaceutical waste by any natural or legal person is subject to an environmental permit issued by the administration in charge of the environment.

(2) the conditions for obtaining the permit referred to in paragraph 1 above are specified by order of the Minister responsible for the environment

Article 15:

Pharmaceutical products from biomedical laboratories, and/or veterinary pharmacy clinics, damaged or expired, are treated under the same conditions as all other medical and pharmaceutical waste, subject to this decree.

TRANSBOUNDARY MOVEMENT OF WASTES

Article 16:

(1) Any waste export operation is subject to authorization issued by the administration in charge of the environment, subject to the consent and written agreement of the State concerned and provided that this waste appears on a nomenclature fixed by regulation. (2) The export of hazardous waste is prohibited to States which prohibit the import of such waste, to States which have not prohibited this import in the absence of their written agreement and to States not parties to the Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and Their Final Disposal.

Article 17:

(1) Any natural or legal person wishing to export hazardous waste shall send, at least 45 days before the start of any movement of such hazardous waste across borders, a written notice to this effect to the administration in charge of the environment and to the competent authorities of the importing country and all countries through which said waste will transit.

(2) The author of the notification submits his intention to export this waste in several shipments for a period of up to one year, subject to the written agreement of the States concerned and the administration in charge of the waste. Environment that can select a shorter or longer period as it deems appropriate on a case-by-case basis.

Article 18:

The export of hazardous waste begins after notification within sixty (60) days following the issuance of acknowledgment of receipt of this notification by the importing country, if no objection has been registered.

Article 19:

The implied consent expires one calendar year after the end of the sixty (60) day period; after this date, notification and renewal of all agreements are required for exports.

Article 20:

The export of hazardous waste may begin immediately upon receipt of all necessary agreements, if the competent authorities of the countries of import and delivery transit concerned provide written agreement within a period of less than sixty (60) days.

Article 21:

(1) A written agreement expires for each importing and transit country one year after the date of that country's agreement unless otherwise specified.

(2) A new notification and renewal of the agreement are required for exports after the deadline referred to in paragraph 1 above.

Article 22

The notice relating to the export of hazardous waste includes:

– the reason for the export of waste;

– an original copy of a duly completed manifest, including the certification required from generator for the proposed export of hazardous waste using the current manifest format;

– the identity of all transit countries and their respective competent national authorities, and all points of entry and types;

– the identity of the country of import and its competent national authority, as well as the point of entry;

– a declaration indicating the individual or general nature of the notice. In

– if it is general, it will specify the requested validity period;

– the anticipated date of the start of the trans-boundary movement of hazardous waste;

– the information (including the technical description of the installation) communicated to the exporter or producer by the waste destroyer and on which the latter has based itself to conclude that there is no reason to believe that the waste will not be managed using environmentally sound methods in accordance with the laws and regulations of the importing country;

– information relating to the contract concluded between the exporter and the destroyer; information relating to insurance and how the exporter, carrier and disposer carry it out.

MANAGEMENT OF CONTROLLED LANDFILLS AND TREATMENT, RECOVERY, INCINERATION, STORAGE AND FINAL DISPOSAL FACILITIES

Controlled landfills

Article 23:

(1) Sanitary landfills are classified according to waste types as follows; Class 1: landfills of hazardous waste (industrial and final); Class 2: landfills of non-hazardous waste (biodegradable agro-pastoral, household and similar); Class 3: landfills of inert waste.

(2) The following wastes are not permitted in landfills; liquid, flammable, explosive, oxidizing, infectious hospital or clinical waste, used tires and any other waste not meeting the criteria for admission to class 1 landfill. The management of this waste is the subject of a specific text.

(3) The technical requirements applied to each of these classified installations are determined by joint order of the Ministers responsible for the environment and industry.

Article 24:

The opening, closing or substantial modification of class 1 and class 2 controlled landfills are subject to authorization from the administration in charge.

Establishments classified after advice from the Minister responsible for the environment.

Article 25:

Controlled landfills cannot be authorized near sensitive areas, prohibited areas, national parks and protected areas, areas of tourist interest, sites of biological and ecological interest, wetlands and forest areas, perimeters irrigated areas, lowlands with high agropastoral potential and outside the sites designated by the waste management plans provided for by this decree.

Article 26:

In the event of closure of a controlled landfill, the operator or owner is required to return the site to its original state or to an ecologically acceptable state.

TREATMENT, RECYCLING AND FINAL DISPOSAL OF WASTE

Article 27:

(1) Any natural or legal person wishing to carry out the activity of recycling, treatment and final disposal of waste is subject to obtaining an environmental permit issued by the administration in charge of the environment.

(2) The conditions for obtaining the environmental permit referred to in paragraph 1 above are defined by order of the Minister responsible for the environment.

Article 28:

In the event of suspension of the recycling, treatment or final disposal of waste, the operator or owner ensures the security of the site.

COMMON PROVISIONS

Article 29:

(1) Any generator of waste or operator of controlled landfills and treatment, recovery, incineration, storage or final disposal facilities of waste as well as any transporter of waste shall ‘keep a register tracing the types, quantities and the nature of the waste that it produces, stores, treats, recovers, incinerates, transports or eliminates.

(2) The register referred to in paragraph 1 above is subject to periodic inspection by the administration in charge of the environment.

ADMINISTRATIVE AND TECHNICAL MONITORING OF WASTE COLLECTION, TRANSPORT AND FINAL DISPOSAL ACTIVITIES

Article 30:

(1) Waste collection, transport and final disposal activities are subject to periodic control by the competent administrative authorities.

(2) Collectors, transporters and destroyers of waste provide all the necessary information to the sworn control agents of the competent Administrations.

(3) The vehicles transporting waste are labeled in order to specify the nature and type of waste transported.

(4) Sworn agents of the competent administrations carry out their missions during the transport of waste and may require opening of any transported packaging or carry out verification during the export of waste.

Article 31:

(1) In the event of imminent danger or threat to human health and the environment, the administration in charge of the environment orders the operators of the installations and the persons referred to in Article 31 (2) above to immediately take the necessary measures to remedy and mitigate this danger.

(2) If the interested parties do not comply, the said authority shall ex officio execute, at their expense, the necessary measures or suspend all or part of the activity threatening human health and the environment.

MISCELLANEOUS, TRANSITIONAL AND FINAL PROVISIONS

Article 32:

The use of goods resulting from waste recycling in the manufacture of products intended to be placed in direct contact with food is subject to compliance with the standards in force.

Article 33:

(1) The abandonment in nature, the burning in the open air of pharmaceutical products, biomedical laboratories and/or veterinary clinics/pharmacies and any other spoiled, expired or seized product in the context of the fight against smuggling and counterfeiting.

(2) The methods for destroying the products referred to in paragraph 1 above are defined by a commission set up by the territorially competent administrative authority.

(3) The products referred to in paragraph 1 above are returned to approved facilities for disposal and the related costs are the responsibility of the offender.

Article 34:

(1) The classification of waste, their characterization and their codification are annexed to this decree.

(2) An order from the Minister responsible for the environment updates the list of toxic and/or dangerous waste as necessary.

Article 35:

The administration in charge of the environment orders the suspension of the activity of all controlled discharge or facility for treatment, storage, recovery or final elimination of waste in the event of non-compliance with the provisions of this decree.

Article 36:

(I) The administration in charge of the environment may, if necessary, call on any experts necessary to carry out analyzes and assess the impact of waste on human health and the environment.

(2) The costs of analyzes and experts incurred for this purpose are the responsibility of the operators of the installations and the persons referred to in article 31 (2) above.

Article 37:

Operators involved in the field of waste management have a period of eighteen (18) months from the date of signature to comply with the provisions of this decree.

Article 38:

This decree repeals all previous provisions to the contrary.

Article 39:

The administrations in charge of the Environment, classified establishments, public health and local authorities are each responsible for the application of this decree which will be registered, published according to the emergency procedure, then inserted in the official journal in French and English//

Yaoundé, September 26, 2012

The Prime Minister, Head of government

Philémon YANG