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Editorial

Dear readers,

Welcome to the seventh volume of the African Resources Development Journal. This journal publishes articles which expose potentials and challenges available in Africa in the exploitation and utilization of its natural resources for sustainable development of the continent. The editorial team wish to congratulate all authors whose papers are published in this issue. After passing through a double-blind independent peer-review, six papers were recommended for publication in this issue.

The journal publishes original research articles and review papers. Paper submitted to this journal must contain original unpublished work and should not be under consideration for publication elsewhere. Any paper submitted to this journal will be subjected to the journal's double-blind review process.

Finally, let me take this opportunity to thank all authors who submitted their manuscript to us and congratulate those who have their articles published in this issue. The editorial team appreciates the work well done by the peer-review experts who have enabled Volume 7 (Issue 1) of the African Resources Development Journal (ARDJ) to roll out. We hope that the articles published herein will widen the knowledge on abundant natural resources available in Africa and thus meet expectations and aspiration of our different esteemed readers of the journal. You are most welcome to send us your research manuscripts and book reviews for consideration in the upcoming issues.

Prof. Emmanuel Patroba Mhache
Chief Editor
The African Resources Development Journal

Analysis of Power Relations on Timber Value Chain in Liwale and Ruangwa Districts, Tanzania

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Abstract

The study intended to investigate power relations among dominant institutions guiding timber value chain in Liwale and Ruangwa districts, Lindi. It adopted across sectional research design whereby qualitative methods of data collection were used. The main objective of this study was to analyze power relations that underlie timber value chain and identify actors on the value chain. Specifically, the study determined the existing power relations on the timber value chain in Liwale and Ruangwa districts. Data were collected through key informant interviews, focus group discussions, and observations to answer the research questions and then analyzed using a DEDOOSE platform. The results indicated that, there were several actors in the timber value chain, including timber dealers, customers, village communities, Village Natural Resource Committees (VNRCs), district governments, forest officers, NGOs, and government agencies. Also, there are three levels of value addition which are community, district and national levels. These were associated with the customer demand from within the specific community, district and national wise. Apart from that the dominant institutions guiding timber value chain were the Tanzania National Forest Policy and the Forest Act which provide a timber value chain framework. Also, institutional, supportive and strategic power relations were the type of power relations that were identified to be underlying timber value chain. Furthermore, power struggles were observed to be existing among the Tanzania Forest Service (TFS) agents and the Forest Officers mainly on the issue of the revenue collected. The study recommends that, all actors in the timber value chain should play their roles in a way that they do not compromise the ability of other actors attain their goals. Also, to solve the issue of power struggles between the TFS and the local government Forest Officers then amendment of rules and regulations should be done.

Keywords: Timber value chain, power relations, dominant institutions, sustainability, Tanzania.

1.0 INTRODUCTION

Timber value chain is a concept used to describe the entire spectrum of activities that contribute quality to timber products (Zamora, 2016). Each node within this chain comprises of various actors, responsible for executing essential activities at their respective points. These actors collectively form a network, ensuring the successful formation and a targeted market reach of a particular product (Arvola *et al.,* 2019). To achieve this success, governance plays an important role.

Similar to social relations, value chains also feature leading firms or individuals who influence other actors in the chain to adopt specific behaviours (Lolila *et al.*, 2021). For the chain's sustainability, a delicate balance of power among actors is necessary. This equilibrium ensures that every participant in the chain remains steadfast in performing relevant activities. Consequently, power relations in the value chains dictate resource management, access rights and crucial decision-making processes (Mbeyale *et al.*, 2021).

With the rapid growth of Tanzania's economy, the demand for timber and timber products has increased (Martin, 2021), resulting in the decline of natural forests and the promotion of industrial and non-industrial timber plantations (URT, 1998). Previous researches have investigated the timber value chains based on non-industrial and industrial plantations (Arvola *et al.,* 2019; Martin, 2021). However, this paper focuses on timber value chains that source their timber from natural village land forests reserves in Liwale and Ruangwa districts, Tanzania.

In Tanzania, forest management is carried out through Participatory Forest Management (PFM) (URT, 2002), which falls under two categories: Joint Forest Management (JFM) and Community-Based Forest Management (CBFM) (URT, 2002). Under JFM, the government owns and manages the forest while sharing benefits with the community. In contrast, CBFM which is the focus of this study, grants ownership, usage, and management rights to local communities (URT, 1998). In the CBFM approach, the local people have the authority to decide who can access their forest resources and make significant decisions on their behalf.

Timber value chains typically involve various actors, including the government (village and district level), middlemen, tree growers, customers, transporters, non-governmental organizations, and timber dealers (Lusambo *et al.,* 2021; Martin, 2021). In Liwale and Ruangwa districts, the timber value chains consist of village and district governments, timber dealers, villagers, non-governmental organizations, and other individuals. Each actor wields different forms of power in the forest utilization process. When power is imbalanced, conflicts arise among actors and hinder the development of the timber value chain (URT, 2004).

The high potential of forest resources in Mikunya, Lichwachwa, Nandenje, and Likombola VLFRs has led to the emergence of various actors with distinct interests. The balance of power among these actors has becomes a significant challenge. Power relation balance, defined as the asymmetries between two actors in their relative ability to exert power over others (Rolin, 2020), restricts benefits to certain stakeholders, such as timber dealers who face suppression due to established practices. Consequently, the growth of the CBFM is hampered (Held *et al.,* 2017; UN, 2021). This study aimed at investigating power relations among dominant institutions that guide the timber value chain in Liwale and Ruangwa districts. The process involved the identification of actors in the timber

value chain, analysing existing power relations, and understanding power struggles within the study areas.

The understanding of power relations along the timber value chain, which sources timber from VLFRs in Lichwachwa, Mikunya, Nandenje, and Likombola, is crucial for promoting sustainable timber value chains. Additionally, it contributes to promoting equity among communities and other stakeholders involved in the value chain. The findings of this study aids in endorsing a balanced power relation among timber value chain actors in Liwale and Ruangwa districts.

2.0 METHODOLOGY
2.1 The study area
The study was conducted in Liwale and Ruangwa districts, Tanzania (Figure 1). The districts are endowed with natural forests which are characterized by dry Miombo tree species, dense forests and wet Miombo with some highly valuable timber species of *Brachystegia sp., Julbernadia sp.,* and *Pterocarpus angolensis.* Liwale and Ruangwa are characterized by two rainy seasons annually, from November to January and March to May respectively. Annual precipitation ranges from 600-1000 mm.
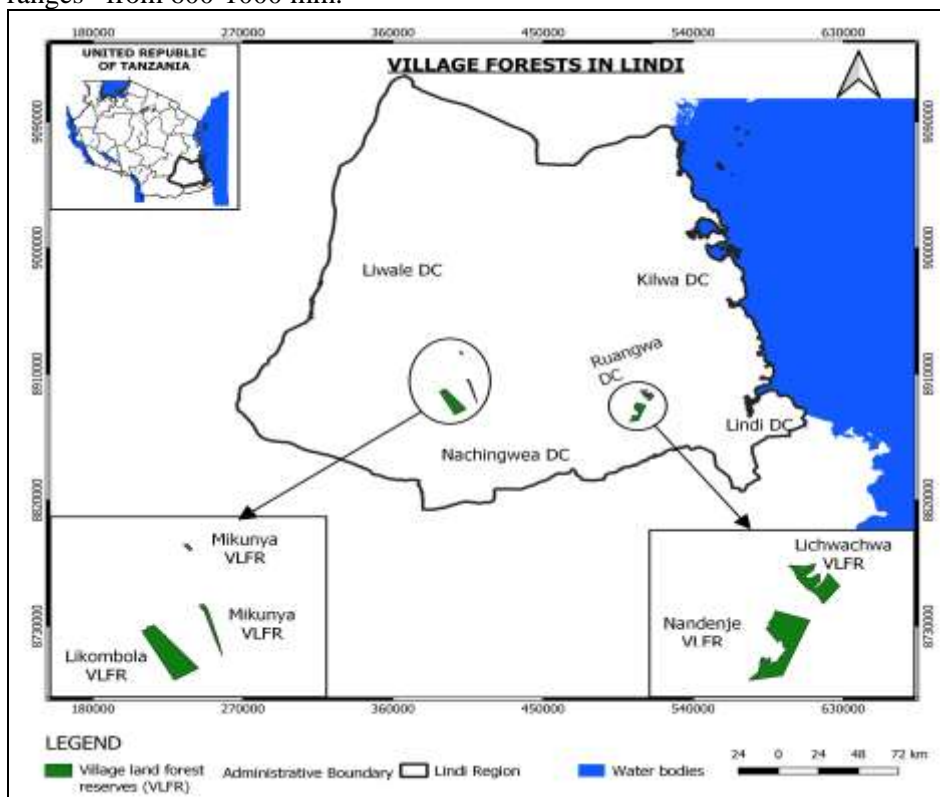
Figure 1: Map showing the study locations and the VLFRs.

2.2   Sample Selection and Data Collection

A purposive sampling approach was employed to select participants for this study who are working along the timber value chain in Liwale and Ruangwa districts. The sample for this study included 40 timber dealers. The sample of timber dealers was obtained from a list of names provided by the district Forest Officer in Liwale and Tanzania Forest Service (TFS) agency in Ruangwa district. Data were collected from four villages in Liwale and Ruangwa districts, which are Mikunya and Likombola in Liwale district and Nandenje and Lichwachwa in Ruangwa district. Data was collected through key informant interviews, focus group discussion and the researcher's own observations. To guide the collection of primary data from timber dealers, Forest Officers, Tanzania Forest Service (TFS) agents, village leaders and village residents, a checklist of open-ended question was used.

Prior to the beginning of each interview and focus group discussion, each respondent was given a thorough explanation of the study, including how their identity would be secured and how the data they provided would be used and verbal free and informed consent from each participant was required. Participants were also informed that they could leave the study at any moment and have their personal information erased.

It should be noted that the majority of the participants for this study were men, as is common in rural African communities (99%). The evert weakness for this study is the lack of women narratives on the timber dealing activities involvement, which should be addressed in future research designs.

2.3   Data analysis

Qualitative data were analyzed by first transcribing all the recorded key informant interviews and focus group discussions. Then, the researcher had to get familiar with the data by reading and re-reading the data. A process that resulted in removing data that was out of scope for this study. The data were uploaded into a DEDOOSE platform form, and the labeling process began whereby paragraphs and sentences were labeled. The conveyed labels held a precise significance for each paragraph and sentence, effectively culminating in themes and sub themes when grouped together. These themes and subthemes encapsulated the essence pertaining to the research questions. Data on the distribution of timber which led to the formation of timber value chain levels were further analyzed in R-studio to form a social network and the igraph package was employed to analyze the data.

3.0   Results

The data collected came up with five themes which were noted to resonate throughout the interviews and focus group discussions that were conducted in order to answer the research questions of the study. Identifying actors, levels of value addition, the dominant institutions that guide the timber value chain and

power relations underlying the timber value chain are the key themes that were analyzed after data were analyzed. Thereafter the following are the results.

3.1   Identified actors and nodes along the timber value chain

A number of actors were identified (Table 1) to interact along the identified nodes in the value chain of timber (Figure 2). In (Figure 3) a map of their interaction at different nodes is shown.

Table 1: Actors along the timber value chain in Liwale and Ruangwa districts

SN	Actor	Category of Actor	Role and position of actors in the value chain
1	Timber dealers	Primary	Key actors in the timber value, they take the risk of utilizing the forest resources and take timber to the market.
2	Customers	Primary	Determine the type of timber to enter and quality the market.
3	Villagers from Lichwachwa, Likombola, Nandenje and Mikunya villages.	Primary	Primary decision makers on who gets access to the village land forest reserve. Manage the forest resources. Decide who gets the VNRC membership.
4	Village Natural Resource Committee (VNRC)	Primary	Responsible for making sure that the timber dealers get the right amount of timber as indicated on their permits.
5	District government	Secondary	Decision making body, which decides on the number of timber dealers to get license to harvest from forests within the district depending on the resources available.
6	Forest Officers	Secondary	Ensure that timber that is moving out of their jurisdictions is graded.
7	FORVAC program	Secondary	Provide financial support, technological support and facilitate capacity building to communities around the forests in order to enhance timber value chains.
8	Tanzania Forest Service Agency	Secondary	Responsible for offering licenses to the timber dealers.
9	Mpingo Conservation and Development Initiative (MCDI)	Secondary	Provision of technological support to promote value chain activities. Offered a mobile machine for timber processing in Lindi.
10	Tanzania Forest Conservation Group (TFCG)	Secondary	Provision of training on forest conservation.
11	The Community Forest Conservation Network of Tanzania (MJUMITA).	Secondary	Provision of training on forest conservation.

Source: Primary data collected in 2022.

Figure 2 Illustrates the nodes found in the timber value chain in Liwale and Ruangwa districts as well as the activities carried out at each node.

Figure 2: Identified nodes along the timber value chain.
Source: Field data collected in 2022

Forest management was the first node identified in the study areas. The actors found in this node were the villagers responsible for managing the forests. This is also done with the help of forest officers of the respective district. The forest officers are responsible for building capacity among VNRC members to better manage forests. In support of this one of the forest officers was quoted as saying:

> *"Through CBFM the communities living around the forest are 100% responsible for the management of the forest; all we do is equip to them with the necessary conservation knowledge."*

Production was the second node identified, with timber dealers being the major players in this particular node. They are responsible for timber logging of various tree species depending on market demand and their customers' choice as well as, what is stated in their harvesting permits. Most timber dealers have been quoted.

> *"We harvest Millettia stulhmanii (*Mpangapanga)*, Afzelia quanzensis* (Mkongo) *and Pterocarpus (Mninga) hardwoods for that are what our customers prefer."*

This was supported by the forest officers who were quoted as saying

> *"Millettia stulhmanii* (Mpangapanga)*, Afzelia quanzensis (*Mkongo) and *Pterocarpus* (Mninga) *species are preferred mostly in our forests, although all timber species are almost of the same quality."*

Processing is the third identified node in which timber is processed and then distributed various markets. The distribution of timber on different markets depends on the demand for timber products in each respective market. The last node identified was consumption, where consumers with different preferences were contacted. It was observed that, most of the timber is distributed to different destinations for furniture manufacturing and construction use.
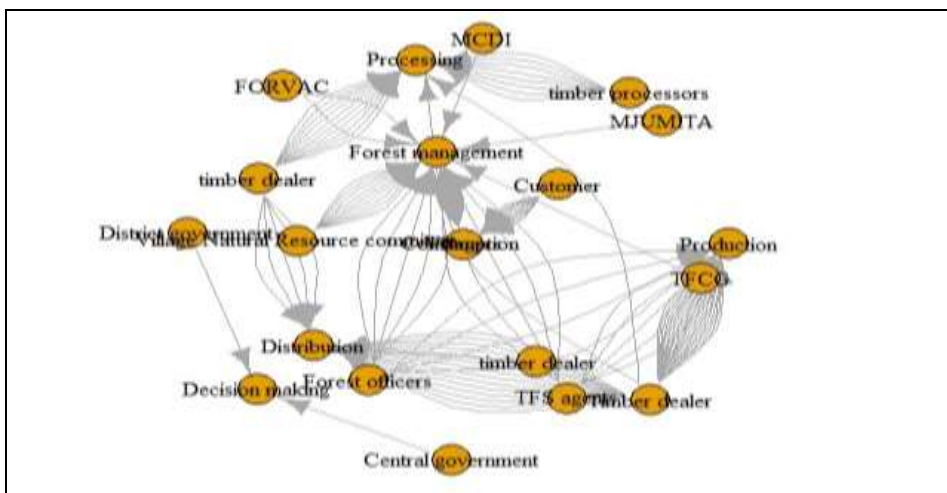
Figure 3: The value chain map of identified actors in the timber value chain.
Source: field data collected in 2022

Note: Arrowhead indicates the interaction of actors at a node, while the tail indicates the actor.

3.2 The levels of the timber value chain based on the distribution of timber

Based on the findings from the focus group discussions with timber dealers, the study shows different levels of value addition on timber, as presented in Table 2. These levels are primarily influenced by two main factors. The first factor being the significant influence exerted by certain actors within the value chain, such as NGOs and the government. Due to their power and authority, they are able to influence and shape the different levels of the timber value chain. The second factor that contributes to the variation in value addition levels is customers' demand. Timber is routed to areas where customer demand is high, leading to increased value addition activities. Conversely, less timber is distributed to areas with lower demand, resulting in comparatively lower levels of value addition in such locations.

Table 2: Levels of value chain addition on timber

SN	Level of value chain	Scale	Characteristics
1	Community level of timber value chain	Small	Fewer customers and financial constraints.
2	District level of timber value chain	Medium	Customers are not many that there are fewer furniture making industries in the districts. Most of the people working at this level are financially depending on themselves
3	National level of value chain	Large	There are a lot of customers, who are found outside of the Lindi region. And the social capital and financial capital is larger compared to the previous levels.

Source: Field data collected in 2022

A social network analysis (Figure 4) conducted on the distribution of timber based on customer demand supports the determined levels of value addition in Liwale and Ruangwa districts.
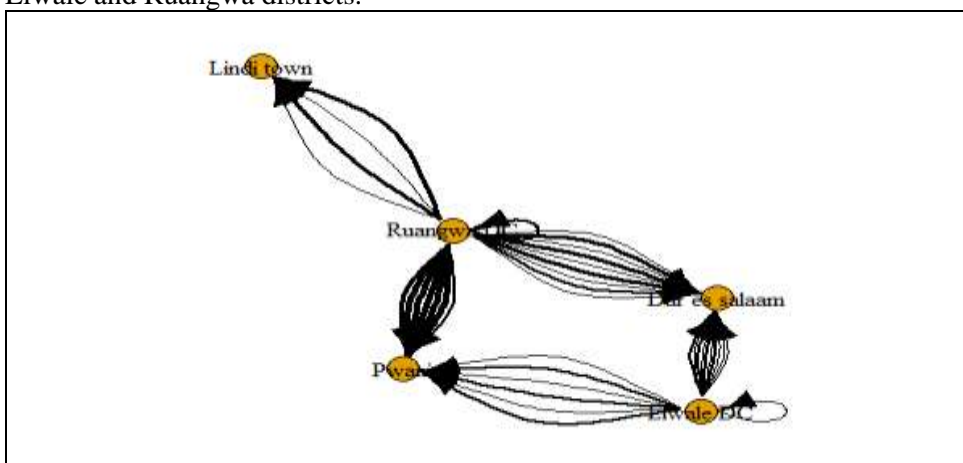
Figure 4: Source and destination of timber products
Source: Field data collected in 2022

Note: Arrowhead indicates the product's destination, while the tail indicates the timber source. Arrow width indicates the timber product's extent (magnitude) from the source to the destination involved in the value chain.

The first level of value addition on timber is at community level. This involves a group of people working in the villages where there are VLFRs. They manufacture furniture and other timber products which are sold to the people in the village to meet their basic household and office needs. Findings from the key informant interview that was conducted in Likombola village with the village chairperson revealed that, there are community furniture making groups that were supported by FORVAC and MCDI technically.

> *"There are community groups supported by the FORVAC program and the MCDI technically, and they are very good at what they do for example the Likombola Furniture Group."*

The second and third levels of value creation are the district and national levels. District level value added activities were noted to be carried out on a small scale in the study areas. Most of the people, who work at this level, are the timber dealers themselves. Finally, the national level of value addition, in which there are many people working there, they collect timber produced from the village forests. These can be found in towns and cities like Dar es Salaam. All of the timber dealers who participated in this study stated that they had customers outside of the Lindi Region.

3.3 The dominant institutions that guide timber value chain in Liwale and Ruangwa Districts

The dominant institutions that guide value chain in Liwale and Ruangwa districts; include the rules and regulations which are mainly presented in a National Forest policy (1998) and the Forest Act (2002). They are established by the central government. In addition to that, there are by-laws which are specific to the study areas; they are provided in the five-year management plan. Furthermore, there are agencies like the Tanzania Forest Service (TFS) Agency.

The interviews conducted among timber dealers in Liwale and Ruangwa districts, are in support of this whereby, all of the timber dealers were referring to the rules and regulations that are provided in the government documents. For instance, there are rules and regulations that are guiding timber value chain at different nodes. In the production node, the timber dealers were quoted saying: -

> *"You cannot legally log trees from the forest without having a license from Tanzania Forest Service."*

That alone is not enough therefore; a timber dealer has to attend the village assembly in the village of interest. Where the villagers would hear him/ her out. And then decide whether the person can work in their village or not. It is then possible for the same villagers to do away with their initial decision.

The Tanzania National Forest policy (1998) provides a basis in which the international community and the NGOs can work with the communities around the forest in order to increase the productivity of the forest. The policies provide technical and financial framework to support the timber value chain. One of the forest officers in Liwale acknowledged that:

> *"It was very hard for us to perform our works when the LIMAS program phased out for the support that the central government offered did not satisfy the needs to meet the supportive functions to the people in villages."*

The members of the Village Natural Resource Committee in Mikunya also affirmed the same. Whereby, one of the members in the VNRC was quoted saying:

> "*When the LIMAS program phased out, we could not carry on with the activities that we hoped we could have done concerning our forest resources*"

These all have brought a conclusion that, the dominant institutions are the established rules and regulations.

3.4 Power relations underlying timber value chain in Liwale and Ruangwa districts

Table 2.3 summarizes the results on the existing power relations that underlay timber value chain in Liwale and Ruangwa districts.

Table 3: Power relations that underlie timber value chain

SN	Type of Power relation	Area of Manifestation
1	Institutional power	This is exercised by the Village and District Governments. Which perform their duties as cited by the Government Notice that: *"The District Committee chaired by the District Commissioner shall be responsible for receiving, considering and determining applications for endorsement and issuance of harvesting license of forest produce"* The village authority was noted to be working hand in hand with the district government. This implies that they cannot decide on their own on who gets the access to utilize forest resources unless the district government decides through the annual meeting done once a year. *"It is the district government which decides the number of timber dealers that are to be involved in the timber business for a year in our village forests depending on the resources available"*
2	Supportive power	From the data collected for this study, it was portrayed by NGOs like MCDI, MJUMITA and TFCG and also the FORVAC Program. They provide technical and financial support to promote sustainable utilization of the forest resources. And most important they conduct workshops aiming at building capacity of the timber traders. In February 2022, during the time for data collection, there was a workshop prepared by MCDI with the aim of building capacity of the people working in the forest sector in Liwale including the timber dealers.
3	Strategic power	This was manifested by the timber dealers. They all have desires on what they want to achieve in their businesses. According to the key informant interviews that were done 95% of timber dealers seemed determined to do anything to get their timbers to towns. 5% of the 95% even complained of about the inspectors at the checkpoints to be standing firm on the rules and the regulations. This is also portrayed by the village government and the district government, especially during the preparation of the harvesting plan. Which is in accordance to the management plan of the respective production forest and the district harvesting committee is responsible for reviewing applications and their endorsement.

Source: Field data collected in 2022 and the 2004 forest regulations.

3.5 Power struggles among actors in the timber value chain in Liwale and Ruangwa Districts

Power struggles were observed to be existing among the TFS agents and the forest officers operating in the study areas. Whereby, there was a tension between the two parties concerning the revenue collected from the timber dealers, especially on the fines and penalties that have been imposed. Some of the TFS agents who were interviewed on the issue pointed fingers to the forest officers to be going against the regulations which instruct the revenue collected from the fines and penalties to be directed to the government. Instead, the forest officers have been misdirecting for the revenue to be going to the local government.

4.0 DISCUSSION

Customers play a great role in timber value chain. Timber dealers harvest the common species of hardwoods which were a preference to their customers. The most preferred species were the *Millettia stuhlmannii* (Mpangapanga), *Afzelia quanzensis* (Mkongo) and *Pterocarpus angolensis* (Mninga). This confirms the results of the study done by Sturgeon (2008) and Loconto (2016) who portrayed that customers have power to influence what type of commodity goes to the market. However, these markets' responsiveness to customers' demands could not be aligned with sustainable practices. Therefore, could lead to species extinction.

Additionally, the role of international community and NGOs as key actors in the timber value chain prompts reflection on the nature of their involvement. Similarly, Martin (2021) reports that, the international community and NGOs through the operating programs offer help in promoting the development of timber value chain through the provision of financial and technical support. However, their involvement could be vested with dependency dynamics apart from empowering the local communities.

Furthermore, the established rules and regulations by the state which are the Tanzania National Forest policy (1998), the forest regulations and the National Forest Act (2002) were found to be the dominant institutions that guide the timber value chain. Similarly, a study by Mulokozi (2021) on power dynamics among actors in the groundnuts value chain found similar results. However, these regulations have been suppressing interests of some actors for instance, the timber dealers whose fees charged for different requirements to engage in the business, have been increasing over the years.

Also, the study reveals the existence of three distinct types of power relations within the study areas which were institutional, supportive and strategic power relations. Whereby, institutional power is manifested by the district government and village government through the Village Natural Resource Committee which are in place to make sure that the rules and regulations are followed to promote sustainable value chain of timber. This confirms a study done by Dallas *et al.*

(2019), which revealed that the local governments in which the raw materials are found have institutional power relation in value chains. Supportive and strategic power relations on the other hand, are manifested when the NGOs and partner's developmental programs in collaboration with the district forest officers, provide technical and financial support towards sustainable utilization of the forest resources. In addition to that, timber dealers manifest strategic power relations when they are determined to do everything in their power to excel in their businesses. A study by Mbeyale *et al.* (2021) found similar results, but these actors could in one way or the other be serving their hidden interests and not being truly collaborative hence, unsustainable management of resources.

Lastly, the issue of power struggles among actors in the timber value chain in the study areas which existed between the Tanzania Forest Service (TFS) agency and the local government forest officers on the issue of revenues collected from the fines and penalties. Raises the issue of accountability and transparency whereby, the revenues could not be directed towards sustainable management of forests rather for some people gains. In the light of Norman Long's theory (1984) on actor interface, which elucidates the inherent power struggles within institutional environments were compelled to critically analyze the structural inequalities and systematic barriers that underpin the timber value chain.

5.0 CONCLUSION AND RECOMMENDATIONS
Power relations cannot be avoided in the development of timber value chain. Understanding power relations among actors along the timber value chain is an important step towards the improvement of the timber sub-sector. Actors in the chain however should play their roles as guided in the National Forest Policy, in a manner that they do not prevent other actors in chain from pursuing their goals and desires.

It is therefore recommended that, actors along the timber value chain should play their roles in a manner that, they do not compromise the ability of other actors to accomplish their goals. The government should consider increasing financial and technical support to the sector and the people working at the community level on the value addition. This will help in achieving the Sustainable Development Goal (SDG) number one which aims to end poverty in all its forms everywhere. The support in such forms will also help in implementing some of the important activities when programs like FORVAC have phased out. There should be a balanced phasing out strategy right from the establishment of these programmes. Lastly, in order to solve the power struggles between TFS and the local government forest officers, the regulation on the revenue collection should be amended to ensure that the local government also get some percentage.

6.0 DISCLOSURE STATEMENT
I Mary Magiri, declare that I have no conflicts of interest or financial relationships that could be perceived as influencing the research presented in this

paper. The research paper titled "Analysis of Power Relations along the Timber Value Chain in Liwale and Ruangwa Districts, Tanzania" is an original work conducted with the utmost integrity and adherence to ethical principles. I have followed the guidelines and regulations set forth by my institution and the relevant governing bodies throughout the research process.

7.0 ACKNOWLEDGEMENTS

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The Fate of Selected Heavy Metals in River Water, Fruits and Vegetables to Potential Human Health Risks: The Case of Rau River in Moshi District, Tanzania

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Abstract

The presence of heavy metals in our environment significantly contributes to pollution in our food supply, particularly in fruits and vegetables. To analyze the levels of Cd, Cu, Fe, Pb, and Zn in green leafy vegetable (Amaranthus sp), fruit Citrullus lanatus (watermelon) and the Rau river water, an Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES) was used. Three sampling sites were selected, including one site with the least impact, Mawela and two highly impacted sites, Majengo and Msaranga. The order of heavy metal concentrations in the river water was found to be $Fe > Cu > Zn > Pb > Cd$, with the majority of the levels exceeding the acceptable standards set by the World Health Organization (WHO). There was significant variation in the concentrations of heavy metals in fruit. For example, the range of concentrations (mean ± standard deviation) observed were as follows: Fe (70.700 ± 1.532 to 221.010 ± 0.661 mg/kg), Cu (1.372 ± 0.047 to 2.540 ± 0.195 mg/kg), Zn (41.072 ± 0.519 to 45.718 ± 0.651 mg/kg), Pb (below detection limit to 0.398 ± 0.012 mg/kg), and Cd (0.031 ± 0.013 to 0.243 ± 0.112 mg/kg). The heavy metal concentration in Citrullus lanatus (watermelon) did not correlate with the levels found in the water samples. This disparity could be attributed to the watermelon's tendency to hyper-accumulate Cd from the river water. The hazard index, which assesses the potential health risks, indicates that the ingestion of vegetables exceeds a value of 1, while that of fruits remains below 1. Despite the heavy metal contamination levels in the tested vegetables and fruits being below the safe limit, there is a significant health concern regarding long-term exposure to even low doses of toxic elements. Therefore, it is crucial to conduct regular monitoring of heavy metals in all types of food items to accurately assess the health risks associated with heavy metal exposure in the human food chain.

Keywords: Heavy metals, watermelon, Vegetables contamination, hazard index, Moshi

1.0 INTRODUCTION

Toxic heavy metals are metallic elements that possess a higher density than water, as defined by Duffus (2002). In recent times, there has been growing

concern worldwide, both ecologically and in terms of public health, regarding the contamination of the environment by these metals (Bradl, 2002). Furthermore, human exposure to these metals has significantly increased due to their extensive utilization in various industrial, agricultural, domestic, and technological applications (He *et al*., 2005). The impact of heavy metals on our environment is substantial, particularly in relation to our food supply, specifically fruits and vegetables (Chauhan and Chauhan, 2014). Various sources of heavy metals in the environment have been reported, including geogenic, industrial, agricultural, pharmaceutical, domestic effluents, and atmospheric sources (Goyer, 2001).

Developing countries such as Tanzania, as highlighted by Alam *et al*. (2018), experience elevated levels of heavy metals in urban areas due to rapid industrialization, wastewater irrigation, and various other human activities. Given that the agricultural sector utilizes a significant portion, approximately seventy percent, of the available water (FAO, 2017); the reuse of treated wastewater plays a crucial role in promoting agricultural sustainability.

The release of industrial waste into rivers carries the risk of contaminating the water. This polluted water has direct repercussions on the soil, agricultural fields, and rivers, leading to the generation of multiple pollution sources, as noted by Butt *et al*. (2005). The presence of heavy metals in both soil and water raises significant concerns regarding public health, agricultural productivity, and ecological integrity, as emphasized by Fergusson and Kim (1991).

The contamination of surface water with toxic heavy metals represents a significant threat to human health, as stated by Yu *et al*. (2020). These metals can persist in the ecosystem as relatively stable and resistant contaminants (Redwan and Elhaddad, 2020), causing pollution in both surface and groundwater resources (Saria, 2016). Given the growing demand for water and the dwindling water supplies, coupled with increasing environmental pollution, it is imperative to monitor water quality, especially for drinking water supplies (Haghnazar *et al*., 2021).

The nutritional value of fresh fruits and vegetables is highly important for human health, as they contain vitamins, mineral salts, water, calcium, potassium, sulfur, and iron, as mentioned by Saria (2020). Furthermore, fruits and vegetables play a crucial role in maintaining health, as well as preventing and treating various diseases (Gwana *et al*., 2014). However, it is important to note that fruits and vegetables can contain both essential and toxic heavy metals, exhibiting a wide range of concentrations, as noted by Veazie and Collins (2004). Watermelon (*Citrullus lanatus*), a prominent fruit from the *curcurbitaceae family*, holds significant nutritional and medicinal value, as mentioned by Gwana *et al*. (2014). This fruit is known to be rich in carotenoids, vitamin C, citrulline, carbohydrates, water, sugar, and dietary fiber, as

highlighted by Bruton *et al*. (2009). Additionally, Ogunbanwo *et al*. (2013) reported that regular consumption of watermelon can contribute to proper kidney function and may provide protection against cancer. In Tanzania, sliced watermelon fruits are typically sold by vendors in various locations such as marketplaces, roadside stalls, schools, and public bus stations.

In recent times, there has been a notable increase in public awareness regarding the health risks associated with the contamination of vegetables and fruits by heavy metals. This has made the risk assessment of heavy metal contamination a significant global concern, as highlighted by Jan *et al*. (2010). Prolonged consumption of vegetables and fruits contaminated with toxic levels of heavy metals can lead to the accumulation of these metals in the liver, kidneys, and bones of individuals, potentially resulting in kidney, cardiovascular, nervous, and bone diseases, as emphasized by Anwar *et al*. (2016). Furthermore, heavy metals may also contribute to the occurrence of congenital disabilities, low birth weight in babies (<2.5 kg), and premature births (<37 weeks of completed gestation), as reported by Taylor *et al*. (2015).

The objective of the present study was to assess the levels of Cd, Pb, Cu, Fe, and Zn in vegetable (*Amaranthus sp*), edible parts of watermelon (*Citrullus lanatus*), and the river water used for irrigation. Additionally, a non-carcinogenic risk assessment was conducted to evaluate the potential impact of consuming *Amaranthus sp* (vegetable) and *Citrullus lanatus* (watermelon) on human health. The study aimed to ensure the safety of the local population in the vicinity of Moshi Municipal.

2.0   MATERIALS AND METHODS
2.1   Study design
The research utilized a quantitative cross-sectional method to collect, compile, and analyze data. Sampling was conducted between October 2021 and June 2022 at three designated study points to facilitate comparisons. The study points, namely Mawela, Majengo, and Msaranga, were conceptually categorized as upper stream, middle, and downstream locations, respectively, based on the direction of water flow.

2.2   Sampling Site
Investigated Rau river is located in the northern-eastern part Kilimanjaro region, Tanzania mainland between 037º30''E and 03º4'59''S. The Lower Moshi irrigation Scheme relies on the Rau river water as its primary source for irrigation. Located approximately 20 km from Moshi town, the Scheme is situated in the Moshi Rural District of the Kilimanjaro region. Excessive extraction of water from the river for irrigation purposes has resulted in the degradation of the riverside wetland (Stuart, 1990). To ensure the preservation of the riverside wetlands in the Rau River, it is essential to maintain a healthy vegetation cover, which will provide habitats for fish and wildlife, aid in water

purification, control soil erosion, and offer recreational opportunities. The Rau River courses its way southward, passing through the Njoro and Kahe forests, ultimately reaching its endpoint where it discharges into Lake Jipe (Odada and Olago, 2006). Three sampling stations were designated for the study, including one site with minimal impact known as Mawela, and two sites with significant impact, namely Majengo and Msaranga. The intensive land use practices in these areas, such as the cultivation of cash and food crops utilizing fertilizers and pesticides, animal grazing, and construction activities, have led to the near-total depletion of riparian vegetation.

2.3   Sampling
2.3.1 Water Sampling
Water samples were collected from three distinct points, namely Mawela, Majengo, and Msaranga. A total of 10 water samples were randomly obtained from each point, resulting in a grand total of 30 samples. Prior to collection, the sampling bottles were conditioned with 5% HNO3 and thoroughly rinsed with distilled de-ionized water, following the guidelines provided by APHA (2012). To ensure proper sampling, the polyethylene bottles were rinsed with river water at each sampling site a minimum of three times. Subsequently, the pre-cleaned polyethylene sampling bottles were immersed approximately 10 cm below the water surface, and approximately 0.5 L of water samples were collected from each site. The collected samples were then stored at temperatures below 4°C and sent to the Chief Chemistry Laboratory for further analysis.

2.3.2 Sampling of Vegetables and Fruits
Three individual 1 kg portions of African green leafy vegetable, specifically Amaranthus sp (commonly known as mchicha), were obtained from local gardens located in Mawela, Majengo, and Msaranga wards. To ensure hygienic conditions, the samples were carefully placed in pre-cleaned polyethylene bags. The collection of samples took place subsequent to removing the stalks from each sample, followed by rinsing them with de-ionized water. After allowing the excess moisture to naturally evaporate at room temperature, the samples were exposed to sunlight for a period of 2-3 days on a clean surface, with regular turning to prevent the growth of fungi.

A total of fifteen watermelon samples were collected from gardens located in Mawela, Majengo, and Msaranga wards, with five samples obtained from each ward. These watermelon samples were cultivated in gardens that were irrigated using water from the Rau River. To maintain cleanliness, the samples were stored in pre-cleaned polyethylene bags and subsequently sent to the Chief Government Chemistry Laboratory for analysis.

2.4   Sample Preparations and Analysis
Prior to determining the metal content, the instruments used were calibrated by utilizing standard solutions of metal ions prepared from salts. These standard

solutions, obtained from Merck (Germany), were of the highest purity level (99.98%). To create the working standard solutions of Fe, Cu, Pb, Zn, and Cd, the commercial annular grade 1000 ppm stock solutions were diluted in $25cm^3$ standard flasks and then filled to the mark with deionized water, resulting in concentrations of 2.0 ppm, 3.0 ppm, and 4.0 ppm for each metal ion. These solutions were analyzed using an atomic absorption spectrophotometer.

To enable accurate analysis using the Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES), digestion was performed beforehand. This process served to eliminate interference from organic matter and convert the metals into a form suitable for analysis. Quality control measures were implemented by employing standard laboratory measurements and techniques, including replication as outlined in the APHA (2012) guidelines.

The test portions were subjected to a drying process in a drying oven set at 105°C until a constant weight was achieved. Afterward, they were cooled to room temperature and crushed using a clean pestle and mortar to obtain homogenized samples. These ground samples were then stored in airtight sealed polyethylene bags at room temperature.

Approximately 2.0g of each processed sample was weighed and underwent dry ashing in a well-cleaned porcelain crucible within a muffle furnace, specifically at 550°C. The resulting ash was dissolved in 5.0 mL of a mixture consisting of HNO_3, HCl, and H_2O (in a ratio of 1:2:3). The solution was gently heated on a hot plate until the disappearance of brown fumes.

To the remaining material in each crucible, 5.0 mL of de-ionized water was added and heated until a colorless solution was obtained. The mineral solution from each crucible was then transferred into a 100.0 mL volumetric flask through filtration using Whatman No.42 filter paper. The volume was adjusted to the mark using de-ionized water. This resulting solution was subsequently used for heavy metal analysis through Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES).

2.4.1 Fruit sample preparation and chemical analysis

The watermelon samples underwent a thorough rinse with de-ionized water. They were then sliced and homogenized using an electric blender equipped with stainless steel rotor knives. The resulting homogenized samples were dispensed into clean sterile sample bottles. To extract the desired components, the homogenized samples followed the acid digestion method described by Cui et al. (2010). Three portions, each measuring 30 mL, were accurately measured and transferred to a 200 mL beaker. Subsequently, 30 mL of 10% concentrated HNO_3 was added, and the mixture was allowed to settle for 15 minutes. Wet acid digestion was then conducted using 10 mL of a 1:3 mixture of concentrated

HCl and HNO3 (obtained from Merck) on a hotplate until a clear solution was obtained. The digested samples were allowed to cool to room temperature.

The digested samples were filtered through Whatman No. 1 filter paper into a 50 mL volumetric flask. The final volume was adjusted to 50 mL using distilled water. The resulting solution was transferred to clean and dry plastic bottles for further analysis. Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES) was employed to analyze the digestate and determine the concentration of heavy metals present.

2.4.2 Analysis of heavy metal parameters

From stock standard solutions containing 1000 mg/L of Cd, Pb, Cu, Zn, and Fe, intermediate standard solutions with a concentration of 100 mg/L for each metal were prepared. To create appropriate working standards, the intermediate solutions were diluted using distilled water in 2M HNO3. To optimize sensitivity, the working standards were aspirated sequentially into the Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES) following the instructions provided in the instrument's operation manual. The absorbance of each working standard was recorded. Calibration curves were generated for each metal standard by plotting absorbance against concentration (mg/L), using different points on the curve. Once calibration was completed, the sample solutions were aspirated into the spectrometer, and the metal concentrations were directly determined by reading the results (as shown in Table 1).

Table 1: Calibration graph absorbance against the concentration of heavy metals (mg/kg)

S/N	Metal	Model for Absorbance vis Concentration	R^2
1	Zn	y = 0.3127x	0.9935
2	Cu	y = 0.0802x	0.9952
3	Cd	y = 0.057x	0.9906
4	Pb	y = 0.0032	0.9917
5	Fe	y = 0.018	0.9929

2.5 Assessment of Potential Human Health Risk

The heavy metals' non-carcinogenic risk to humans was determined by assessing the estimated daily intake (EDI) and hazard quotient (HQ).

2.5.1 Estimated daily intake (EDI)

The daily intake of metals from green leafy vegetables or from fruits depends on both the metal concentration in food and the daily food consumption. In addition, the body weight of the human can influence the tolerance of contaminants. The EDI are a concept introduced to consider these factors. The EDI is calculated using equation 1.

$$EDI = \frac{C x IR x EF x ED}{BW x AT}$$ ……………………………………………………(1)

Where EDI denotes estimated daily intake of heavy metals (mg/person/day); BW stands for adult body weight considered as 70 Kg (USEPA, 1989; FAO/WHO, 2019); C is the trace element concentration in the exposure medium (mg/kg); IR is the ingestion rate (kg/d), for the presents study the ingestion rate for vegetable was 0.32 kg/day and fruit was 0.22kg/day (Pipoyana et al., 2018; Storelli, 2008); EF is the exposure frequency (for investigated fruit and vegetable is 183 d/year); ED is the exposure duration 66 years (average Tanzania life expectancy) (UN, 2022). AT is the time period over which the dose is averaged (365 d x number of exposure years).

2.5.2 Hazard Quotient (HQ)

The risks to human health via the consumption of metal contaminated vegetables were estimated on the basis of the hazard quotient (HQ), which is defined as the health risk due to exposure of a pollutant with respect to the estimated daily intake (EDI). The HQ was calculated by dividing the estimated daily intake (mg/kg/day) of the contaminant through vegetable ingestion by the reference oral dose, as follows (equation 2).

$$HQ = \frac{EDI}{RfD} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(2)$$

Where: EDI is the estimated daily intake; RfD (mg/kg/day) is The reference oral dose. This is an estimated value of tolerable daily ingestion of pollutants (maximum permissible risk) by human beings during a lifetime. The values of RfD used in this study were taken from De Miguel et al. (2007) and Sharma et al. (2016) where Pb = 0.004. Cd 0.001, Cu = 0.04, Fe = 0.7, Zn = 0. If the hazard quotient of a particular contaminant is less than one (<1), there would be no obvious adverse effects expected on the exposed population.

2.5.3   Hazard Index (HI)

Hazard Index (HI) measures aggregated non-cancerous risks because of heavy metals intake via regular ingestion of contaminated vegetables or fruits. To estimate the risk to human health through more than one heavy metal, the target hazard index (HI) has been developed (US EPA, 2013). The hazard index is the sum of the hazard quotients for all HMs, which was calculated by equation 3.

$$HI = \sum_{j=1}^{N} HQ_j = \sum_{j=1}^{N} \frac{EDI_j}{RfD_j} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(3)$$

If the value of HI >1, it is considered to have possibility of substantial health hazard (Schaefer et al., 2000). If HI < 1, the non-carcinogenic adverse effect due to a particular route of exposure or chemical is assumed to be insignificant.

3.0   RESULTS AND DISCUSSION
3.1   Concentration of Heavy Metals in River Water

A comprehensive analysis was conducted on the total water samples to identify and quantify five heavy metals, namely Fe, Pb, Cu, Zn, and Cd. The levels of

these heavy metals, based on the results obtained, followed the order Fe > Cu > Zn > Pb > Cd in the water samples collected from Rau River (Table 2).

Table 2: Heavy metal contents in water samples from Rau River (mg/L)

Metal	Mawela	Majengo	Msaranga	WHO (2008)	TBS (2005)
Zn	0.427±0.030	0.179±0.024	0.286±0.054	3.00	5.00
Cu	2.623±0.244	3.023±0.108	2.571±0.062	2.00	2.00
Fe	3.974±0.124	4.7393±0.0823	3.741±0.0956	3.00	3.00
Pb	0.320±0.018	0.2313±0.006	0.2602±0.027	0.01	0.01
Cd	0.110±0.01	0.2102 ±0.019	0.1193±0.045	0.003	0.002

The concentration of Fe varies from 3.741±0.096 mg/L (at Msaranga ward) to 4.739±0.082 mg/L (at Majengo ward). Similarly, the concentration of Cu ranges from 2.571±0.062 mg/L (at Msaranga ward) to 3.023±0.108 mg/L (at Majengo ward). These values exceed the limits set by WHO (World Health Organization) and TBS (Tanzania Bureau of Standards), which are 3.0 mg/L and 2.0 mg/L, respectively. The increased concentration of iron in river water could stem from various sources, such as runoff from small-scale industrial waste, natural geological influences, agricultural practices introducing fertilizers or pesticides, and the corrosion of iron-based structures along the riverbanks (Togibasa *et al*. 2018). Additionally, variations in pH levels or changes in the water's oxygen content could also influence the solubility and concentration of iron in the water, leading to elevated levels beyond recommended thresholds. These findings are consistent with a previous study by Parihar *et al*. (2020) which reported copper levels in river water ranging between 3.579 and 4.968 mg/L and iron levels between 2.578 and 2.690 mg/L. Although iron is an essential element, its high concentration in river water can lead to various problems, such as incrustation, clogging of water treatment facilities, acidification of water leading to pipe corrosion, decreased soil productivity, and unpleasant taste in drinking water (Parihar *et al*., 2019). Additionally, high iron intake by humans can result in "haemochromatosis," a disorder that necessitates frequent blood transfusions (Parihar *et al*., 2020). Copper is a naturally occurring element that is commonly found in water even at low concentrations, and it can be toxic. In mammals, it is known to cause brain damage (Fatoki *et al*., 2002).

The concentration of Pb varies from 0.231±0.006 mg/L (at Majengo ward) to 0.320±0.018 mg/L (at Mawela ward), while the concentration of Cd ranges from 0.110±0.014 mg/L (at Mawela ward) to 0.210±0.019 mg/L (at Majengo ward). Both of these values exceed the permissible limits for drinking water set by the WHO (2008), which are 0.01 mg/L for Pb and 0.003 mg/L for Cd. These results are lower compared to the values reported in a previous study by Nkinda *et al*. (2021) on water samples from the tributaries of the Mara River in Tanzania, which showed concentrations of Pb to be 0.76±0.09 mg/L and Cd to be 0.74±0.1 mg/L.

The presence of Cd is of major concern due to its potential health risks to both humans and aquatic organisms. The detected levels of cadmium may be attributed to emissions through air and water from hazardous waste sites and nearby factories along the river. High levels of Cd have been associated with various diseases, including memory loss, reproductive defects, cancer, as well as damage to the lungs, kidneys, and immune system, which can ultimately lead to death (WHO/UNICEF, 2015). Similarly, elevated levels of Pb exceeding 0.01 mg/L have been linked to anaemia, memory loss, anorexia, brain damage, and even fatality (DWAF, 2002).

The concentration of zinc ranges from 0.18 mg/L (at Majengo ward) to 0.43 mg/L (at Mawela ward). These levels are below the permissible limits set by the WHO (3.00 mg/L) and TBS (5.00 mg/L). Zinc is an essential element for the human body, serving as a catalytic or structural component in numerous enzymes involved in energy metabolism (Roohani *et al*., 2013). However, high doses of zinc can lead to health complications such as fatigue, dizziness, and neutropenia (Laura *et al*., 2010).

3.2   Concentration of Heavy Metals in Water Mellon (Citrullus lanatus)

Table 3 present the concentrations of Fe, Cu, Zn, Pb, and Cd in watermelon samples collected from three sites along the Rau River.

Table 3: Heavy Metals Concentration in Water Mellon (Citrullus lanatus) (mg/kg)

Metal	Mawela	Majengo	Msaranga	JECFA (2002)
Zn	44.860±0.631	41.072 ±0.519	45.718±0.651	99.4
Cu	2.540±0.195	1.372±0.047	2.169±0.115	73.3
Fe	70.700±1.532	221.010±0.661	208.187±0.625	425.5
Pb	BDL	0.321±0.081	0.398±0.012	0.3
Cd	0.031±0.013	0.243 ±0.112	0.230±0.072	0.2

The concentrations of Fe, Cu, Zn, Pb, and Cd in the watermelon samples showed significant variations. The range of concentrations observed were as follows: Fe (70.700±1.532 to 221.010±0.661 mg/kg), Cu (1.372±0.047 to 2.540±0.195 mg/kg), Zn (41.072±0.519 to 45.718±0.651 mg/kg), Pb (BDL to 0.398±0.012 mg/kg), and Cd (0.031±0.013 to 0.243±0.112 mg/kg).

These values were found to be higher compared to the concentrations reported in watermelon samples from Saudi Arabia by Ali and Khairia (2012), where Fe was 112.8 mg/kg, Cu was 3.21 mg/kg, Pb was 3.67 mg/kg, and Cd was 1.13 mg/kg. However, the concentration of Zn was lower in this current study compared to the findings from Saudi Arabia (29.78 mg/kg).

With the exception of Cd in Majengo and Msaranga, the concentrations of the other metals in the watermelon samples were below the maximum acceptable limits set by JECFA (2002). The elevated concentrations of Fe and Zn could potentially be attributed to the use of fertilizers, pesticides, organic waste dumping, and the utilization of sludge in the area.

The study revealed that the concentrations of selected heavy metals in watermelon were not directly proportional to those found in the water samples. Specifically, the highest concentration of Cd in the water samples was measured at 0.12 mg/kg, whereas in the watermelon samples, it was found to be 0.24 mg/kg. This observation could be attributed to the watermelon's tendency to hyper-accumulate Cd from the soil or water, as suggested by Hussain *et al.* (2021). Additionally, other potential sources of Cd exposure, such as wastewater irrigation, might also contribute to the elevated levels detected in the watermelon samples.

The relatively low levels of copper observed in all the sliced watermelon fruits may be attributed to minimal copper deposition in the soils (Akinola and Ekiyoyo, 2006) and minimal contamination during processing. Ashish *et al.* (2013) reported that the ingestion of copper beyond its permissible limit can lead to liver and gastrointestinal problems, while Flora *et al.* (2007) highlighted that exceeding the upper limit of copper intake can result in anemia, anxiety, insomnia, and cardiovascular diseases. Therefore, it is crucial to monitor copper levels in food to prevent them from exceeding the maximum permissible limit.

Zinc (Zn) is a vital element for both plants and animals, but even a slight increase in its concentration can disrupt physiological processes. Interestingly, the presence of Zn appears to play a crucial role in counteracting the toxic effects of cadmium (Cd). In the present study, the highest quantity of zinc was detected in the melon samples, with a concentration of 45.718±0.651 mg/kg. This finding deviates from the results reported earlier in Libya by Elbagermi *et al.* (2012), where the zinc concentration was reported to be 8.24 mg/kg.

3.3 Concentration of Heavy metal in Amaranthus sp (Mchicha)

The average concentrations of heavy metals (Fe, Cu, Zn, Pb, and Cd) in Amaranthus sp (Mchicha) collected from three sites along Rau River are presented in Table 4.

Table 4: Heavy Metal Concentration in *Amaranthus sp* (Mchicha)

Metal	Mawela	Majengo	Msaranga	WHO/FAO, 2007
Cd	0.220±0.007	0.142±0.012	0.238±0.007	0.2
Cu	0.279±0.032	1.922±0.143	1.230±0.055	73.3
Fe	13.500±0.370	31.820±1.059	28.269±0.446	425.5
Pb	0.140±0.021	0.020±0.014	0.130±0.008	0.3
Zn	48.560±0.855	51.647±0.867	45.718±0.687	99.4

The concentration of iron (Fe) in Amaranthus sp was found to be below the permissible limit set by WHO/FAO (2007). These findings align with the results reported by Zahir *et al.* (2009), who analyzed various vegetable samples and observed high concentrations of Fe (7.9-24.8 mg/kg) in Pakistan. Similarly, Waheed *et al.* (2003) conducted a study on raw foodstuffs grown in wastewater

industrial areas and reported Fe concentrations ranging from 17.0 to 35.60 mg/kg.

The concentration of zinc (Zn) in Amaranthus sp varied from 45.718±0.687 mg/kg at Msaranga ward to 51.647±0.867 mg/kg at Majengo ward. These results were notably higher than those reported by Singh *et al*. (2004), who found Zn concentrations ranging from 3.56 to 4.59 mg/kg in vegetables. Conversely, our findings were consistent with the results obtained by Al Jassir *et al*. (2005), who reported Zn levels ranging from 14.14 to 76.28 mg/kg in certain vegetables. Overall, the present study demonstrated that the concentration of Zn in Amaranthus sp was below the international standards limits (99.4 mg/kg, WHO/FAO, 2007).

The Amaranthus sp (Mchicha) samples collected from Mawela and Msaranga wards exhibit the highest recorded concentration of Pb, with values of 0.140±0.021 and 0.130±0.008 mg/kg respectively. These concentrations fall below the acceptable limits set by the WHO/FAO (2007). Despite the fact that the Pb concentrations in the vegetable are within permissible levels according to FAO/WHO standards, it is crucial to consider the quantity consumed and the frequency of intake in the long term (Chove *et al*., 2006). The cumulative effect of sustained intake of heavy metals is significant since they tend to persist in the body and are not easily eliminated.

At Majengo ward, the Amaranthus had the highest recorded Cu concentration of 1.922±0.143mg/kg. The present findings indicate lower levels of Cu than those reported previously by Sharma *et al*. (2006) for vegetables grown in wastewater areas of Varanasi, India, which ranged from 2.25-5.42 mg/kg.

The reduced Cu concentration in vegetables can be attributed to the relatively lower release rates of copper from contaminated soils compared to other heavy metals, as indicated by Sukreeyapongse *et al*. (2002). The high tendency of added copper to persist in the soil acts as a significant controlling factor for its uptake by plants. Additionally, this phenomenon is likely due to the absence of industrial areas and areas with intense human activity along the Rau River, which runs near the sampled sites.

The highest concentration of cadmium was detected at Msaranga ward, (0.238±0.007 mg/kg) was exceptionally lower compared to values found in vegetables from Titagrah, West Bengal, India (17.79 mg/kg) (Gupta *et al*., 2008). Furthermore, it was lower than values reported in China (0.73 mg/kg) (Liu *et al*., 2005), but significantly higher than values observed in vegetables from Egypt (0.008 mg/kg) (Doghein *et al*., 2004). The lower Cd values in Msaranga ward can be attributed to soil pH levels. Soil pH plays a role in the uptake of cadmium by vegetables, with pH values below 5.5 increasing Cd uptake, while pH values above 6 reduce Cd uptake in crops. In the study area,

the soil pH ranges from 6.6 to 7.3 (TARI, 2020), resulting in lower Cd uptake by the vegetables.

3.4 Non-carcinogenic Health Risk Assessment

Table 5 present results of the assessment conducted to determine the health risk posed to the residents of Moshi Municipality and its surrounding areas due to the intake of heavy metals from consuming Amaranthus sp and watermelon. The study calculated the daily intake of metals (DIM), health risk index (HRI), and hazard quotient (HQ) using equations 1, 2, and 3, respectively.

3.4.1 Daily intake of heavy metals from fruit and vegetable (DIM)

The results of the DIM analysis in Table 5 were compared to the recommended daily intake of metals and the upper tolerable daily intake level (UL) set by the Institute of Medicine for individuals aged 19 to 70 years (FDA, 2001; Garcia-Rico, 2007).

Table 5: Average Daily Intake of Heavy metals in Vegetable and Fruits (mg/day)

Metal	Sample	Mawela	Majengo	Msaranga	Upper Limit*
Cd	*Amaranthus*	5.04×10^{-4}	3.25×10^{-4}	5.47×10^{-4}	0.064
	Citrullus lanatus	3.47×10^{-4}	2.24×10^{-4}	3.76×10^{-4}	
Cu	*Amaranthus*	6.39×10^{-4}	4.41×10^{-3}	2.819×10^{-3}	10.0
	Citrullus lanatus	4.40×10^{-4}	3.03×10^{-3}	1.94×10^{-3}	
Fe	*Amaranthus*	3.09×10^{-2}	7.29×10^{-2}	6.48×10^{-2}	45
	Citrullus lanatus	2.13×10^{-2}	5.01×10^{-2}	4.45×10^{-2}	
Pb	*Amaranthus*	3.21×10^{-4}	4.60×10^{-5}	2.98×10^{-4}	0.24
	Citrullus lanatus	BDL	3.20×10^{-5}	2.05×10^{-4}	
Zn	*Amaranthus*	1.11×10^{-1}	1.18×10^{-1}	1.05×10^{-1}	40.0
	Citrullus lanatus	7.65×10^{-2}	8.14×10^{-2}	7.20×10^{-2}	

* (UL) Upper limit levels of heavy metals in foodstuffs (FDA, 2001; Garcia-Rico, 2007)

Table 5 clearly shows that the vegetable species Amaranthus had the highest estimated daily intake of metals for Zn (8.14×10^{-2} mg/day), Pb (3.21×10^{-4} mg/day), Fe (7.29×10^{-2} mg/day), Cu (4.41×10^{-3} mg/day), and Cd (5.04×10^{-4} mg/day). On the other hand, the fruit species Citrullus lanatus had the highest estimated daily intake of metals for Zn (8.14×10^{-2} mg/day), Pb (2.21×10^{-4} mg/day), Fe (5.01×10^{-2} mg/day), Cu (4.40×10^{-4} mg/day), and Cd (3.76×10^{-4} mg/day).

In this study, the detected daily intake values of heavy metal were found to be lower than those reported in a previous study by Elbagermi *et al*. (2012). Elbagermi *et al*. (2012) found that the average contribution of heavy metal intake from a fruit-based diet for an average human being was 0.03689 mg/day for Pb, 0.0554 mg/day for Cd, 0.205 mg/day for Zn, and 0.288 mg/day for Cu. In the same study, the estimated daily intake levels of Pb, Cd, Zn, and Cu from vegetable consumption were 0.25 mg/day, 0.14 mg/day, 8.15 mg/day, and 3.36

mg/day, respectively, which are higher than the values found in this current study.

Both studies' results are significantly lower than the recommended daily intake of metals and the upper tolerable daily intake level (UL). It is noteworthy that 60% of the highest estimated daily intake of the analyzed heavy metals in vegetables and fruits was observed in Majengo ward, which is considered a middle-ranking area. The elevated levels of Cd and Zn measured in Majengo ward could potentially be attributed to the excessive use of fertilizers and pesticides in Mawela ward, given that crop production dominates the land use in this catchment area. Additionally, it is possible that some individuals in this area consume more than twice the average amount of rice, resulting in their daily dietary intake of heavy metals surpassing the DIM. The high daily intake of heavy metals from vegetables and fruits in Majengo ward is suspected to originate from industrial activities, traffic emissions, and hospital waste.

3.4.2 Hazardous Quotient (HQ)

Figure 2 shows that the hazard quotient (HQ) of the tested heavy metals in the selected leafy vegetables and fruits from the Rau river area are all below 1.0. Based on the results, the consumption of these vegetables and fruits can be deemed safe, with no significant risk to human health. In both the vegetable (Amaranthus sp) and the fruit (Citrullus lanatus), the hazard quotient (HQ) followed a descending order of Cu < Fe < Pb < Zn < Cd. It is important to note that while the HQ-based risk assessment method does not provide a quantitative estimate of the probability of adverse health effects in an exposed population, it does offer an indication of the risk level associated with pollutant exposure (Chary *et al*., 2008). The reliability of the risk estimation method has been acknowledged by many researchers (Chary *et al*., 2008; Khan *et al*., 2009; Wang *et al*., 2005), and its validity and usefulness have been demonstrated.
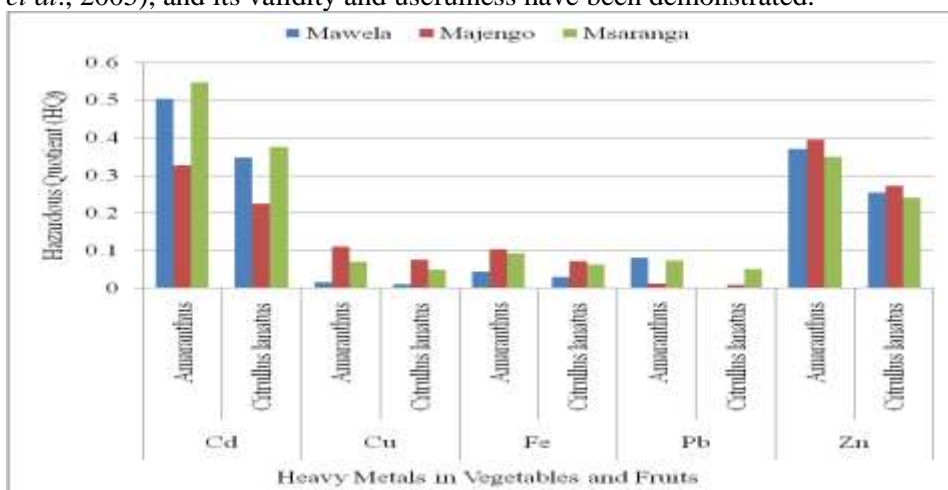

Figure 2: Hazard Quotient (HQ) of the Tested Heavy Metals in Vegetable and Fruit

3.4.3 Hazard Index

The hazard index calculated on the basis of ingestion of vegetable is higher than 1, indicating an axiomatic adverse health impact to residents (Figure 3).
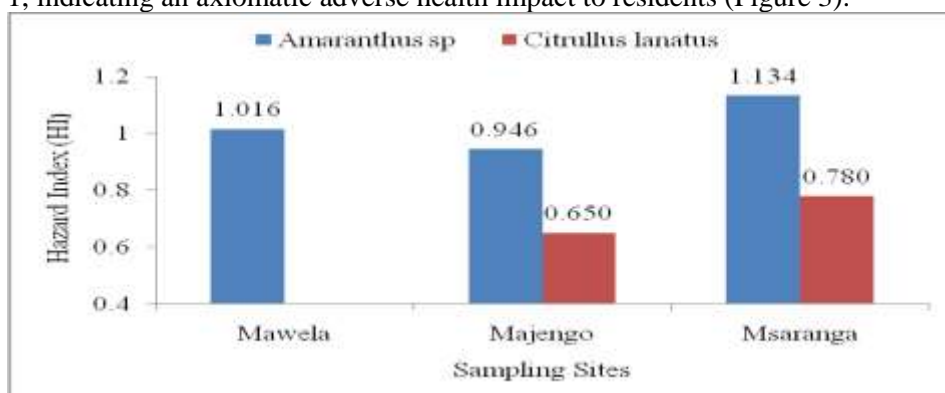
Figure 3: Hazard Index for heavy metals resulting from vegetable and fruit analyzed

Nevertheless, the health risk associated with fruit ingestion was found to be below 1, indicating that the potential health risk posed by consuming fruits in the Rau River and its surroundings is not significant.

4.0 CONCLUSION AND RECOMMENDATIONS

Several research studies have established a clear connection between the excessive bio-accumulation of heavy metals and various health abnormalities. These heavy metals not only present immediate environmental health risks but also pose long-term threats. Leafy vegetables and fruits that are cultivated in open-fields or irrigated with contaminated water have been found to contain high concentrations of heavy metals, thereby posing a significant risk to overall health and well-being. The hazard index calculated for vegetable ingestion exceeds 1, indicating a potential health risk. On the other hand, the hazard index for fruit ingestion is below 1, suggesting a lower health risk. However, it is important to note that when considering all other routes of heavy metal exposure, the potential health risks for the residents of Moshi might actually be higher.

The findings of this study suggest several recommendations. Firstly, raising awareness about the benefits of organic farming and promoting the long-term application of fertilizers, pesticides, and sewage effluents should be prioritized. Discouraging practices such as the direct release of untreated sewage water into agricultural fields or river bodies is crucial. Furthermore, Tanzanian food and health agencies should take a proactive approach in providing the public with information on permissible limits (both minimum and maximum) for contaminants in food. Regular monitoring of heavy metals in vegetables and other food items is essential to prevent their excessive accumulation in the food chain. It is imperative to emphasize the need for continuous monitoring of heavy metals in all types of food, not just fresh produce, to accurately assess the

potential health risks associated with heavy metal contamination in the human food chain.

5.0 ACKNOWLEDGEMENTS

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Peri-Urban Land Use/Cover Change in Songea Municipality, Tanzania

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Abstract

Peri-urban land cover change in developing countries is taking place at a rapid rate following an increase in population in urban areas. This paper assessed land cover changes in peri-urban areas in developing countries. It specifically focuses to determine land cover changes which have occurred between 2003 and 2016 and exploring causes of land cover change in Songea peri-urban areas. The study applied a mixed research design as it involved quantitative and qualitative approaches. 132 heads of households were randomly selected and used in the study as a sample. Data were collected using questionnaires and interviews. Arc-Map 10.1 was used to analyse Google earth downloaded images of 2003 and 2016. Other data were analysed using SPSS version 20 based on descriptive analysis and content analysis was used for collecting qualitative data. Findings revealed that land cover changed from farm, grassland, and swamp into the built-up area following population increase in Ruhuwiko. The built-up area increased from 31% to 61 % while the cultivated area decreased from 31% in 2003 to 15% in 2016. 82% of the respondents pointed out that population increase in peri-urban areas were the main cause of land cover change. The study concluded that peri-urban land cover is changing toward built up areas and population increase is the main cause for peri-urban land cover change unlike climate change and infrastructural development. The study recommends enforcing urban planning regulation to avoid unplanned settlements.

Keywords: Land cover, land cover change, land cover detection, Songea Municipality

1.0   INTRODUCTION

Peri-urban land cover change in developing countries is taking place at a rapid rate following an increase of population in urban areas (Winkler *et al.,* 2021). Land cover change has been taking place since human being discovered fire and gained momentum when the establishment of permanent settlements came into practice (Feurden *et al.,* 2020; Wang *et al.,* 2020a, Wang *et al.,* 2020b). The rate of changing land cover increased as the number of people increased and so does to technological advancement (Ochola, Nyamai, and Owuor, 2019; Minale, 2013; Winkler *et al.,* 2021). Human needs such as food (Wang *et al.,* 2015), shelter, transport, and raw materials to mention a few pushed changes in land

cover following the clearance of the existing vegetation by introducing farming areas, road routes, and settlements. Peri-urban areas, especially in developing countries, play the role of accommodating most urban dwellers who cannot afford cost of living in the central part of the urban area. Peri-urban is the area is considered to be a transition area where transformation of land use/cover manifests (Mortoja *et al.*, 2020). Normally these areas are found in suburban areas where agriculture economy is dominant. Built up land use is mostly favoured at the expenses of agriculture, bush land, forests, and wetlands.

Globally land cover change continues to take place. Land reclamation done in the Netherlands is a good example of land use/cover change whereby portions of sea and lakes filled up with soil whereby land for urban expansion (settlement and commercial centres), recreation, and agriculture was obtained. More than 1650 km^2 of the new land portion was obtained after the reclamation of the Zuiderzee, Beemster and Haarlem lakes (Hoeksema, 2006 & 2007). The situation of land cover change in peri-urban areas is quite different between developed countries and developing countries. The difference is manipulated in terms of direction and magnitude, causes, and impact. Factors such as level of technology, government priorities, and migration (Abhishek, Jenamani & Mahanty, 2017) have also been enlisted among causes of land cover change particularly in developing countries.

Land use cover change in African countries reported in many countries. Urbanization, population increase, construction of infrastructure and agricultural improvement influence land cover change in peri-urban. Rawat & Manish (2015) in Welde and Gebremariam (2017) reveal impact of land cover change occurring peri-urban areas of Ethiopia particularly adjacent Tekeze dam. Again, a study done in Kenya highlighted that 97.5% among factors that encourage transformation of peri-urban area associates with land use/cover change (Mwangi *et al.*, 2016). Built up areas increases in many per-urban areas of mega cities, municipal and towns in African countries at the expenses of agriculture land (Follmann *et al.,* 2021), urban forest (Belay *et al.*, 2014; Kukkonen & Kayhko, 2014), urban wetlands (Welde & Gebremariam, 2017; Ntongani, 2014) and shrubs and grasslands (Midekisa *et al.,* 2017; Bullock *et al.,* 2021*)*. About 18,154,000 ha have changed its land cover in the period of three decades since 1998 to 2017 in cumulative of areas in Ethiopia, Malawi, Uganda, Zambia, Rwanda, Kenya and Tanzania (Bullock *et al.,* 2021). Provided data indicate that peri urban areas in African countries including East African are in dynamic state of cover change to build up areas.

In Tanzania, the National land use policy of 1997 mentioned urbanization, and population growth being among factors affecting land use cover change in the country (United Republic of Tanzania [URT], 1997). Further, the demand for land for settlement is quite large (Aribigbola, 2007; World Bank, 2012). Referring to the Tanzanian census report of 2012, World Bank estimates that

more than 38 percent (approximately 28 million) will be living in urban areas by 2030 of the total population in the country (World Bank, 2012). Such estimation highlights an increase in land cover change in peri-urban areas where most people might focus on them establishing their settlements.

Songea urban is growing at a rate of 2.5% per annum (Songea Municipal profile, 2010). The Census report of 2022 confirms an increased population as a result there was an expansion of urban areas through the extension of municipal boundaries (URT, 2013). This made Songea municipality increase the number of wards from 17 wards in 2002 to 21 wards in 2012. Kironde (1995) critically pointed out that peri-urban areas of small and large towns are ingested up to enlarge the boundaries of urban areas. Four wards that were not part of Songea municipality before 2012 were Tanga, Lilambo, Mwengemshindo, and Mletele. These wards depended on agriculture as the main economic activity. After being included as part of Songea municipality slowly change from depending on agriculture activities to different activities for their economy. Many people purchased land portions and developed them in wards located in the periphery of Songea municipality including Ruhuwiko because cost is low (Haule, 2014). It is, therefore, this paper focuses to assess land cover change in Ruhuwiko ward as part of peri-urban area of Songea municipality. It specifically focuses to examine land cover change that occurred between 2003 and 2016 and explaining the causes of land cover change.

2.0   METHODOLOGY

The study was conducted in Songea municipality specifically Ruhuwiko ward. The ward is located on the western side of Songea municipality headquarters. It is one among peri-urban area wards where mixed economy of agriculture and trade activities is being performed. Being located in peri-urban areas, the ward experiences an increase in population which enhances changes in land cover. Figure 1 indicates the position of Ruhuwiko ward in Songea municipality. The study used google earth images of 2003 and 2016 to detect land use-cover change and a sample of 132 from households in Ruhuwiko ward involved in filling questionnaires. In the process of analyzing data, the two images were analyzed using ArcGIS whereas supervised classification was used to identify land use-covers. On the other hand, questionnaires' collected data were analysed by using descriptive statistics where frequency and percentage were involved and content analysis was used for qualitative data. Finding of the study were presented by using tables, maps, pie charts and narration text.
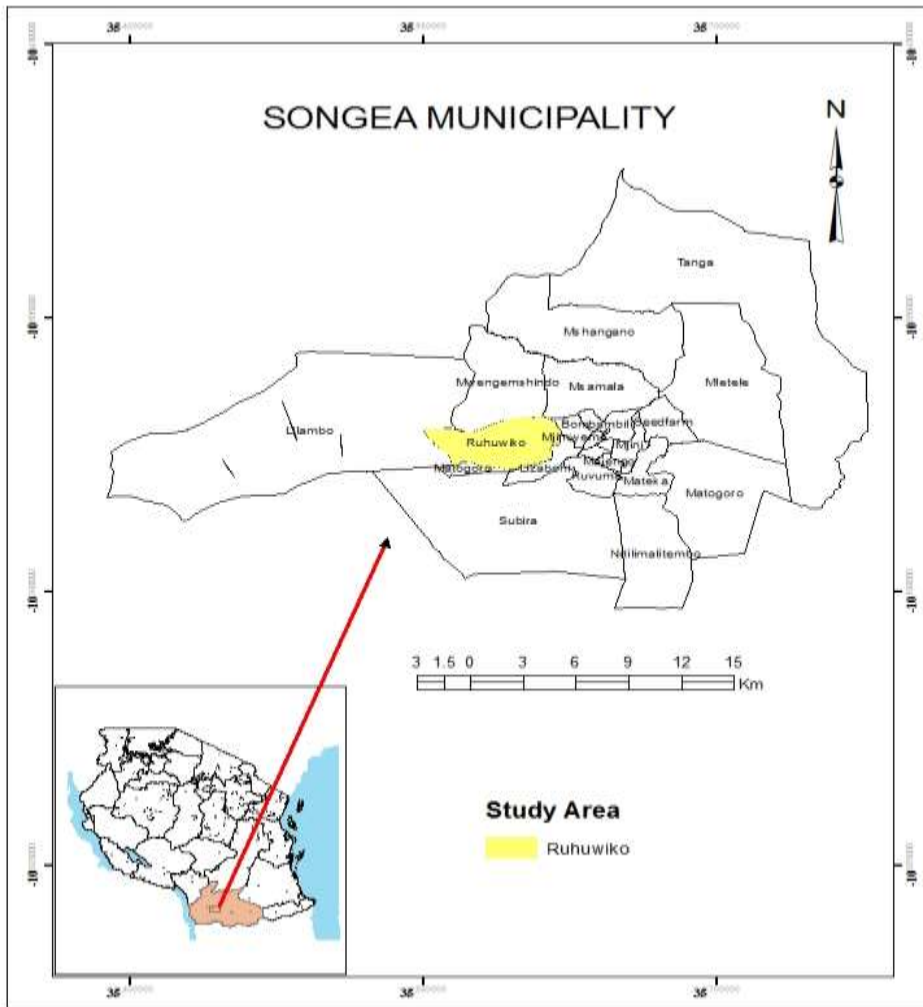
Figure 1: Songea Municipal Map of the study area
Source: Modified from National Bureau of Statistics 2012

3.0   FINDINGS AND DISCUSSION
3.1   Change in Land use/land cover between 2003 and 2016

Supervised classification through ArcMap 10.1 indicated that Ruhuwiko ward had several land covers including swampy, built-up area, cultivated area, and bushland which changed over time. Table 1 shows the distribution of land cover into four classes in 2003 and 2016 with a total of 1339.41 hectares. A cultivated area dominated in Ruhuwiko ward whereby 35% of the land was used for cultivation, this was followed by built-up area which covered 30.8%, swamp 19.1%, and bushland 15. 1%. This implied that in 2003 Ruhuwiko ward was part of Songea municipality peri-urban area where urban agriculture was dominant. Figure 2 shows the land cover in Ruhuwiko for the years 2003 and 2016.

Table 1: Land Cover of Ruhuwiko in 2003 and 2016

2003				2016		
Land cover	**Area ha**	**Percentages**		**Land cover**	**Area (ha)**	**Percentages**
Swampy area	256.36	19.1		Swampy area	249.17	18.6
Built-up area	412.33	30.8		Built-up area	812.32	60.7
Cultivated land	468.94	35		Cultivated land	200.07	14.9
Bushland	201.78	15.1		Bushland	77.85	5.8
Total	**1339.41**	**100**		**Total**	**1339.41**	**100**

Source: Analysis by ArcMap, 2022
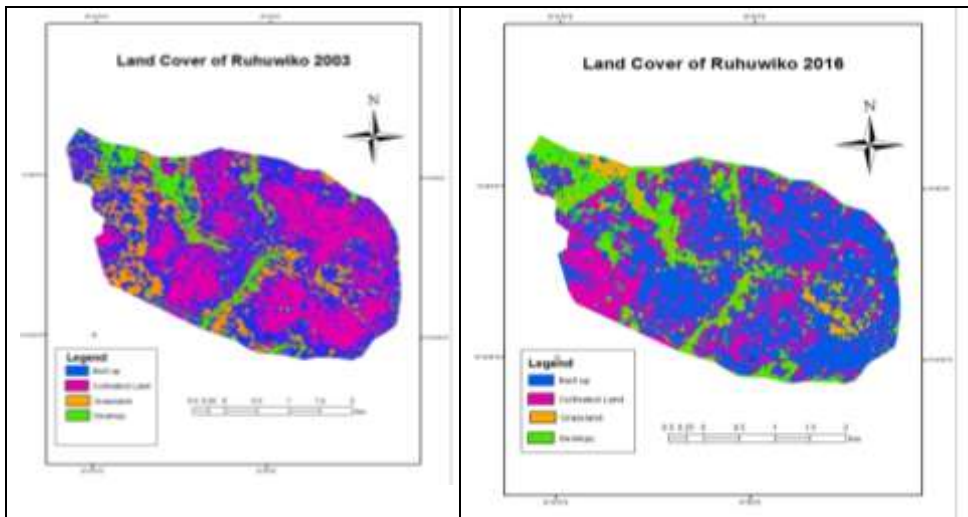
Figure 2: Land Cover of Ruhuwiko in 2003 and 2016
Source: Analysis by ArcMap 10.1, 2022

In 2016, supervised classification by ArcMap 10.1 detected a change of land cover from grassland, cultivated land, bushland, and swampy to built up between 2003 and 2016 (Figure 2; Table 1). Built-up area increased by 29.9% from 30.8% to 60.7% which is more than half of the total land of Ruhuwiko ward swampy area follows having 18.6%, cultivated land 14.9%, and bushland was 5.8% (Table 1). This finding reveals that Ruhuwiko ward is under transformation. Peri-urbanization drives land cover change in Ruhuwiko ward. This situation has affected community livelihoods in both positive and negative ways. Further, an increase in built-up area in the study area caused an increase in land value as an asset as result many residents sold their land plots/portions to migrants and moved outwards.

Table 2 shows differences between land cover between 2003 and 2016 indicating that only built-up area got a positive value of 399.99 ha which implies it had increased from 30.8% to 60.7%. Swampy slightly decreased from 19.1% to 18.6 which is equal to -7.19 ha, cultivated area decreased to 14.9% from 35% in 2003 and bushland decreased tremendously from 15.1% in 2003 to 5.8% in 2015.

Table 2: Land Cover Change in Ruhuwiko ward between 2003 and 2016

	2003		2016		Land-use Change (t2- t1)	
Land Cover/use	**Area (ha)**	**Area %**	**Area (ha)**	**Area %**	**Area (ha)**	**% change**
Swampy area	256.36	19.1	249.17	18.6	-7.19	2.8
Built-up area	412.33	30.8	812.32	60.7	399.99	97
Cultivated land	468.94	35	200.07	14.9	-268.87	57
Bushlands	201.78	15.1	77.85	5.8	-123.93	61
Total	1339.41	100	1339.4	100		

Source: Analysis by ArcMap 10.1 (2022)

Land cover change revealed that cultivated land, swamp (waterlogged), and bushland had decreased following the increase in built-up areas. Bushland decreased following their clearance to acquire land for building, and laying bricks and trees were cut down for burning bricks. A decrease in the swampy area was associated with the increase in built-up area and horticultural activities. The result of this study concurs with Dekolo (2015) who found that in Ikorodu a metropolitan area of Lagos there was consistent loss of forest and agricultural land with the increase of built-up area.

Findings from questionnaire conform to findings of land cover change from GIS as they indicate that built-up area had increased. 67.3% of respondents changed their plots of land from farms, bush land, and swamps into the built-up area and 32.7% did not change the land cover of their plots. 47.3% of land portion changed to the built-up area for family houses, 10% for renting, 8.2% shops, 0.9% building for keeping cattle, and 15.4% did not change while 18.2% did not own land portions between 2003 and 2016.

The result of this study supports what Masanja (2003) pointed out that rapid growing urban population is the central driving force for land cover change as it gives rise to two major constraints namely housing to accommodate the growing population and improving the existing environment. This implies that buildings dominated the process of changing land cover over time in Ruhuwiko. Construction of commercial/residential buildings is noted to provide higher returns compared to agriculture.

3.2   Causes of land cover change in peri-urban areas

Table 3 indicates that 89.1% of respondents regarded the increase in population in the study area as being responsible for land cover change while 10.9% of respondents opposed it. 70% of respondents denied that construction of infrastructure was one of the causes of land cover change while 30% accepted it, 76.4% of respondents said that construction of social services centres was not a cause of land cover change and 23.6% of respondents said it was a cause of land cover change. Concerning climate change as one of the factors for land cover change found that only 27. 2% accepted it and 76.8% said no. Table 3 indicates questionnaire responses on causes of land cover change.

Table 3: Causes of land cover change

	Frequency		**Percentage**		
Causes	Yes	No	Yes	No	Total
Population	117	15	89.1	10.9	100
Infrastructure	40	92	30	70	100
Social services	37	95	23.6	76.4	100
Climate change	36	96	27.2	72.8	100

Source: Field Data, 2022

The findings presented in Table 3 revealed that land cover change of Ruhuwiko ward, in general, depended much on the increase of population as peri-urban residents struggled to earn their livelihoods. The results of this study support what Jelili (2012); Lambin *et al*. (2001) and Maro (2010) pointed out that the population has been increasing at a different rate for different regions. This implies that the population increase in Ruhuwiko ward highly facilitated land cover change to occur. However, infrastructure and social services had a very low contribution as there were only two tarmac roads, three primary schools, and 2 secondary schools. Figure 3 presents the causes of land cover change in a study area.

On the other hand, it was revealed that the population increase in the study area was caused by the immigration of people from various places in Ruvuma region and outside Ruvuma region; 29.1 % of respondents came from Mbinga District, 14.5% of respondents came from Songea District, 22.7% of respondents were natives of Songea Municipal, 5.5% of respondents came from Namtumbo District and 2.7% from Tunduru District while 25.5% of respondents came from outside Ruvuma region such as Dar es salaam, Mbeya, Iringa, Mtwara and Tabora. Figure 4 indicates the places of birth of respondents. This is supported by Jelili (2012) and Lawi (2013) who found that urban population growth results from uncontrolled rural-urban migration.
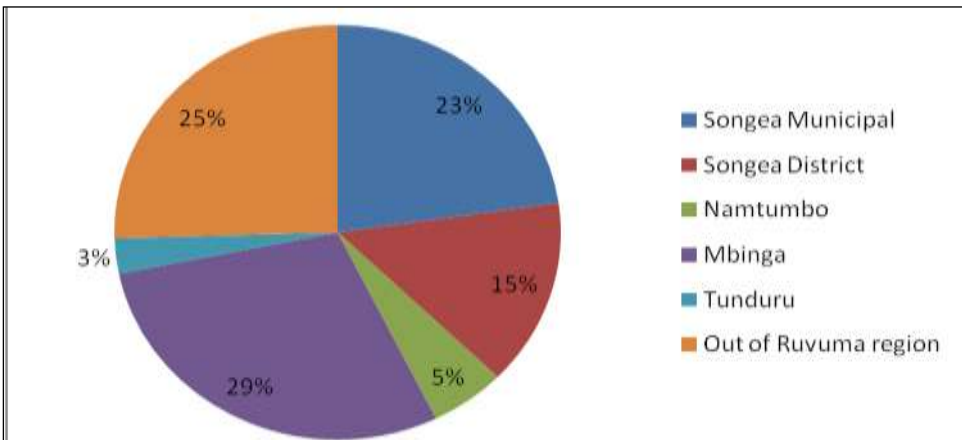
Figure 3: Birth Places of Head of Households in Ruhuwiko
Source: Field data, 2022

The rate of land cover change into built-up area increased with the increase in the human population. For example, the population of Ruhuwiko was 2583 in 2002 and 3565 in 2013 (URT, 2011; 2013), and 6732 people in 2016 according to the village executive officer of Ruhuwiko. The built-up area covered 30.8% in 2003 and 60.7% in 2016 in the study area. Swampy area, cultivated land, and bushland decreased from 19.1%, 35%, and 15.1% to 18.6%, 14.9%, and 5.8% respectively.

On the other hand, peri-urban areas showed an increase in population densities over time which contributed to land cover change. Following the increase in the number of people, some wards had to be divided to form new two wards. For example, in 2002 Mwengemshindo ward was a part of Ruhuwiko ward with a population density of about 125 – 160 people per kilometre. In 2012, Mwengemshindo became a separate ward with about 93 – 126 population density and Ruhuwiko ward had 408 people per kilometre square. Also, parts of Songea rural areas had been transferred to Songea municipality. For instance, Lilambo, Ndilima-Litembo and Tanga wards were parts of Songea rural district council in 2002 had been transferred to Songea municipality hence became peri-urban area (Figure 5). This is supported by Masanja, (2003) and Kironde, (1995) who maintained that the urban population grows and towns expand outwards, hence rapid growing urban population is the central driving force for peri-urban land cover change. This is supported by Brovkin, *et al* (2012) and Jelili, (2012) claimed that about one-third to one-half of the land surface has been modified by humans and the extent is likely to increase in the future to accommodate a growing demand for land.

Figure 4: Population Density of Songea in 2002 and 2012
Source: NBS census 2002 and 2012 shape files

4.0   CONCLUSION AND RECOMMENDATIONS

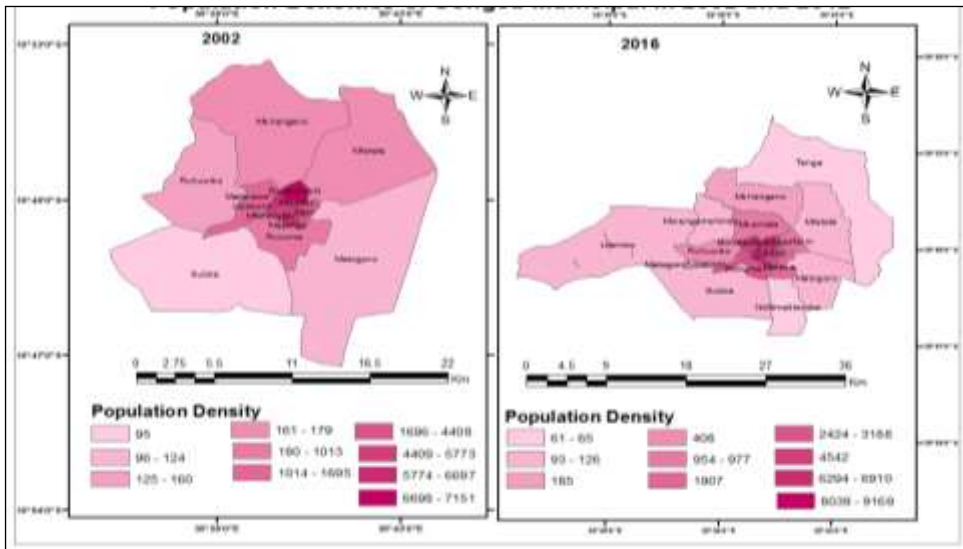Peri-urban land cover change in developing countries is taking place at a rapid rate following an increase of population in urban areas. The finding of the study revealed that land cover in peri-urban areas transforms very rapidly. It changes to the built-up area at the expense of bush lands, agricultural areas, and swampy areas.   These changes in land covers are highly connected to the increase of population through immigration to peri-urban areas. Other factors such as climate change and construction of infrastructures have insignificance contribution to the occurrence of land cover change in peri-urban areas. The study recommends that there should be enforcement of urban planning laws to avoid development of unplanned sub-urban area. The impact of peri-urban land cover change on natural resources management is recommended for further research.

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Decentralisation of Wildlife Conservation in Tanzania: Analysing Stakeholders' Power Relationship in Makao Wildlife Management Area

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Abstract

This paper examined power devolution in Makao Wildlife Management Area (WMA) using the descriptive research design. Three villages, Jinamo, Mwabagimu, and Makao, were purposively selected out of seven villages. The data collection method included questionnaires (281 heads of households), key informant interviews (9), focus group discussions (1 in each village), and a literature review. Results showed that WMA actors were internal (local community) and external (State agencies and investors). External actors were powerful and influenced most decisions in WMA, hence the lack of power devolution. Results further showed that the state remains a very authoritative player in all decision-making processes where stakeholders in the whole process are practically powerless, and formations of Authorised Associations do not empower the local communities. The study found several effects of power disparities like limited resource access, ineffective conflict resolution, insufficient enforcement of regulations and reduced accountability. This study recommends advocacy for local 'community empowerment to minimise power disparity among WMA actors through legal and policy reforms.

Keywords: *Decentralisation, Actors, Stakeholder power, Wildlife conservation, Makao Wildlife Management Area*

1.0   INTRODUCTION

In the milieu of natural resources management, Dahl (1957) typifies power as a relationship between individuals, while Nuijten (2005) relates power to interaction, restriction, compulsion, social relationship and societal consent. Power is applied in institutions depending on what is commonly accepted. Raik *et al.* (2008) state that stakeholder power is the degree to which stakeholders can influence or coerce others into taking specific actions and making decisions. Nevertheless, power manifests in various forms: Strategic, Structural or Domination, and Institutional or Government power (Lemke, 2003). Strategic power arises from everyday interactions among individuals and groups, taking shape through ideological manipulation, rational argumentation, moral guidance,

or economic exploitation (Lemke, 2003). Structural power denotes stable and hierarchical power dynamics that resist change, resulting in asymmetrical power relations where marginalised individuals possess limited freedom (Kajembe *et al*., 2016; Lemke, 2003; Nuijten, 2005). Government or institutional power pertains to organised, regulated, and reflective modes of power that surpass spontaneous acts of authority (Lemke, 2003; Nuijten, 2005). Institutional power establishes distinct subjectivities, such as citizens and civil servants, via discursive rituals and administrative practices (Kajembe *et al*., 2016; Lemke, 2003; Nuijten, 2005; Rose, 1999).

Therefore, "power" is a condition in which decisions are accepted and followed; however, counter-power occurs when some communities are marginalised and withstand the worst decisions (Kajembe *et al*., 2016). Some communities could raise their voices while others resort to soberer actions (Nuijten, 2005; Scott, 1986). According to Nelson (2010), power is a significant component of community-based conservation projects. This is because power predicts the 'actors' obligation. Power is gained through election, appointment, customary leadership, employment, NGO functions, and private investments. Ribot (2002) argued that power entrenched in a particular group/individual determines resource conservation and socio-economic development outcomes. According to Ostrom (1990), local community participation in natural resources management and conservation is higher when they have the influence and power to formulate or amend rules and decide how to use a particular resource. Therefore, power obliges when actors are well informed with essential machinery to make informed choices and have financial resources to implement conservation rules (IIED 2005; Raik *et al.,* 2008).

The actors involved in conservation possess differing levels of influence over policy and institutional decisions, as well as varying degrees of "potential" or "significance" in accomplishing specific objectives (IIED 2005; Nuijten, 2005). In wildlife management, community participation holds substantial importance, particularly when all stakeholders are actively engaged and inclusively involved in decision-making. This inclusive approach reduces the costs of implementing changes (Ribot, 2004). Full participation helps people develop a sense of ownership and a feeling of being the change realised and improving the acceptability and quality of mitigation and monitoring processes (Lwankomezi *et al.,* 2021; Ribot *et al*., 2006). Therefore, an actor's participation can be *a 'means'* and an "*end',* as communities are given a chance to define and address resource problems and help in attaining the solutions, while the latter signifies the conservation outcome like improving conservation and socio-economic conditions and able to bare conservation consequences (Campbell & Harper, 2012).

In Tanzania, other types of protected areas exist, namely National Parks and Game Reserves, where human habitation was forbidden, and Game Controlled Areas and the Ngorongoro Conservation Area, where settlement is allowed but

subject to strict regulations (URT, 2007), wildlife management has been decentralised by establishing Wildlife Management Areas (WMA) (Kicheleri *et al.*, 2018; Nelson, 2007; Nelson & Agrawal, 2008; URT, 1998). The Wildlife Policy 1998 (revised to 2007) identifies WMAs as a new protected area category for community-based wildlife management. Villages agree to set aside their land to form WMA. Nevertheless, the processes and mechanisms that lead to efficient operation are lengthy and bureaucratic. According to Kiwango *et al*. (2015), WMA regulations and guidelines provide the first stage of WMA creation, which is the sensitisation of communities on the benefits, cost, and right of conserving wildlife, which is explained either by the wildlife division or conservation partners organisations like Conservation NGOs, Tanzania National Parks, District Councils, and Ngorongoro Conservation Area Authority. The second stage allows the aspirant village, under the Trustees Incorporation Act (URT, 2018), to establish a Community-Based Organisation (CBO), draw a constitution, and become the Authorized Association (AA) responsible for daily operational activities of WMA on behalf of the local community (Mariki, 2018).

WMA was launched in 2003 and expected to be "community-based" and address local community development needs, according to the Wildlife Policy 1998. In contrast, the process of founding the WMA was government-driven and externally motivated (Mariki, 2015). In 2002, the Tanzanian government introduced the WMA regulations, providing principles and processes for creating a WMA. In 2003, WMA formation processes were launched, and 16 pilot WMAs were identified for establishment (Nelson, 2007), which saw them move to 38 in 2018 (Kicheleri *et al*., 2018; Mariki, 2018). Currently, there are 14 operating WMAs, and WMAs evaluations have shown some weaknesses in formulation and functioning (MNRT, 2022). For example, Wilfred (2010) and Lwankomezi *et al.* (2023) demonstrate a general lack of capacity to push the WMA implementation process forward. There is little or no legal capacity to draft constitutions and negotiate contracts. In addition, local communities are unable to generate resources for the creation of WMAs, and they are also unable to absorb and manage some of the investments.

From 2003 to 2012, the government implemented several initiatives, including developing guidelines for the designation and management of WMAs, assessing and evaluating pilot WMAs in 2007, releasing the Wildlife Conservation Act in 2009, and implementing new WMA regulations in 2012. These government initiatives give pertinent technical information for decision-making and smooth nationwide implementation of WMAs. However, Nelson (2007) argues that the nature of rights granted in Tanzania to communities serves as a significant constraint on implementing WMAs. In some cases, communities were not earning a substantial income from the WMA because of limited income-generating investments". Similarly, according to Kajembe *et al.* (2000), despite establishing WMA in Tanzania, local people saw the program as a restraint and a burden rather than a developmental alternative. At the same time, Wildlife

Policy pushes for complete community responsibility for wildlife management; in some locations, the CBO's rights and capacity to make management decisions in gazetted WMAs are limited.

Makao WMA was Established in 2007 and officially gazetted in 2009 (URT, 2012). Makao WMA holds immense significance in conservation within Tanzania's protected areas. It is a crucial wildlife corridor linking the Maswa Game Reserve, Ngorongoro Conservation Area, and the Serengeti National Park (URT, 2012). However, information on how power is exercised among stakeholders is equally missing. The Wildlife Policy 1998 (revised to 2007) envisions decentralisation by devolution in which the Authorized Associations are accountable to the communities. However, evidence has shown that Authorised Associations are more answerable to the central government than the local communities they save (Kicheleri *et al.,* 2018; Makupa, 2013). This goes against the devolution principle that envisages power transfers to elected local authorities.

It is, therefore, imperative to determine how stakeholders in Makao WMA exercise their power through the following questions: (i) who are the 'actors'? (ii) what type of power do actors own in Makao WMA? (iii) what are the actors' roles and interests in Makao WMA functioning? (iv) What are the effects of power disparities in WMA? The article aims to support decision-makers in designing ways to minimise power disparity among WMA actors.

2.0 THEORISING WMA GOVERNANCE, DECENTRALISATION AND STAKEHOLDER POWER RELATIONSHIP

The article draws from the common property resources theory expounded by Ostrom (2002). The theory is guided by the principle that resources are managed successfully if users can decide how they are used. Ostrom further argues that successful common property management requires the users of the resources to have a strong sense of community and to be able to cooperate effectively. In this article, "power" means how actors manage shared resources. Wildlife management areas (WMAs) are common property regimes (CPRs) in which communities are expected to manage and benefit from wildlife sustainably (Rihoy *et al.,* 2010; Shilereyo, 2010). The interconnection between governance, decentralisation, and power transfer in WMAs is crucial for achieving effective and sustainable exploitation of resources (Hutchcroft, 2001; Wunsch, 2001; Lemos & Agrawal, 2006). Governance refers to the complex system of procedures, rules, and organisational arrangements that oversee making decisions and distributing resources within a given society (Agrawal, 2001). In contrast, decentralisation refers to the intentional transfer of decision-making power and responsibilities from central governing entities to local or regional levels of governance (Ribot J. 1999; Zeitouna & Allan, 2008). Strong governance is essential to guarantee the fair and transparent allocation of resources while promoting sustainability (Lemos & Agrawal, 2006; Kiwango *et*

al., 2015). Decentralisation enhances this process by granting local communities and pertinent stakeholders a direct involvement in creating strategies for managing resources, thus promoting a more accurate synchronisation of resource allocation with local requirements and preferences (Lemos & Agrawal, 2006).

Power transfer within the WMA refers to the reallocation of decision-making power from conventional or centralised authorities to a wider range of stakeholders, such as local communities, indigenous groups, and non-governmental organisations (Dahl, 1957; Noel, 1999; Lemke, 2003). Transferring power can foster increased levels of accountability and equity in the management of resources (Ribot, 1999; Sanwal, 2004). This is because it allows individuals directly affected by decisions regarding resources to actively engage in developing these decisions (Lemke, 2003). Moreover, it fosters the possibility of generating adaptive and context-specific solutions, as local stakeholders generally possess a more nuanced understanding of the complex ecological and societal dynamics inside their areas (Sanwal M. 2004; Lemos & Agrawal, 2006). According to Zeitouna & Allan (2008), the interconnectedness of efficient governance, decentralisation, and power transfer forms a mutually reliant framework that, when carefully executed, can promote the objectives of sustainable and equitable management of natural resources. This is accomplished by engaging a wider range of individuals and organisations with vested interests and ensuring that the decision-making processes are guided by a deep comprehension of the specific circumstances and requirements of the local area (Agrawal, 2001; Lemke, 2003).

According to Lemos & Agrawal (2006) three distinct justifications for the decentralisation of environmental governance are available. It can produce greater efficiencies because of competition among subnational units; it can bring decision-making closer to those affected by governance, thereby promoting higher participation and accountability; finally, it can help decision-makers take advantage of more precise time- and place-specific knowledge about natural resources. However, it is argued that decentralisation in resource governance is not just an occasion for optimism that less powerful human agents may come to exercise a greater voice in how they and their resources are governed. There is also room for the cynicism that decentralisation policies have typically been motivated by powerful state actors to enhance their political positions (Nuijten, 2005; Lemos & Agrawal, 2006; Nelson & Agrawal, 2008). Without effective safeguards against the arbitrary exercise of localised power and clear relations of accountability, decentralisation may lead to forms of regulation even more suffocating than those encouraged by more centralised control (Noel, 1999; Wunsch, 2001). Therefore, the contingent outcomes of contemporary governance shifts depend crucially on how local actors mobilise and establish alliances across sociopolitical and administrative scales of governance.

3.0   CONTEXT AND METHODS
3.1   Description of the study area

Makao Wildlife Management Area is located in Meatu District, within the Simiyu Region (Figure 1). This significant conservation area was officially gazette in 2009 and spans an impressive 780 km^2 (Lwankomezi *et al.,* 2023). It encompasses seven villages: Jinamo, Sapa, Mbushi, Mangudo, Mwabagimu, Iramba ndogo, and Makao. Makao Wildlife Management is a vital wildlife corridor connecting the Ngorongoro Conservation Area, Maswa Game Reserve, and Serengeti National Park. The study was conducted between 2019 and 2022, and three villages were purposely selected for this study Jinamo, Mwabagimu and Makao. The selection of the three villages was carefully made based on the indication that there are varying perspectives regarding the exercise of power within the WMA based on experiences from Ikona WMA (Makupa, 2013), Burunge WMA (Kicheleri *et al.,* 2018), and Wami Mbiki WMA (Mariki, 2018). The study revealed a notable disagreement among the stakeholders involved in managing the WMA. These villages chosen reflect the WMA's diversity of perspectives and interests (Lwankomezi *et al.,* 2023; Mgonja, 2023)

Figure 1: Map presenting three study villages Jinamo, Mwabagimu and Makao

3.2   Data collection and sampling procedures

The number of households was obtained from Meatu's socio-economic profile (URT (2019), and the sample size was given by the formula.

$$n = \frac{N}{1 + N(e)^2}$$ Where**:** n – sample size, N- population size, e, expression constant SD (0.05). A sample of 281 heads of households was selected from the villages of Jinamo (91), Mwabagimu (95), and Makao (95) using proportionate stratified sampling, employing a village roster book. Subsequently, a random number generator was utilised to choose heads of households through simple random sampling for the survey. A structured questionnaire was applied with face-to-face interviews and focus group discussion, and a few open-ended questions were included to allow for further explanation. The questionnaire aimed to identify respondents' socio-economic activities, awareness of WMA actors (with awareness/no awareness), actor accountability, and effects of power disparity in WMA governance. Respondents were provided with several statements to determine the effect of power disparity, which were measured using Likert scales. The responses were grouped into four levels: (i) strongly agree, (ii) agree, (iii) disagree (iv) strongly disagree. Questionnaires were administered to heads of households at an agreed time and date by the first author.

Focus group discussions (FGDs) were organised to delve further into the study's themes. Each study village hosted one FGD, with a group size of five participants per session. To capture the diverse perspectives within the community. Key informant interviews were also conducted with village executive officers from the study villages, district game officers, and officials from the Makao Authorized Association and Wildlife Division. These key informant interviews aimed to gather valuable insights and information from these knowledgeable individuals. Interviews with key informants were conducted until no new information could be obtained or until the data saturation point was reached (Guest e*t al.,* 2006). The focus group discussions and interviews with key informants aimed to identify the powers held by the key actors and the roles resulting from these power differences.

3.3   Ethical consideration
Before the survey, we informed the village leaders by explaining the objectives and methods of our research and sought their consensus. We also received permission from the Tanzania Wildlife Authority (TAWA), the Simiyu Region Administrative Office, Meatu District Council, and Makao WMA to conduct the study. Before the respondents were briefed on the survey's aim and then asked for permission to include the respondents in our survey. We proceeded with our interview after receiving their verbal consent. Answers were recorded anonymously, and during the interview, we obtained a private place to obtain minimum biased and reliable information. Confidentiality of their information and identities was ensured, and proper acknowledgment of sources was maintained.

3.4   Data analysis

Data were analysed using Statistical Package for Social Science (SPSS) version 21. A frequency run was conducted for all variables to verify any values that may have been entered incorrectly and determine data entry uniformity. Descriptive statistics were performed, and later, inferential analysis was undertaken. Chi-square tests were used, and the statistical significance was set at p values <0.05. Content analysis was used to analyse data from interviews and focus group discussions, as suggested by Bengtsson (2016). Data analysed related to different categories of power possessed by different actors in the WMA. All data were recorded, transcribed, translated, and analysed by grouping 'respondents' answers to each question and developing information by classifying each group of answers. The responses were ranked by scores and categorised into related themes. Linked categories conveying similar meanings were identified, explained, clarified, and interpreted through the inductive analytic process (Creswell, 2013).

4.0   RESULTS
4.1   Respondent's profile

The current study provides significant demographic insights about the study participants. Notably, there is a gender imbalance, with 65.5% of respondents being male and 34.5% female. A substantial portion of participants (21%) had no formal education, while the majority (69.4%) had only completed primary education, with 2.1% having a college education and 7.5% completing secondary education. Additionally, considering the diverse age groups in the study, 43.8% were aged 49 or above, and 33.4% were between 29 and 48. Regarding socio-economic activities, the current study found that livestock keeping was predominant at 45%, Crop cultivation at 43.4%, with only a minority, 6.4%, relying on wage labour across all study villages. Therefore, local communities in Makao WMA were predominantly smallholder farmers and livestock keepers who were heavily dependent on natural resources for their livelihoods.

4.2   Actors and type of power in the management of WMA

The results indicate that 65% of respondents were unaware of the actor's power in governing Makao WMA (Figure 2). This is due to a lack of engagement, which disconnects the local community from authorities responsible for conservation efforts. Another plausible explanation is limited participation, as Lwankomezi et al. (2023) identified. When people are unaware of the actors, they may be less likely to participate in conservation activities or comply with regulations. This undermines efforts to protect wildlife within the WMA.
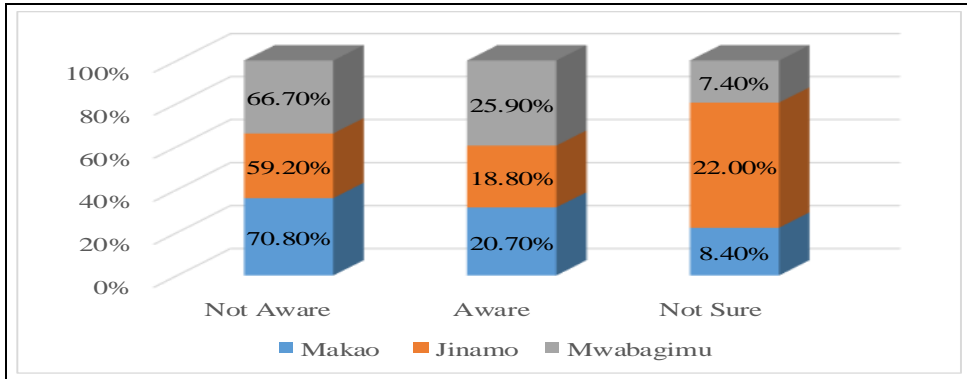
Figure 2: Local community awareness of actor's power WMA

Key informant interviews identified the following actors: local communities through Village Councils, CBO through Authorised Associations, District and Wildlife Division Officials, funding agencies, TANAPA, and investors (Table 1). Results further showed that the village council had institutional and structural power related to cultural or social positions in the community. The investor had strategic power related to wealth and education level, influencing negotiations. Authorised associations, the district council, TANAPA, and NGO's and Wildlife divisions hold institutional and strategic power. These actors have power that suppresses the local community's decision-making.

Table 1: Actors, roles, interests, and type of power in Makao WMA

Actor	Roles	Interests	Type of power
Village Council	Representing villagers in all matters about the 'villagers' wellbeing.	Protecting their fellow 'villagers' rights and promoting their interests	Structural and institutional
Authorized Association	Managing the WMA on behalf of the villagers. Ensuring wildlife conservation and associated benefits are realised at the WMA level.	Act as a power broker between the villagers and the central government agencies and local government	Institutional/governmental, strategic
District Council	Oversee management of the WMA.	Making sure wildlife is conserved. Generating benefits from the WMA	Institutional/governmental, strategic
Wildlife Division	Making rules for WMA management.	Increasing the area of protected landscapes. For example, wildlife corridors where most WMAs are located. Collecting revenues from tourism investments in the WMA.	Institutional/governmental, strategic
Non-Governmental Organisations (Funder)	Facilitating WMA establishment.	Conserving wildlife and ensuring the increase of protected landscapes, including wildlife corridors between otherwise protected areas.	Institutional/governmental, strategic
Investors	Entering into contracts with the Authorised Association to undertake business ventures in the gazetted WMA.	Generating profit through wildlife conservation.	Strategic
Tanzania National Parks Authority (TANAPA)	Conserving Wildlife	Ensuring that Makao WMA acts as a buffer zone and corridor.	Institutional/governmental, strategic

4.3 Roles and interest in WMA management

The actor's role and interest are presented in Table 1. During the focus group discussion, it was indicated that village council is responsible for protecting their fellow 'villagers' rights and promoting their interests by providing land for the designation and establishment of a Wildlife Management Area, coordinating natural resources activities at the village level, approving mechanisms for benefit sharing among the villages forming the Wildlife Management Area in accordance with guidelines issued by the government from time to time; and ensuring that Authorised Associations implement sectoral policies while entering into agreements on the management of a Wildlife Management Area. The village council operates through the village assembly, where village meetings are conducted to deliberate issues regarding community needs. During the interview, it was revealed that Village meetings are the legal forums for informing community members about development issues, management, and governance of the WMA. The Makao WMA guidelines provide for the need to convene village meetings every three months, but this is not the case in Makao WMA, as local communities could not remember the date of the last meeting.

The article indicates that monitoring AA's activities was beyond the village council's capacity. The village council had no authority to influence any Makao WMA management activities, and the AA was not accountable to the village government. In support of the above, the village leader from Jinamo said, "*...AA has more power than all villages in the WMA. When they come to our village, we are informed of what has been done most of the time. We have no power to question the activities we think are important to our village wellbeing".* Results further show that the village councils in all study villages were inferior to the WMA officials and could not influence WMA management decisions. This inferiority ultimately resulted in the local community's lack of information on WMA management through village assembly, reducing their influence regarding WMA planning.

The Authorised Association (AA) is central to Makao WMA governance, which determines the success or failure of the area. In addition to its role in conservation, the AA should serve as a power broker between local communities and central/local government organs. However, this study found that the Authorized Association mainly represented the central government, contrary to WMA regulation. Results indicate that the Authorized Association is not implementing its activities based on local community interests; hence, it is not accountable to the local community.

Wildlife Division manages wildlife management outside the Ngorongoro Conservation Area and National Parks. Also, the division is responsible for policy formation, coordination, and regulation. The study results revealed that the Wildlife Division performs another revenue collection function from WMAs. However, this contradicts the expectation of local communities, who were promised complete control and total management of benefits from wildlife

resources on their land. Communities believed the Wildlife Division had usurped AA's legitimate authority stipulated in WMA Regulations Part 1 Section (2), that*"... A community-based organisation, whose primary objective is to conserve wildlife resources for the benefit of local community members ordinarily residing in that area ...."*

The Strategic power allows investors to influence and win tenders for investing in the Makao WMA. Therefore, the investor uses its strategic power to stay in the tourism market by paying taxes to the Wildlife Division instead of local village governments. The study indicates that WMA investors had power above the village council and AA. Results indicate that investment contracts in the area were never discussed with local community representatives. The AA was called for negotiation to determine that the contract was already prepared and awaiting signatures. The District Advisory Board acted as a negotiation agent while abandoning its advisory role as stipulated in the WMA guidelines. One AA official said, "…We *did not discuss the contract nor participate in contract preparation. We were required to sign on the directive of the District Advisory Board…."* According to Makao, secretary of tendering, the process did not adhere to the procedures outlined in the Wildlife Act's Section 51(1). Section 31(7) was also subject to Sub-regulation (2). Findings revealed that the current investor was still awarded the contract despite not being rated as the best bidder by the evaluation committee and failing to meet the minimum scoring requirements. This action goes against Section 51-(10), which states that "… no *renewal shall be made unless the applicant has attained a minimum score as prescribed in the Wildlife Conservation (Tourist Hunting) Regulations*".

4.4   Effects of power disparities in Makao WMA

Results from the questionnaire (Table 2) indicate that the effect of power disparities in WMA management in order of preference was Ineffective Conflict Resolution (80.2%), Reduced Accountability (78.6%), Ineffective Conflict Resolution (76.3%) and Insufficient Enforcement of Regulations (59.2%). The results indicate no statistical difference (P= 0.878) among respondents in study villages on Power Disparities Effects in Makao WMA. This implies that the issues surrounding power imbalances are not specific to one particular village but are shared concerns among all communities within the WMA. This provides valuable insights into the perceived challenges posed by power disparities in the context of wildlife management, helping to inform potential strategies for improvement.

Table 2: Effects of power disparities in WMA

Power disparity effects	Responses in percentages (%)			Average	P-value
	Makao (n=95)	Jinamo (n=91)	Mwabagimu (n=95)		
Inefficiency Resource Access	71.5	87.9	63.1	74.2	.878
Ineffective Conflict Resolution	54.7	90.1	84.2	76.3	
Insufficient Enforcement of Regulations	74.7	46.1	56.8	59.2	
Reduced Accountability	86.3	57.1	92.6	78.6	
Ineffective Conflict Resolution	92.6	72.5	75.7	80.2	

Key –*percentage total to more than 100 because of multiple responses*

5.0   DISCUSSION
5.1   Actors and type of power in the management of WMA
This study identified three types of powers: the village council had structural power, investors held strategic power, and the District Council, Authorized Association, Wildlife Division, TANAPA, and NGOs had institutional and strategic powers. The democratically elected Village Governments comprise the Village Councils representing the communities that jointly make decisions at the Village Assemblies. The structural power owned by the Village Council is related to cultural or social positions based on local communities' structures like household heads, clan heads, or tribe leaders. Kajembe *et al.* (2016) posit that traditional societies have widespread structural powers. However, structural powers cannot supersede strategic or institutional powers unless full discretionary powers are devolved. Therefore, the village's ability to influence Makao WMA management decisions was constrained. Thus, for structural power to impact various levels of governance, it should be supported by either institutional or strategic power. This study suggests that village councils have remained powerless despite centralisation. District Council, AA, and Wildlife Division hold institutional power to make the most WMA management decisions. The local community's ability to exert institutional power is constrained. Therefore, the institutional structure of WMA affects the village councils' capacity to influence WMA management and performance. This shows how the central government recentralises the WMA management.

Makao WMA investors hold strategic powers, allowing them to invest in village lands. The strategic power relates to the investor's wealth and level of education. Strategic power offers the investor an advantage in winning tenders for investing in the Makao WMA. Therefore, strategic power enables the investor to remain in the tourism market by paying taxes to the Wildlife Division instead of local village governments. Kicheleri *et al.* (2018) arrived at a similar conclusion in Burunge WMA.

Institutional power is related to the position owned by the government or external organisation actors, and they hold power that supersedes the local community in decision-making. Local communities believe that the external actors used their positions to manipulate them into accepting the WMA establishment in their village land. It was noted that NGOs like the African

Wildlife Fund (AWF) and World-Wide Fund (WWF) held both strategic and institutional powers. During the establishment of Makao, WMA manipulated local communities to advance their agendas. Therefore, the central government, investors, and NGOs held institutional and strategic powers. Meanwhile, democratically elected Village Councils held structural powers and lost most of their pre-WMA institutional powers to newly constituted AAs.

5.2 Actors' role and interest in WMA functions

WMA actors had different agendas when establishing Makao WMA. Local communities were interested in improving their livelihoods; the investors wanted profit maximisation. The Wildlife Division was concerned with expanding protected environments, such as wildlife corridors, and collecting revenue from tourism investments. Owing to conflicting interests - where some actors' pushed self-interests with no regard to other actors' - a power struggle in managing wildlife resources ensued between NGOs, state agencies, and local communities. Again, conflicting interests pose immense challenges, particularly in ascertaining conservation problems and solutions. The underlying cause for such conflicts could be power disparities among the key actors in WMA management. This, in turn, determined how the most influential actors perceive and design the rules and procedures for natural resource protection at the expense of local communities.

In line with these findings, Mukewa (2023) observed that local communities in Zimbabwe and Zambia managed not wildlife but revenues from wildlife because WMA proponents fail to involve and integrate the very people they want and expect to implement the programs. Ribot (2004) discovered that non-governmental organisations that design and support conservation policies and projects regard local communities as harmful and unsustainable. This led to strict measures limiting community involvement in accessing, using, and governance of wildlife resources. However, Nelson (2010) concludes that when local communities are denied their rights, they resort to illegal means like disobedience and theft to sustain their life. Mbaiwa & Stronza (2010) support improving the rural economy and empowering people to manage their resources for long-term ecological, economic, and social benefits. Changes in wildlife management are predicated on institutional reforms that decentralise authority to local actors (Muchapondwa & Stage 2015).

The study further suggests that the Village Council lacked the power to manage WMA as stipulated in WMA regulation Section 17 on responsibilities to be undertaken by the Village Council. WMA regulations Section 17 (g) states that the Village Council shall '*Monitor the activities of the AA* and *report to the Village Assembly and District Council.* 'Contrary, local communities through Village Assembly were rarely informed about all activities in the WMA through the AA. Similarly, Section 17 (i) states that the Village Council shall '*Ensure that the Authorized Association implements sectorial policies while entering into agreements on a Wildlife Management Area.'* Another contradiction to this

statement was that the WMA Regulations Section 24 excluded Village Councils as members of the District Natural Resources Advisory Board (URT, 2012). This study's view is that excluding Village Councils from this Board limits their ability to influence AA's governance of WMAs. This is similar to the findings by Kicheleri *et al*. (2018) in Burunge Wildlife Management Areas.

Furthermore, study results show that the investment contract in Makao WMA was between the Investor and Makao AA, not the Village Council, on whose land the WMA was established. This indicates that the Village Council's role in managing and overseeing village affairs was ignored with the creation of AAs, given the power to negotiate and sign contracts with the investor. This is stipulated in WMA Regulations Section 18 (i) that "*In compliance with the requirements of Section 31(7) of the Act, negotiate and enter into contractual agreements relating to the utilisation of wildlife resources and investment*".

Yet again, the investment contract for Makao WMA was never discussed with local communities or the AA. Instead, the AA was called for negotiation to find that the agreement was already prepared pending signing. In this instance, the District Advisory Board acted as a negotiation agent, thus abandoning its advisory role as stipulated in the WMA Guidelines. It was further noted that, during tendering, procedures were not followed contrary to Section 51 (1), which states that '…an *AA shall in* accordance *with Section 31(7) of the Act and subject to sub-regulation (2) have the authority to appoint a tourist hunting company to conduct tourist hunting activities in its WMA'*. These findings are similar to Kiwango (2017), who recommends WWA actors come to the drawing board to negotiate and renegotiate to avoid conflicts that arise due to their positions, interests, and power, hence jeopardising WMA development.

Findings from interviews show that the evaluation committee did not consider awarding the tender to the current investor during the tender evaluation. Since the company did not attain the minimum required scores, it still awarded the contract contrary to Section 51 (10), which states that "… *no renewal shall be made unless the applicant has attained a minimum score as prescribed in the Wildlife Conservation (Tourist Hunting) Regulations"* (URT, 2012*).* Results from Interviews further show that AA did not agree with awarding the investment contract to the investor. The investor prepared the contract to sign with the Meatu District officials' directives. This clearly illustrates that the AA was never involved in drawing the contract, which was supposed to consider community interest, hence not answerable to local communities.

Results from Interviews further revealed that AA was not accountable to local communities because local communities were only given information about what was going on and were not given a chance to be at the centre of decision-making, resulting in better WMA governance. Consequently, downward accountability was the main impediment to community wildlife conservation.

Wildlife's enormous value motivates central players to keep *de-facto* control even after *de-jurede* centralisation. Although WMA regulation Section 18 states, *"An Authorised Association shall be accountable to the Village Council"* (URT, 2012), this contradicts what is practised in the Makao WMA. This implies that power owned by the local community in resource governance is much restricted by the central government and repealed by the WMA regulations 2012. The Director of Wildlife or District Council again regulates all powers given to the AAs. Section 62 (1) states, "*An investor may not enter into an investment or joint venture agreement without the Director of Wildlife's prior approval*"(URT 2012).

This hinders decentralisation because the AA owns the full power of the WMA management. The consent is left to the Director of Wildlife. Section 62 (4) specifies, "*Under these regulations, the Director of Wildlife has the authority to advise the AAs to revoke, withdraw or change any investment agreement*" (URT 1998; URT 2012). This implies that the power to revoke any contract is also with the Director, not the AAs, clearly illustrating how dominant recentralization had occurred in WMAs. In line with these findings, other studies, for example, Kajembe, Kimasa, Monela, & Zahabu (2000), Kicheleri *et al*. (2018), Murphree (1993), Sibanda (1996), found that the intended local actors had not yet been granted 'Proper Authority' in management of resources in conserved areas. Decentralisation of resources has a role in shifting decision-making processes to a broader range of stakeholders with different interests. Decentralised resource governance aims to shift power, authority, accountability, and resource access to lower-level actors, bringing responsibility, acceptance, and decision-making. Kiwango (2017) arrived at a similar conclusion. Results in this study indicate that the central government remains a very authoritative player in all decision-making processes where stakeholders in the whole process are practically powerless, and formations of local management structures (CBOs) stay with the same notion of community disempowerment.

5.3   Effects of power disparities in Makao WMA
The study found several effects of power disparities resulting in power struggles in WMA governance. These include limited resource access, ineffective Conflict Resolution, Insufficient enforcement of regulations, and reduced accountability. Failure to decentralise power in the management of protected areas can have several negative effects on both the effectiveness of conservation efforts and the well-being of local communities; this confirms a study by Bluwstein *et al.* (2016).

The current study found the existence of resource-use conflicts in the study area. This is due to communities bordering PAs or sharing land with wildlife incurring many economic and social costs like denied access to resources, property damage through crop-raiding, livestock depletion, wildlife-related accidents, and transmission of wildlife diseases. Kideghesho *et al.* (2007) in Serengeti, Mariki

(2018) in Wami Mbiki WMA, and Lwankomezi *et al.* (2021) in Makao WMA arrived at a similar conclusion. The current study found that conflict incidences were not reported to authorities. The probable reason for this was that some reported cases were not taken seriously, and communities showed discontent with the bureaucratic nature of authority responses, especially crop damage and wildlife attacks. Therefore, local communities continue to endure costs associated with wild animals without obtaining sizeable benefits at the household level, diminishing community interest in supporting wildlife conservation.

In this study, local communities alleged that they had never been compensated for damages. The results are also comparable to those of Nelson & Agrawal (2008), who states that residents of the conservation area partially bear the costs of conservation in PAs and need compensation. Similarly, Mutandwa and Gadzirayi (2007) reported comparable findings in the CAMPFIRE Gonono ward, where community members claimed they had never been reimbursed for wildlife damage. The current study, nevertheless, found no specific participatory and transparent mechanisms exist to manage and resolve conflicts within Makao WMA. Instead, actors use different means and ways to push their agendas.

The current study indicates that centralised management has led to reduced accountability, as decisions are made by top authorities who are not directly affected by the consequences of their choices. This is similar to a study by Kicheleri *et al.* (2018), who found that most decisions in Burunge WMA were not made at the village level, undermining local community power to manage and influence most decisions. However, Kiwango *et al.* (2015) have said that making bottom-up decisions improves transparency and accountability, improving WMA governance. Moyo *et al.* (2016) indicate that effective decentralisation enables the development of sustainable livelihoods for local communities through activities such as ecotourism, sustainable agriculture, or non-timber forest product harvesting. Failure to decentralise can result in missed opportunities for poverty reduction and community development (Kajembe *et al.,* 2000; Kicheleri *et al.,* 2018).

The article indicates that, while there may be a shift of power from central governments, the study results indicate that it may be transferred to new, emerging elites instead of intended stakeholders. This leads to inappropriate power transfer that turns most decentralisation reforms into charades. This legislation excludes local communities from crucial resource management procedures and decisions and integrates rural livelihoods, and biodiversity conservation remains a lofty but elusive goal. Surprisingly, the state has remained a very authoritative player in all decision-making processes, where local stakeholders are practically powerless, and local management structures (CBOs) formations remain with the same notion of community disempowerment.

6.0   CONCLUSION AND RECOMMENDATIONS

The article identified various actors involved in the Makao WMA with different understandings, interests, and roles. Actors included local communities through Village Councils, Community-Based Organisations (CBOs) through Authorized Associations, District and Wildlife Division Officials, NGOs, TANAPA (Tanzania National Parks), and conservation investors. Despite their diverse perspectives, the primary objective shared among these actors is supporting wildlife conservation. The article further revealed that the Village Council holds institutional and structural power within the community due to their cultural or social positions. Investor possesses strategic power, influenced by their wealth and education level, enabling them to influence negotiations and secure tenders for investments in the Makao WMA. The Authorized Associations, District Council, TANAPA, NGOs, and the Wildlife Division hold institutional and strategic power, potentially suppressing the local community's decision-making authority. This power disparity suggests that decision-making processes are influenced by external actors who have more authority and resources, limiting the community's involvement and control over WMA management and leading to potential imbalances and reduced empowerment. The study found several effects of power disparities like limited resource access, ineffective conflict resolution, insufficient enforcement of regulations, and reduced accountability. This study recommends advocacy for local 'community empowerment to minimise power disparity among WMA actors through legal and policy reforms.

7.0   ACKNOWLEDGMENTS

8.0   DECLARATION OF INTERESTS STATEMENT

The authors declare no conflict of interest.

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Assessment of Community Participation in Solid Waste Management in Lindi Municipal Council, Tanzania

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Abstract
The study examined determinants of community participation in solid waste management in Lindi Municipal Council, Tanzania. The results of the first objective found that majority (92%) of household members were willing to pay for solid waste management services. Female were more willing to pay by (94%) in comparison with males (88%). In the second objective, 87 (64%) respondents reported that motivating factors to pay for solid waste management services was for them to make their environment clean. The other findings indicated that respondents 79 (59%) were not satisfied with the services of solid waste management provided by Lindi Municipality. Further findings revealed that (88%) of the penalties imposed on those who breach solid waste laws and regulations agreement were weak. It is recommended to community and all the stakeholders to cooperate in participation and willingness to pay for solid waste management services. Further, the Municipalities, Ministries of the Environment, Health and Social Services, Education, Water and energy resources, Policy makers, NGOs, CBOs, as well as private-public partnerships (PPPs) must collaborate in coordination, facilitation, monitoring and evaluation on solid waste management in Tanzania. There should be a separate department to deal directly with waste management in the country to enhance effectiveness.

Keywords: Community, participation, solid waste management, Municipalities

1.0   INTRODUCTION

Waste is directly linked to human development, both technologically and socially. The composition of different wastes varied over time and location, with industrial development and innovation directly linked to waste materials. Some components of waste have economic value and can be recycled once correctly recovered (Awunyo *et al*., 2013). Low community participation of households comprises issues such as low community priority for solid waste management, low willingness to participate in collection systems and in keeping public spaces clean, and low willingness to pay. Fees payments can be based on the amount of garbage generated the income level of the household and the introduction of subsidies. Community Based Organization (Lauwo, 2005) in Korogwe Town Tanga, Tanzania & NGOs (Muzvendwa, 2021) in Nyanga Township Zimbzbwe, could be an important institutions in facilitating the improvement of solid waste Management, also participate in formulating by-laws, and enforcement of the regulations. This helps to generate some income, and conserve the sanitation of the environment.

Waste includes all items that people no longer have use for, which they either intend to get rid of or have already discarded. Examples, household rubbish, sewage sludge, wastes from manufacturing activities, packaging items, discarded cars, old televisions, garden waste, and old paint containers (European Environment Agency, 2013). The municipal waste problem is frequently discussed, and it has become the main issue in urban management. The issue of waste management is more complex and challenging in the future due to the tremendous growth in urban populations and their consumption patterns. Environmental Protection Agency (Environmental Protection Agency, 2020) predicts a three-fold increase in waste production in low-income countries by 2050. It is argued that the greater the economic prosperity and the higher the percentage of urbanization, the greater the amount of solid waste produced, and managing waste become more complex (Hassan, 2000).

Solid Waste Management is a crucial public service issue affecting both the environment and public health. It is not only limited to the collection of waste and its disposal, it requires clear strategies for the collection, transportation, sorting, and recycling of waste. Municipal waste is generated by households, commercial activities, and other sources whose activities are similar to those of households and commercial enterprises. Municipal waste is made up to residual waste, bulky waste, secondary materials from separate collections like paper and glass, household hazardous waste, street sweepings, and litter collections. It is made up of materials such as paper, cardboard, metals, textiles, organics from food and garden waste, and wood (European Environment Agency, 2013).

Every task, from preparing a meal to manufacturing a computer and so forth, is accompanied by the production of waste material that cannot be used for other things and needs to be disposed of effectively (Awunyo *et al.,* 2013). That means if waste is not contained and handled appropriately and in a sanitary manner, there is a great chance of creating favourable conditions for causing public health problems such as diseases like cholera, diarrhoea, and typhoid including favourable breeding grounds for flies, cockroaches, mosquitoes as well as potential environmental and the air pollution. At this time the world is now facing an extreme situation of waste management from both sides, from industrial and municipal waste management especially in underdeveloped countries (Kamara, 2011).

In Tanzania, Local Government has been given the duty to manage and minimize solid waste (Environmental Management Act, 2004). Furthermore, the authority has been assigned the duty to perform and undertake services of solid and liquid waste management (Public Health Act, 2009). Despite having good laws and regulations, as well as bylaws on SWM, the situation of solid waste management is not convincing, the problem here is how these laws and regulations are enforced. Implementation and enforcement of waste regulations and conventions is severely constrained by the lack of good governance, transparency, and the prevalence of corruption in some cases. Lack of

awareness, community participation and appreciation of best practices for environmentally sound management of waste is a major constraint (Jumanne, 2010).

However, the challenges of SWM in Lindi Municipality like other municipalities in developing countries continue to be one of the most pressing challenges if the relevant mitigation measures are not taken for the coming decades. The magnitude of the problem is likely to increase with the population growth and potential economic activities in the southern zone in particular Lindi municipality following the exploration of natural gas and other economic opportunities in Lindi Region.

There is a need to address the problems in such a way that should be solution which can give proper management of both kinds of waste. For this purpose, public awareness about the waste management can play a crucial role in controlling the waste generated by community members. The obstructed mindset, that SWM has generally been the local government's responsibility, in terms of planning and financing through own sources allocated, thus making the municipal authority to have sole responsibility for waste collection and transfer to final disposal (Jumanne, 2010). The situation tends to increase the irresponsibility to the household as well as individual community members not to care for the waste they produce, and this accelerate in indiscriminate disposal of waste.

The average municipal waste produced in Lindi Municipality is 55.66 tons per day (Lindi Municipal Annual Report, 2013) while according to reports of the Municipality, the capacity for collection for disposal per day is 13.3 (24%) this means 42.36 (76%) tons remains accumulating within the residential surroundings. The situation is unhealthy, it provides favourable breeding ground for vermin and insects to breed and creates a potential source for air pollution, contamination to surface and underground water sources. In the nearby future it is expected to have an influx of people in Lindi with a huge exploration of natural gas. According to the prevailing situation Lindi Municipal Council, the problems of solid waste collection and disposal is well beyond the ability of the Council own sources to tackle. Therefore, there are necessity of effective involvement of the community in SWM for the improvement of the situation. Thus, this study examined determinants hindering community participation in solid waste management in the Lindi Municipal Council, Tanzania.

2.0   MATERIALS AND METHODS
2.1   The Study Area
Lindi Municipal Council in Lindi Region is situated at latitude 9º 45' and 10º45' south of the Equator; Longitude 39º50' and 39º36' East of Greenwich (Figure 1). It is surrounded by Lindi District Council on both sides except on the eastern side where there is an Indian Ocean. Administratively, the Lindi Municipal Council is divided into 3 divisions, 18 wards and 83 streets.

Figure 1: Map of Lindi Municipality showing the study area
Source: Lindi Municipality, 2023

A cross-sectional survey was used to capture data from large number of different categories of respondents at a particular point in time. According to Mugenda and Mugenda (2003), this design is used when the study aims at collecting data from respondents without the need to make a follow-up of the same respondents thus enabling the researcher to save time in collecting the necessary information. Data was collected using mainly interviews and questionnaires and analyzed using descriptive analysis.

2.2   Sampling Procedure and Techniques

This study employed both qualitative and quantitative methods for the purpose of triangulation. The use of both quantitative and qualitative approaches was suitable because the study intended to capture participants' views regarding community participation in solid waste management as part of validating quantitative data and this mixed method allowed the computation of variables, percentages, frequencies, correlation coefficient and at last drawing up the conclusion from the findings. The stratified random sampling was used to obtain respondents from the study using household as sample unit. Three strata were established according to the wealth of the community that is low, middle and high income which was determined according to area of residence of the participants. The sampling frame of the households was established with the help of ward executive officer.

The sample size of 135 households was drawn from three wards (Rahaleo, Mwenge and Mtanda). A sampling frame of the household was established from

the register of ward executive officer and street chairperson. A sample of 5% was selected using simple random sampling (Lauwo, 2005; Noor *et al.,* 2023). The respondent was selected from three categories that is low income, Middle- and High-income classes according to settlement areas in those three Wards in Table 1. The income categories of the household were determined by key informers within the area. The target participants of this study were community members such as head of the households and officials of the health department.

Table 1: Sampling procedure

Wards	No. Population	No. Household	No. household Selected (sample size)
Rahaleo (Low income)	2,111	596	30
Mwenge (middle income)	2,808	806	40
Mtanda (high income)	5,683	1,524	65
Total Population	**10,602**	**2,926**	**135**

2.3   Data Collection Methods

Both primary and secondary sources of data were collected. The primary sources included the respondents whereas the secondary sources were a variety of published and unpublished written materials. The multiple methods used in data collection were questionnaire, interviews and documentary review as described hereunder.

Semi-structured interview was used to ensure that there was consistency in the collection process; the interviews were structured with fixed questions whose wording sequence was identical for every respondent. The questionnaire on community participation on solid waste management were provided to the sampled heads of households in Lindi Municipal. Closed-ended questions were used to collect data and other information from respondents in a short period. Documentary review helped the researcher to get relevant information from the primary sources for the analysis of the study. These included quarterly and annual reports on Environmental sanitation in Lindi. The information from these sources was used to determine the level of community participation in solid waste management.

2.4   Data Analysis

The analysis of data was done according to the information gathered and edited by the researcher. The response of respondents was coded by using numbers in different questions and tabulation of data collected, processed into tables and charts for meaningful and easy interpretation (Kothari, 2004). Data collected through questionnaires and documentary review on how community participate on solid wastes management was entered and processed by using Statistical Packages for Social Sciences (SPSS, version 20). In addition, Microsoft Excel program was used for drawing some charts with multiple responses to simplify interpretation of the data so collected. Qualitative analysis was done to provide the necessary explanations to quantify data, and to share observations made

through the interviews. The interview data were subjected to content analysis. All responses were read, and the main ideas were extracted to obtain the core meaning (Cohen *et al*., 2000) description and presented in percentages.

3.0   RESULTS AND DISCUSSION
3.1   Education level and the length of staying in the study area
Education level was considered among the variable to measure the level of willingness to pay for solid waste management. The findings revealed that majority of the respondents 78 (57.8%) had primary education level, 32 (23.7%) had secondary education while 10 (7.4%) had no education. Out of the total 135 respondents 6 (4.4%) had degree and above, 7 (5.25) had an ordinary diploma level while 2 (1.5%) had certificate education level. Further, findings indicated that 125 (92.6%) had formal education with 10 (7.4%) of the respondents had no formal education as in Table 2.

Table 2: Respondents' Level of Education

Education level	N = 135	Percentage
Had no education	10	7.4
Primary Education	78	57.8
Secondary Education	32	23.7
Had Certificate	2	1.5
Had Diploma	7	5.25
Degree & above	6	4.4
Had formal Education	125	92.6
Had non-formal Education	10	7.4

Length of stay of the respondents was measured as one of the variables that might influence an individual to participate and pay for the improvement of solid waste management. Most respondents, 78 (57.8%) had more than 20 years' time of stay in Lindi Municipal Council. 16 (11.9%) had a few years of stay that range between 1- 3 years. The total mean average time of stay for all the respondents was 4.6 years.

3.2   Respondents Level of Satisfaction regarding Services Provided
The level of satisfaction was measured in relation to service of solid waste management in the Lindi Municipal Council. The respondents were asked to give opinion on satisfaction for the services provided. The findings indicated that, majority of respondents 79 (59%) were not satisfied with the services of solid waste management provided in Lindi Municipal Council. On the other hand, 32 (23.7%) of the respondents were satisfied with the services of solid waste management provided. Out of 135 respondents, 24 (17.8) respondents were undecided, not either side of satisfied or dissatisfied.

The research also evaluated the efforts in solving the challenges by asking the respondents to give their views on the efforts made by the Lindi Municipal Council to solve the problem of solid waste management. Responses revealed

that 62 (46%) of respondents reported that solid waste management services provided in Lindi Municipal Council is poor. While 45 (33%) of the respondents claimed that the effort to provide solid waste management in the Lindi Municipal Council is fair. And 28 (21%) of respondents reported that the services provided is good.

3.3   The fairness of the penalties imposed by the Municipality

The respondents were asked to evaluate the fairness of penalties provided by Lindi Municipal Council in case of breaching rules and regulations on solid waste management. Majority of participants 88 (65%) responded that penalties imposed were very weak. But 24 (18%) of the respondents stated that penalties provided was fair. Another small group of respondents reported that the penalties provided were strong 23 (17%). Majority 93 (69%) of the participants said that they were aware of the presence of the rules and the regulations on solid waste management. But 105 (78%) of the participants indicated that they had never seen violators of the rules and the regulations on solid waste management penalized.

3.4   Knowledge of waste separation at household level

Different options of waste separation at the point of generation in household level were assessed to see whether it is practiced or otherwise. The findings show that majority of the respondents 107 (79%) do not separate the types of waste produced at the household level. There were 17 (13%) respondents said they usually separate wastes by burning the dry wastes and giving food waste to their animals. However, about 11 (8%) of the respondents reported practicing separation by keeping dry and wet waste in different containers. When asked the reasons for not separating the waste majority 78 (58%) responded that they do not have knowledge of separation. About 91 (67%) of the respondents, said that there are no micro or macro enterprises that deal with solid waste collection in their areas. 127 (94%) respondents claimed that the location of their houses are not barrier for waste collection services.

3.5   Willingness to pay in improving solid waste management

The respondents in the study area were assessed on their willingness to pay to improve solid waste management. Majority of the participants 124 (92%) were willing to pay to improve waste collection services. Only 8 (6%) respondents replied that they were not willing to pay for solid waste management services. Out of 135 interviewed respondents, there were 3 (2%) respondents reported that they do not know whether there are payments. The findings revealed that in Rahaleo Ward, which was categorized as low income, 28 (93%) were willing to pay to improve solid waste services while 2 (7%) respondents were not willing to pay. In Mwenge Ward, categorized as middle income about 36 (90%) respondents were willing to pay and 4 (10%) were not willing to pay. Mtanda Ward, a high income, 60 (92%) of the respondents were willing to pay while 5

(8%) were not willing to pay. Percentage of willingness to pay did not differ very much in both Wards.

3.5 Willingness to pay with respect to gender and the three Wards

Willingness to pay was compared with respect to gender and the findings shows that out of 84 females 79 (94%) and out of 51 male respondents 45 (88%) were willing to pay for solid waste management services. Thus, it implies that the female respondents were more willing to pay for solid waste management services in comparison to the male respondents. The research was interested to know at what amount they would pay per month; it was revealed that majority of those who were willing to pay 120 (97%) could pay the amount number of Tanzanian shillings 1000/= to 5000/= per month for solid waste management services. Very few 2 (1.6%) respondents reported to pay an amount ranging between Tanzania shillings 6000/= to 10, 000/= and above up to 16,000/= Tanzanian shillings (Tshs).

Respondents' willingness to pay were also analysed in according to the Wards of the respondents and findings revealed that 4 (3.2%) of the respondents in Mtanda Ward were willing to pay more than Tshs 5000/= than the other two Wards as shown in Table 3.

Table 3: Willing to pay in improving solid waste management with respect to gender in 3 Wards

Categories	N = 135	Percentage
Willingness to pay	124	92
Not willing to pay	8	6
Out of 84 Women	79	92
Out of 51 Men	45	88
Paying 1,000 - 5,000/= a month	120	97
Paying 6,000 - 16,000/= a month	2	1.6
Mtanda High Income Ward to pay More than Tshs 5,000/=	60	92
Mwenge Middle Income	36	90
Rahaleo Low Income	28	93

3.6 Health problems on knowledge associated with poor solid waste management

The respondents were asked to air out their different opinions on the health aspect of solid waste management in the Lindi Municipal Council. Majority of the participants 95 (70%) strongly agreed that they know about public health problems which are associated with the poor solid waste management. Less than half of the respondents 56 (41%) indicated that the laws and regulations on solid waste management were imposed to those who do not act in accordance. Only 40 (30%) of the participants indicated that the community is well educated and informed about solid waste management in their respective areas in order to avoid health problems.

3.7   The average solid waste generated per month per household

The research also assessed the average solid waste generated per month and the response indicated that solid waste reported as high generated in household per month was ashes (39%), plastic or textile wastes (30%), grasses/leaves (26%) and food wastes (21%). Conversely, very small solid wastes that household generated per month was Bones (47%), metal (46%), woods (30%) and papers (22%) (Table 4).

Table 4: Average solid waste generated per month per household

S/No.	Type of waste	Amount generated in percentage
1	Bones	47
2	Metal	46
3	Ashes	39
4	textile wastes	30
5	Woods	30
6	grasses/leaves	26
7	Papers	22
8	food wastes	21

3.8   Reasons for not collecting solid waste in the respective locations

Findings of this part revealed that there were 49 (36%) respondents reported that the absence of waste collection by Municipality services in their areas was the main reason for them not getting solid waste collected. About 35 (26%) of the participants responded that lack of motivation to waste collectors was one of the reasons. There were 21 (15%) respondents who said that poor Municipal Council coordination of waste management was an obstacle for waste collection services to their areas. Another 13 (10%) respondents reported that poor equipment for waste collection was the reasons. Only 12 (9%) of the participants responded that they don't know.

3.9   The options for Household waste disposal & who is responsible for solid waste management

The findings revealed that out of total interviewed 52 (39%) participants reported to keep the waste at home until the collectors arrive. A fair number 47 (35%) of the respondents do not dump their waste in the open space far from main roads. A good number 63 (47%) of the respondents do not throw waste in sewerage systems while, 66 (49%) respondents do not dump waste along the ocean shores and 44 (33%) mentioned to dig holes around their houses and burn the solid waste.

44 (33%) respondents said the household members were responsible for solid waste management in Lindi Municipal Council. Only 38 (28%) responded that Municipal Council is responsible for solid waste disposal in Lind Region. A number of 27 (20%) respondents said that Municipal Council and Households

are all responsible for solid waste management while 26 (19%) responded that all stakeholders are responsible for solid waste disposal in their particular areas.

3.10 Motivating factors influencing Household members to manage solid waste

The findings show that majority of the participants 87 (64%) reported that the motivating factors to manage solid waste were to make their environment clean. And 20 (15%) participants reported that the motivating factors was the ability to pay. About 15 (11%) of the respondents reported that motivating factors was to prevent environmental pollution and the spread of the infectious diseases. And few respondents 4 (3%) like to manage solid waste because of the enforcement of the bylaws and the regulations.

4.0 DISCUSSIONS

The findings revealed the number of female respondents was higher compared to that of males in the study on solid waste management in Lindi Municipal Council Tanzania. The same trend was observed in the study conducted in Durban-South Africa on the importance of gender in waste management planning (Poswa, 2004). Other findings from Mengistie and Baraki (2010) in Kersa Woreda eastern Ethiopia indicated that 98.4% responsibility of waste management was left to women and the girls. Lindi Region in Tanzania is among the Regions which the indigenous people believe in matrilineal practice. This might contribute to some extent males to become less active in some issues related to household affairs including handling of waste management.

The study found that majority of the respondents were married and said were more willing to participate and pay for solid waste management than other groups. The study conducted in Kampala Uganda by (Okot *et al.* 2012) on households' willingness to pay to improve Municipal solid waste management services was similar that married people are likely to be more responsible to keep the environment clean and willingness to pay for the improvement of solid waste management.

The findings revealed that majority of the respondents had formal education that means primary to degree education levels. With this level of majority having formal education, the level of understanding of the respondents on the consequences of unsanitary disposal of solid waste is high. The study conducted in Uganda on households' willingness to pay for improved Municipality solid waste in Kampala City revealed the same that household respondents who had attained secondary, post-secondary and graduate level of education were more willing to pay for improved solid waste management (ibid). Family size was related to the number of individuals in the household who have direct relationship with waste generation and the number of individuals who might affect positively or negatively the willingness to pay for the improved solid waste management services. Households with big family size generate more

solid waste. The study by Niringiye (2010) in Kampala indicated that the greater number of people in the household the more waste generation hence disposal become problem, thus they are more willing to pay to keep a clean environment. This can happen in Lindi Municipality by the authorities to organize appropriate mechanism to involve the community to pay for solid waste management services.

It was revealed that more than half of the total respondents were not satisfied with solid waste services provided by the Lindi Municipal Council, while a third was satisfied with the services of solid waste management. A quarter of the respondents were neither satisfied nor dissatisfied with the services provided. With a greater number of the respondents who are not satisfied, this implies that the situation of solid waste management in the Lindi Municipality is in uncertainty state. This is similar with the study conducted in Urban Accra Ghana that more than a half of the households were not satisfied with solid waste management services, (Yoada *et al.,* 2014).

The study conducted on solid waste management in Dar es Salaam, to Privatize and Improve revenue collection by ILO (2007) and International Ocean Institute (2009), revealed the same trend that residents were not satisfied with the quality of the services provided by the private agents. The major reasons pointed out included poor infrastructure and equipment arrangement were not adequately coordinated. A study conducted in Morogoro Municipal Council by Jumanne (2010), on community participation in solid waste management in informal settlement; found they failed to achieve an effective community participation in solid waste management due lack of the appropriate organization, mobilization and coordination of local resource including community empowerment. The situation that prevailed in Morogoro may also exist in Lindi Municipality if there are no appropriate organization, mobilization, and coordination in dealing with solid waste management.

Lauwo (2005) revealed that Community Based Organization (CBOs) are important tools for facilitating the improvement of solid waste management and effective enforcement of legislation as the best ways of incorporate community in solid waste management. This indicates that if community is full involved and participate in the solid waste management with firmly enforcement of legislation it is expected that even the level of satisfaction of the community on solid waste management may become higher. When comparing the findings on the satisfaction level of waste management services and the efforts made so far, it was found the satisfaction was in the level of very good, good and fair. Despite of the higher level of appreciation by the respondents, still the proportion of those who were not appreciating the efforts made by the Municipal Council in solid waste management were relatively higher, poor and very poor.

The majority of the respondents urged that penalties imposed to enhance solid waste management are weak/very weak. It is not the issue whether the penalties

provided is strong or weak, but the presence of these rules and regulations, including the bylaw is one step, while the main challenges which face most of the Councils is how, who and when to enforce bylaws. Lauwo (2015) in the study conducted in Korogwe Town Council –Tanzania indicated that bylaws could help to improve solid waste disposal in townships. She suggested the effective enforcement of legislations were found to be the best way of incorporating community on solid waste management.

Information gathered from Environmental Department of Lindi Municipality revealed that there were no proper arrangement and coordination of the enforcement of the by-laws and the other existing environmental regulations to the violators. Thus, there is a need to strengthen the coordination to institute appropriate arrangement and mobilization of local resources including the enforcement of existing rules and regulations of solid waste management for improvements. The findings show that majority of the respondents do not practice waste separation at the household level. Despite the fact that the remaining few respondents reported to practice separation in different approaches. This is very common to most of the households in Africa as reflected in other studies in African cities, by (Peter, 2021). The situation creates favourable environments for vermin and vectors to breed hence pose threat to the public health. However, most of the respondents urged that they do not have knowledge of solid waste separation while one third do not visualize importance of separation of waste. The study conducted in the Urban Accra Ghana (Yoad *et al.* 2014), indicated the same trend. There is a need to strengthen education on solid waste management with the intention of changing the behaviour of individuals towards solid waste management. Despite that majority of the respondents agreed that the amount of waste generated in their household has the direct link to their lifestyles, still there was very little effort made to ensure sanitary disposal of the solid waste generated. The prevailing situation is the major constraints to the community's willingness to implement the sound environmental management practices. It is high time for the Municipality authorities to implement and enforce waste management rules and regulations, strengthen the community participation in solid waste management.

Although, majority of respondents reported that they were aware of the existing rules and regulations of solid waste management, still there had never seen the breach of the rules and the regulations of solid waste management being penalized, thus there is low enforcements. Also, majority of respondents reported that the regulations are weak, and a few said that regulations are strong. A few responded that Municipal Council does not apply the existing regulations at all, while others said that they are not aware if the Municipality impose the regulations to those violators in Lindi (Mniwasa & Shauri, 2001). Information gathered from the Lindi Environmental Department indicated that for those violators, the penalty was Tshs 50,000/= according to Lindi Municipality bylaw. The concern of interest is how the bylaws are enforced to the violators of solid

waste management. This implies that there is a lack of appropriate organization, mobilization, and coordination in solid waste management. Most of the respondents urged that there are no micro or macro enterprises that collect solid waste at homes, while one third reported that there were micro or macro enterprises that collect solid waste from collection sites. The research findings show that there is little involvement of the Community Based Organizations (CBOs) in the solid waste management. This is another area which needs more investigation to look upon the roles and responsibilities of the CBOs on solid waste management in Lindi Municipal Council. The study conducted in Khulna city Bangladesh indicated that 9 to 12% of total generated wastes were collected from door-to-door collection system was provided by Non-Governmental Organizations (NGOs) and CBOs using non-motorized van, (Ahsan *et al.,* 2012). The importance of private sectors to participate in solid waste management is well stipulated in the Sustainable Development Goals 3, 6, 11 & 15 (Yoada *et al.,* 2014). Respondents were asked whether location of their house is the barrier to facilitate waste collection. Most interviewee said that the location of their houses does not hamper the collection of the solid waste from their premises.

The study findings revealed that most of the respondents were willing to pay for solid waste management services. Yoada *et al.* (2014) indicated that more of the community members would be willing to pay when better waste disposal management practices are employed. This situation provides evidence that even in Lindi Municipality community can participate to improve solid waste services if the authorities institute a well-functioning mechanism which is appropriate and affordable. It was observed that willingness to pay does not differ very significantly in all wards in spite of the wealth and income categories. A few respondents from Mtanda Ward who are well off were willing to pay from Tshs 6000/= to Tshs 16,000/= compared to the rest of the respondents of Mwenge and Rahaleo Wards. A study conducted in Accra Ghana revealed that households were not satisfied with solid waste management services in the community due to the irregular pattern in waste collection and high costs of contracting the private collectors (Yoada *et al.,* 2014). It further indicated that the community was willing to pay more when better waste disposal practices were employed (ibid). This implies that the community members were willing to pay the costs subject to the service provided.

The willingness to pay were compared between gender and trend revealed that most females interviewed and about half males interviewed were willing to pay for the service respectively. Data shows that females were more willing to pay by 6% compared to males. This reflects many other studies which support that female have more positive influence to pay for solid waste management services than males (Afroz *et al.* 2009; Addai and Danson-Abbeam, (2014).

Regarding public health related problems associated with unsanitary solid waste management, the findings revealed that majority of the respondents were aware

of the public health problems related poor solid waste management. They were even aware that improper solid waste management might lead to diseases such as cholera, typhoid, intestinal worms and diarrhoea, that account among the top ten diseases in the hospitals. These findings reflect that education level increase awareness of solid waste management, hence has the positive relationship to willingness to pay (Kamara, 2009). However, the recordable level of understanding in the study area does not correspond to the observed practices as there are evidence of heaps of solid waste abandon on the roadside, street drains and even in open spaces through observation. The findings are inconsistent to Kampala city study that revealed that the level of understanding does not have direct influence on the willingness to pay for improvement of waste management, (Niringiye, 2010). More efforts are desired to be established by Municipality authority to ensure that levels of understanding negative adverse impacts on poor solid waste management showed by respondents are used as a milestone for the changing mind-set of community toward positive practices of solid waste management. Further findings show that very few respondents perceived that Municipality has the capacity of providing solid waste management services to the satisfaction level of the community. It was found that almost half of total respondents were willing to pay for solid waste management services. Similarly, a study conducted in Khulna, Bangladesh, recorded that people perceived that city authority has the responsibility of providing nuisance free habitats as they pay taxes. In fact, the community would appreciate and be more willing to pay for the services when they observe the positive impact of the services with the respect of their taxes. A study in Accra Ghana (Yoada *et al.,* 2014) shows that the community would be willing to pay more when better disposal practices are employed. Strictly use of the exiting by-law regarding solid waste management would help in improving solid waste practice, (Lauwo, 2005). Information gathered from Lindi Environmental department indicated that the Municipality has the bylaws in place, although the challenges remain in the strict enforcement.

Attention is normally taken by the policy makers when a mass of people dies through the outbreak of unsanitary related diseases such as cholera. The findings indicated that ashes were also produced which reflects firewood and charcoal was used as the sources of fuel at the household level involved in this study. This is reflected on issues of environmental and forests degradation due to massive cutting of trees for charcoal production and firewood as a source of power. Plastics type of waste rank second grass and food waste. These findings differ relatively from the study conducted by Fobil *et al.* (2007) at Urban Accra, Ghana which shows that waste generated in high amount was food debris (93%), plastics (64%), papers (47%) and clothes (21%) respectively.

Plastic waste generation is increasing as it is fashionable package replaced other form of packaging and these have likely implications on the disposal since

plastics are not biodegradable. The situation supports the finding that plastic waste generation is increasing in Africa cities (Achankeng, 2003).

Further, the finding indicates about half of respondents claimed that there were no waste collectors to their areas, which might reflect the truth. It was indicated that the household head refuses to pay waste collectors for services provided because they did not get satisfied due to irregular schedules of collection, hence made them to find other alternatives (Personal communication in this study). Very challenging issue on solid waste collectors is motivation as half of the respondents mentioned the lack of motivation. It was observed almost available waste collectors do not have protective gears and proper equipment for handling waste. Another reason which hinders the service was mentioned to be poor council management. Studies conducted in Dar es salaam, (International Ocean Institute, 2009), Morogoro Municipal Council (Jumanne, 2010) both indicated that lack of proper organization, coordination and management arrangement contribute to failure in achieving solid waste management services. The observed situation that happened Dar es Salaam and Morogoro by then could be the same in Lindi Municipality.

Although findings show the respondents do not throw waste in seashores, sewerage system and in open spaces, but these findings do not reflect the real situation in the ground. Observation indicated that there is evidence of heaps of wastes indiscriminately dumped in the open spaces, roadsides and even backyard of houses. This is inconsistent to 1960s philosophy of disposal practices which was governed by thinking "out of sight, out of mind" (Yoada *et al.,* 2014). These findings implied that indiscriminate disposal of wastes was exiting that provide a favourable environment for the breeding of vermin and vectors responsible for the transmission of diseases such as cholera, diarrhoea, trachoma, and other environmental sanitation related illness (Achankeng, 2003).

Furthermore, the study findings show that there is sense of sharing responsibilities, hence half of the respondents reported that the responsibilities belong to all stakeholders both Municipality and the households. Other half respondents indicated household members are responsible for solid waste management. This maintains the policy statement that environmental management must be everybody's responsibility. The findings revealed that the perceptions that the Municipality has the sole responsibility for solid waste management still account. The study conducted in Dar es Salaam (International Ocean Institute, 2009) and Urban Accra Ghana study (Yoada *et al*. 2014; Peter, 2021) show similar notions that dwellers perceived government has the responsibility to provide solid waste services free of charge. However, few respondents reported that both Municipality and household members have the responsibilities which concur with those reported that all stakeholders are responsible.

The individual earnings were not assessed in relation to the determinants influencing willingness to pay for service in this study. On the other hand, a study conducted in Dar es Salaam by Kibonde (2014) revealed that were not complying with solid waste collection charges as it has been high and also the poor perception that the government has the sole responsibility to provide services for solid waste management free of charge.

5.0 CONCLUSION AND RECOMMENDATION

The main objective of this study was to investigate the factors affecting community participation in solid waste management in Lindi Municipal Council Tanzania. Majority household members were willing to pay for solid waste management services provided that solid waste management services are done at a level of the community to appreciate the positive impact of the improved services. There was very low coverage of solid waste management education to community on how to disposal waste generated at household level in hygienic manner which increase risks of public health and environmental pollution problems.

Lack of enforcement of solid waste management laws, by-laws and regulations encourage indiscriminate solid waste disposal. Despite the Municipal Council to have Solid waste management bylaws in place, there is no effective enforcement which contributes to inefficiency implementation of solid waste management services and hence community members continue with solid waste malpractices. Regardless of the efforts made in the improvement of solid waste management, it was found that a high proportion of the respondents were not satisfied with solid waste management services provided in Lindi Municipal Council. Generally, it was revealed that the penalty imposed to those who breach the solid waste laws and regulations were weak but still they were willing to pay the expenses for solid waste management after Municipality improving the services.

According to results from this study of the determinants affecting community participation on solid waste management in Lindi Municipal Council – Tanzania, Therefore, the researcher recommends that community members should adhere to the Environmental Policy statement that everybody has the responsibility to make the environment clean through participating in solid waste management services provided in the Municipal Councils. Ward Executive officers and hamlet chairpersons should emphasis community and other stakeholders in their respective areas for sanitary collection and disposal of waste to the designated place according to existing Municipal Council bylaw. The community should be informed and educated that there are solid waste management rules, regulations and bylaw, and penalties will be imposed upon contravene. The Municipal Council should strengthen the Environmental Department at the level capable of providing good solid waste management services at the satisfaction of the community and according to existing rules and regulations. The Ministries of the Environment, Health and Social Welfare

Services, Education Sector, Water and energy resources, Policy makers, NGOs, CBOs, as well as all private-public partnerships (PPPs) must collaborate in coordination, facilitation, monitoring and evaluation on solid waste management in Tanzania. There should be a separate department to deal directly with waste management in the country to enhance effectiveness. Thus, proper organization and coordination for the enforcement of rules and regulations of solid waste management should be roused up in cooperation with all the stakeholders. The success in solid waste management in the Municipal Councils require collaborative approaches of communities, NGOs, CBOs, Private institutions, and the Government make clean environment.

6.0 ACKNOWLEDGEMENTS

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Qualitative Assessment of Marine Environmental Quality Along the Coast of Dar es Salaam, Tanzania

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Abstract

This paper presents qualitative assessment of marine environmetal quality on the selected beaches and coastal areas including the port of Dar es Salaam. With the long-held misconception, the huge and resilient ocean could tolerate anything; ocean degradation has been happening for decades. From that ideology, this work came up with a research study with focuse on the qualitative assessment of the quality of marine environments along the coastline of the Dar es Salaam Region in Tanzania. In this paper field survey and observation, interviews, and questionnaires were employed to assess the situation. Results showed that, approximately 70% of the respondents visit the beaches frequently, showing their familiarity with the beach environments. However, 50% of the respondents have witnessed regular beach cleaning exercises, although they have commented that there have been inadequate cleaning efforts around the beaches. Additionally, all respondents commented that human activities in the study area are attributed to 90% of the environmental pollution. Also, from the methodology approached, this research work identified various anthropogenic activities contributing to marine environmental pollution on the coastline of the Dar es Salaam region, where the authors of this work propose measures such as clean-up campaigns, social media initiatives, educational programs, and the enforcement of laws and policies, aiming to minimize pollution and promote sustainable practices along the Dar es Salaam coast.

Keywords: Coastal Pollution, Anthropogenic Activities, Environmental Conservation.

1.0   INTRODUCTION

Anthropogenic ocean damage has been occurring for decades, driven by the belief that the vast and resilient ocean could withstand anything (Reynolds *et al*., 2022). However, tangible evidence of human activities along the coasts now exposes the flaw in this belief. Only 13% of the ocean remains untouched by

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humanity (Li *et al*., 2024; Olivelli *et al*., 2023). The global population and consumption increase have led to unsustainable growth and practices in industries reliant on the ocean, such as fishing, land development, and oil and gas (Nchimbi *et al*., 2024; Packman *et al*., 2022). These industries not only impact the ocean's well-being but also have consequences for aquatic systems, environmental health, and societies globally (Galindo Montero *et al*., 2023; Munno *et al*., 2024; Wei *et al*., 2023).

The coast, extending from the coastline to the inland rise of land, represents a zone or strip of land marked by the level of high tide (Donato *et al*., 2024; Guggisberg, 2024). The World Health Organization defines coastal pollution as the introduction of substances or energy by humans into the marine environment, resulting in deleterious effects on living resources, marine life, human health, marine activities, water quality, and amenities (Abate *et al*., 2024).

Coastal areas play a strategic role in economic and ecological development, providing numerous benefits. (Bertolazzi et al., 2024) highlights disparities in services offered by the coastal system, such as climate regulation and recreational services. Additionally, it reveals that 40% of the world's population resides within 100 km of the coastline (Ullah *et al*., 2023). The coastal area is intricately linked to the morphology of the sea-land (Zhang *et al*., 2024). Despite its significance, the coastal area is subjected to harsh environmental impacts from both human activities and natural factors (Yose *et al*., 2023).

Efforts to address coastal pollution have been undertaken, but further action is required due to the positive impact of the coast on people's well-being and the national economy. Scholars such as Alomar *et al*. (2024); Hu *et al*. (2024); Jones *et al*. (2024); Micella *et al*. (2024); and Zheng *et al*. (2024) emphasize the necessity of raising awareness about the effects of coastal pollution. Various studies in Tanzania have assessed contamination levels in the coastal regions. For example, Machiwa (2010) examined microbial contamination, heavy metals, and persistent organic pollutants, comparing them with recommended environmental quality targets (EQTs) for the West Indian Ocean (WIO). Maione (2021) investigated the emergence of plastic pollution on tourist beaches in Zanzibar, Tanzania, revealing the impact of the tourism sector on coastal pollution in Dar es Salaam. However, these studies lack detailed information on the identified causes of coastal pollution. This study aims to provide a comprehensive examination of anthropogenic activities and their contribution to coastal pollution.

The Dar es Salaam port receives and exports goods through various types of vessels, which can contribute to pollution. Domestic wastes from residents and the operation, repair, and maintenance of vessels pose significant contamination risks. Although studies have assessed contaminant concentrations in aquatic

environments, no current studies focus on identifying anthropogenic sources of marine pollution and assessing their associated effects around Dar es Salaam Harbour. This study aims to explore these sources, anticipate their effects on the marine ecosystem, and propose preventive and control measures. This study is therefore aimed at examining the anthropogenic activities of coastal pollution. To examine how anthropogenic activities, affect coastal pollution, the conceptual framework was developed and used in this study (Figure 1). Seven key elements were established in this study, namely: trading activities, dredging activities, extraction of coral polyps, boat maintenance, recreational activities, agricultural activities, and industrial activities.
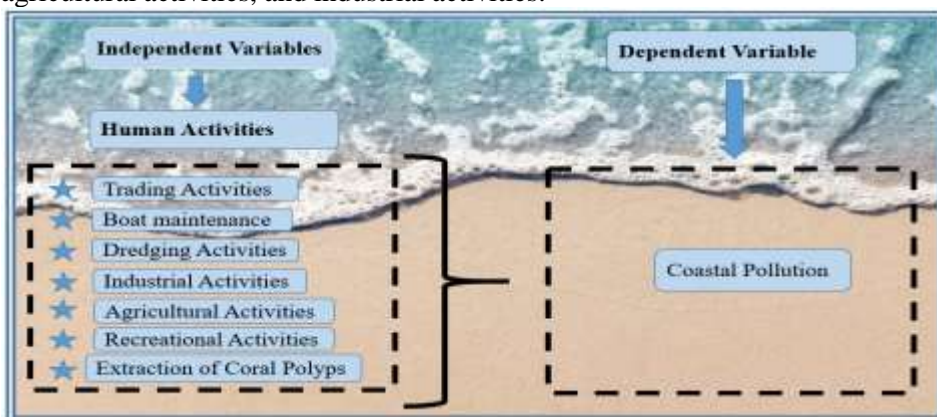
Figure 1: Contribution of human activities to coastal pollution

2.0 METHODOLOGY

The study employed a case study design and adopted qualitative research approach. The case study design was deliberately chosen due to its ability to provide comprehensive explanations of scientificbehavior. Furthermore, it facilitates the investigation and comprehension of intricate matters that were present in a specific region.

2.1 The study area

The study was conducted in Dar es Salaam Region with focus on the water of the Dar es Salaam harbour, stretching from the Aga Khan Hospital area (531843.79 East, 9248119.03 North) to the new Kigamboni Bridge (532801.84 East, 9241834.96 North), covering a coastline of approximately 9.45 km (Figure 1). The study specifically examined a 1.6 km section along the coastline of the harbour. The Tanzania Ports Authority (TPA) is responsible for the management and control of this area.

For the study, a sample was collected from five coastal sites along the Indian Ocean, situated in three different districts within Dar es Salaam city. These districts are Kigamboni (6° 49' 38.3844" S and 39° 18' 56.2068" E), Ilala (-6°47'42.00" S and 39°15'57.60" E), and Kinondoni (6.7053° S, 39.1127° E). The

five coastal beach sites were named as follows: Mikadi Beach (6°22'5.578" S and 34°53'6.702" E), Kipepeo Beach (6°51'5.556" S and 39°21'41.738" E), Sunrise Beach (38°10'33.1125" S and 92°47'3.679" E), Kunduchi Beach (6°40'52.514" S and 39°12'13.035" E), and Coco Beach (6°46'8.694" S and 39°16'55.993" E).

2.2   Data collection

The respondents were purposively selected based on the criteria that the respondents were frequently working on the coasts of the Indian Ocean. So, coastal users such as fishermen, boat drivers, tourist guides, beach visitors, and other knowledgeable coastal users were purposively selected. Generally, the collected data were thematically analyzed. The study used survey and observation, interviews and questionnaire approaches to gather the information. A total of 76 coastal users were involved in this study; from which 34 were interviewed and 42 responded positively to the questionnaires. In addition, observation, which involved a guide list and photographs taken were used.

To identify the anthropogenic activities taking place around the harbor water, primary and secondary data were collected. Primary data collection mainly involved field surveys and observation, interviews, and questionnaires. Also, in a few cases interviewing was conducted to get deep insight. The questionnaires were designed to get information on the different activities around the port as well as their associated effects on the quality of water. The questionnaires were given to ward environmental committee officers, TPA officers, fishermen, cooks at the port areas, and randomly selected passengers. In addition, physical observation around the Harbour area was done during the field campaigns to complement the information obtained from the questionnaire and checklist. Secondary data involved the review of different books, journals, and research papers.

3.0   RESULTS AND DISCUSSION
3.1   Responses from Interviews and Questionnaires

The results of the number of visits of the respondents to various beaches are given in Table 1.

Table 1: Frequencies of beach visits per week

Number of Visits (Frequencies)	Responses		Percentages (%)	
	Interview	Questionnaire	Interview	Questionnaire
One time	11	21	32	50
Two times	10	8	30	19
More than two times	13	13	38	31
Total	34	42	100	100

The interview results have shown that about 70% of the respondents (n = 34, 30+38) have been visiting the beaches two or more times a week. These results

implied that the respondents have adequate experience and trustworthy information about the beach environments. Results have shown that 50% of the respondents (n = 42, 19+31) have been visiting the beaches two or more times a week. It implies that the respondents have average experience and information about the beach environments.

Figure 2 indicates the responses of the interviewed respondents to the frequency of beach cleaning exercises. Only about 50% (n = 34) of the respondents (Figure 2a) have witnessed the beach cleaning exercise being conducted 3 times or more in a week. Similarly, only 20% (n = 42) of the respondents using the questionnaire (Figure 2b) have witnessed the beach cleaning exercise being conducted 3 times or more in a week. It implies that there exists inadequate beach cleaning along the surveyed beach sites.
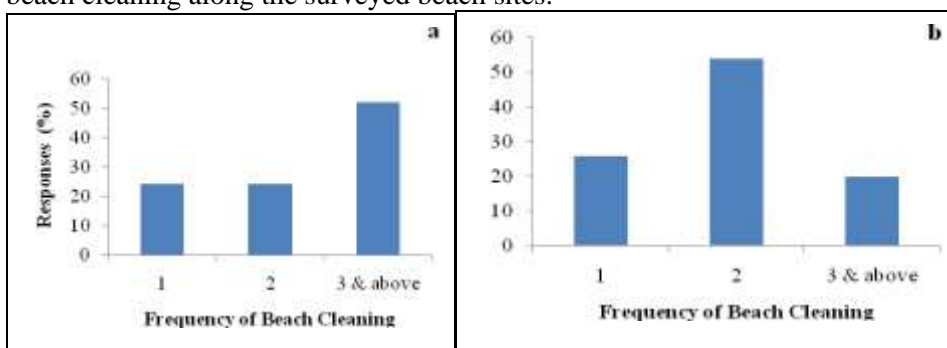
Figure 2: *Frequency of responses from the interview (a) and questionnaire (b) on beach cleaning by the managing authorities*

Table 2 shows that all the interviewed respondents (n = 34) and all who filled out the questionnaire (n = 42) have witnessed a particular type of pollution along the surveyed beaches. This calls for immediate efforts to control and minimize pollution along the surveyed coastal areas. About 90% of the interviewed respondents (n = 34) agreed that the coastal pollution was due to anthropogenic activities. All interviewed respondents and those who filled out the questionnaire (100%, n = 76) agreed that anthropogenic activities are the source of pollution.

Table 2: Respondent's Responses Regarding Coming across Some Kinds of Coastal Pollution

Beach Name	Responses		Percentage (%)		Strongly agreed		Agreed	
	Interview	Questionnaire	Interview	Questionnaire	Interview	Questionnaire	Interview	Questionnaire
Kipepeo Beach	8	9	23.5	21	6	7	2	2
Coco Beach	8	7	23.5	17	4	6	4	1
Sunrise Beach	7	9	20	21	5	3	2	6
Mikadi Beach	5	9	15	21	5	5	0	4
Kunduchi Beach	6	8	18	20	6	4	0	4
Total	34	42	100	100	26	25	8	17

4.0 Anthropogenic Activities in the Beaches
4.1 Trading activities

The food and beverage business lead to environmental pollution due to the disposal of food waste and beverage cans along the sea coast. A response from the majority of the interviewees about trading activities along the study area's shore showed the increased of pollution on the environment. Based on the interview conducted, the anthropogenic activities contributed to the pollution in the beaches and coastal areas. Anthropogenic activities include small-scale trading activities, repairing of marine vessels, recreational activities, dredging activities, as well as agricultural activities. Selling and buying goods and services along the beaches are some of the human activities observed. These are a retail business establishment that serves alcoholic beverages, ice cream, and other soft drinks. The evidence was found in Kunduchi Beach where hotels around the beach serve coastal users around the respective beach. For example, improper disposal of glass bottles of beer, plastic bottles of soft drinks, sewage, and other wastes from food processing. The same situation was observed in Longoni Beach where ice cream, popcorn, and food sellers were selling along the coastal areas (Figure 3).

Figure 3: Vendors along the Coastal Area of Indian Ocean

The findings discloded that, "the remains of rotting fish lead to air pollution and cause a bad smell along the sea coast"; in other findings showed that," fish remains lead to environmental pollution when they are thrown along the coast of the sea". An explanation provided by the vast majority of interviewees regarding how fishing activities along the study area's shore add to the pollution of the

environment. Various fishing activities were observed along the offshore Dar es Salaam coast such as hand gathering, spearing, netting, angling, and trapping. Some of these methods are prohibited by the government since they capture small fish and other aquatic animals such as molluscs, cephalopods, crustaceans, and echinoderms (Fisheries Act, No. 22, 2003). As a result, small fishes were left to rot on the coastal line shores contributing to pollution on the beach. In addition, fishnets and lines were left unattended along the coast at Mikadi Beach (Figure 4).

Figure 4: Netting for Fishing at Mikadi Beach

4.2   Dredging activities

Dredging activities associated with the removal of sediment and debris was observed to cause erosion and environmental degradation of the beach area (Figure 5). Such activities could result in coastal pollution and hence loss of biodiversity and ecosystem imbalance.

Figure 5: Dredging activities along Mikadi Beach

4.3   Repairing of marine vessels

Repairing of marine vessels was observed to use anti-fouling paints for coating vessels on the outboard to the hull of the ship or boat facilitating the detachment of subaquatic organisms and slowing the growth of marine species. Chemicals, pieces of wood, cleaners, oil bottle remains and other materials were observed around the areas (Figure 6). These wastes were found to be discharged along the coastline and could eventually cause coastal pollution.

Figure 6. Repairing of Marine Vessels at Mikadi Beach

4.4   Recreational activities

Recreational activities along the coast or beach tourism include swimming, snorkeling, scuba diving, sailing, fishing, and surfing. Swimming is one of the most popular forms of ocean recreation as was observed at Kunduchi Beach (Figure 7).

Figure 7. Recreational and business activities at Kunduchi Beach

It is widely accepted that tourism is one of the world's largest and fastest-growing industries. Historically, sandy beaches have played an important role as

locations for recreation and as attractions upon which tourism development has been based. These recreational sites along the beach had significant impacts on the environmental, social, and economic welfare of the people and nation associated with tourism development. It was observed that such areas accommodate some of the tourists and people who used to go for recreation at that beach litter and leave behind garbage like-plastic wrappers, and cigarette butts in the beach or surrounding environment.

4.5   Agricultural Activities

The transport of animals such as horses and camels cause environmental pollution by leaving excrement along the beaches. A response from a majority of interviewees regarding how agricultural activities along the study area's shore add to environmental damage. There is an increasing agricultural activity, particularly urban livestock keeping along the coast and beaches. A flock of sheep and cattle were observed walking along the Indian Ocean coast (Figure 8). Such animals could leave excreta that could cause coastal pollution by increasing the organic matter in the areas. The presence of hotels along the coasts and beaches could increase the amount of untreated waste along the coasts.

Figure 8. Animal grazing at Coco Beach

To minimize coastal and beach pollution, plausible measures are proposed. The local government authorities and institutions like the Colleges of Agriculture Science and Fisheries Technology (COAF) and Environmental Protection Agency (EPA) can plan clean-up campaigns, for example, along the Kunduchi and Saga coasts. Social media campaigns on cleanup may involve policymakers

in making better policies that will protect the coastal environment. Moreover, the campaign will aim to educate people on the need to protect the coastal environment. For example, active cleaning programs also include governmental and non-governmental organizations' cleaning programs and other youths-based cleaning campaigns. Furthermore, coastal users and Tanzanians at large should be educated on the need to protect the coastal environment; students should be taught from the lower level on the need to protect our coastal environment. Social media campaigning through (Facebook, Twitter & Instagram) is an important tool for addressing the effects of coastal pollution. Placing signs that act as a precaution against coastal pollution on ocean beaches will help people know that dumping waste on ocean beaches is prohibited. Placards such as those in Figure 9 help raise awareness of environmental and beach protection.

Figure 9: Placard on coastal environment

To manage wastes and coastal pollution, rules, principles, and guidelines should be instituted to enhance coastal conservation to ensure that the policy is used to influence behavior during various social activities. Moreover, coastal conservation agencies such as marine parks and reserves in Tanzania should implement the available laws to protect the coastal environment. Information on the sources and harmful effects of coastal pollution needs to become part of people's lives. The parliament should amend the laws that seem to be inactive in the fight against coastal pollution. For example, the adoption of Tanzania National Environmental Management Policy, 1997 (henceforth NEP) and other laws such as the Merchant Shipping Act, The Fisheries Act No 22 of 2003, the National Environment Management Act,' Tanzania Harbors Authority Act, "Territorial Sea and Exclusive Economic Zone Act, 5, Marine Parks and Reserves Act, 7 Mining Act, 8 and Petroleum (Exploration and Production) Act 9. These laws and policies help to protect the environment including the coastal environments of Tanzania.

4.6   Anthropogenic Activities around Dar es Salaam Harbour

During the field survey and observation, various anthropogenic activities were observed to take place around Dar es Salaam harbour most of them have the possibility of releasing some pollutants into the marine environment. Such activities are described hereafter.

4.6.1 Painting and welding of marine vessels

Marine vessels require periodic maintenance including painting. Wastes resulting from marine paints require careful management to ensure they do not end up contaminating ground or surface water. During the field survey, it was observed that some residues of marine paints were not properly managed as per the requirements of sound environmental practice resulting in the possibility of polluting the water (Figure 10).

Figure 10. Poor Handling of Products (Left and Middle) as Compared to Proper Handling around the Harbour (Right)

About 81% of the respondents did not know where the paint buckets should be placed after using the intended inside products. Also, 7%, responded that wastes are collected in especially available containers according to the by-laws and orders from the authority. 5% claimed that they could just mix them with other solid wastes.4% of them admitted that paint containers are thrown into the ocean and 3% claimed that wastes being thrown elsewhere

4.6.2 Loading and offloading of goods

During the loading and offloading of different commercial, agricultural, mining, and industrial goods there were a lot of spills of cargo observed, which suggests the absence of proper programs to handle the materials appropriately. Spilled cargo could contain metals, oils, grease, and Nutrients. For example, spills of fertilizers were observed which could contribute to increased nutrients in the water, particularly during the rainy season.

4.6.3 Discharge of industrial effluents

The field survey observed discharges of untreated wastewater at Gerezani Creek (Figure 11) which are discharged into the sea. It was previously observed that most industries in Temeke Municipality discharge wastewater into streams and then into the sea around the Dar es Salaam Harbour area (Bryceson, 1983).

These effluents may pose a problem to available aquatic species that are sensitive to dissolved oxygen since the wastewater contains a lot of nutrients.

Figure 11: Discharge of Effluents at Gerezani Creek (Left) and Oil from Marine Vessel (Middle) and KOJ (Right)

Various activities at the harbour such as cleaning up engine rooms for marine vessels (tugs) and washings from workshops generate a lot of liquid waste. Most marine tugs are not equipped with waste reception facilities which would help in managing waste sand oils from engine washings. The survey identified uncontrolled disposal of wastewater which could affect water quality and living conditions at the Dar es Salaam harbour (Figure 11). At Dar es Salaam harbour, there is a Kurasini Oil Jetty (KOJ) that receives 750,000 metric tons of crude oil per year that are discharged from tankers into an offshore coupling pipeline located to the west of inner Makutumba Island.

During a review of secondary data, it was previously observed that there was an oil spillage accident at KOJ (Figure 11). Also, there was no available data by that time, which indicated the magnitude and effects of oil spillages around the harbour area. In addition, there was no record found from the authority for oil spillage at the harbour. Similarly, smaller vessels such as tugs, pilot boats, and other harbour crafts are normally not fitted with oily/sludge tanks and oily water separators (OWS). The absence of these fittings causes operators of marine equipment to discharge oily water and other liquid waste into the harbour, therefore, degrading its water quality (Davis et al., 1989).
 Similarly, the discharge of oily ballast and oily bilge water by vessels using the harbour can cause pollution. The effects can be detrimental to fish, shellfish, and other organisms particularly when they come into contact with the contaminated water. For example, oil adversely affects eggs and larval survival; adult fish may experience reduced growth, enlarged livers, and changes in heart and respiration rates.

From the field survey also discharges from food vendors that empty food remains and residues from cookware into the free channels and the ocean (Figure 12) were observed. Considering that there are about 200 food vendor groups off the harbour road, the effect of these discharges cannot be

underestimated. In addition, during the field survey, it was observed that various wastewater channels were directing their discharges into the ocean and as such the sources could not be easily traced.

Figure 12: A Food Vendor Performing her Duties along the Water Channel to the Ocean

This underestimated wastewater from these cooks and laundry entourages from food vendors as well as the presence of industries and urban runoffs could increase the levels of nitrates and phosphates in ocean water

4.6.4 Discharge and emission from maintenance and operations of marine vessels

During the field survey, it was observed that sandblasting is still conducted at the Dar es Salaam Harbour. These undertakings, which are performed during the repair of marine vessels and normal ship operations, could generate pollutants including metallic debris, oil wastes, bilge water, ballast water, and other residues. Out of 92 respondents who are involved in sandblasting processes; 72 (78.3%) prefer to clear the wastes directly into the ocean, and 11 (11.9%) use recommended methods for handling sandblasting specks of dust and sand.

Sandblasting dispenses sand or other media at high velocity to remove or clear coat, paint, rust, and other surface imperfections from metal surfaces. Sandblasting produces a lot of dust-containing pollutants which ultimately end up degrading the harbour water. This practice has been banned for use in the developed world due to its detrimental health effects but it continues to be practiced around the Dar es Salaam harbour. Since most auto body paint contains heavy metals, such as lead, chromium, and barium, sandblasting waste could potentially be harmful to human health and other living organisms that

depend on seafood as an alternative nourishment supplement. The wastes emanating from blasting contribute to the degradation of seawater quality.

The use of antifouling paints is a common mankind activity at the harbour for preventing estuarine or marine organisms from attaching to submerged surfaces or killing them should they succeed in attaching by relinquishing their grip and falling off. Severe damage to aquatic life has been caused by antifouling paints containing organic tin compounds such as tributyl tin. Careless application of antifouling paints can introduce significant chemical concentrations into harbour water degrading its quality.

Shipbreaking is also done at Dar es Salaam harbour in which the beaching method is used where a ship is cut into small recyclable scrap metals at the beach area. This activity pollutes the marine environment and exposes workers to health and safety dangers and terrible working conditions. The practice also renders the quality of harbour water seriously degraded.

4.6.5 Agricultural and fishing activities

The survey has identified urban agricultural activities that are conducted in streams that empty their water into the ocean. For example, vegetable cultivation along the Gerezani Creek that pours into the harbour (Figure 13); whereby the water coming from the creek could be carrying various pollutants (metals, nutrients, organic matter, pesticides, etc.).

Figure 13: Small scale agricultural activities adjacent to Gerezani Creek (L) and fishing around the Dar es Salaam Harbour (R)

Such pollutants can pollute the ocean, the organisms living in it, and those who consume them as food. The level of contamination in the rivers and estuaries due to agrochemicals in Tanzania has not yet been evaluated. However, detected contamination levels of polychloro dibenzodioxins and polychloro dibenzofurans (PCDD/Fs), metals and organic matter emanating from human activities call for immediate intervention.

The use of fertilizer along the harbour is considered to be high since 71% of the respondents claimed to use industrial fertilizer against 20% of respondents who use manure and 9% who do not apply any fertilizer in their farming practices respectively. The water coming from the creek could be carrying various pollutants (metals, nutrients, organic matter, pesticides, etc.) that can pollute the ocean, the organisms living in it, and those who consume them as food, especially sea fishes and vegetables from the seedlings and granges grown along the harbour.

The field interview with some of the fishermen has identified the continued use of ammonium nitrate fuel oil (ANFO) and other chemicals in fishing. This is correlated well with the recent government confiscation of fish at the Dar es Salaam fish market alleged of been obtained through illegal explosive fishing.

4.6.6 Poor solid waste management

It was also observed that there is dumping of solid wastes very close to the seawater around the Dar es Salaam Harbour area. The wastes originated from the port offices, storage yards, workshops, and social human activities at the harbour (Figure 14). As a result of a long storage time, these solid wastes could pollute soil through leachate, which might percolate and reach seawater through ground flow or be swept by surface water runoff into the ocean. About 62% of the respondents throw their waste haphazardly whenever they finish using and they do not know who will come to collect and dispose of them.

Figure 14. Poor disposal of solid wastes at Dar es Salaam Harbour

These pollutants could significantly contribute to metal and nutrient contaminants in the seawater. Similarly, plastics when broken down into small pieces may cause micro-plastic pollution in the ocean, which is dangerous to aquatic life.

5.0   CONCLUSION AND RECOMMENDATIONS
5.1   Conclusion
The preservation and sustainability of the coastal line are of utmost importance for the well-being of humans and other living organisms in coastal areas. Unfortunately, the researchers have identified that various human activities are posing a significant threat to the availability and attractiveness of beaches and other coastal resources, leading to coastal pollution and negative impacts on the ecosystem. One concerning observation from the conducted survey is the direct discharge of untreated industrial effluents into the Indian Ocean, which indicates a lack of compliance with environmental protection policies.

This qualitative assessment reveals a potential threat of marine pollution around Dar es Salaam Harbour, primarily due to inappropriate anthropogenic sources. While most of the pollutants originate outside the Harbour, there are a few instances of pollution caused by ship repair and maintenance, marine operations, tug engine room cleaning, fishing, untreated sewage discharges, illegal dumping of solid wastes, oil spills, sandblasting of marine vessels, loading and offloading of commercial goods, as well as painting and welding of marine vessels.

Based on the study results, it is recommended to conduct more systematic quantitative studies that focus on the physical, biological, and chemical levels of contaminants in and around the harbour, as well as their associated effects. This will help in gaining a comprehensive understanding of the pollution levels and their impact.

5.2   Recommendations
The study provides several recommendations first, regular inspections and audits by the National Environmental Management Council and other regulatory authorities to ensure adequate environmental management controls are in place to prevent pollution of the Harbour water from anthropogenic sources.

Second, Regular monitoring of maintenance and repair activities, cutting and grinding of metallic plates, marine vessels painting, cleaning of tugs engine rooms, welding, sandblasting, spills and leakage from the Central Mechanical Workshop, and waste dump sites within the harbour area to prevent metal pollution. Third, the development and implementation of a waste management plan by the management of Dar es Salaam Harbour to control different types of waste and prevent their disposal into the ocean. Fourth, the construction of sufficient latrines around the Harbour, connected to treatment systems, to comply with environmental laws and conventions on the prevention of marine pollution. Fifth, the implementation of a water monitoring program by the management of Dar es Salaam Port to proactively identify pollutants in the harbour water and take timely remedial actions. This program should include an analysis of oil and grease in water samples collected just below the surface, as well as a sampling of coastal sediment and floating objects for the determination of various pollutants. Last, further investigation is required to understand the response of biota and habitats in the harbour to predicted climatic changes and

the interactive effects of stressors on ecosystem functioning and services. This will facilitate the development of holistic risk assessments and integrated management strategies.

In summary, addressing the threats posed by human activities, improving waste management practices, implementing monitoring programs, and conducting further research are essential for the preservation and sustainable management of the coastal zone in Dar es Salaam.

6.0   ACKNOWLEDGMENTS

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