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Ecological impacts of improper waste management frameworks on biodiversity conservation in Nairobi County, Kenya

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Abstract
Nairobi County is a world's unique biodiversity hub with an attractive national park in the city detailing its beauty. For the last decade, urban migration has led to an increase in population, resultantly an increase in its waste generation depicted by the sporadic mushrooming of unplanned dumpsites. With expected double inhabitants by 2050, the urgent call to address improper waste management framework and their impact on biodiversity explicate its severity. The socioeconomic benefits notwithstanding the environmental sustainability serve as push factors to mitigate the ecological effects on biodiversity in Nairobi County. Most Nairobi County residents are not conscious of proper and well-maintained waste management systems nor possess knowledge of biodiversity conservation practices. The paper seeks to illustrate the ecological impacts of improper waste management on biodiversity conservation in Nairobi County. The study area was Nairobi County, where stratified sampling was carried out to select the sample. Data collected using semi-structured questionnaires to 384 households and key informant interviews purposively sampled. Transect walks used to capture more data on the ecological impacts of improper waste management on biodiversity. The results elucidate costly environmental effects on biodiversity conservation and the need to empower the respondents to curb the adverse consequences for ecological management.

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Introduction

Solid waste management in global cities is an essential service and critical to the well-being of the city. A lapse in this function has detrimental effects on the ecosystems where biodiversity thrives (World Bank, 2018a; World Bank and International Solid Waste Association (ISWA), 2019). Fundamentally, humanity depends on the goods and services nature generates, and biodiversity underpins nature's ability to deliver these goods and services over the long term, which Nairobi County can benefit wholesomely and sustainably (Seddon *et al.*, 2016; Watts, 2018). Ecological impacts of unchecked improper waste management in Nairobi emanates from the domestic and industrial waste generation whose increase will double by 2030, posing a considerable threat to biodiversity hubs in the city (IPBES, 2019; Kathambi and M'Ikiugu, 2018a; Ogutu, *et al.*, 2019; UNEP, 2018a). More precisely, economic per capita for developing countries such as Kenya have the projection of a nearly three-fold increase in waste generation and the impacts of poor waste management on the environmental will not go unnoticed (IPBES, 2019; Ogutu, *et al.*, 2018; UNEP, 2018a; WEF, 2019).

Negative ecological impacts from the rising number of unplanned dumpsites in developing countries cripples the realization of sustainable cities and more unique cities that have biodiversity cities (IPBES, 2019; UNEP, 2005, 2018a; WEF, 2019). In Nairobi County, inadequate frameworks for Solid Waste Management takes the form of mushrooming dumpsites which is predominantly dogged by ineffective collection methods, inadequate coverage of the collection system and improper disposal of municipal solid wastes and an increasingly growing culture of ad hoc waste disposal (Kathambi and M'Ikiugu, 2018a; Ogutu, *et al.*, 2018; UNEP, 2018a). Key to note is that the knowledge of biodiversity conservation in a unique city like Nairobi is below average thereby posing a threat to biodiversity hubs notwithstanding the inadequacies in proper funding for waste management (Kathambi and M'Ikiugu, 2018a; Ogutu, *et al.*, 2018; Oyake, 2017; UN-

HABITAT, 2018). Improper waste management frameworks result in unplanned dumpsites in Nairobi County, resultant from poor garbage collection services offered by the County government and other relevant service providers, poor waste management education and slack enforcement of waste management laws (Njoroge, *et al.*, 2014; Ogutu, *et al.*, 2019; Oyake, 2018; UN-HABITAT, 2018). Globally, Nairobi is the only city with a national park which places untold pressure on biodiversity conservation from ecological impacts from improper waste management frameworks (Kathambi and M'Ikiugu, 2018a; Ogutu, *et al.*, 2019; UN-HABITAT, 2018). Thus, environmental governance which incorporates rules, processes, and behavior by which interests are articulated, resources are managed, and power is exercised would play a pivot role in curtailing negative ecological impacts on biodiversity spots in Nairobi County (Kathambi and M'Ikiugu, 2018a; Oyake, 2018; UNEP, 2018a; UN-HABITAT, 2018). Ogutu, *et al.* (2019) notes that effective environmental governance frameworks of Solid Waste Management should incorporate; practical, well-enforced laws and regulations that foster mechanisms for reducing negative ecological impacts on biodiversity in Nairobi County.

Progressively, biodiversity conservation will be enhanced if proper integration and collective implementation of both local and international conventions, policies, and environmental administrative structures would capitalize on their synergy for environmental sustainability (IPBES, 2019; Kathambi and M'Ikiugu, 2018a; UNEP, 2018a; WEF, 2019).. Importantly, institutions that are mandated with ensuring seamless waste management in the city are empowered with knowledge of biodiversity conservation targeting to mitigate the negative ecological impacts (Bowen *et al.*, 2017; Kathambi and M'Ikiugu, 2018b; Ogutu, *et al.*, 2019; UN-HABITAT, 2018). Additionally, human activities have the potential to generate waste harmful to the environment, animals, plants, and the ecosystem indicating the ecological impacts of unplanned dumpsites on biodiversity hubs in Nairobi County

(IPBES, 2019; Kathambi and M'Ikiugu, 2018a; Watts, 2018; WEF, 2019). It imperative to underscore that only sound environmental governance can limit the damage done to the environment and reverse negative ecological impacts of improper waste management on biodiversity in Nairobi (Kathambi and M'Ikiugu, 2018a; Ogutu, *et al.*, 2019).

In developing countries, biodiversity loss has been treated only as an environmental quandary with no association with the possible potential for economic and social growth (IPBES, 2019; Kumar, 2012; Seddon *et al.*, 2016; WEF, 2019). Unabated biodiversity loss not only reduces the gains made in the environmental sector but also the economic gains that would spur a country's G.D.P. (IPBES, 2018; Kathambi and M'Ikiugu, 2018a; Roe *et al.*, 2019).

The unexploited gains of biodiversity in Nairobi County are further threatened by thousands of tons of functional solid waste that are generated daily resulting in open dumps on wetlands, contaminating surface and groundwater thereby posing major health hazards to human beings and the environment as illustrated by growing unplanned dumpsites in Nairobi County (IPBES, 2019; Ogutu, *et al.*, 2019; Roe *et al.*, 2019).

Increases in solid waste generation in Nairobi County challenge solid waste frameworks due to lack of equivalent capacity increase by the relevant institutions, illustrating the ecological impacts on biodiversity (Kathambi and M'Ikiugu, 2018a; Ogutu, *et al.*, 2019). Consequently, proper management of waste becomes the most pressing and challenging environmental problem in Nairobi County with its impacts on biodiversity hubs a possible threat and could be reality (Bowen *et al.*, 2017; IPBES, 2019; Roe *et al.*, 2019). The motivation of the study was necestitated by the increase in unplanned dumpsites whose impacts on the environment go unrecorded and more specifically on biodiversity spots. Previous studies on solid waste management structures and policy frameworks elucidated the gaps that exist in institutional capacity to cater for the growing city population and waste

generated as well as the importance of biodiversity did not have a priority check on it. Thus the gaps exist in strengthening the partnerships in biodiversity conservation and waste management in cities and urban centers to decelerate environmental degradation. This paper sought to underscore ecological impacts of improper waste management on biodiversity conservation in Nairobi County.

Materials and methods
Research Design
The study adopted a descriptive research design which provided a framework to examine current conditions, trends, and status of events. Descriptive research design is more investigative and focuses on a particular variable factor which is ecological impacts of improper waste management frameworks on biodiversity conservation in Nairobi County.

Study Area
The study area was Nairobi City County which is also the capital city of Kenya. The study area was purposively chosen because of its unique nature of being a city with national park and various biodiversity spots.

Data Collection and Analysis
Sampling was done to ensure equal representation of the views of the respondents and a sampling formula employed giving a sample size of 384 households (Kothari and Garg, 2019; Williams, 2011). Primary data was collected using semi-structured questionnaires, key informant interviews, focus group discussions and transect walks on the sampled sub counties of Lavington, Kibra and Embakasi.

Field reconnaissance played a pivotal role in recording and collecting data on the exact ground locations in Nairobi County. The digital camera was used to take photographs ecological impacts of unplanned dumpsites on biodiversity that were covered in the study. The shape.-file of Nairobi City County was uploaded on the Digital Globe satellite image website for identification of the area of study (Walter, 2018).
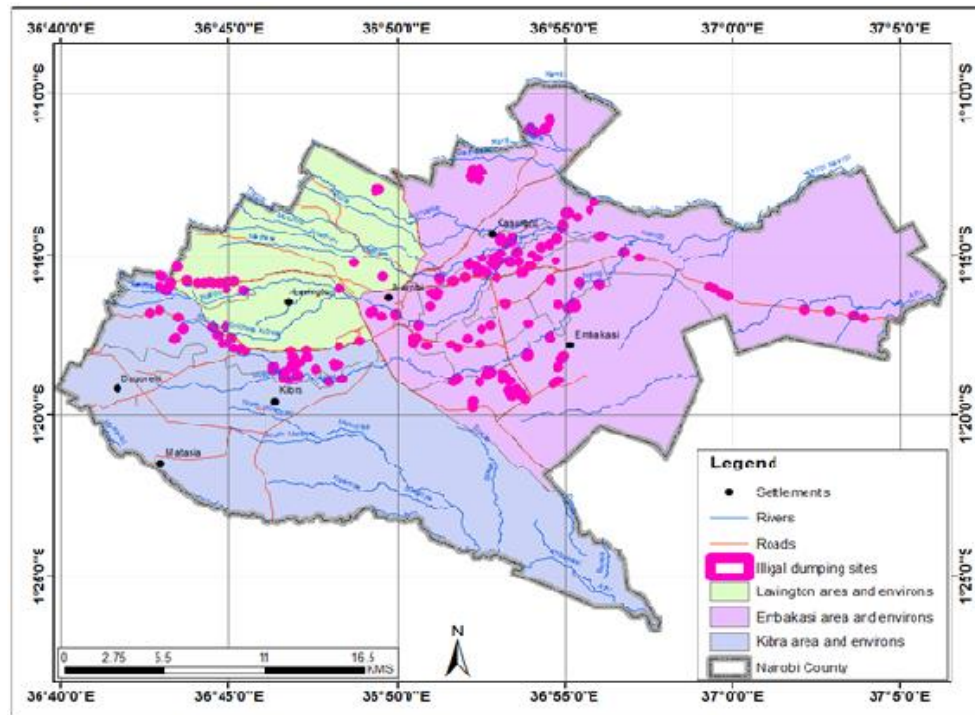
Fig. 1. Digital Map of the Study area in Nairobi County.

Results

Respondents' Perceptions on Impacts of Waste Management Frameworks on Biodiversity Conservation in Nairobi County
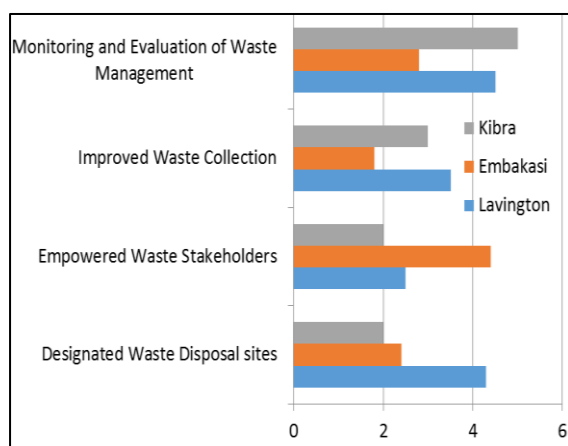

Fig. 2. Respondents' Perceptions on Impacts of Waste Management Frameworks on Biodiversity Conservation in Nairobi County.

Majority of the respondents agreed that monitoring and evaluation of waste management will impact on biodiversity conservation as well as having designated waste disposal sites, improved waste collection mechanisms and empowering waste management stakeholders in Nairobi County.

Ecological Impacts on Biodiversity Conservation enhanced by Respondent's Awareness and Waste Management Education in Nairobi County
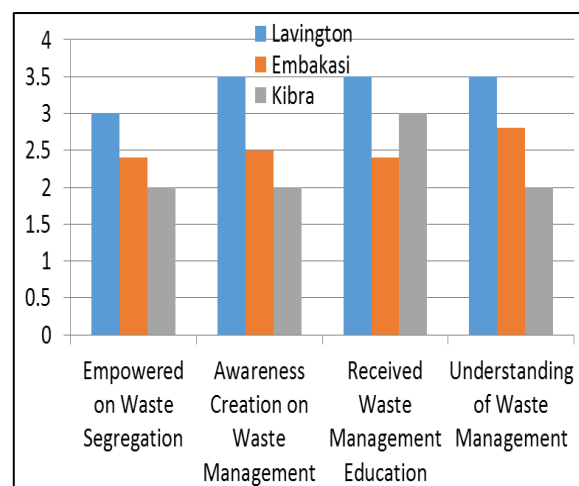

Fig. 3. Ecological Impacts on Biodiversity Conservation enhanced by Respondent's Awareness and Waste Management Education in Nairobi County.

Respondents from the three sub counties had positive outlook on biodiversity conservation if waste education and awareness creation was done. Majority of the respondents agreed that waste management education and awareness contribute to the ecological impacts either positively or negatively on biodiversity conservation.

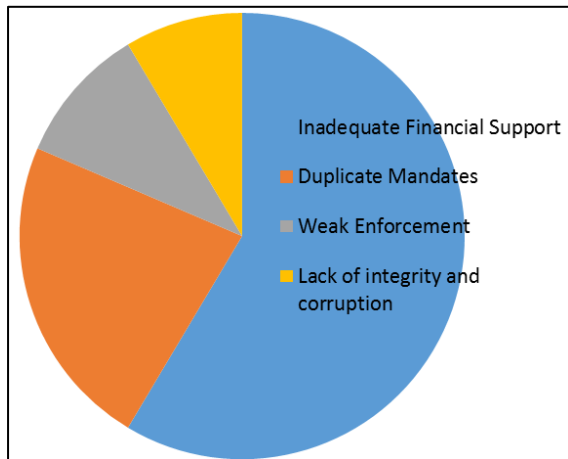*Factors Enhancing Improper Waste Management Frameworks in Nairobi County*

Fig. 4. Factors Enhancing Improper Waste Management Frameworks in Nairobi County.

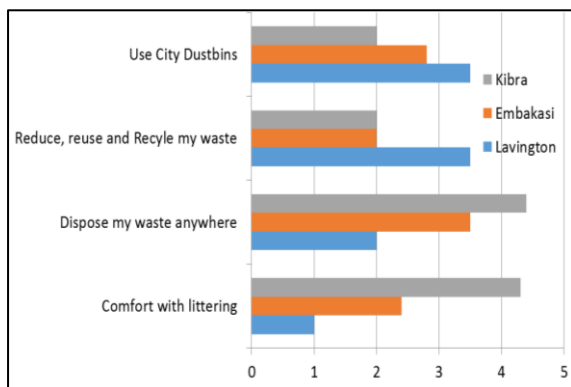*Respondents' Practices that enhance Improper Waste Management Frameworks in Nairobi County*

Fig. 5. Respondents' Practices that enhance Improper Waste Management Frameworks in Nairobi County.

The results show respondents in the three sub counties have carried practices which contribute to improper waste management in Nairobi County. In Lavington sub county, use of city dustbins and reducing, reusing and recycling is done significantly while being comfortable with littering and disposing waste anywhere averagely low unlike Embakasi and Kibra.

Literature Review

The study was supported by a theoretical framework based on institutional, capacity, planned behavior, and socio-ecological theory. Institutional and capacity building theories are used to illustrate the ecological impacts of improper waste management frameworks on biodiversity conservation in Nairobi County.

Institutional theory illustrates interaction of the three pillars, which include; regulative, normative, and cognitive that can either limit or support the operation of organizations or institutions in waste management and biodiversity conservation (Kathambi and M'Ikiugu, 2018a; Ogutu, *et al.*, 2019; Scott, 1995). Regulative pillar deals with policy frameworks, legal structures, and responsibilities, which include fear, force which have impacts on how waste management systems are enforced and how they can enhance biodiversity conservation (Delbridge and Edwards, 2013a; Seddon *et al.*, 2016). Normative pillar involves duties and responsibilities, moral obligation and norms which are critical in shaping the attitudes and practices of residents on waste management and biodiversity (Johnson *et al.*, 2017; World Bank and International Solid Waste Association (ISWA), 2019). Cognitive pillar is in agreement with cultural systems, values, beliefs, and personal desires which are vital in biodiversity conservation especially on plant species (Delbridge and Edwards, 2013a; Seddon *et al.*, 2016).

These pillars have influence on behaviour of individuals as they collaborate in their activities, social, economic, and political in ensuring proper waste management and biodiversity conservation (Roe *et al.*, 2019; UN-HABITAT, 2018). Concerning biodiversity conservation, in terms of enforcement of waste management laws of proper waste handling; the way the different actors interact in an institutional structure; either together or incoherent, can influence the success or failure of biodiversity conservation outcomes (Delbridge and Edwards, 2013b; Wilson *et al.*, 2013; Wilson and Velis, 2015).

Capacity building theory involves empowering institutions, individuals, and communities to execute functions and solve problems to attain the progress of their goals satisfactorily ensuring efficiency (UNEP, 2002a; UNEP and ISAWA, 2015). Inadequate capacity is an obstacle to biodiversity conservation in

many urban centres of sub-Saharan Africa and the loss of biodiversity is growing at a rapid growth (Roe *et al.*, 2019; Seddon *et al.*, 2016; UNEP, 2002b). A practical and sustainable waste management laws on biodiversity conservation entails building management capacity from the local authority personnel, key stakeholders, technical, financial, and regulatory for operating, maintaining, and supervising the process of waste management (McAllister, 2015; UNEP, 2002b; UN-HABITAT, 2018). However, many workers in biodiversity conservation, including government institutions, private sector, N.G.O.s, and C.B.O.s, have inadequate technical, regulatory and financial capacities to operate effectively, illustrating ecological impacts of improper waste management frameworks, especially in developing countries, with Nairobi being an example (Bailey, 2015; IPBES, 2019; UNEP, 2002b; Wilson *et al.*, 2013).

The theory of planned behaviour is used in predicting and understanding human behaviour, defines the relationship between attitude and behaviour concerning pro-environmental behaviour and environmental knowledge on biodiversity conservation, ecological impacts derived from improper waste management frameworks (Ajzen, 1991; Ajzen and Fishbein, 1980).

The theory postulates that behaviour is deliberate and, therefore, can be planned and predicted therefore proper waste management behaviour can be planned as with biodiversity conservation behaviour (Kathambi and M'Ikiugu, 2018a; Ogutu, *et al.*, 2018). Attitude is defined as a "function of salient beliefs at a given point in time" and are critical influencing behaviour thus the planned aspect (Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975). Subjective norm, deals with an individual's belief and how the behaviour will be judged by others (what do others think l should do?) and lastly perceived behavioural control indicates that the individual recognizes that they can control the behaviour (can l do it?) which serve a critical role in planned behaviour (Ajzen, 1991).

This theory is relevant to this study; public awareness and environmental values and ethics are lacking in biodiversity conservation exacerbated by improper waste disposal frameworks, a threat to biodiversity hubs in N.C.C (Kathambi and M'Ikiugu, 2018a; Ogutu, *et al.*, 2018). Most people in Nairobi city, knowledge of biodiversity is limited, thus the ecological impacts evident by the rising number of open dumpsites, reversing the gains of goods and services nature generates (Johnson *et al.*, 2017; Roe *et al.*, 2019). Only sound environmental governance can limit the damage done to the environment and reverse the negative ecological impacts of improper waste management on biodiversity conservation in Nairobi (Bowen *et al.*, 2017; Kathambi and M'Ikiugu, 2018b; Ogutu, *et al.*, 2019; UN-HABITAT, 2018).

Positive attitudes in biodiversity conservation can be enhanced to the public through empowered institutions with knowledge of biodiversity, help to mitigate the ecological impacts, done through education and awareness campaigns, resulting to responsible behaviour towards the environment (Ajzen, 1991; Kathambi and M'Ikiugu, 2018a). Additionally, when the public adopt the behaviour of complying to the polices in biodiversity conservation through proper management of waste, this would minimize ecological impacts on the environment and human health; thus they will have a positive attitude towards the behaviour to do so (Jain and Jain, 2020; Roe *et al.*, 2019; Stern, 2000).

Pro-environmental behaviour, where the individual does not degrade the environment and comply with proper waste management frameworks of environmental policies and regulations, for biodiversity conservation are up scaled by awareness creation and public education (Knockaert *et al.*, 2019; Ogutu, *et al.*, 2018; Oliver *et al.*, 2015). The public has to be motivated and educated to make those choices through collective efforts of all stakeholders, including Government structures at local, national, and global level, since people are at the center of any environmental activities (Avis, 2016; Bowen *et al.*, 2017).

The socio-ecological theory is relevant through its four components, which include; individual (the public), social environment, physical environment, and policy environment (Stokols, 1992). SWM is complex, and the increased waste generation globally, nationally, and locally reflects the extent of the problem, impacting on biodiversity loss and ecosystems (McAllister, 2015; UN-HABITAT, 2018).

The theory posits that individual personal factors like beliefs, socioeconomic status, knowledge, attitudes, beliefs, among others, can either increase or decrease healthy environmental choices, like proper waste disposal where there is no littering for a clean and healthy environment. Thus policy interventions should include education and awareness programs in Nairobi County, whose context is improper waste management frameworks (IPBES, 2019; Johnson *et al.*, 2017; Nunoo, 2019; Ogutu, *et al.*, 2019).

Social environment includes cultural background, socioeconomic status of the community, institutions, and organizations where the individual interacts which impact on waste management behaviour (Angoua *et al.*, 2018; Stokols, 1992). Additionally, the policy environments include; legislation, regulatory, financial, environmental policies which impact on biodiversity conservation, thus influence the behaviour of the individual through community education, awareness programs, for instance, the culture of most Nairobi residents of not seeing proper waste management as a public responsibility, not in my backyard syndrome, thus sporadic growth of illegal dumpsites through littering, can be discouraged through such initiatives (Kasozi and Von Blottnitz, 2010; Ogutu, *et al.*, 2018; Oyake, 2018).

The physical environment includes natural and human-made, and this is where environmental activities take place in terms of the waste management system, infrastructure, and institutions with rules and norms that regulate how human's beings (people/public) interact with the environment. It also involves availability and access to these facilities, which remain vibrant for a sustainable waste management system for biodiversity conservation, provides opportunities for intervention through governance structures, which should be prioritized before education (awareness programs in the communities, like Nairobi City County (Kathambi and M'Ikiugu, 2018a; Ogutu, *et al.*, 2019; Roe *et al.*, 2019; Sallis *et al.*, 1998; World Bank, 2018a).

Discussion

The Nairobi County hosts the capital city of Kenya explicates the ever-growing population from rural-urban migration denoting the increment in waste generation thereby signifying potential threat to biodiversity spots (IPBES, 2019; Kathambi and M'Ikiugu, 2018a; Ogutu, *et al.*, 2019). The low knowledge of biodiversity conservation practices coupled with improper waste management frameworks forms a solid ground for intervention to further environmental degradation (Oyake, 2018; Roe *et al.*, 2019; UNEP, 2018a). Nairobi County characterized by rapid population growth due to employment opportunities, lucrative business ventures has a projection of doubling solid waste generation relatively impacting on biodiversity if improper waste management frameworks go unchecked (Gakungu, *et al.*, 2012; Hardoy *et al.*, 2001; UN-HABITAT, 2018; WEF, 2019).

The ecological impacts of unplanned dumpsites and lack of adequate knowledge on biodiversity heightens the need to create awareness and increase proper funded waste management mechanisms as illustrated by practices that support improper waste management in Fig. 5 (Adebayo Bello and bin Ismail, 2016; mcAllister, 2015; Ogutu, *et al.*, 2019). The eyesore of solid waste management in Nairobi requires serious scrutiny of policies, institutions, and governance instruments to change the current trajectory affecting biodiversity conservation supported by the results in Fig. 4 (Bailey, 2015; Ezechi *et al.*, 2017; Kathambi and M'Ikiugu, 2018a; Roe *et al.*, 2019).

Additionally, Nairobi's status is highly characterized by low coverage of solid waste collection, pollution from uncontrolled dumping of waste, inefficient

public services such collection and disposal of waste, unregulated and uncoordinated solid waste management are the enabling factors in enhancing the growth of unplanned dumpsites (Delbridge and Edwards, 2013b; NEMA, 2014; UNDP, 2017, 2016). The rapid changes in organic waste and an increase in plastic and other non-biodegradable wastes can be attributed mainly to the residents changing lifestyles and the culture of dumping indiscriminately impacting heavily on biodiversity in the Nairobi County (Ayobami *et al.*, 2016; Ogutu, *et al.*, 2018; UNEP, 2018a; UN-HABITAT, 2018).

Ecological impacts on biodiversity from improper waste management in Nairobi County is enhanced due to an increase in population, lack of public awareness on waste disposal mechanisms and low knowledge of biodiversity conservation which is further supported by the results in Fig. 3 (Bundhoo, 2018; Kathambi and M'Ikiugu, 2018b; Ogutu, *et al.*, 2018; Watts, 2018). With an expected double population in 2050 in Nairobi County, an increase in solid waste generation explicates the potential ecological threats to biodiversity conservation and their likely impacts where waste management frameworks are not improved (Godfrey *et al.*, 2019; Haregu *et al.*, 2017; Knockaert *et al.*, 2019; Ogutu, *et al.*, 2019).

As previously noted by UNEP, (2018), the level of industrialization in Nairobi County will increase making an inference to an increase in the waste generation which require enhanced solid waste management frameworks (IPBES, 2019;mcAllister, 2015; World Bank, 2018a). Besides, the limitation of legal dumpsites and clear designated waste collection and disposal sites, the ecological impacts on biodiversity conservation will be realized in Nairobi County if the same are not addressed promptly (IPBES, 2019;mcAllister, 2015; UNEP, 2018b; WEF, 2019). In a report by IPBES, it notes the industrialization and urban migration as possible threats to biodiversity and their untold impacts form a basis for urgent intervention which explicates the need for awareness creation as supported by data in Fig. 3 (IPBES, 2019; World Bank, 2018b; World Bank

and International Solid Waste Association (ISWA), 2019). Notably, sporadic growth of unplanned dumpsites are a consequence of an overstretched legal dumpsite and improper waste management challenges that underscore the synergy required to mitigating negative ecological impacts on biodiversity conservation in Nairobi (Bundhoo, 2018; Kathambi and M'Ikiugu, 2018a; Magrini *et al.*, 2020; Ogutu, *et al.*, 2019). The biased public attitude towards waste management in Fig. 4, minimal empowerment on environmental values and ethics and biodiversity conservation fail to encapsulate the potential for wealth creation using waste and biodiversity (Haregu *et al.*, 2017; Kathambi and M'Ikiugu, 2018b; Marshall and Farahbakhsh, 2013; Ogutu, *et al.*, 2018; Oyake, 2018).the future of biodiversity conservation in Nairobi county will be enhanced by improved solid waste management frameworks, waste management education and creation of public awareness of socioeconomic and environmental benefits accrued from both biodiversity and waste (Kathambi and M'Ikiugu, 2018a; Knockaert *et al.*, 2019; Ogutu, *et al.*, 2019; Roe *et al.*, 2019; UN-HABITAT, 2018).

Conclusion

The ecological impacts of improper waste management in Nairobi County elucidates and forecasts the potential negative impacts it has on biodiversity depicting the importance of synergy among institutions in enhancing biodiversity conservation. The future of biodiversity conservation and curtailing of negative ecological impacts from poor waste management frameworks is pegged on good governance whose tenets are equity, participation, pluralism, transparency, accountability, and the rule of law. The findings indicate a variety of factors enhancing improper waste management frameworks have great impact on biodiversity thereby a need to bridge the gap between stakeholders in waste management and biodiversity conservation through inclusivity and active participation.

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