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Editorial

Dear readers,

Welcome to the eighth 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 Paper submitted to this journal must contain original unpublished work and should not be under consideration for publication elsewhere.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 manuscripts 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 8 (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

Enhancing Urban Spacing to Address Juvenile Delinquency in Dar es Salaam, Tanzania

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Abstract

Juvenile delinquency is a universal phenomenon in which youth engage in deviant behaviour. Urban spacing is an important factor to juvenile delinquency which can impinge upon access to education. This paper attempts to show how urban spacing precipitates juvenile delinquency. Methodologically, this study employed a systematic review which involved seven steps as suggested by Evidence for Policy and Practice Information and Co-ordinating Centre (2007). The significant findings were that there is a correlation between urban spacing and juvenile delinquency in the city of Dar es Salaam. This was exemplified through disparities in dwelling places (mono-functional spaces), disapproval and sanctions; lack of sense of responsibility amongst parents; changing social relationships; failure to accommodate huge population, lacking basic social amenities and hidings of juvenile delinquent activities. This study concluded that the undue urban spacing has impacted juveniles' behaviour tremendously, plunging them into juvenile delinquency. The study recommended that the government and other actors ensure towns and cities are well arranged/ spaced to minimize hidings, set out playgrounds and recreation activities for children and youths, and create awareness among parents on responsible parenthood in urban areas.

Keywords: Juvenile, Juvenile delinquency, social amenities, urban spacing, Dar es Salaam

1.0 INTRODUCTION

Urban spacing planning is a vital tenet of human development; it is a process of planning urban areas to meet the required societal needs and addressing problems such as juvenile delinquency. Juvenile delinquency is a universal phenomenon where youth engage in deviant behaviour (Ferdoos & Ashiq, 2015) such as petty stealing, bullying, drug abuse and truancy. It is a critical problem globally and ultimately in Tanzania, due to its effect on juveniles that exposes them to different forms of vulnerability including limited chances to education.

Traditionally, the spacing of Dar es Salaam has been performed via Master Plans (MoLHHSD, 2016). Ironically, its growth has not been consistent with the master plans, which also overlook sustainable urban development and social aspects such as playgrounds (Peter and Yang 2019). The current Dar es Salaam City Master Plan 2016-2036 is built upon the Master Plan, which was prepared

in 1979 for twenty years up to 1999 and strives to ensure orderly growth and development in the city (MoLHHSD, 2016). Peter and Yang (2019) argued that findings suggest that master plans should not be used as a mere urban growth control tool; instead, they are supposed to be designed and conceptualized as a comprehensive strategy and integrated with different aspects of urban development, which can play a crucial role in enforcing sustainable urban development for the city (Peter and Yang 2019). The first master plan for Dar es Salaam 1947–1949 outlined a rational pattern for the city's growth to become the British Tanganyika colonial territory's significant administrative, commercial, and transportation center (Peter and Yang, 2019).

The current Dar es Salaam spacing through the City Master Plan 2016-2036 strives to ensure orderly geographical growth and development by utilizing spaces properly (MoLHHSD, 2016). According to the National Population and Housing Census (2022), Dar es Salaam is the largest city in Tanzania. The city began as a fishing village in the mid-19th Century (MoLHHSD, 2016). Dar es Salaam is an Arabic name meaning "haven of peace" and was originally a tiny village named Mzizima (Kiswahili for a healthy town) dating back to 1857, which was formally founded in 1866 by Majid bin Sayyid, the Sultan of Zanzibar (MoLHHSD, 2016). The German East Africa Company established a trading station there in 1887, which grew to become the administrative and commercial center of the colony and the eastern terminus of the Central Railway Line that ran into the interior of German East Africa (MoLHHSD, 2016). British forces took control of Dar es Salaam and German East Africa after the First World War; they renamed the colony Tanganyika but retained Dar es Salaam as the capital (Mbise et al. 2019). There was a European section (Oyster Bay) and two African sections (Kariakoo and Ilala); eventually, a fourth section was developed for Asians (MoLHHSD, 2016). When Tanganyika became independent in 1961, Dar es Salaam became its first capital (ibid).

According to the National Population and Housing Census (2022), Dar es Salaam was the largest city in Tanzania with a population of 5,383,728, whose 100 percent were living in urban areas, whereby 37.1 percent were children under 17 years (MoFP, 2022). This number of children is significant in the entire city population. Citing U.N., HABITAT, 2008, Rasmussen (2013) argued that informal settlements host 75 percent of dwellers in the city, showing one of the fastest-growing urban growths in the world by ranking 9th among 100 studied cities. Informal settlements are usually unplanned neighborhoods where a mix of middle and low-income earning families lives (Rasmussen, 2013). While walking in such geographical neighborhoods, it is possible to identify tactics used by the dwellers to build a community with physical mutuality (ibid).

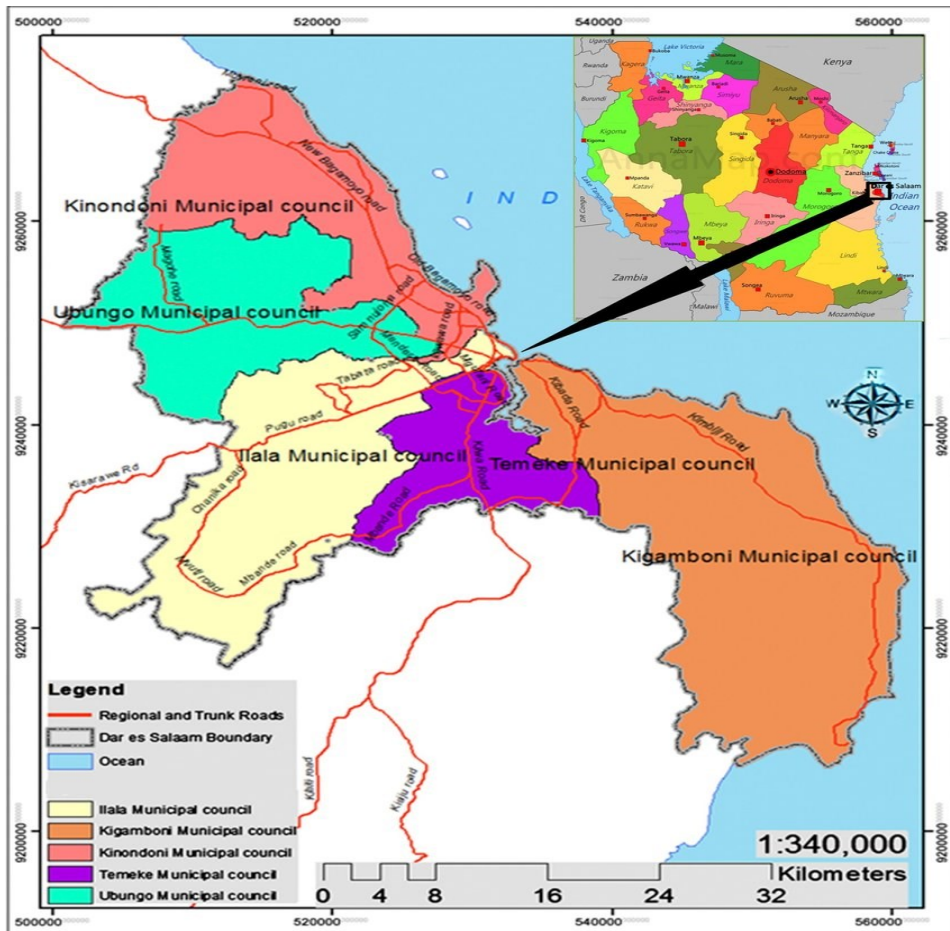


Figure 1: The map of Dar es Salaam City
 Source: ResearchGate, 2022 cited by Chanila, 2024

2.0 THEORETICAL FRAMEWORK

The systems theory informs well the relationship between poor urban spacing, and juvenile delinquency. System theory is a dominant tradition, particularly on issues related to child protection (Hutchinson and Oltedal, 2014). The contemporary ideas of what makes up the Systems Theory have grown in diverse areas, exemplified by the work of biologist Ludwig von Bertalanffy (ibid). It has influenced and spawned theory and research since the 1960s more in the 1980s based on relationships and interdependence among components as they interact (Lai & Lin, 2017). Systems have commonly identified properties, such as hierarchical ordering, coupling, permeability, holism, emergence, and homeostasis (ibid). Systems theory focuses on the relations between the parts rather than reducing and arrangement of connections between the components and how they work together as a whole; how the pieces are organized and how they interact determines the properties of that system (Chikere and Nwoka, 2015).

It further contends that any entity has multiple parts, whether a group, an organization, or a community, and these entities can be best understood as systems with interconnecting components (Bronfenbrenner, 2005). A system is delineated by its spatial and temporal boundaries, surrounded and influenced by its environment (Robbins, 2012). Changing one part of the system affects other features and the whole system; the point is reiterated by Mandin (2007), who argued that a slight change in a part of the system could have wide-ranging and unexpected consequences. In contrast, one of the fundamental ideas of systems theory — is that 'the whole is greater than the sum of its parts' (Mandin, 2007).

Additionally, Dupuis (2010) observed that in a systems framework, elements within it are interconnected; this is to say, the effects on one member of the family would ultimately have an equal and opposite outcome to the rest, and a system interacts with its environment (ibid). In turn, the environment affects the system, after which every system must be considered as a whole to be distinguishable from its background (ibid). This means a system is more than just a collection of individuals, and as such, a system needs to be viewed in its entirety (Robbins, 2012)

This theory is relevant to this study because it facilitates the understanding that urban spacing, and juvenile delinquency, which do not exist in a vacuum but in the interconnectedness and interplay of sub-systems. The systems theory is essential as it draws the actors related to juvenile delinquency, and the urban spacing to help intervene at multiple stages in an individual juvenile delinquent life and generally humankind. Another relevance of the theory is its broad spectrum. Hepworth et al. (2010) pointed out that a significant advantage of the systems model is its broad scope; hence, a researcher can have a comprehensive picture of systems and the environment in which research is done. Also, system theory can inform practice, providing insight into the effects and influences of techniques on and with children and families (Tilbury, 2013). Indeed, Munro (2010) argued that adopting a systems approach will help to understand how the system supports social actors and other professionals to work together. Overall, systems theory is supported by research evidence and policy drivers and is increasingly employed as it can be beneficial in working with juveniles and families (Tilbury, 2013).

3.0 MATERIALS AND METHODS

In developing this article, a systematic review method was employed. A systematic review entails identification of primary research studies, critical assessment and synthesis of studies that meet the eligibility criteria with the aim of bringing evidence together to answer a pre-defined research question (Pollock and Berge, 2018). In analysing how the urban spacing contributes to juvenile delinquency, which in turn hinders access to quality juveniles' education, the consideration was on both qualitative and quantitative empirical studies. The

review involves seven steps of systematic review as suggested by Evidence for Policy and Practice Information and Co-ordinating Centre (2007).

The first step was the development of inclusion and exclusion criteria. In the context of this study, the consideration was based on the following: limiting the scope by considering studies which address urban space, and juvenile delinquency, published after peer-reviewed process as journal articles in reputable sources as well as government sources. The cornerstone were literatures that had a bearing on the Dar es Salaam city. The second step was searching for relevant studies to the topic. This involved a critical search of studies from three scientific search engines, which included Emerald, Francis and Taylor and Google Scholar. Specific keywords such as urban spacing, juvenile delinquency, education, and Sustainable Development Goals were carried out from various scientific databases to obtain relevant research articles related to the topic. The third step was screening articles as per inclusion and exclusion criteria outlined in the first step. Screening the abstracts and full texts resulted in a total of 104 full articles which met the criteria for inclusion. The fourth step involved descriptive mapping which involved checking research articles and their relevance with the research question. Descriptive mapping was made reflecting on three aspects which included the technological limitations addressed, recommendations, and participants involved in the study. The fifth step included appraisal of the research articles which aimed at checking the quality of identified research articles and their relevance to the research questions. The rubric strategy was adapted from Charmaz and Thornberg (2021); and Tracy (2010) in which each review scored on each article based on the theoretical, methodological and the contribution of the article to the current analysis. The rubric included credibility, resonance, originality and usefulness. There were regular exchanges between the review team of which the consideration was based on the guideline provided by Laws (Laws, 2010) on demonstrating the quality of the research product. The sixth step was synthesising the findings. For a meaningful summary, a table was developed to summarise various limitations regarding the subject under study. The Aggregative synthesis approach was employed while reflecting on the stages suggested by Bazeley (Bezeley, 2014) regarding grouping into sub-groups while focusing on the context, characteristics and nature of the findings. Further synthesis of categories resulted in seven major themes. The seventh step was conclusions and discussions in which findings were summarized into six major themes in which the discussion followed by addressing the themes. Furthermore, the discussion gave rise to recommendations.

As afore noted, it is worthy of understanding that government documents (grey literature) also contributed to getting data and information, related to urban spacing, and juvenile delinquency. In this study, despite books and journals, government sources such as the Dar es Salaam Master Plan of 2016, The Law of the Child Act, Cap 13, R.E. 2019 and The National Population and Housing

Census, of 2022 were of the pivotal and very much contributed to the rigor of the study. In getting data and information, this study employed a secondary data analysis method in which various secondary documents related to urban spacing, and juvenile delinquency, were analysed.

Owing to this phenomenon, various key themes emerged, upon which data analysis was made and presented. The key themes were as follows:

- i) The connection of urban environment to juvenile delinquency,
- ii) The urban structure and infrastructures
- iii) Focus on economic development,
- iv) Ecstasy in urban environment,
- v) The globalization process,
- vi) Increased urbanized populations,
- vii) Break away from the traditional values and cultural norms,
- viii) The globalisation process.

4.0 FINDINGS AND DISCUSSION

The findings and analysis which were done in line with the objective of this study, do form an important part of any rigorous study. In this part the major findings are aired, and analysis made regarding the themes of the study. This study echoes urban spacing as a predisposing factor to juvenile delinquency and which in turn hinders access to education in Dar es Salaam. In this regard findings and discussion are noted through the following themes:

4.1 The Urban Structure and Infrastructures

Dar es Salaam city is characterized by a mono-centric urban and administrative structure (Rasmussen, 2013). Grymer (1981) argued that this contemporary pattern of urban structure and infrastructure is essentially mono-functional, relatively rigidly compartmentalized as an outgrowth of economic motivations to protect property at the expense of low-income owners. In the same vein, a careful look into the current structure of the city of Dar es Salaam will denote disparities in dwelling places based on income, such as low-income areas, for instance, Manzese, middle-income, such as Sinza, and high-income areas, such as Oyster Bay. Cities are also arranged in the form of residential areas such as Sinza, business/commercial such as Kariakoo, and administrative areas such as Posta. This transcends the colonial and post-colonial arrangement, which categorized major towns into three categories: first, Uzunguni - (areas mainly resided by Europeans, which were well served by social services); second, Uhindini such as Upanga- areas resided mainly by Asians, and Uswahilini such as Buguruni and Magomeni (MoLHHSD, 2016), which were poorly served by infrastructure and social amenities. Peter and Yang (2019) reiterated that the functional relationship established during the colonial period played a fundamental role in Dar es Salaam's post-colonial development as Tanzania's dominant urban center/city. The third construct is the administrative area, such as Posta, Kariakoo, and Kimara, and industrial areas, such as Vingunguti.

Squatter or slum settlements are an extension of Uswahilini, which should not be looked at as chaos; instead, there should be deliberate efforts to understand them as they resonate with the socio-economic structure of societies (Rasmussen, 2013).

All these arrangements and prohibitions discriminate children and juveniles whose needs are ignored within these structures (Peter & Young, 2019). Their instinctive attempts to use mono-functional spaces for unauthorized activities meet with disapproval and sanctions against 'deviant' and 'delinquent' behavior from adults conditioned into accepting these constraints. Their reactions to the structural violence of the environment express themselves through stress and other psychosomatic ailments, juvenile delinquency being but one of the responses to urban environmental violence by the least powerful (ibid). Others who cannot cope with such conditions choose to move to the suburbs, slums, or very remote squatter settlements as forms of internal withdrawal and resentment, where those areas are not equally served with infrastructure such as schools, roads and other social services (ibid). The low-income areas or slums provide hidings for juvenile delinquent behavior, hence precipitating it. The literature resonates the situation in Dar es Salaam, where in addressing challenges such as juvenile delinquency had been mainly focused on providing essential public services to its residents, that have temporarily been solving the negative consequences of rapid urban growth/urbanization. Indeed, such measures did not devise proper urban spacing mechanisms which could foster access of juveniles to education opportunities.

4.2 The Connection of Urban Environment to Juvenile Delinquency

The urban space can be a breeding stock of juvenile delinquency, which in turn can hinder access to education by juveniles. This notion resonates with the literature surveyed as the urban environment seems feasible for committing juvenile delinquency (Peter and Yang, 2019; Ferdoos and Ashiq, 2015; Rasmussen, 2013). This owes much to the fact that urban growth has changed the structure of society through changing social relationships entirely. Owing to this phenomenon, it is complicated for parents to keep an eye on children, as they are over-engaged in their work. Consequently, children get exposed to numerous harmful activities, which make them delinquents (Ferdoos and Ashiq, 2015). Arguably, juvenile delinquents cannot access school, especially when they are detained in remand homes, are kept in prisons where they must follow a lengthy procedure of case determination in the legal system. The situation has been evident in Tanzania as several studies such as UNICEF in 2011 and Mashamba (2013) found that 1400 juveniles languishing in prisons. Mashamba (2013), pointed out that the Commission for Human Rights and Good Governance Report (2011), revealed 1400 children who were held in adult prisons and detention facilities whose education needs were compromised.

Owing to this situation, the number of juveniles who went through the Remand home in Dar es Salaam is alarming, as especially those who are in such custody find it difficult to continue with education. This means committal of juvenile delinquency exposes them to remand custody or prisons which hinders their education opportunities. The table below indicates the number of juveniles who went through the Dar es Salaam Remand Home alone from 2015 to 2022 (Table 1). The table indicates that the number of male juveniles who went through the DRH was predominantly higher compared to female (1,235 males to 94 female). One of the reasons can be that male children are socialized for “outdoor” and masculinity which expose them to risk taking behaviours (such as juvenile delinquency) as compared to their female counterpart who are often subjected to social control. Out of these, 1,329 juveniles who went through the DRH, only 14 were there awaiting transport to Irambo Approved School in Mbeya, after getting convicted.

Table 1: Number of Juveniles who were served at the Dar es Salaam Remand Home

Year	Male	Female	Total	To Approved School
2015/16	102	5	107	2
2016/17	102	11	113	3
2017/18	105	5	110	2
2018/19	98	3	101	1
2019/20	119	4	123	1
2020/21	99	3	102	1
2021/22	132	7	139	1
Total	1,235	94	1329	14

Source: DSW, Dar es Salaam Remand Home, 2023

4.3 Focus on Economic Development

According to Peter and Young the city's ongoing environmental and social dilapidations have been associated with a massive emphasis on economic development in urban areas, which has led to a call for sustainable urbanization (investing in human capital) to curb past urbanization problems and implement a sustainable future (Peter and Yang, 2019). This echoes urban planning in Tanzania which has focused mainly on economic development, where the government prioritizes large-scale modern white elephant projects to increase national income and propel world-class urban settlements and buildings such as PSSF Tower near the Mlimani City shopping malls which are found in the study area (Dar es Salaam). Such an environment which includes high rise building and malls expel and purge out the poor and young people, who can do so with resentment, making them resort to juvenile delinquency in the new suburbs or squarer settlements created out for the expelled (Ferdoos & Ashiq, 2015)

4.4 Break away from the Traditional Values and Cultural Norms

The structure created by the urban environment breaks away from the traditional values and cultural norms that were encored on the philosophy of *ubuntu* (I am because we are) through which there were numerous initiatives manifested, with

a raft of non-formal locally arranged endeavors to address juvenile delinquency (Twikirize and Spitzer, 2019). Grounded on peoples' cultural, beliefs, values, and norms, these traditional initiatives are culturally sensitive, which denoted the fundamental recognition that one is because of other persons (Tutu, 1999). The basis on which the communal and collective approach from which the Igbo and Yoruba (Nigeria) maxim, "*it takes a village to raise the child*" stemmed from (Twikirize and Spitzer, 2019). The extended family dominated traditional African society, strengthening love and care and adult persons were socialized to care for the young ones, and children were considered an asset, where everyone in the community was responsible for correcting a deviant child (Mabeyo and Mvungi, 2019). Today, the social fabric network that held people together has ruptured (ibid). Indigenous models of education and problem-solving existed since immemorial and are continually becoming a popular way of solving people's problems in many parts of the world (Twikirize and Spitzer, 2019). To this end, Mabeyo and Mvungi (2019) recommended *Msaragambo* (practiced in the Kilimanjaro region) as a valuable mechanism for solving people's ailments, arguably children's education problems. *Msaragambo* is a self-help scheme that is used to help people towards mutual assistance, especially in difficult times (Mabeyo and Mvungi, 2019). Nowadays it is common to find in urban areas a child suffering or being abused and no one gets concerned. This situation calls for such an indigenous way of looking at things and a knowledge base that will facilitate the acquisition of appropriate knowledge and education to address the predicaments that befall juveniles, including juvenile delinquency.

4.5 Irresponsibility among Parents in Monitoring and Taking Care of their Children

Urban planning and city structures offer a breeding stock to juvenile delinquency. Ferdoos and Ashiq (2015) posited that most significant cause of juvenile delinquency in urban areas were lack of responsibility among parents in monitoring and taking care of their children appropriately and less control over their children, which plunges them into a society with insufficient spiritual values. In such an environment, misleading information from the media, such as television, magazines, newspapers, and the internet, acts as a source of acceptable knowledge and education instead of healthy norms and values (Ferdoos and Ashiq, 2015). This means, parents are influenced by the urban planning, structures, and its associated urbanism (as a way of life in urban areas) hence do not give time to have an eye on their children. The situation which leaves juveniles learn and practice delinquent behaviour from peer groups or people whom they are associating with. Delinquent behaviour such as stealing, drug use, truancy, and bullying become normal as a result juveniles fail to continue with education.

4.6 Ecstasy Anticipates from Juveniles

Ferdoos and Ashiq (2015) further argued that the urban environment anticipates ecstasy from juveniles, including modernity, new lifestyles, expensive materials,

facilities, and items such as expensive cars, houses, TVs, clothes, and telephone sets, to quench their needs. In this regard, juveniles may engage in activities that are clearly against the law or are juvenile delinquency to meet their needs (ibid). Once in such a situation, for example, through using illegal means they can find themselves in retention facilities/remand homes or prisons, where they can no longer easily access education. This is common in a country like Tanzania, where a study conducted by UNICEF in 2011 found that 1400 children ceased education since, they were in adult prisons. Indeed, once that child enters the traditional legal/ court system in Tanzania, it becomes difficult to continue with school. In Tanzania, the Law of the Child Act (LCA), PART X (S. 121) allows a convicted child to be committed to an approved school where he/she can continue with education for one to three years. Yet, practically, this is not always done as usually the procedure is lengthy and cumbersome to a single approved school that exists in Tanzania. Also, even though the approved school gives room for further continuing with education once a child is sentenced to it (for one to three years), usually, this takes place at a later stage of the post-trial process when the chances for re-entry in school are already diminished and slim, hence most likely losing the child's education opportunity. As argued herein the causative factor to this situation is the urban environment which anticipates ecstasy from juveniles, through modernity and new lifestyles.

4.7 The Globalization Process

Furthermore, as engendered by the mass media, such as television, radio, and newspapers, and coupled with technological advancement (including the broader use of the internet), globalization has had a lot of impact in the country as young men can learn new ways of life or easily imitate other practices and activities. This exposes them to delinquent tendencies rather than enabling them to concentrate on educational activities. Along with other factors as highlighted in this study, cause an alarming number of juvenile delinquents whose education opportunities are hindered. In this regard, the number of juveniles who went through the Juvenile Court in Temeke was alarming as such children especially who are in Remand custody or whose cases took a long time to dispose of, found it difficult to continue with education. The table below indicates the number of juveniles who went through such an institution in Dar es Salaam.

Table 2: Number of Juveniles who went through the Juvenile Court

Year	Male	Female	Total
2021	106	5	111
2022	161	3	164
2023	136	3	139
Total	403	11	414

Source: Juvenile Court at Dar es Salaam, 2023

4.8 Increased Urbanized Populations

Moser (2006) pointed out that geographical analyses suggest that countries with more urbanized populations have higher registered crime rates, arguably juvenile

delinquency, than those with well-rooted rural lifestyles and communities. The phenomenon owes much to the failure to accommodate huge populations, which give rise to squatter and slum settlements that provide hiding to juvenile delinquent activities. Such juvenile delinquents cannot access education. The settlements often lack basic social amenities like tarmac roads, schools, and health services.

Indeed, the high urbanization rate has exacerbated the degradation of the city's environment, including poor road infrastructure and child-friendly environment to enable young people to access school. Rasmussen (2013) noted that Dar es Salaam city is characterized by a mono-centric urban and administrative structure, which makes juveniles eschew, get resentments, and resort to juvenile delinquency. This can hinder access to education due to long-term detention facilities or imprisonment. Mashamba (2013), pointing to the Commission for Human Rights and Good Governance Report (2011), revealed 1400 children who were held in adult prisons and detention facilities whose education needs were jeopardized. The same data was provided by UNICEF (2011) attesting to the presence of juveniles in adult prisons in Tanzania. Arguably, poor urban spacing is one of the vital precipitating factors for the commission of juvenile delinquency (Grymer, 1981) and impinges upon access to education for young people in Dar es Salaam.

The findings and the analysis tie well with theoretical framework (systems theory) which echoes the effectiveness of the system through the inter connectedness of parts of the whole, where failure of one part, i.e. Poor urban spacing can cause breakdown on a system, manifested in form of juvenile delinquency then young people who cannot access education opportunities. Similarly, on the conceptual framework, through the model applied in this study, the symbiotic relationship between variables was eminent. This means, it was noted that poor urban spacing is causative to juvenile delinquency which in turn eschews access to education for the juveniles.

5.0 CONCLUSION AND RECOMMENDATIONS

To conclude, as indicated in this study, the monofunctional pattern of the Dar es Salaam urban spacing has tremendously impacted the behaviour of young people, plunging them into juvenile delinquency. Other factors include focus on economic development, the globalization process, increased urbanized populations, and a break away from the traditional values and cultural norms. This calls for concerted action by all the pertinent actors including the central, local government and civil society organization, private individuals to work together. This also entails professionals such as teachers, sociologists, social workers and city planners to work together in city planning which ensures wellness of juveniles, and their needs are taken on board.

Based on the findings and discussion that have arisen in this paper, it is hereby recommended that: First, the central government and the local government should strive to ensure that towns and cities are well arranged/placed to limit squatter and slum settlements that can provide hidings to delinquent behavior due to denial of essential social services such as roads, playing grounds, schools, and a haven to deviant behaviors. This also entails a clear political will, on allocating a proper budget for urban spacing and taking stern measures against those who snatch areas allotted for recreation and playgrounds.

Second, the government and other actors (including researchers) should invest into research on indigenous models and practices that can help to put in place indigenous ethics so that children can grow up as responsible persons. Moreover, research should identify the indigenous knowledge appropriate for living in urban areas to be taught in school education syllabi. Third, vocational and entrepreneurial skills should be imparted in primary and secondary school curricular so that children can be able to create sources of meaningful economic livelihood upon graduation from compulsory education to address predicaments of poverty.

Four, all juvenile actors should establish awareness programs for parents on parenting skills and enable them to take time to listen and know children/juvenile needs, including the kind of education or knowledge they require. Lastly, city planners should design cities and infrastructure that engender not only economic prosperity, but rather balance with social needs, and they should not provide hidings that engender delinquency.

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The Role of Boda Bodas in Shaping Residential Patterns: A Case Study of Urban Expansion in Tanzania

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Abstract

This study explores the social and cultural implications of bodabodas (motorcycle taxis) on residential patterns in Tanzania, focusing on how this informal mode of transport has reshaped urban spaces, influenced social cohesion, and altered patterns of daily life. Specifically, it examines the role of bodabodas in shaping residential patterns in Goba and Chanika, two peri-urban areas of Dar es Salaam, Tanzania. These areas, previously considered remote due to poor infrastructure, have experienced significant growth and urbanization, largely facilitated by the advent of bodabodas. The study employs a qualitative case study design, using interviews and focus group discussions with residents and bodaboda operators. Findings reveal that bodabodas have enabled residents to transport building materials, commute to urban centers, and establish homes in areas that were once inaccessible. Beyond enhancing our understanding of urban expansion, this research offers insights into how technological and infrastructural shifts reshape community structures, influence social networks, and transform cultural practices. Despite their positive impact on mobility and urban expansion, the study also highlights the risks associated with bodabodas, including accidents, fatalities, and involvement in criminal activities. Drawing on theories of Urban Ecology and Lefebvre's Production of Space, the study analyzes the socio-spatial transformations driven by these informal transport systems. It concludes with recommendations for improving safety, regulating the sector, enhancing road infrastructure, and fostering public-private partnerships to ensure sustainable urban growth. These steps aim to mitigate the risks associated with bodabodas while maximizing their contribution to the urbanization process in Dar es Salaam.

Keywords: *Boda Bodas, Informal Transport Systems, Residential Patterns, Urbanization*

1.0 INTRODUCTION

1.1 Urban and informal transport

Urban growth and social change in Tanzania have been significantly influenced by various forms of transportation, which shape not only physical landscapes but also social organization and cultural practices. In recent years, the rapid expansion of motorcycle taxis, popularly known as bodabodas, has transformed the way people move and settle in urban and peri-urban areas. These informal transport networks have provided unprecedented access to areas previously

considered remote, thereby facilitating a broader spatial distribution of residences, particularly in locations where formal public transport such as commuter buses (daladala) is scarce.

From a sociological and anthropological perspective, the rise of bodabodas represents more than just a shift in transport options. It is emblematic of deeper socio-cultural changes in how Tanzanians relate to space, mobility, and urban life. Historically, residential settlements in urban centers were concentrated along major roads or near bus stops, where social infrastructure was readily available. However, the emergence of bodabodas has enabled people to build homes and establish communities far from traditional transport routes, leading to the reconfiguration of urban boundaries and social interactions.

This paper seeks to explore the social and cultural implications of bodabodas on residential patterns in Tanzania, focusing on how this informal mode of transport has reshaped urban spaces, influenced social cohesion, and altered patterns of daily life. By examining the interplay between mobility and settlement, the study will contribute to our understanding of how technological and infrastructural changes drive not only urban expansion but also shifts in community structure, social networks, and cultural practices.

1.2 Factors influencing settlement patterns in Tanzania

Historically, settlement patterns in Tanzania have been shaped by both natural and social factors. Geographically, people tended to settle near water sources, fertile land, and trade routes, which provided essential resources for daily life and economic activities (Ogotu & Ochola, 2017). Socially, factors such as extended family ties, traditional land tenure systems, and ethnic affiliations influenced where individuals chose to live. These social networks played a critical role in determining how land was distributed and who had access to it, particularly in rural areas (Mabula, 2020). In urban settings, access to infrastructure especially transportation became a key determinant of residential location.

In line with the Urban Ecology theory developed by sociologists like Park and Burgess (1925), urban growth was conceptualized as a process of spatial competition where different social groups competed for access to desirable land and resources. This theory posits that cities grow outward from a central core, with wealthier populations settling in areas with the most accessible infrastructure and services, while poorer populations are pushed to the urban periphery. In Tanzania, this pattern was evident during the early stages of urbanization when the availability of public transport, such as the daladala buses, dictated where people could live and work. Settlement areas grew in concentric zones around transportation hubs, and the outer areas of cities were often

reserved for informal settlements or low-income communities with limited access to services (Ravallion&Wodon, 2019).

Traditionally, areas along major roads and transport routes became focal points for residential development. This created a spatial hierarchy where urban centers were densely populated, and less accessible areas were left undeveloped. The socio-economic divide within cities became entrenched, as access to public transport, particularly daladalas, shaped both the physical and social organization of urban spaces. Urban Ecology helps explain this dynamic, as competition for proximity to essential services, jobs, and economic opportunities became a key factor in settlement decisions (Sutherland et al., 2021).

In addition to transport and economic factors, cultural considerations also influenced settlement patterns. Many Tanzanians, especially in rural areas, chose to live near family and clan members. This kinship-based settlement structure not only reinforced social bonds but also facilitated communal land ownership, which has historically been a key feature of Tanzanian land distribution (Mabula, 2020). Rural-urban migration patterns often mirrored these familial ties, as people sought support from extended family networks in the city.

1.3 Shifting trends in urban and peri-urban settlement: The role of bodabodas

In recent decades, the introduction of motorcycle taxis, known as bodabodas, has drastically altered the settlement landscape in Tanzanian towns and cities. The availability of these informal transport options has expanded residential opportunities, allowing people to settle in areas that were previously considered too far from major roads or public transport networks. This shift can be analyzed through the lens of Henri Lefebvre's Production of Space theory (1974), which argues that space is not a static entity but is socially produced through the interactions and practices of individuals and groups.

The rise of bodabodas reflects a profound change in the way urban and peri-urban spaces are conceived and organized. Traditionally, areas far from public transportation were not attractive for settlement, as they were perceived as being too remote and inaccessible. However, with the increased availability of bodabodas, the physical and social meanings of distance have changed. Residents can now live up to 10 or 15 kilometers from the nearest main road and still maintain a viable connection to city centers through these flexible transport options (Msigwa & Mbise, 2022). This has led to the decentralization of urban settlements and the growth of peri-urban areas, where land is cheaper and more readily available.

From a Network Society perspective, as theorized by Manuel Castells (1996), the emergence of bodabodas can be seen as part of a broader trend of

decentralized mobility networks that transform urban spaces. Castells argued that modern urbanization is increasingly defined by the flow of people, goods, and information across flexible, decentralized networks. The bodaboda system fits this description, as it operates outside formal transportation systems, yet plays a critical role in linking previously disconnected urban and rural spaces. This informal network allows for greater fluidity in how people move across the urban landscape, which in turn has influenced how they choose to settle.

Bodabodas have democratized mobility in urban Tanzania by offering an affordable and accessible means of transport for a wide range of socio-economic groups. This has encouraged the expansion of informal settlements and peri-urban developments, as individuals no longer have to rely solely on formal transport networks to commute to the city center (Mwita & Kweka, 2021). This trend has also led to changes in the urban fabric, as formerly rural areas have been incorporated into the urban sphere through the increased flow of people and resources facilitated by bodabodas.

The expansion of bodabodas as a transport option has also had cultural implications for settlement patterns. Lefebvre's (1974) notion of the social production of space is evident in how bodabodas have enabled people to reimagine their living environments. Areas once considered remote or inaccessible are now seen as viable residential options, not only because of their affordability but also due to the ease with which residents can now connect to economic and social centers. This has resulted in the creation of new forms of social organization, as previously rural or peri-urban areas take on more urban characteristics (Komba, 2023). As residents move further from urban centers, they bring with them the cultural and social practices of the city, blending urban and rural life in new and innovative ways.

In addition to reconfiguring physical spaces, the rise of bodabodas has fostered new social networks around informal transport operations. The drivers of these motorcycles often belong to local communities, and their intimate knowledge of less accessible areas has facilitated new settlement patterns (Ngowi, 2022). They serve not only as transport providers but also as informal guides, helping potential residents navigate land markets and identify suitable places to live. This aspect underscores Lefebvre's (1974) argument that space is a product of social relations, as the connections between bodaboda drivers and local residents help shape the contours of urban expansion.

The traditional determinants of settlement in Tanzania were heavily influenced by factors such as geography, social ties, and access to public transportation. However, the emergence of bodabodas has ushered in a new era of urbanization, characterized by greater flexibility and mobility. The application of sociological

theories such as Urban Ecology, Lefebvre's Production of Space, and Castells' Network Society provides a deeper understanding of how this informal mode of transport has reshaped not only the physical layout of urban spaces but also the social fabric of Tanzanian towns and cities. As urban expansion continues, the role of bodabodas in influencing settlement patterns will remain a crucial factor in the development of both urban and peri-urban areas.

1.4 Traditional Factors Influencing Settlement Patterns Tanzania

Physical, economic and cultural factors influence the location and siting of settlements (Rashid, 2020). Sometimes combined effect of all these factors or sometimes one or two factors assist in determining a settlement's location. The classification of settlements according to the suitability of site/location assists in highlighting the various kinds of geographical advantages which lead to the origin and growth of settlements. Socially, factors such as extended family ties, traditional land tenure systems, and ethnic affiliations influenced where individuals chose to live. These social networks played a critical role in determining how land was distributed and who had access to it, particularly in rural areas (Mabula, 2020). In urban settings, access to infrastructure especially transportation became a key determinant of residential location.

In line with the Urban Ecology theory developed by sociologists like Park and Burgess (1925), urban growth was conceptualized as a process of spatial competition where different social groups competed for access to desirable land and resources. This theory posits that cities grow outward from a central core, with wealthier populations settling in areas with the most accessible infrastructure and services, while poorer populations are pushed to the urban periphery. In Tanzania, this pattern was evident during the early stages of urbanization when the availability of public transport, such as the daladala buses, dictated where people could live and work. Settlement areas grew in concentric zones around transportation hubs, and the outer areas of cities were often reserved for informal settlements or low-income communities with limited access to services (Ravallion & Wodon, 2019).

Traditionally, areas along major roads and transport routes became focal points for residential development. This created a spatial hierarchy where urban centers were densely populated, and less accessible areas were left undeveloped. The socio-economic divide within cities became entrenched, as access to public transport, particularly daladalas, shaped both the physical and social organization of urban spaces. Urban Ecology helps explain this dynamic, as competition for proximity to essential services, jobs, and economic opportunities became a key factor in settlement decisions (Sutherland et al., 2021).

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1.5 Shifting trends in urban and peri-urban settlement: The role of bodabodas

In recent decades, the introduction of motorcycle taxis, known as bodabodas, has drastically altered the settlement landscape in Tanzanian towns and cities. The availability of these informal transport options has expanded residential opportunities, allowing people to settle in areas that were previously considered too far from major roads or public transport networks. This shift can be analyzed through the lens of Henri Lefebvre's Production of Space theory (1974), which argues that space is not a static entity but is socially produced through the interactions and practices of individuals and groups.

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The traditional determinants of settlement in Tanzania were heavily influenced by factors such as geography, social ties, and access to public transportation. However, the emergence of bodabodas has ushered in a new era of urbanization, characterized by greater flexibility and mobility. The application of sociological theories such as Urban Ecology, Lefebvre's Production of Space, and Castells' Network Society provides a deeper understanding of how this informal mode of transport has reshaped not only the physical layout of urban spaces but also the social fabric of Tanzanian towns and cities. As urban expansion continues, the role of bodabodas in influencing settlement patterns will remain a crucial factor in the development of both urban and peri-urban areas.

2.0 MATERIALS AND METHODS

2.1 Study Area

Dar es Salaam, Tanzania's largest city, presents a dynamic case for studying residential patterns, particularly in relation to transport innovations like bodabodas. The city has expanded rapidly, with peri-urban areas increasingly becoming critical to urban development. This urban sprawl is influenced

significantly by the availability of informal transport options, such as motorcycle taxis (bodabodas), which have reshaped residential trends by connecting previously inaccessible areas to the city center.

Chanika, located approximately 50 kilometers from downtown Dar es Salaam, exemplifies this phenomenon. Historically, Chanika was less desirable for settlement due to its distance from the city and the limited transport infrastructure. Prior to the advent of bodabodas, only areas along the main road were inhabited due to the challenges in commuting to the economic hubs in the city. However, with the introduction of bodabodas, residents can now live further from the main road, enabling settlement expansion even up to ten kilometers from primary transport routes. This shift reflects how informal transport systems like bodabodas alleviate transport challenges, fostering residential growth in areas once perceived as remote.

Goba, though geographically closer to the city center than Chanika, faced similar challenges due to inadequate infrastructure. The area's uneven and difficult terrain made it hard for public transport to operate effectively, limiting access for many years. Until 2008, Goba was primarily served by pick-up trucks and mini trucks, colloquially referred to as "Chai Maharage," which were the only viable means of transport for both passengers and goods. However, the introduction of bodabodas significantly improved accessibility, making it easier for residents to commute. This shift spurred rapid settlement growth as the area became more connected and convenient for daily commuting. Bodabodas thus played a critical role in transforming Goba from a sparsely populated area into a thriving residential hub.

The contrasting experiences of Chanika and Goba demonstrate the pivotal role of bodabodas in shaping residential patterns in Dar es Salaam. While Chanika was initially avoided due to its distance from the city center and Goba struggled with poor infrastructure, bodabodas bridged these gaps, enabling both areas to experience significant urban expansion. The development of these regions underscores how informal transport systems have reshaped settlement dynamics, making them ideal locations for studying the impact of technological and infrastructural changes on urban growth and residential decisions.

2.2 Research Design

The study employed a qualitative case study design to explore the role of bodabodas in shaping residential patterns in Chanika and Goba. This approach allowed for an in-depth examination of the phenomenon within its real-life context, capturing the transport system's impact on urbanization. As noted by Denzin and Lincoln (2018), qualitative case studies are effective for

investigating complex social dynamics, offering the flexibility to explore multiple intersecting factors.

The population included residents of Chanika and Goba, alongside bodaboda operators. Purposive sampling was used to select around 30 participants—20 residents (10 from each area) and 10 bodaboda operators—based on their experiences and involvement with settlement patterns. This method ensured the inclusion of participants with direct knowledge of the subject, which, as Denzin and Lincoln (2018) suggest, is crucial for obtaining rich and relevant data.

Table 1: Distribution of respondents

S/no	Study area	Respondents	
		Type	Number
1.	Goba	Bodaboda	5
		Residents	10
2.	Chanika	Bodaboda	5
		Residents	10
Total			30

Data collection involved semi-structured interviews discussions, which facilitated the gathering of both personal and collective insights. The data were then transcribed and analyzed using thematic analysis, which is ideal for identifying patterns and themes within qualitative data (Braun & Clarke, 2006). The analysis followed Denzin's qualitative guidelines to ensure an accurate interpretation of participants' experiences within the socio-cultural context.

3.0 RESULTS

The findings illustrate that the availability of informal transport, particularly bodabodas, significantly influenced the decision to settle in Goba and Chanika. Participants consistently pointed to poor road infrastructure as a barrier to settling in these areas, and it was only the introduction of bodabodas and tricycles that made these locations more accessible for residential purposes. The following sections present insights from participants on their reasons for choosing these areas, the challenges they faced, and how bodabodas facilitated their decisions to live there.

When participants were asked why they chose to settle in Goba, many highlighted that the poor condition of the roads initially deterred them from building their homes. One participant recalled:

"I bought my plot here in 2000, but I didn't start building until ten years later. The roads were so bad that it didn't make sense to build because I couldn't even bring the construction materials in. Once bodabodas

became popular, everything changed. It became easier to move around, so I finally started building in 2013." (Resident 1, Goba, 10th March, 2024).

This experience was shared by other residents as well, with many acknowledging that the introduction of bodabodas played a key role in making Goba accessible, allowing them to move forward with construction projects that had been delayed.

Another resident who settled in Chanika shared a similar story:

"I bought land in 1999 but waited a long time before starting to build. It wasn't until I saw bodabodas and tricycles being used to transport building materials that I thought, 'Okay, now I can build too.' Before that, it was too difficult to transport materials with the roads in such bad shape." (KII, Resident 2, Chanika, 6th March, 2024).

This reflects a common trend in both areas, where participants noted that bodabodas and tricycles were essential in enabling them to transport heavy construction materials to their sites, even in areas where road infrastructure was inadequate for larger vehicles.

In Focus Group Discussions (FGDs) with residents, many participants echoed these sentiments, emphasizing how bodabodas had revolutionized mobility in their areas. One participant from Goba remarked during the FGD:

"Before bodabodas, most of us wouldn't have built houses here. The roads were impossible, and it took forever to get anywhere. But once bodabodas started working, we could bring in materials, and people started building homes more easily." (FGD Resident 1, Goba 11th March, 2024).

This collective view highlights how critical bodabodas were in enabling settlement, particularly in areas where traditional forms of public transport were unavailable or impractical due to the poor road infrastructure.

Another resident from Chanika explained how bodabodas specifically facilitated their decision to settle in the area, even though it had long been considered remote:

"People used to avoid this place because of how far it is from the city and the bad roads. But with bodabodas, the distance is no longer an issue. I can get to the city center quickly if I need to. It's cheap, fast, and reliable. Without bodabodas, I would never have considered living here." (KII, Resident 3, Chanika, 6th, March 2024).

This statement highlights how bodabodas not only facilitated the transportation of materials but also provided residents with an affordable and reliable way to commute, making these once-remote areas more attractive for settlement. In addition to transport for construction purposes, many participants emphasized how bodabodas became an integral part of their daily lives once they had settled in these areas. One Goba resident commented:

"I rely on bodabodas for everything such as going to work, taking my kids to school, even running errands. The roads are still bad, but bodabodas can get through even when other vehicles can't. It's what makes living here possible." (KII, Resident 4, Goba, 10th March 2024).

This participant's experience underscores the critical role of bodabodas in providing daily mobility in areas where traditional public transport remains unreliable or inaccessible. Without bodabodas, participants noted, they would have faced significant challenges in navigating daily life in these locations.

Another respondent from Goba shared a similar view, noting that without bodabodas, they would have reconsidered their decision to live in the area:

"Before bodabodas, this area was almost impossible to live in. The roads are still bad, but with bodabodas, I can get to the main road and catch a bus to the city center. It's affordable and convenient, and it has made living here much easier." (Resident 5, Goba, 10th, March 2024).

This shows how bodabodas serve as an essential link between these residential areas and the rest of the city, particularly for residents who rely on them to access main roads and bus routes. Participants also described how the flexibility and availability of bodabodas made them an indispensable mode of transport in both Chanika and Goba. One resident from Chanika explained:

"The bodaboda drivers know all the backroads and shortcuts, so even when the main road is blocked or too rough, they can find a way through. I use them every day, and they are always available, even early in the morning or late at night. That's what makes living here possible." (KII, Resident 6, Chanika, 6th March, 2024).

This flexibility and availability of bodabodas helped residents overcome the transportation challenges posed by the poor infrastructure, making daily commuting and travel to the city center much more manageable.

The bodaboda drivers also shared their perspectives on how they have contributed to the growth and development of these areas. During the FGD with bodaboda operators, one driver commented:

"We have been here since the beginning, and we saw how people struggled to get around. But after we started offering rides, more people began to come, buy land, and build homes. We made it easier for them to settle here." (FGD BodaBoda Driver 1, Goba, 11th March 2024).

This sentiment was echoed by another bodaboda driver who pointed out their role in helping residents transport materials:

"Most of the people here used bodabodas and tricycles to bring their materials for building. We helped them find shortcuts and navigate the bad roads. Without us, many houses you see now wouldn't be here." (FGD BodaBoda Driver 2, Chanika 8th March 2024).

These comments illustrate the pivotal role bodaboda drivers played not only in providing transport but also in facilitating the overall urbanization and settlement processes in these areas. Furthermore, participants in the FGDs acknowledged that bodabodas were crucial for their everyday lives. One resident noted:

"We still don't have good roads everywhere; only a few areas have proper roads. However, thanks to the bodabodas, we are able to manage. They have become an essential part of our lives, and we rely on them for everything, from work to emergencies." (FGD Resident 2, Goba, 11th March 2024).

This demonstrates how bodabodas have become an integral part of the local infrastructure, filling the gaps left by inadequate public transport systems and enabling residents to live more comfortably in previously inaccessible areas.

Many residents in Goba also recalled the challenges of relying on mini trucks, known locally as "Chai Maharage," before the introduction of bodabodas. One resident shared:

"Before bodabodas, we had to rely on the Chai Maharage trucks to transport anything. These trucks would leave from Mbezi Tanki Bovu, and you had to wait for a long time, especially if you had heavy materials or goods. The roads were so bad that sometimes the trucks would get stuck. But with bodabodas, I can now move much faster, even when the roads are difficult." (KII, Resident 4, 10th March 2024 Goba).

This highlights the slow and unreliable transport options that residents had to endure before bodabodas became a regular and more reliable mode of transport. Another resident from Goba recalled:

"When I first moved here, we didn't have bodabodas. I used to go to MbeziTankiBovu to catch the Chai Maharage trucks to transport building materials. It took hours for the trucks to arrive, and once they did, they could only go part of the way before the road conditions made them stop. Now, bodabodas can go directly to my house, and I don't have to wait." (FGD, Resident 8, Goba, 11th March 2024).

This further demonstrates how the poor infrastructure and long waiting times associated with the Chai Maharage trucks hindered the settlement process and delayed construction efforts.

In summary, the findings reveal that bodabodas have played a critical role in making both Chanika and Goba viable residential areas. They have facilitated the transport of building materials, enabled easier daily commuting, and contributed to the overall development of these locations. Participants consistently emphasized that without the availability of bodabodas, they would not have considered settling in these areas or would have faced significant difficulties in their daily lives. As a result, bodabodas have become a fundamental part of the urbanization process in these formerly remote and inaccessible parts of Dar es Salaam.

4.0 DISCUSSION OF THE FINDINGS

This study aimed to explore the role of bodabodas in shaping residential patterns in Goba and Chanika, areas of Dar es Salaam traditionally considered remote due to inadequate transport infrastructure. The findings revealed that bodabodas have played a pivotal role in transforming these once-inaccessible areas into viable residential zones. This transformation aligns with the theoretical frameworks of Urban Ecology and Henri Lefebvre's Production of Space. The Urban Ecology theory, which posits that urban growth occurs in concentric zones around transport hubs, is evident in the way bodabodas have facilitated the expansion of residential areas beyond traditional transport routes. Before the introduction of bodabodas, these areas were largely underserved, with residents relying on slow and unreliable mini trucks (Chai Maharage) or facing significant delays due to poor road conditions. The findings indicate that the arrival of bodabodas significantly reduced the barriers to living in these areas, enabling not only the transport of building materials but also improving daily mobility, which was critical to sustaining residential life.

The findings are consistent with Lefebvre (1974)'s Production of Space theory, which asserts that space is socially produced through human interactions and practices. The bodaboda drivers themselves have become central agents in reshaping the physical and social landscapes, facilitating the redefinition of space by creating new pathways and networks of mobility where formal infrastructure failed. As noted by participants, bodabodas have made living in

these areas more manageable by connecting people to the urban core and enabling them to carry out essential activities like work, school, and accessing services.

The literature supports the view that informal transport systems, such as bodabodas, are increasingly crucial to urban mobility in cities with rapidly expanding populations and underdeveloped infrastructure (Msigwa&Mbise, 2022; Mwita & Kweka, 2021). These transport options democratize mobility by providing affordable and flexible solutions for people who would otherwise be excluded from the benefits of urban living. Bodabodas in Dar es Salaam exemplify how informal systems can bridge gaps in formal infrastructure, promoting greater social inclusion and encouraging urban expansion into previously underserved areas.

By integrating these findings with existing literature and theoretical frameworks, it becomes clear that bodabodas have not only reshaped the physical space of Goba and Chanika but have also transformed the social dynamics of these areas. The mobility they provide has allowed for greater fluidity in settlement patterns, making once-remote locations accessible and livable. The study further demonstrates the role of informal transport in enabling urban growth and how such systems can be critical drivers of social and spatial change in rapidly urbanizing contexts.

Overall, the study confirms that bodabodas are integral to urbanization in Dar es Salaam, and their role in expanding the city's residential footprint cannot be underestimated. The findings suggest that future urban planning should consider the informal transport sector's role in urban mobility and settlement development, as it offers valuable insights into how cities can grow sustainably in the face of infrastructural challenges.

5.0 CONCLUSION AND RECOMMENDATIONS

This study highlights the significant role of bodabodas in enhancing mobility and supporting urban expansion in Goba and Chanika, though it also points to challenges such as accidents and criminal activities. To optimize their benefits, several key recommendations are proposed. First, improving road safety through mandatory use of helmets, safety training, and public awareness campaigns is crucial. Additionally, regulating bodaboda operators by implementing licensing systems and background checks will enhance safety and professionalism while reducing crime.

Improving road infrastructure is also essential, as better roads will reduce accidents and facilitate more efficient transport, particularly for construction materials. Public-private partnerships can help integrate bodabodas into formal

transport systems, while promoting alternative livelihoods for bodaboda operators will reduce their exposure to risks. Lastly, fostering community-based initiatives among operators and residents will improve safety and reduce crime.

In summary, addressing these issues through regulation, infrastructure improvements, safety measures, and community integration will maximize the positive impact of bodabodas, ensuring safer and more sustainable urban growth.

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Evaluating Interagency Collaboration for Environmental Compliance: A Case Study of Tanzania's Mining Regulations

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Abstract

This study evaluated the collaborative efforts among Tanzania's key regulatory agencies overseeing Tanzania's mining sector, specifically the Tanzania Mining Commission (TMC), the National Environmental Management Council (NEMC) and, the Occupational Health and Safety Authority (OSHA). The study focuses on how the actors from these institutions interact in fulfilling their regulatory roles. It seeks to address the tendency to overemphasise the institutional dimension of environmental regulation, leaving behind the relational approach. This was planned to answer two fundamental questions: i) how environmental regulators interact in fulfilling their shared responsibilities and, ii) what challenges they encounter at an interpersonal level. A mixed-method approach was employed, combining qualitative interviews, field observations and, statistical evaluations of compliance data. The findings indicate that regulators engaged in various forms of joint and independent activities to enforce compliance. They worked together through joint inspections, audits, and compliance monitoring. However, the degree of cooperation varied significantly across different locations and, low trust deterred cooperation. Some areas, like Geita and North Mara, exhibited strong interagency collaboration due to, relatively high trust among regulators. In contrast, those in other areas experienced fragmented regulatory oversight due to inconsistent cooperation and trust deficits. This underlines the recommendation for proactive measures to foster open communication and strengthen interpersonal relationships among regulators, which are requisites of trust building.

Keywords: Mining Regulation, Interagency collaboration, Trust reciprocity, jurisdictional overlaps, Tanzania

1.0 INTRODUCTION

Tanzania possesses a wealth of mineral resources both on the surface and beneath the subsoil. These resources include metallic minerals such as gold, silver, and copper; gemstones like diamonds, tanzanite, and ruby; industrial minerals including gypsum, phosphate, lime, and salt; construction materials such as gravel and sand; and energy minerals like coal and uranium (NBS, 2017). Mining activities in the country are categorized into three scales of operation: large-scale, medium-scale, and small-scale mining (MEM, 2014). These activities significantly contribute to the national economy, accounting for

4.8% of GDP in 2016 and generating approximately 50% of Tanzania's foreign exchange earnings (NBS, 2017).

Despite the centrality of the country's mining sector, its sustainability and profitability are jeopardized by the regulators' failure to streamline interagency collaboration, which is a strategic process that enables multiple agencies to complement one another toward achieving regulatory objectives. It is now uncommon to observe effective interagency collaboration which would be characterized by knowledge sharing, cooperative decision-making, and network governance, where formalized structures and processes facilitate the active participation of all stakeholders (Knoke et al., 2017; Ballard et al., 2018; Baeza et al., 2020).

Despite efforts to foster interagency collaboration in Tanzania's mining regulation, there is insufficient evidence to assess field experiences in the actual interactions between regulators. Moreover, regulators' field experiences and personal perspectives are only minimally documented in the current literature. Previous studies have primarily focused on governance structures and regulatory efficiency, while relational factors influencing collaboration have received little attention. This concern is based on the belief that while institutional and legislative frameworks establish the foundation for cooperation, interpersonal relationships, trust, and communication between regulators play a significant role in determining the effectiveness of interagency collaboration. The present study examines these relational aspects to provide a more nuanced understanding of how regulatory agencies interact and the barriers they face in enhancing interagency collaboration.

1.1 Theoretical Underpinning of Interagency Collaboration

The existing theoretical literature highlights institutional trust as a crucial factor in fostering and maximizing inter-agency collaboration (DiMaggio & Powell, 1983; Mayer, Davis, & Schoorman, 1995). Theoretical explanations of institutional trust emphasize its role in reducing uncertainty, enhancing cooperative behaviour, and ensuring the efficiency of collaborative efforts. Several scholars have underscored that trust acts as a mechanism to facilitate coordination and sustain long-term partnerships across agencies.

Institutional trust theory suggests that trust in institutions arises from their legitimacy, consistency, and adherence to norms (DiMaggio & Powell, 1983). When institutions follow standardized protocols, they reduce uncertainty and foster cooperation among agencies. Ikwuanusi et al. (2024) emphasize that digital transformation enhances institutional accountability, thereby improving inter-agency collaboration in public service delivery. The authors argue that when public institutions adopt transparent digital solutions, they reinforce trust, reducing bureaucratic inefficiencies that hinder collaboration (Ikwuanusi et al., 2024). Institutional trust also plays a significant role in emergency response and

crisis management. Riharjo and Jianghui (2024) highlight that during the COVID-19 pandemic, inter-agency collaboration was most effective when institutions maintained high public trust levels, ensuring compliance with public health measures (Riharjo & Jianghui, 2024). Similarly, Tapia (2024) underscores the importance of inter-governmental trust in coordinating emergency responses.

The theory highlights further that mutual trust between agencies leads to increased information sharing and cooperative decision-making (Mayer et al., 1995). According to Tukura and Tukura (2024), institutional trust is vital in combatting transnational security threats, as it ensures intelligence agencies share resources effectively (Tukura & Tukura, 2024). Similarly, Udochukwu and Uchenna (2024) identify institutional barriers as key obstacles in intelligence coordination, demonstrating how trust deficits undermine inter-agency collaboration (Udochukwu & Uchenna, 2024).

In light of the above, institutional trust is a foundational element in enhancing inter-agency collaboration, ensuring transparency, accountability, and effective decision-making. Theoretical frameworks from institutional theory highlight how trust facilitates cooperation, especially in intelligence, crisis management, and policy implementation. However, structural weaknesses and lack of transparency remain challenges. Adhikari (2025) identifies weak institutional frameworks as barriers to effective inter-agency coordination in national projects (Adhikari, 2025). Similarly, Musa and Olowonihi (2024) note that intelligence agencies in Nigeria face institutional mistrust, preventing the seamless exchange of security information (Musa & Olowonihi, 2024).

1.2 Existing Research on Interagency Collaboration in Tanzania's Mining Sector

Academic literature on Tanzania's mining sector has extensively examined governance structures, policy coordination, and regulatory effectiveness. While these studies have contributed to a better understanding of the institutional landscape governing mining regulation, they have largely overlooked the interpersonal dynamics that shape regulatory collaboration. Governance challenges and interagency coordination have been widely studied.

Mwita and Ng'ang'a (2023) examined governance barriers in Tanzania's mining sector, highlighting bureaucratic inefficiencies and conflicting regulatory mandates as major obstacles to effective collaboration. Their findings suggest that rigid institutional structures have impeded the ability of agencies to coordinate regulatory efforts. Similarly, Mbogo and Mwangi (2022) analyzed policy coordination mechanisms and identified both opportunities and challenges for improving interagency collaboration. Their research underscores the need for enhanced dialogue among regulatory bodies to streamline compliance processes.

Research has also explored coordination mechanisms and their impact on regulatory efficiency. Masanja and Kiwia (2023) assessed existing coordination frameworks and recommended strategies to improve regulatory alignment and interagency communication. Their findings suggest that structured decision-making processes and enhanced communication channels could significantly improve collaboration. Mushi and Mwakasege (2022) further examined the relationship between interagency collaboration and regulatory compliance, demonstrating that improved cooperation among agencies leads to higher compliance rates and enhanced industry performance. While institutional coordination is essential, effective regulatory collaboration also depends on interpersonal relationships, trust, and communication among regulatory personnel. The role of relational dynamics in interagency collaboration has not been adequately explored, leaving a gap in understanding how interpersonal factors influence regulatory effectiveness.

2.0 MATERIALS AND METHODS

The study employed a mixed-method research design, integrating both qualitative and quantitative approaches. It employed field observations, in-depth interviews, and documentary reviews to enhance the validity and reliability of the findings. Data collection involved direct field observations in four key mining districts—Msalala, Kahama, Geita, and North Mara. Field observation was particularly instrumental in uncovering implicit behavioural patterns that might not have been fully articulated by interview respondents (Denzin & Lincoln, 2017).

The observations focused on the interactions between environmental regulators, guided by the premise that understanding relational patterns in regulatory settings is best achieved through first-hand experience (Creswell & Poth, 2018). Additionally, qualitative data was gathered through in-depth interviews with 15 environmental regulators from TMC, NEMC and OSHA, who were deemed knowledgeable about environmental compliance and regulatory interactions. The selection of interview participants followed a purposive sampling technique to ensure that respondents had relevant expertise (Bryman, 2016).

To supplement and cross-validate primary data, an extensive review of compliance reports, regulatory frameworks, and other relevant documents was conducted. This triangulation of data sources enhanced the credibility of the study by integrating observed behaviours, stakeholder perceptions, and documentary evidence (Yin, 2018). The analysis of qualitative data followed a thematic approach, where key themes related to “trust” and “willingness to cooperate” were identified, coded, and categorized (Braun & Clarke, 2006).

Interview transcripts were analyzed to detect similarities and discrepancies in stakeholders' perspectives, while field observation data was examined through systematic interpretation of interaction patterns among regulators (Patton, 2015).

Quantitative data, primarily derived from compliance reports, was used to cross-check and verify primary data (Field, 2018). The combination of qualitative and quantitative methods was crucial in the validation process. While qualitative interviews provided in-depth insights into relational complexities, quantitative data offered empirical support to validate these findings.

3.0 RESULTS AND DISCUSSION

3.1 The Conduct of Environmental Regulators in Mining Fields

Regulating the mining sector in Tanzania is a multifaceted endeavour involving multiple agencies that work both independently and collaboratively to ensure compliance with environmental and mining laws (Kinyondo & Huggins, 2021). Officials from these agencies engage in activities such as auditing, inspections, and compliance monitoring, with some operations being conducted jointly while others remain independent. A key example of this inter-agency cooperation is the National Environmental Management Council (NEMC), which frequently collaborates with private environmental auditors and inspectors to conduct environmental audits (Field Survey, May 2019).

Among the regulatory bodies, the Tanzania Mining Commission (TMC) played a central role in field operations. TMC officials, including Zonal Mines Officers (ZMOs) and Mines Resident Officers (MROs), are responsible for overseeing mining activities, issuing permits, and ensuring compliance with regulatory standards. In certain cases, TMC officials worked alongside other government agencies such as NEMC to conduct joint regulatory exercises. However, the extent of inter-agency collaboration varies across regions. For example, areas such as Geita and North Mara demonstrated high levels of cooperation, whereas in other locations, regulatory agencies operated with minimal coordination (Field Survey, May 2019).

Environmental compliance monitoring remained a core responsibility of NEMC officials, who collaborate with TMC officers to oversee mining operations and conduct environmental audits. However, research has highlighted NEMC's limited capacity to fulfil its regulatory mandate effectively. Schoneveld et al. (2018) and Maliganya & Bengesi (2018) noted earlier that due to NEMC's broad responsibilities beyond the mining sector, resource constraints often hinder its ability to conduct proactive inspections. This challenge underscores the necessity of inter-agency collaboration to mitigate capacity limitations. Without such cooperation, NEMC officials can only respond to reported cases of non-compliance rather than proactively enforcing environmental standards.

Beyond environmental compliance, occupational health and safety oversight falls under the jurisdiction of the Occupational Health and Safety Authority (OSHA). OSHA inspectors provide safety training and professional guidance to mine workers while conducting routine workplace inspections. Their statutory responsibilities include workplace registration, risk assessments, and accident

investigations, all in accordance with the Occupational Health and Safety Act (OHS Act, 2003). Working in teams, OSHA officials ensured that employees operate in safe conditions and that mine operators adhere to occupational safety regulations (Field Survey, May 2019).

When OSHA inspectors detected regulatory violations, they issued compliance orders requiring mine operators to rectify deficiencies (Field Survey, May 2019). These orders include improvement notices with deadlines for corrective action and, in cases of imminent hazards, stop-work orders. Generally, mining companies complied with these directives, fostering a cooperative regulatory environment. Legal enforcement was rarely necessary, as OSHA officials encountered minimal resistance from industry stakeholders, reflecting a climate of mutual understanding between regulators and mining companies.

Despite the observed cooperation among regulatory agencies, challenges related to inter-agency coordination persisted. Field observation has identified instances of regulatory disjointedness that negatively impact enforcement effectiveness (Field Survey, May 2019). One of the major obstacles is the inefficient sharing of regulatory reports and information among agencies. Bureaucratic hurdles and legal confidentiality restrictions often impede the timely exchange of crucial data. This lack of coordination resulted in delays in regulatory decision-making and enforcement. Many regulators perceived these challenges as indicative of distrust among agencies, further complicating efforts to foster effective inter-agency collaboration (Field Survey, May 2019).

3.2 Status of Interagency Collaboration in Tanzania's Mining Regulation

In the Tanzanian context, interagency collaboration is governed by legislative frameworks, interagency coordination mechanisms, and technological integration. The Mining Act of 2010, revised in 2017, establishes the legal basis for interagency collaboration by allocating specific responsibilities to multiple regulatory bodies, some of which overlap to ensure comprehensive oversight. The TMC plays a central role in coordinating regulatory activities, working closely with the NEMC to enforce environmental protection policies. Regular interagency meetings, joint task forces, and structured information-sharing systems have been implemented to enhance communication and coordination among these institutions.

Additionally, joint inspections and audits further reinforced accountability by enabling regulators from different jurisdictions to assess compliance collectively (Schiavi, 2013; Field Survey, May 2019). These mechanisms aimed to strengthen regulatory efficiency and ensure sustainable mining practices. In addition, joint audits and inspections allow multiple agencies to assess regulatory compliance collectively, reinforcing accountability and streamlined oversight (Mining Policy Framework, 2018; Field Survey, May 2019).

Beyond formal coordination mechanisms, technological integration has played an increasingly vital role in improving interagency collaboration. The adoption of digital platforms has facilitated real-time information sharing among regulators, significantly enhancing the efficiency of regulatory oversight. The implementation of an online mining cadastre system has enabled electronic application and management of mining licenses and permits, providing a centralized platform for stakeholders to access regulatory information. According to the Tanzania Mining Commission's 2021 Annual Report, the integration of digital platforms has improved data transparency and strengthened collaboration among regulatory agencies (TMC, 2021).

Despite these efforts, challenges persisted in achieving seamless interagency collaboration. Limited financial and human resources constrained the capacity of regulatory agencies, affecting their ability to engage in effective communication and joint regulatory activities. Fragmented data management practices have further complicated interagency coordination, as the lack of standardized data collection methods caused inconsistencies in compliance reporting. Additionally, the presence of multiple stakeholders with competing interests, including mining companies, local communities, and civil society organizations, complicated communication and regulatory enforcement.

3.3 Relational Challenges Encountered by Tanzania's Mining Regulators

Environmental regulators faced relational challenges that hindered effective interagency collaboration. The relational challenges were empirically reflected in the lack of trust and had constantly and commonly impeded regulatory efforts (Field Survey, May 2019). Lack of trust was evident and widespread due to communication gaps and conflicting interests. While not unique to the case of Tanzania, the trust deficit widely undermined cooperation, reduced transparency, and created inefficiencies in enforcing mining regulations (Jenkins, 2019; Onyango, 2022; Judijanto et al., 2023).

3.3.1 Lack of trust due to communication gaps

Field observations revealed a lack of cooperation among regulators from different agencies, primarily due to trust deficits (Field Survey, May 2019). Regulators worked for different agencies were often reluctant to assist one another in their duties, opting instead to gather similar data separately rather than share information. For example, both NEMC and OSHA required access to the same environmental and occupational safety data from mining operators and each collected the information independently. This lack of collaboration was an indication of inter-agency distrust. Worse still, some information suggests that trust deficit revolved internally within individual agencies. One respondent reflected on this, stating:

"Several undesirable incidents taught me not to trust even my co-workers. I have had unfortunate experiences in which confidential information from my files was leaked to an OSHA inspector. This information was

used to their advantage, leaving me vulnerable to blame. This created unnecessary tension and distress, particularly with those I shared office space with" (Interview with TMC1, May 24, 2019).

This testimony illustrates how breaches of confidentiality within regulatory institutions contribute to distrust among colleagues. The failure to uphold professional secrecy undermines collaboration and weakens the effectiveness of inter-agency partnerships.

According to institutional trust theories, when trust deteriorates, it can lead to reduced cooperation and limited information sharing (Edelenbos & Eshuis, 2012). Trust deficit affects the relationship between regulatory agencies, resulting in fragmented enforcement efforts and regulatory inconsistencies (Temby et al., 2015).

3.3.2 Lack of trust due to conflicting interests

Temby et al. (2015) highlighted that conflicting interests and mandates are a major barrier to institutional collaboration. This was true in the study areas in that the conflicting interests among regulators caused distrust and eventually hindered interagency collaboration. The data indicates that regulators originated from diverse professional backgrounds and had differing priorities that led to competition for control over regulatory processes and enforcement priorities (Field Survey, May 2019). This created tension among agencies, further complicating collaboration.

Multiple agencies with overlapping responsibilities competed over mandates instead of working cooperatively. This resulted in redundant enforcement activities, inefficient resource allocation, and inconsistent policy implementation. This is problematic as remarked by Mu et al. (2019) who conceived power struggles between concomitant agencies which operate without a clear jurisdictional demarcation. In the study areas, the lack of a clear jurisdictional demarcation caused agencies with greater political backing or financial resources to dominate regulatory activities, sidelining less influential agencies. This state of affairs reinforced distrust and further fractured inter-agency relations.

3.4 Thematic Analysis of Trust and Willingness to Cooperate

Participants highlighted that trust, both interpersonal and systemic, is a key determinant of the quality of relationships among regulators. When colleagues' decisions were perceived as reliable, regulators demonstrated a greater willingness to engage collaboratively and share information. However, when the trust was weak, it attracted scepticism and minimal cooperation. A senior official from TMC noted,

"Trust is the foundation of any effective regulatory system. If each of us believes that we are working for a common goal and in goodwill, it would be feasible to cooperate willingly." (Interview, NEMC1, June 2019).

This perspective was echoed by a respondent from NEMC, who described trust as a prerequisite for open communication and effective enforcement. However, despite the acknowledged importance of trust, the interviews revealed several barriers that hinder its development. One of the most frequently cited challenges was the lack of sustained engagement among regulators. Participants noted that regulatory interactions were often limited to compliance inspections and enforcement actions rather than ongoing dialogue and collaboration. An official from OSHA explained,

"We meet and share some information only when there is a violation. There is little opportunity to build relationships outside of enforcement, which makes it harder to establish trust." (Interview, OSHA1, August 2019).

This ad-hoc system of engagement is seemingly unhealthy for sustainable interagency collaboration (Judijanto et al., 2023). The interview data suggests the necessity of building a culture of trust to enhance interagency collaboration. Participants identified several strategies to strengthen trust and improve willingness to cooperate among environmental regulators.

A widely supported approach is pointing to increasing stakeholder engagement through constant sharing of information rather than limiting that to some selected incidents. Respondents suggested that regular forums and collaborative environmental initiatives could help bridge the gap and enhance cooperation between regulators. A senior officer from TMC remarked, *"We need to build long-term trust and encourage cooperation."* (Interview, TMC3, August 2019). This sentiment was shared by several other regulators who emphasized the need for joint operations to enhance trust and, in return, to foster cooperation.

Generally, participants held the idea that trust is not merely an abstract concept but a critical factor for interagency collaboration. When trust is present, the willingness to cooperate increases, making enforcement efforts more effective. However, achieving this trust requires proactive engagement and constant interactions.

4.0 CONCLUSIONS AND RECOMMENDATIONS

To address relational challenges in interagency collaboration, scholars have recommended various mechanisms that could be effective in the case of mining regulation in Tanzania. If implemented properly, the following strategies could enhance cooperation among regulatory agencies, improve enforcement efficiency, and foster a more coordinated regulatory environment.

4.1 Developing Clear Interagency Agreements Defining Roles and Responsibilities

One of the key recommendations is to develop clear interagency agreements that define the roles and responsibilities of each regulatory body, helping to minimize conflict (Jenkins, 2019). Developing interagency agreements can help clarify roles, enhancing communication can reduce regulatory inefficiencies, and sustained joint training programs can foster long-term trust among regulators. A structured interagency agreement could provide clear guidelines on the specific responsibilities of each institution, ensuring accountability and streamlining regulatory processes. For instance, if it is explicitly established that NEMC will oversee all environmental audits while OSHA is solely responsible for occupational safety inspections, regulatory agencies can avoid unnecessary overlaps and minimize tensions. However, for this recommendation to be successful, it requires the commitment of agency leaders to foster a shared regulatory vision. Without common will and institutional alignment, these agreements risk remaining ineffective.

4.2 Enhancing Communication Channels to Facilitate Information Sharing

Another crucial recommendation is the enhancement of communication channels to facilitate information sharing and transparency (Edelenbos & Eshuis, 2012). This is certainly a workable solution in the Tanzanian mining regulatory context. Establishing efficient communication mechanisms would enable real-time data exchange, improve regulatory responsiveness and reduce bureaucratic delays. A centralized regulatory database accessible to TMC, NEMC, and OSHA could serve as a common platform where agencies can upload and retrieve compliance records, fostering regulatory coherence. However, concerns over data confidentiality and security must be addressed to prevent breaches of sensitive information. Strong data governance policies, outlining clear protocols on access and usage, would be necessary to ensure that enhanced communication does not compromise professional integrity.

4.3 Building Trust through Joint Training Programs

Another significant recommendation is building trust through joint training programs that encourage professional relationships and shared accountability among regulators (Temby et al., 2015). When agencies operate in isolation, it leads to fragmented enforcement, misaligned regulatory priorities, and weakened oversight capabilities. Joint training programs offer an opportunity to cultivate trust by allowing regulators from different agencies to interact in a structured environment, develop a common understanding of enforcement priorities, and establish professional networks. A multi-agency workshop on environmental compliance and occupational safety, for example, could bring together officers from NEMC, OSHA, and TMC, facilitating dialogue on best practices and reinforcing cooperative approaches to regulation.

Such initiatives not only enhance professional rapport but also create a sense of shared responsibility, reducing the tendency for agencies to operate independently. However, for these training programs to be effective, they must be part of an ongoing effort rather than sporadic initiatives. Institutionalizing interagency training—where all newly appointed regulatory officers are required to undergo collaborative professional development—would ensure that trust-building efforts are sustained over time. While these recommendations provide viable solutions to the relational challenges faced by Tanzania's mining regulators, their success ultimately depends on strong leadership, policy commitment, and continuous institutional engagement. If these mechanisms are effectively implemented, they could transform Tanzania's mining regulatory framework into a more coordinated and efficient system, ensuring better compliance with environmental and safety regulations while fostering sustainable mining governance.

From the foregoing, it can be re-stated that interagency collaboration is integral to ensuring regulatory compliance in Tanzania's mining sector. Regulatory agencies in Tanzania's mining sector worked together through joint inspections, audits, and compliance monitoring. However, the degree of cooperation varies significantly across different regions. Some areas, like Geita and North Mara, exhibited strong interagency collaboration, while others experienced fragmented regulatory oversight due to inconsistent cooperation among agencies. The key challenges against interagency collaboration included bureaucratic inefficiencies, inconsistent participation of agencies in field operations, and jurisdictional overlaps.

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Measures taken by Industries in Increasing their Capacity of Carbon Sink in Tanzania

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Abstract

This paper examined measures taken by industries to increase their capacity for carbon sinks in Tanzania. The study was carried out in the Coast Region of Tanzania. The study design adopted was cross-sectional, whereby a sample of 92 industries was drawn from 1192 industries located in the Coast Region. Industries involved were energy plants, processing industries, and manufacturing industries. Data were collected using documentary review, interview, and observation. Descriptive statistics and content analysis were used to analyze the data collected. The results were presented in the form of charts and percentages. Findings revealed that industries used different strategies to reduce the generation of carbon dioxide such as material substitution, improving resource use efficiency, industrial symbiosis, and fuel switching to electrification. Study found that employed by industries in reducing the emission of carbon dioxide include; producing low-carbon products, investing in low-carbon infrastructures, improving productivity, climate diplomacy, and international cooperation, installing low-carbon technologies. Study recommends that the existing policy should provide clear incentives such as grants, tax incentives, or recognition programs for industries investing in carbon-sinking measures. Industries should invest in research and development to advance carbon capture technologies and practices as a result these technologies will be more accessible and economically viable for industries. Industries should implement capacity-building initiatives through training programs that focus on best practices in carbon sinking and sustainability; this will foster a culture of environmental responsibility. The study concluded that industries are working on reducing the generation of carbon dioxide from their sources.

Keywords: Industries, climate change, carbon sink, Coast Region, Climate change measures

1.0 INTRODUCTION

Climate change is a big threat to the whole world (IPCC, 2018). It is considered to be one of the most serious threats to sustainable development and its effects have been a major concern globally (Abolmaali, Tarkesh, & Bashari, 2018;

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Ballew et al., 2019; Jug et al., 2018; Rifkin, Long, & Perry, 2018); ICAO, 2010; URT, 2011). Anthropogenic activities are responsible for almost all of the increase in greenhouse gases in the atmosphere. The global mean surface temperature has increased by 1.0 °C since pre-industrial levels, and is still ongoing at a speed of 0.2 °C per decade (IPCC, 2022). Anthropogenic activities, especially industrial and related activities, have caused a substantial increase in the concentration of carbon dioxide (CO²) in the atmosphere (Change, 2018; Masson-Delmotte et al., 2021; USGS, 2008). This increase in atmospheric CO² from about 280 to more than 380 parts per million (ppm) over the last 250 years is leading to measurable global warming. According to UNEP (2018), worldwide emissions from human activities totaled nearly 46 billion metric tons of greenhouse gases, which were expressed as carbon dioxide equivalents in 2010. Since the beginning of the industrial revolution over 200 years ago, atmospheric concentrations of greenhouse gases such as carbon dioxide (CO²) and methane (CH₄) have significantly increased the atmospheric concentration of carbon dioxide (FAO, 2016). Globally, the Industrial sector contributes 21% of Green House Gases (GHGs) emissions to the atmosphere (FAO, 2016). Global CO₂ emissions from energy and industry increased in 2017, Total annual greenhouse gas emissions, including from land-use change, reached a record high of 53.5 GtCO₂e in 2017, an increase of 0.7 GtCO₂e compared with 2016, among of reasons for an increase of CO₂ emissions in 2017 was intensive use of fossil fuels in energy and industrial sectors (UNEP, 2016).

Africa is the among of less contributor of greenhouse gases taking third position in the world emitting 3-5% followed by South America and Oceania in second and first position as lesser emitter of greenhouse gases by the rate of 5% and 1-2% consecutively while Asia is the largest emitter which account for 50% of global emissions then followed by North America and Europe that accounts for 20% and 15% of the total global emission of greenhouse gas (IPCC, 2023). The total emissions in Africa have significantly increased by more than twelve-fold since the 1950s, and this level is projected to increase further (Golubski, 2017). Africa continent is the most vulnerable region to climate change in the world due to the fact that the continent has diverse climates and ecosystems making some regions more susceptible to extreme weather, droughts, and floods. In addition, Tanzania has set itself the goals of development through increasing investment in human capital and industrialization (Malenda, 2020; Suru, Seni, & Mbalamula, 2019; UNDP, 2017). The number of industries has increased from 50656 in 2015 to 59133 in the year 2019, with almost 8,477 industries established across the country, including small, medium, and large-scale industries (URT, 2017, 2020). Even though the industrial sector is very important in the country, the sector plays a huge role in the contribution of climate change including through the emission of Greenhouse Gases (GHGs).

The industrial sector in Tanzania contributes approximately 18-20% of the country's total greenhouse gas emissions. This includes emissions from

manufacturing, mining, and construction activities (URT, 2020). The primary contributors within this sector are energy-intensive industries such as cement and processing industries, along with emissions from fossil fuel use and industrial processes (URT, 2020). Tanzania is the second in emissions of greenhouse gas about 0.37% in East African countries which is categorized as among the countries which have lower GHG emissions in the world (WRI CAIT, 2015). Even though industrialization produces a large number of emissions which lead to climate change, industrialization is also an effective means for climate change mitigation. Industrialization is also fundamental in climate change mitigation through technological progress, the retirement of inefficient technologies, changes in the structure of energy systems, and patterns of energy services (Okereke et al., 2019).

The National Environmental Policy of 1997 describes that industries are one of the sectors contributing significantly to environmental challenges such as land degradation mainly during the extraction of raw materials and energy resources (NEMC, 2017). According to National Carbon Monitoring Centre (NCMC) in dealing with the carbon reduction campaign Tanzania developing Africa's largest carbon offset project whereby the memorandum of understanding (MOU) agreed between the Tanzania Wildlife Management Authority (TAWA) and Green Cop Development PTE Ltd as Singapore registered company developed the carbon –offset project credit billions to bankroll conservation of territory covering 2.4 million hectares in Southern Tanzania. The project promises substantial new green jobs to implement measures to avoid greenhouse gas emissions (NCMC, 2023). Jiang *et al.*, (2021) outlined 20 top countries with the highest land carbon sink with which the implementation range within 45 years from 2005-2050 where the expectation is 62.1pg C. Among them, are Russia, Canada, USA, China, and Brazil. This carbon sink consists of four components production-driven change and turnover-driven change, change in instantaneous carbon storage potential, and interaction between production-driven change and turnover-driven change. The four components account for 49.5%, 28.1%, 14.5%, and 7.9% of the land carbon sink respectively. Despite this truth, little is known about Measures taken by industries in increasing their capacity of carbon sink capacity in Tanzania. Therefore, this study assessed measures taken by industries in increasing their capacity of carbon sink capacity in Tanzania.

2.0 MATERIALS AND METHODS

2.1 The study Area

This study was conducted in the United Republic of Tanzania specifically the Coast Region. The coastal region is located in the Middle East side of Tanzania Mainland between latitudes 6⁰ and 8⁰ south of the equator and longitude 37⁰30' and 40⁰ east of Greenwich. For the case of climate, the region experiences a tropical climate with an average temperature of 28⁰C, and rainfall range from 800mm to 1000mm while the region's topography is within a coastal belt ranging from (0-100m) above mean sea level, and nature of soil is clay, loamy,

silt and alluvial. Water bodies, the region has enough rivers (Rufiji, wami, and Ruvu) that pour their waters along the Indian Ocean. In addition to that, the region is blessed with many economic activities such as; Agriculture, Industries and trade, Beekeeping, Fisheries, Forest, Tourism and wildlife, and mining (URT, 2022). The reason for choosing this region as a study area is because, the region experienced a mushroom rise of industries because of being allocated near Dar es Salaam city, and the majority of industries had shifted from Dar es Salaam to the Coastal region because of the potentiality of resources such as land, and other materials which required by industries. This situation marks the region to have 1192 industries (ranging from large scale to small scale).

2.2 Research Design

The descriptive research design was used in this study to collect information from industries located in coastal regions on the role of industrialization in promoting climate change mitigation. This type of design was used to allow a researcher to collect information, summarize, interpret, and present data for further clarification. Also, Creswell (2015) argued that the descriptive research design is more typically structured and formalized with evaluative questions that are clearly stated. Thus, based on such reason the study selected this design due to its ability to warrant the increased objective and reliability of the evidence collected.

The sampling frame under this study was industries located in the Coast Region. Therefore, respondents were drawn from industries. A representative sample size with known confidence and risk levels was selected, based on the work of Yamane (1967). The Coast region comprises 1192 industries whereby only 92 industries were surveyed by this study. Both probability and non-probability sampling procedures were used to select respondents. Simple random sampling was used to select industries while purposive sampling was used when selecting key informants who were industrial managers, operators, and responsible ministries as well as officers from headquarters of concerning district councils of the Coastal region where industries are being located.

In this case, both primary and secondary data were collected to address the study objectives. Primary data comprises both qualitative and quantitative data and collected direct from the industries through interviews and observation methods. Secondary data was collected from published documents and relevant reports. Multiple methods for data collection were used in this study to make the study valid and free of mistakes and biases, these included interview, observation, documentary review, and questionnaire respectively. The interviews were held with industrial managers, operators, and officers from headquarters of district councils of the Coastal region where industries are located as well as officers from NEMC and responsible ministries. On the other hand, questionnaires were administered to normal industrial workers.

This study used both qualitative and quantitative techniques for data analysis. In quantitative data analysis, descriptive statistic methods were used. Descriptive statistics were used in analyzing data in terms of frequencies and percentages from responses. Statistical Package for Social Science (SPSS) was used to derive descriptive statistics to meet the objectives. The descriptive findings in this study are presented in the form of tables and frequencies as an important part of the process of report writing. On the other hand, qualitative data was analyzed through content analysis thematically, in this case, themes generated from audio records after being transcribed.

3.0 3 RESULTS AND DISCUSSION

3.1 Types and Location of Industries in Coastal Region

The findings of the study indicated that, 92 industries in the study area fall under five types as indicated in Table 1. The table also displays the distribution of the industries in the study area.

Table 1: Types and location of industries

Variables	Frequencies	Percentages
Type of industries		
Steel processing industries	11	12.0
Food processing industries	28	30.4
Construction materials industries	37	40.2
Electronic and motor spare industries	12	13.0
Leather processing industries	4	4.3
Industry location		
Mkuranga	17	18.5
Kibaha Town council	31	33.7
Kibaha District council	22	23.9
Chalinze	16	17.4
Bagamoyo	6	6.5

Source: Field data, 2022

3.1.1 Types of industries

The study findings revealed that about 40.2% of the surveyed industries engaged in the production of construction material, about 30.4% of industries engaged in food processing, and 13% of industries engaged in electronic and motor spare industries. It was found that 12% of industries engaged in steel processing and very few 4.3% industries engaged in leather processing (Table 1). This result implies that the study area is occupied by many industries related to construction materials, spare part making, leather, steel, and food processing. Therefore, the existence of those numbers of industries in the Coastal region had an impact on the environment since greenhouse gases are mainly produced by the industrial sector. According to IPCC (2022), industries are categorized as among of major producers of greenhouse gases because depend much on energy consumption which accounts for 73.2% of global emissions.

3.1.2 Industry location

The study found that about 33% of all industries are located in the Kibaha district council and about 23.9% of them are located in the Kibaha town council. Furthermore, the study noted that 18.5% of industries are located in the Mkuranga district while 17.4% of industries are located in the Chalinze district and a few 6.5% of industries are located in the Bagamoyo district (Table 1). This is an indication that the Coast region has abundant industries in its districts, and statistics indicate that the Coastal region had 1192 total number of industries (URT, 2023). Therefore, those industries located in various districts of the Coastal region are responsible for making sure the environment is kept safe by reducing the emission of greenhouse gases.

3.2 Measures taken by Industries in order to reduce the emission of carbon

The study findings noted that there are measures taken by industry to reduce the generation of carbon dioxide rather than directly improving well-known carbon sink such as de-carbonation, capacity building, and technological transfer strategies. It noted that the implementation of measures involves multiple stakeholders in the chain of industrial production activities. Measures to increase carbon sink capacity included those taken by industries as primary stakeholders in the process of climate change mitigations, also there are measures taken by other stakeholders mainly the government in collaboration with different institutions

3.2.1 De-carbonization strategies

During the survey it was noted that industries play a great role in reducing the generation of carbon dioxide as presented in Table 2.

Table 2: De-carbonization strategies

De-carbonization strategies	Frequencies	Percentages
Material substitution	13	14.1
Improving resource use efficiency	1	1.1
Industrial symbiosis	13	14.1
Fuel switching to electrification	16	17.4
Supporting policy framework	15	16.3
Producing low carbon products	14	15.2
Investing in low carbon infrastructure	10	10.8
Carbon leakage mitigation	10	10.8
Thriving for low carbon materials	7	7.6
Improving productivity	8	8.7

Source: Field data, 2022

Material substitution: The study in Table 2 revealed that, about 14.1% of the industries confirmed material substitution plays a great role reducing emission of greenhouse gases in particular carbon dioxide. Within the study area some industries opted to use alternative material for production to reduce process in

production process. Material substitution in the context of carbon reductions refers to the practice of replacing high-carbon materials with lower-carbon alternatives in industrial processes, this strategy aims to reduce greenhouse gas emissions associated with the production and use of materials. The use of material substitution by industries reduced the level of energy and material used in the production process, also it reduces the use of materials. Study noted that material substitution keeps industrial products and material to be used for long time, this process has benefit to the environment by reducing emission of greenhouse generation. Furthermore, material substitution revealed by study to go directly with improving production designs in order to ensure durability, repair ability and recyclability. Furthermore, materials substitution is using low carbon products or materials than more emission products or materials. Industries are opted to produce low carbon goods by substituting organic fibers for grown fibers. It knows that organic or natural fibers use less energy and have low carbon emissions. TEC (2017) argued that material production and processing require a lot of energy and it is a main driver of GHG emissions in industry production activities. CO₂ emissions can also be reduced substantially through increased material efficiency this included material substitution through the recycling of products and the re-use of materials is an effective way to reduced energy demand and GHG missions. This is due to the fact that the reused material does not need to be augmented as new material; therefore, energy-intensive chemical reactions can be avoided. Moreover, the interview with one of respondent from diamond cement industry confirmed that;

“Our industry uses material substitution as strategy to reduce the production of CO₂ in several ways such as; replacing carbon-intensive materials, adopting lightweight materials, utilize renewable and recycled materials”. An interview with factory manager, 13/03/2022

Improving resource use efficiency: The study in table 2 found out that, about 1.1% of the industries reduce carbon dioxide generation; industries opted to improve resource use efficiency. Improving resource use accompanied by energy efficiency measures. Study noted that resources and energy use efficiency including reuse of waste products, furthermore, industries recycled waste products as raw material. Through this production of products reduced by number of processes hence reduced energy demand in production process. Improving energy efficiency revealed to consider maintaining the same quality and level of output while using less energy in the process. Furthermore, the findings revealed that improving energy efficiency goes directly with the approaches such as repair, recycling, reuse and reducing quantity of materials used within manufacturing. These findings align with Lv and Qin (2016) who pointed out that improving energy efficiency considered as more effective way of optimal utilization of resources. Energy saving and resources efficiency offer reduction of greenhouses gases emission also offer reduction of production cost by industries. Furthermore, resource efficiency provides financial sustainability

of industries and in carbon-intensive industries, improved resource use efficiency are considered to reduce greenhouse gas emission.

Industrial symbiosis: The results in Table 2 show that only 14.1% of industries reported using industrial symbiosis as one of their main strategies to mitigate carbon dioxide emissions. Industrial symbiosis involves repurposing secondary by-products from one industrial process as inputs in another, creating interdependence among industries through the exchange of raw materials and enhancing resource efficiency. This strategy reduces doubling of efforts in producing the same kind of raw material. It revealed that most food processing industries does not produce their own package for their product rather they purchase from packaging manufacturing industries. Furthermore, study revealed that other industries depend on by-products and waste products from other industries, this included industries produced goods related to metal products and plastic related products. In his study Boons, Chertow, Park, Spekkink, and Shi (2017) pointed out that industrial symbiosis provides interconnected network which play a great role in functioning on ecosystem by reducing greenhouse gases emission and environmental pollution. Industrial symbiosis reduces the environmental footprint of the industries involved. It reduces the use of virgin raw materials required in production process also it reduce the need waste management and disposal. Furthermore, it reported that, industrial symbiosis allows value of the material to be created and remain in the industrial system for long time of which otherwise would be discarded as waste. Also, the interview with one of respondent from Madoweka Co. Ltd-Vikindu reported that;

“We are producing variety of plastic packages such as plastic bottles, and other plastic utensils like water containers, cups, bowls, plates, as well as PVC for construction purposes. Our major customers are food beverage companies which place many orders for plastic bottles that used as packages of drinking water and juice” (An interview with marketing manager, 27/03/2022)

Fuel switching to electrification: The study findings in table 2 revealed that, only 17.4% of industries opted to switch from fossil fuel to electricity with low carbon play a great role in reduce carbon dioxide which regarded as one of the highly greenhouse gases emitted by industries. Technologies such as electric furnaces are more energy efficient when compared with fossil fueled energy options. Study found out that, electrification technologies reduce energy demand from industrial processes, in particular in low-temperature heat applications. Roelofsen, Somers, Speelman, and Witteveen (2020) supported the findings by reported that, fuel switching to electricity stand as option for reducing the intensity fuel use by industry through moving to lower carbon generation option for example gas use instead of coal use. Fuel switching practiced by industries is the great platform for reducing emission of greenhouse gases from industrial production activities. In Tanzania some industries already opted to switch from heavy fuel oil into the use of National electrical grid which mainly generated by

hydro-electric energy resources, this included Twiga cement, Tanzanian Breweries, Aluminum Africa and Karibu textiles (Pye, Watkiss, & Savage, 2010).

Supporting policy frameworks: Table 2 shows that, only 16.3% of the industries take into consideration the full set of policies related with environmental issues, technologies and resources utilization. This is an indication that, few industries in the study area supported low carbon manufacturing by implementing policies that aiming to encourage green production without significantly impacting the cost to end consumers. These findings align with TEC (2017), which notes that industries adopt various policy measures aimed at minimizing carbon emissions. This included strategic planning, economic instruments, institutional creation and information and education, regulatory instruments, research, development and deployment, and voluntary approaches.

Producing low carbon products: The study findings in table 2 revealed that, 15.2% of the industries within the study area are producing low carbon products as their strategy to reduce emission of greenhouse gases in particular carbon dioxide. Production of low carbon products started from material used in production process, among of the low carbon materials used are organic materials and recycled metal materials. It found out that aluminum and steel making industries products recycled some metal to avoid the production process of metal products which is highly carbon intensive, recycled of metal products are significantly reduce production energy consumption. Also, it noted that recycled metals maintaining metal properties.

Investing in low carbon infrastructures: Findings presented in Table 2 indicate that industries established in the area are increasingly adopting low-carbon infrastructures. This trend is particularly evident in locations with reliable access to environmentally friendly energy sources, such as hydroelectric power and natural gas. According to government data on energy availability in the study area, most industries rely on hydroelectric power as their primary source of energy. Investment decisions regarding low-carbon infrastructure appear to be strongly influenced by the type of energy resources accessible within the area, with industries prioritizing clean and sustainable options. According to TENESCO report of 2021 show that, Tanzania is endowed with diverse renewable energy resources which ranging from biomass, geothermal, HEP, Solar and wind, and current Tanzania total power installed is 1,602 MW of which 48% from natural gas, followed by hydro 31%, 18% petrol, 1% solar, and 1% biofuels (URT, 2021).

Uses of automatic production machines: The study findings in table 1 found that, 8.7% of the industries opted to use automatic production machines instead of manual production machines to improve production efficiency. Automatic machines revealed to be connected with computer system which make easy to be

controlled and monitored by operators. It revealed that, automated programmable logic controllers have high ability of monitoring and controlling factors like temperature, gas emitted and waste generated. Automated programmable logic controllers revealed to play a great role in saving energy since it gives opportunity to track and analyze macro-level data which used to determine the need of machines maintenance and optimum performance of the manufacturing process. The use of automatic machines reduced emission of greenhouse gases in particular carbon dioxide by discovering early problem of machines which are likely to generate more carbon dioxide unnecessary and increase energy consumption. The use of automatic technologies on surveyed industries revealed to have high ability to produce consistent high-quality performance in a short period of time which means that industries ramp up production without worrying about a drop in quality.

Climate diplomacy and international cooperation: The study results found that, government and its institutions have been collaborating with industries in climate diplomacy and international cooperation. Government and industrial stakeholders have been attending in number of events intended to discuss reduction of greenhouse emission from industrial sector in particular carbon dioxide gas. Climate diplomacy involves preparation of appropriate strategies for decarbonization which included policy and legal framework. It revealed that, climate diplomacy involved efforts such as mobilizing capacity and strategic focus which aim to ensure effective decision-making related to climate change mitigation by stakeholders in industrial sector, also ensuring effectively allocation of human and funding resources, training and coordination among and between stakeholders. Furthermore, the government has been working together with number of nations and unions such in assisting industrial sector to overcome the challenges facing industries in tackling greenhouse gas emission, also in assisting technological transfer and development by local industries. Climate diplomacy and international cooperation noted by study to be used as tool by industrial stakeholders for setting common goals and objectives due to the fact that climate change and mitigation it is the issue of global concern. In his study Hristova and Chankova (2020) adding that climate diplomacy and international cooperation serve as the engine in climate change mitigation in industrial sector. Climate diplomacy generates assessment of other nations' interest and intentions in finding the agreement in climate change matters. Furthermore, it reported that ultimate goal of climate diplomacy is to create political condition for international agreement, coordination and cooperation in tackling emission of greenhouse gases also implementing UNFCCC.

Installing low carbon technologies: The study results in table 2 found that, industries within the study area shifted to advanced technology which characterized by low carbon generation in the production process, these technologies are electrified with high efficiency when compared fueled technology which involve direct burning of fuel. It revealed that to reduce

energy consumption some industries within the study are installing solar energy technology which mainly used for lighting purposes. Low carbon technology installed by industries possessed number of characteristics included ability to recycle byproduct and reduce the use of raw materials. In industries related production of packaging products such as plastic bottles and bags mainly used plastics material from waste products as raw materials after being gathered from the communities from within the study area also on nearby regions. The use of low carbon technology resulting in low carbon products. Finding from Lv and Qin (2016) reported that for industries to reduce emission of greenhouse gases must opt on the use of low-carbon technologies. In his finding he reported that low carbon technology focusing on reducing or avoiding the use of fossil fuels, evolving new energy, energy conservation and use of alternative energy sources. Furthermore, low carbon technology which adopted by industries must be sustainable and efficient. In country perspective investing in low carbon technologies ensures the sustainability of industries and also a sustainable economy and environment for Tanzania as a country. Low-carbon technologies have the potential to provide Tanzania with more carbon finance which can be used for sustainable industrial investment and sustainable economic growth (Lv & Qin, 2016).

3.3 Capacity Building Strategies

To increase carbon sink industries noted to use capacity building to their workers through different strategies. The study noted that strategies used are both field and off-field strategies as indicated in Table 3.

Table 3: Capacity building strategies

Building capacity strategies	Frequencies	Percentages
Training	16	17.4
Sharing technology information	10	10.9
Outreach program	9	9.9
Field visit	7	7.6
Meetings	18	19.6
Monitoring and evaluation programs	14	15.2
Stakeholder involvement and collaboration	12	13.0
Integrating climate agendas into plans	6	6.5

Source: Field data, 2022

Training: The findings in Table 3 found that the majority of the industries about 17.4% use training strategies to create and extend knowledge and skills about issues related to the environment to their workers, among the issues is climate change and its aspects like climate change mitigation. The study revealed that training on climate change focuses on the appropriate use of machines and energy. Also, it revealed that training covers appropriate waste management generated by the industry during the production process. Furthermore, training and skills upgrading aim to ensure that industry workers are able to absorb

international know-how on all matters related to climate change, technology, and environmental pollution. Also, the narration with one of the respondents from Tazpack Industries limited who confirmed that;

“Of course, our industry used different training programs to impart knowledge to the employees on issues regarding climate change and environmental matters. These training programs cover different aspects for instance raising their knowledge of new machines and technologies responsible for low carbon emissions which are installed in our factories. The purpose of these training is to enhance the capacity building among the employees in towards climate change and environmental issues in our industry” (An interview with training manager, 05/04/2022).

Sharing technology information: The study findings in Table 3 revealed that, to extend knowledge and skills on climate change issues, energy issues, and technology, about 10.9% of the industries are sharing information. Sharing information between and among industries is used to address capacity and expertise gaps on matters related to climate change. It noted some industries within the study area are sharing technological information also they are sharing technological information with other industries found inside the country and outside the country. The study found that common information sharing by industries included the availability of new technology for production in the market, also the quality of technology in terms of energy consumption and waste generated by technology. Other information shared included the price of technology, durability of technology, operation, and maintenance of technologies. In his study, Goldar et al. (2019) added that sharing information about climate change mitigations between and among stakeholders related to the industrial sector is very important since it offers formulation and implementation of strategies for climate change mitigations. Industrial stakeholders should prepare information transparently and ensure information is easily accessed by all stakeholders on different platforms such as online documents and media. This plays a great role in industries to tackle climate change through the use of environmentally friendly technologies.

Outreach program: The study findings in Table 3 revealed that about 9.9% of the industries used outreach programs to promote knowledge and skills of workers to climate change issues and their roles towards overcoming the challenge related to climate change and also their role in climate change mitigation. Outreach programs between and among industries aim to help, uplift, and support each other on matters related to climate change. According to Rosen (2015) argued that outreach programs enhance leadership and, a sense of responsibility toward climate change mitigation. It revealed that outreach provides industries opportunities to understand their position in climate change and make them aware of the effort they need to put into reducing the emission of carbon dioxide. Industrial outreach helps industries function better by assessing their needs and guiding them to the appropriate use of resources and technologies for the mitigation of climate change. The industry outreach

programs aim to connect and collaborate with leaders in industries and government to create industry readiness for climate change mitigation and also to foster development in future discoveries of technology and its applications. Outreach programs revealed to focus on influencing the government to make policy changes needed to accommodate them in addressing climate change issues including climate change mitigations.

Field visit: The study findings in Table 3 confirmed that about 7.6% of the industries agreed that field visits among industries play a great role in upgrading knowledge and skills about climate change mitigation and the role of industries in mitigating climate change. The study revealed that industry managers, engineers, and operators have tours to other industries inside the country but mostly outside the country in particular in countries such as China, Malaysia, and India. Their main aim is to gain knowledge and skills on the technologies innovated which are user-friendly to the environment through using less energy while producing high quality and quantity products with minimum waste generated and greenhouse gas emissions such as carbon dioxide. Furthermore, it revealed that field visit helps industrial operators to improve their machines by gaining new formulas for the production process which is less energy consuming and carbon generation. The interview results with one of the respondents from Hill water pure drinking industry;

“Our expert team made frequent field visits to collect information that can provide a deeper insight into the environmental impacts posed by our industry to take effective measures. Our team inspects the whole system of our factory to identify the leakages that cause the pollutants, and our team visits the communities that surround our industry to grasp their perceptions on whether there is pollution caused by our industry” (An interview with the manager, 08/04/2022).

Meetings: The study findings in Table 3 revealed that, the majority of the industries about 19.6% used meetings to upgrade the knowledge and skills of industrial workers on matters related to climate change. It noted that among other industries have environmental engineers while others have invited environmental engineers as their consultants to assist them in understanding the environmental standards required during the production process. It revealed most of the time meetings between and among workers are considered as the best platform for them to strengthen knowledge about environmental issues including climate change issues and the role of industries in mitigating the generation of greenhouse gases, particularly carbon dioxide gas. Also, the interview results with one of the respondents from Sino Tan Kibaha Industrial Park contended that;

“We have regular meetings with our workers and stakeholders as the way forward of addressing the climate change. Meetings enable us to make discussions different strategies towards climate change, for instance

making action plans which help in the provision of education on sources of emissions and taking right actions, raising awareness on policies, and regulations, etc.” (An interview with Environmental Engineer Officer, 21/04/2022).

Monitoring and evaluation programs: The findings in Table 3 revealed that about 15.2% of the industries strengthened their knowledge, skills, and practices on climate change mitigation issues by industries to their workers during the production process. The study revealed that the industries within the study area introduced and implemented monitoring and evaluation programs for workers on their performance in operating industrial machines. It noted that monitoring and evaluation of programs introduced by industries focused on industrial operation activities to climate change mitigation by covering energy consumption during the production process, machines maintenance, waste generation, and management. The main target of monitoring and evaluation programs is to ensure industrial operators use their knowledge and skills to ensure there is unnecessary emission of carbon dioxide as a result of machine problems which lead to the increase of carbon dioxide generation. For instance, delaying changing dirty oil to clean oil resulted in increased carbon dioxide emissions at the same time increased energy consumption and sometimes increased raw material consumption. Also, the findings concur with an interview held with one of the respondents from the Soap Manufacturer Industry who argued that;

“We have regularly scheduled monitoring and evaluation programs with our workers, especially assessing their effectiveness in operating and utilizing low-carbon machines. In this case, help us to note out the default for training to keep them aware” (An interview with Program Manager, 28/04/2022).

Stakeholder involvement and collaboration: The results in Table 3 revealed that about 13.0% of the industries involved several stakeholders these included governments and their related institutions; also, it included researchers, technology producers, and traders of technology, innovators, and manufacturing industries. Respondents from the surveyed industries admitted that involving stakeholders in ensuring the production process by industries tends to consider the emission of greenhouse gases in particular decarbonization issues. Industries revealed to collaborate with the government in creating an environmental condition that allows them to import technology that is user-friendly to the environment in terms of energy consumption level of technology pollution also level of raw material consumption. The government takes into consideration issues of tax for those kinds of environmentally friendly technology imported by industries. The findings concur with Detlef et al., (2021) who contended that involving stakeholders is crucial for industries in effectively addressing climate change for several compelling reasons: first of all, stakeholder involvement and collaboration bring diverse perspectives, knowledge, and expertise to the table. This includes environmental NGOs, local communities, governments, consumers, investors, and supply chain partners. Their input can lead to more

comprehensive and innovative solutions to climate challenges. Also, engaging stakeholders helps industries identify and mitigate risks associated with climate change. This includes physical risks from extreme weather events, regulatory risks from changing environmental policies, and reputational risks from perceived environmental impacts.

Integrating climate agendas into plans: The study findings in Table 3 found that, about 6.5% of the industries within the study area integrate climate change issues in particular climate change mitigation in their industrial operation plans. Their main intention of use these strategies to ensure their products are produced under international standards which are highly restricted about the quality of products. It revealed that most industries integrating climate agenda into their plans are those industries that are selling their product in international markets which is highly restricted on the kinds of the products they produce and their process in production. The study noted that mainly this applied to food processing industries and packaging-related industries. Among the issues revealed to be integrated into their plans included energy technology used in production, level pollution, waste management, and raw materials used in production. Also, the study findings related to Dagnachew et al., (2021) who confirmed that integrating the climate agenda within industries' plans involves several key intentions and objectives such as facilitating the integration of climate goals into their plans, industries demonstrate a commitment to sustainable development and environmental stewardship. This includes reducing greenhouse gas emissions, conserving resources, and minimizing environmental impacts.

3.4 Technological transfer and development Strategies

The results in Table 4 indicate technological transfer and development strategies as one among of strategies applicable by industries in reducing greenhouse gas emissions.

Table 4: Technological transfer and development

Technological transfer and development	Frequencies	Percentages
Public-private partnerships	21	22.8
Provision of financial resources and investment	12	13.0
Information development and sharing	21	22.8
Technology cooperation	5	5.4
Human resource and Institutional development	10	10.9
Partnership and networking	9	9.8
Collaborative research and development (R&D).	14	15.2

Source: Field data, 2022

Public-private partnerships: The study in Table 4 found out that, about 22.8% of the industries from the study area have used the public-private partnership approach for technological transfer and development with the main target to help them in climate change mitigation by reducing greenhouse gases generation

mainly carbon dioxide. It revealed that public-private partnerships involve the private sector in public structure, also public sectors are involved in private sector agendas such as technical expertise assistance. Within the study area. The public-private partnership stands as a key element of industries in technology transfer, innovation, and development. Furthermore, public-private partnership was used as a platform for building industrial networks, and technology platforms, also it noted that this approach plays a great role in the development of research about technological transfer, innovation, and development. The public institution is used as a catalyst for supporting the development of science, creating conditions, standards, quality services, and regulatory environment for industries to play their role in reducing carbon dioxide generation while industries implement technological transfers and offer innovative solutions to climate change mitigation. Abu-Lebbeh et al., (2013) added that Public-private partnerships (PPPs) for technology transfer play a crucial role in addressing climate change among industries for several important reasons: First of all, PPPs facilitate the transfer of advanced and sustainable technologies from public research institutions or government agencies to industries. This access allows industries to adopt state-of-the-art solutions for reducing greenhouse gas emissions, improving energy efficiency, and promoting renewable energy sources. Another reason, PPPs encourage Cost Sharing and Risk Mitigation. Technology development and deployment often involve high costs and risks. PPPs enable cost sharing between public and private sectors, reducing financial burdens on industries while mitigating risks associated with technology adoption.

Information development and sharing: The study findings in Table 4 found that about 13.0% of the industries use information development and sharing as a platform for technological transfer with the target of reducing carbon dioxide emissions during the production process. It revealed that common information developed and shared between and among industrial stakeholders included the availability of environmentally friendly technology, characteristics of technology in relationship with energy consumption, and technological compliance to standards rules, and regulations developed by the government to guide technological development and use. The study revealed that different approaches were used by industries in sharing information between and among industries the approaches included advertisements, meetings between industrial stakeholders, and online forums. An interview with one of the respondents from Global Packaging limited who confessed that;

“We are not an isolated island, in the dissemination of information regarding various low carbon emissions we are using different platforms with our stakeholders and other industries to learn how others are doing, and it’s not bad to learn from business partners and rivalries because the climate change is the country and global issue which needed the collective efforts to address it” (Environmental Engineer officer, 30/04/2022).

Human resource and institutional development: The study findings in Table 4 found that about 10.9% of industries used human resources and institutional development to facilitate technology transfers, utilization, and development. It revealed that institution development included capacities for technological assessment, incubation, testing, and demonstration to reduce the emission of carbon dioxide from industries during the production process. Furthermore, found that institution development goes with human resource development by training industrial workers in adapting, operating, and managing technology for climate change mitigation through reducing greenhouse gases generation in particular emission of carbon dioxide. The study findings concur with OECD and IEA (2003) reported that Human resources and institutional development play pivotal roles in facilitating technology transfer and utilization to address climate change in several significant ways: Human resources development involves training and equipping personnel with the skills and knowledge necessary to understand, implement, and manage climate-friendly technologies. This includes technical training on renewable energy systems, energy-efficient practices, carbon capture technologies, and sustainable production methods.

Technology cooperation: The study findings in Table 4 found that about 5.4% of the industries admitted to enhancing technological cooperation among industries from the study area also from other sides of the country and outside the country proved by a study to be effective in technological transfer for climate change mitigation. Most surveyed large industries have technological relationships with industries from other countries such as China especially those producing similar products. Technological cooperation revealed to maximized efforts for decarbonizing target from industries. The study revealed that technological cooperation included financial and technical assistance that supports technological innovation, utilization, and development for tackling the emission of carbon dioxide from industries. However, it noted that industries from the study area are much more technical than financial. It also revealed climate change mitigation involves a wide range of stakeholders that bring together for low-carbon technological innovation, development, and deployment as a result industries stand as primary stakeholders for implementing international treaties and norms under consideration on the capacities and regulatory frameworks of the country.

Partnership and networking: Successfully of technological transfer and development revealed by study to rely on partnership and networking. The study findings in Table 4 show that, about 9.8% of the industries from the study area use this approach as a means of enhancing technological capabilities, sharing knowledge, and fostering innovation which is necessary for tackling emission of carbon dioxide emissions. It noted partnership and networking play a great role in capacity building among industries, industries reported benefits from the approach, among the benefits included contributing to mobilizing resources,

market access for technology, and technological expertise for technological utilization in tackling carbon dioxide emission. In addition to that, the results interview results held at Silafrika Tanzania-Plant 2: Blow Molding show that;

“Sharing of technology is a good step towards addressing climate change, in this case through collaboration in terms of technological aspect is the best way since gives room for exchanging knowledge on energy efficiency, renewable energy, carbon capture and storage, and many other de-carbonation technologies. Additionally, technological collaboration allows us to have joint research on the best technology that can enable our industries to reduce the emission of greenhouse gases, and this will increase our efforts towards addressing climate change”

(An interview with the Electrical Technician, 06/05/2022).

Collaborative research and development (R&D): The study findings in Table 4 found that about 9.8% of the industries from the study area collaborate with local and international institutes in research and development for technological transfers between and among industries from within the country and from outside the country. It reveals that industries from the study are using this approach in accessing technology for production across different parts of the world. Industries reported that research reports give the confidence to utilize technology recommended since it passes through several tests before being suggested by researchers and research institutes. The study results supported by Farooqui & Pawar (2023) who confirmed that Partnerships and networking play critical roles in enhancing technological transfer among industries towards addressing climate change in several key ways like partnerships which allow industries to access specialized expertise, resources, and knowledge that may not be available internally. This includes collaborating with research institutions, technology providers, government agencies, and non-governmental organizations (NGOs) with relevant experience in climate-friendly technologies.

4.0 CONCLUSION AND RECOMMENDATIONS

Based on the results and discussion, industries developed strategies to reduce the generation of greenhouse gases from production activities. Strategies developed by industries differ from one industry to another based on financial, technological, policies, and knowledge reasons. Among the strategies used by industries included capacity building strategies associated with training programs, outreach programs, field visits, meetings stakeholder involvement, monitoring and evaluation programs as well as integrating climate agendas into industrial plans. Also, de-carbonation was another strategy employed by industries as a measure towards the carbon sink. In this case, industries adopted various strategies such as; material substitution, improving resource use efficiency, industrial symbiosis, fuel switching to electrification, supporting policy framework, and investing in low carbon infrastructure.

The study recommended that the existing policy should provide clear incentives such as grants, tax incentives, or recognition programs for those industries that

investing in carbon-sinking measures. Also, the study recommended the promotion of research and innovation, therefor industries should invest in research and development to advance carbon capture technologies and sustainable practices as a result these technologies will be more accessible and economically viable for industries. Also, industries recommended implementing capacity-building initiatives through different training programs and workshops that focused on best practices in carbon sinking and sustainability, fostering a culture of environmental responsibility. Another recommendation is based on the encouragement of collaborative efforts between the government, private sector, NGOs, and local communities to share resources, knowledge, and best practices for effective carbon sinking. On top of that, the study recommended that, industries required to establish comprehensive monitoring systems by creating robust monitoring and reporting frameworks to track carbon sinking efforts, ensuring transparency, and enabling continuous assessment and improvements.

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The Role of ODL in the Promotion of Renewable Energy Education for Sustainable Development in Tanzania

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Abstract

Renewable Energy Education (REE) is vital for a society to shift from fossil fuels to clean and sustainable green energy. While the promotion of Renewable energy technologies is positive for sustainable development, the users are still facing many challenges due to lack of expertise, technical support services and public knowledge regarding these technologies. Education plays a pivotal role in creating awareness and promotion of Renewable energy concepts amongst the general public. This paper intends to prove that, ODL system is the best reliable and affordable education system for training the larger part of population to empower them on adoption of renewable energy technologies. The study based on literature review and documentation to reveal the way renewable energy education is being disseminated through Open and distance learning. The findings prove that ODL system stands a better chance of educating a larger part of the population compared to conventional systems. It is recommended that ODL institutions consider the establishment of courses that meet the energy market demand for sustainable development.

Keywords: *Renewable Energy Education, Open and Distance Learning, Sustainable Development*

1.0 INTRODUCTION

Energy is essential to economic and social development and improved quality of life in all countries (Acikgoz, 2011). The investment and transition to Renewable Energy (RE) sources for energy harness is a fundamental part of the Sustainable Development Goals (SDGs), goal number 7 emphasizes the member nations to ensure the access to affordable, reliable, sustainable and modern energy for all while increasing substantially the share to renewable energy in the global energy mix (UN, 2018). To achieve the Sustainable Development Goals education plays a pivotal role in creating awareness and promotion of renewable energy concepts amongst the general public.

Agenda 21 produced at the 1992 Earth Summit in Rio noted that the need to control atmospheric emissions of greenhouse and other gases and substances will increasingly need to be based on efficiency in energy production, transmission, distribution and consumption, and on growing reliance on environmentally sound energy systems, particularly renewable sources of energy (Bhattacharya, 2011). Renewable energy, often referred to as "clean energy" or "green energy," is energy that is derived from natural resources that are

continuously replenished and can be used without depleting them. The renewable energy sources include; hydropower, wind, solar, geothermal, and biomass. These resources are considered renewable because they are naturally replenished on a human timescale, typically over a short period of time compared to the time it takes for fossil fuels to form. Renewable energy sources are a sustainable and environmentally friendly alternative to traditional fossil fuels, which are finite and contribute to environmental pollution and climate change (IRENA, 2022).

Furthermore, rising international concern about global warming and the rapid development of the renewable energy industry over recent years has led to a need for multidisciplinary programs in energy studies (Jennings and Lund, 2011). The renewable energy industry is facing difficult to obtain suitably qualified personnel with appropriate training and expertise, as a result there exists an opportunity for universities and technical institutes to meet this need (Charko & Jennings, 2008).

According to Acikgoz (2011) many countries around the world took initiatives for the development and dissemination of renewable energy technologies immediately after the first oil crisis in 1973 spurred by the 4th Middle East War. However, in spite of ambitious programmes of many countries in this direction, the dissemination of these technologies has not met the expectations of the planners and implementing organizations resulting in a few successful cases of the adoption of renewable energy technologies.

The poor dissemination of renewable energy technologies according to Acikgoz (2011) may be attributed to several factors; one of the important inhibiting factors is the lack of a structured framework for providing renewable energy education. His study concluded that it is essential to develop and implement well-designed energy education programs, including formal and non-formal education in cooperation with all foundations dealing with energy. The hypothesis this paper intends to prove is that, Open and Distance Learning (ODL) system is the best reliable and affordable education system for training the larger part of population to empower them on adoption of renewable energy technologies.

The International Renewable Energy Agency (IRENA) Framework defines Renewable Energy Education (REE) as a lifelong learning process that empowers individuals and communities to understand, contribute to, and benefit from the transition to a renewable energy future. It describes the key elements of REE to include 'the importance of renewable energy, types of renewable energy technologies, their benefits and challenges. REE also include acquiring knowledge and skills in installation, operation and maintenance of respective facilities. It also promotes values and attitudes on sustainability, environmental stewardship and social equity (IRENA, 2022).

The most in-demand skills for renewable energy professionals include; technical, soft skills, business, environmental and innovative skills. According to U.S Bureau of Statistics, skills required for renewable energy technologies include; engineering for designing, developing and testing renewable energy systems and technologies. They need to have a strong understanding of engineering principles, as well as the specific technologies they work with. Renewable energy technologies further rely on a variety of physical principles, such as thermodynamics, electromagnetism, and fluid dynamics. Furthermore, renewable energy professionals need to be able to use mathematics to solve problems, analyze data, and design and optimize renewable energy systems. They also need knowledge on computer science, renewable energy systems are increasingly becoming computerized so renewable energy professionals need to have some basic computer science skills, such as programming and data analysis.

Communication skills are also needed by renewable energy professionals to be able to communicate effectively with a variety of stakeholders, including engineers, scientists, policymakers, and the public. They need to be able to explain complex technical concepts in a clear and concise way. Renewable energy professionals also need to have project management skills in order to plan, organize, and execute renewable energy projects successfully. In addition to these technical skills, renewable energy professionals also need to have strong soft skills, such as problem-solving, teamwork, and adaptability (U.S. Bureau of Labor Statistics, <https://www.bls.gov/>).

The Renewable Energy Education (REE) is vital for a transition to clean and sustainable green energy if it is implemented early in the education system. This will help students to comprehend the RE technologies and gain motivation and interest to pursue higher education and career in this sector (Hoque *et al.*, 2022). Renewable energy is one of the fastest-growing sectors in the world, offering a variety of career opportunities for professionals with different backgrounds and skill sets. However, like every new emerging technology, RE need to be promoted (Yuksel, 2019). In that case, education systems play a crucial role in increasing awareness and developing positive attitudes toward the adoption of renewable energy technologies and environmental conservation at large.

This paper aims to highlight the contribution of Open and Distance Learning (ODL) in promoting REE in the tertiary education level with the assumption that ODL is the best alternative to meet educational needs for a larger part of the population as compared to the conventional education system. This is in line with Sustainable Development Goals number 4 that emphasizes the access to inclusive and equitable quality education for all at all levels including University (UN, 2018).

ODL can be defined differently from different angles from which a person has decided to target it. Technically, one can deduce the meaning of ODL from two main concepts. The first concept is Distance Education and the other being Open Learning; the combination of these two concepts leads to what is known as Open and Distance Learning. The concept 'distance education' to mean the ability to study from the distance, while 'open Learning' is the ability for anyone to access the educational offer from where one is (Wawa & Hashil, 2019).

There are several salient features of ODL that favor the training of a larger part of the population, these features include; accessibility, flexibility and affordability. ODL entails a student-centered approach that gives students flexibility and choice over what, when, where and how they learn. It opens the academic boundaries to all in need of education and educable. An essential characteristic of Open Learning is the removal of barriers to learning, where technologies and mode of delivery that are available to everyone need to be used.

A second feature for ODL is freedom of time for meeting the programme requirements; ODL system allows for a learner to study on his/her own pace. This has been made possible through freedom in taking a number of units preferred by a student, the university conducting several examination sessions during the academic year. Learners are not constrained to write examinations in a particular period. In Contrast to conversional systems, a student is bound to a specified period of time to complete his or her programme, with specific examination sessions and location restricted. A third salient feature of ODL is Freedom of Place in which a person wants to study. In ODL, students are not required to fulfill a residency requirement at the host institution. Students in ODL system are not required to leave their home or work place as they pursue a program of study. So being a student at an ODL University from a different region, country or continent it is 100% possible to pursue and complete studies without being physically present in the academic institution.

Technological advancement for instance the use of mobile phones as devices for web-based education is major contributor for ODL success hence open doors for everyone to access education. The use of ICT though challenged with connectivity problems and affordability of the appropriate devices still availability of internet cafes up to district levels remains as alternatives. All these features prove that ODL is the best alternative that is inclusive and accessible to all people including rural communities to access education wherever they are.

2.0 MATERIALS AND METHODS

This study adopted a qualitative research approach. Kumar (2011) describes qualitative research as the one whose purpose is primarily to describe a situation, phenomena, problem or event and if the analysis is done to establish the

variation of such situation without quantifying it. The situation described here is the role of ODL in promotion of renewable energy education as the effort to minimize the lack of public knowledge and expertise in energy sector for sustainable developments.

The literature search was adopted as a data collection tool that involved searching for the existing knowledge by analyzing what has already been done by other researchers in renewable energy education. This helped to integrate the research findings into the existing body of knowledge (Kumar, 2011). The reviewed literatures were from books, journals and from electronic databases. This was carried out through search engines like; Google scholar, Google, Publish or perish to find out the published literatures by using the keywords identified in this study. The key words include; renewable energy education, open and distance learning and sustainable development.

Kumar describes the procedure of reviewing the literature to involve; searching and selecting the published literature relevant to the research topic, reading them and pull together themes and issues relevant to the study. While going through the literature a researcher should examine and note the significant differences of opinions among the researchers on the subject matter and identify the gaps that exist in the body of knowledge (Kumar, 2011).

Along with the literature review, this study also employed the documentation method. Different writers on qualitative research methods have acknowledged that documentation can serve as a valuable data collection instrument in various research, organizational, and information management contexts (Mack *et al.*, 2011; Kumar 2011; Creswell, 2018). Creswell states that documentation is one of the primary sources of data for qualitative researchers. He defines documentation as any written record that describes, explains, or interprets a phenomenon of interest. He provides examples of documentation such as diaries, journals, letters, emails, government documents, meeting minutes, and historical records (Creswell, 2018). In this study, The Open University of Tanzania Prospectus, Facts and figures 2022, Faculty of Science Technology and Environmental Studies Booklet and OUT Strategic Plan 2023-2026 were used as relevant documentations this study. These documents served as sources for the programme offered, their contents; and information on implementation or operation related to REE. Furthermore, personal experience of the researcher was used to support the opinions from other writers; particularly on energy field. Personal experience can be a valid data collection method in certain research contexts, particularly in qualitative research. However, it is crucial to acknowledge the subjectivity of personal experiences and take steps to ensure the data's reliability and validity (Kumar, 2011).

Literature review and documentation was adopted for this study due to the available existing studies on renewable energy education. The reviewed

literature has described a lot on the need for REE to different levels of education systems and to general public, mode of delivery both formal and informal, methods of delivery including traditional class room teaching, and online learning. However, little has been done on teaching about REE through a formalized Open and Distance learning, a gap that this study intends to fill.

This study considered The Open University of Tanzania as a case study. It describes the role played by ODL in disseminating renewable energy education. The selection of OUT was contributed by a 23 years' work experience of the author in this institution as a teacher and researcher in the energy field. This enabled easy access to documentations in the respective departments, course delivery and personal experience on prospects and challenges related to REE through ODL.

3.0 RESULTS AND DISCUSSION

3.1 ODL and Renewable Energy Education

This section presents the findings of this study and discusses the emerging themes aligned with the research objective, namely the role of ODL on Renewable Energy Education. The section starts by highlighting that adoption of renewable energy technologies is linked to education as a major factor for awareness creation and acquiring of knowledge.

Hoque *et al.* (2022) who conducted a study in Malaysia and Bangladesh found that developing countries were ambitious to implement policies related to harnessing energy from renewable sources but with low achievement. The common factor in not achieving their respected goals was the lack of awareness, and availability of knowledge on renewable energy concepts amongst the general public. This can be supported by the writer of this article who conducted a study on adoption of biogas technology in Tanzania. The main objective of the study was to explore the root causes for low adoption of biogas technology as an alternative source of renewable energy in semi-arid areas of Tanzania. She found that despite the potential and existence of favorable conditions for technology adoption and the existence of biogas programmes in the study area for more than 15 years, the adoption was at a low level and at the decrease rate. The identified factors among others were; little knowledge of the biogas technology, unavailable and unreliable technical services which discouraged both adopters of the technology as well as those who showed interest in adopting it. The study recommended among others, education for the community for awareness creation and training for biogas users on proper operation and maintenance of biogas plants for sustainability of the technology (Wawa, 2012). Hoque *et al* (2022) comment that education plays a pivotal role in creating and promoting awareness about various concepts that in turn help to drive society to achieve its goals. Similarly, renewable energy education is vital for a society to shift to clean and sustainable green energy from fossil fuels.

Jennings and Lund (2011) also establish that energy studies is rapidly emerging as a new discipline of relevance to meeting future energy needs within the context of ecologically sustainable development. They reveal that many energy professionals lack formal training in the skills and disciplines needed to undertake work on renewable energy systems and energy management. They propose that the availability of external, online courses is proving attractive to people interested in energy policy and energy systems. In support to that, Hoque *et al.* (2022) establish that mobile learning is a mean of equipping people with greater mobility, communication, and access to resources all over the world via the Internet. Online and mobile learning as suggested by these authors is based on internet; the Internet is expected to play a significant role in university-level education in general and renewable energy education (REE) in particular as suggested by Bhattacharya (2011).

Bhattacharya (2011) however reveals that, REE at different universities is characterized by a lack of uniformity in terms of duration, coursework and emphasis on research. He recommends the establishment of guidelines and standards regarding academic programs and to establish a system of accreditation, preferably global, of REE in different academic disciplines and departments. Universities will need to make considerable adjustments to meet their expected role in the future and in response to certain developments, particularly the internet. In the same line Kandpal and Broman (2014) emphasize that renewable energy education should focus on providing functional knowledge and understanding of facts, concepts, principles and technologies for harnessing renewable energy. He further emphasizes that REE should target the entire population as its audience. They propose for both formal and informal modes of education delivery to be used where formal education includes instructions given in schools, colleges and universities, expected to be well-planned, and controlled in an organized system. Informal education on the other hand involves learning from mass communication media that help those who have never gone to school or adults interested in acquiring new skills and knowledge on renewable energy.

Extracted from these studies with connection to this study is that renewable energy education is vital to help the countries to implement the policies related to harnessing renewable energy technologies. This can be done by learning institutions developing programmes that meet the education needs of the public in general through formal and non-formal education systems. This study considers online delivery modes under a formalized ODL mode that is more flexible, inclusive and accessible to a greater part of the population.

Kandpal & Broman (2014) revealed that at the university level many countries are offering courses related to REE at both undergraduate and postgraduate levels. These courses cover the disciplines of applied sciences, Energy management, Climate change and energy, Carbon Management, Global energy

management and Sustainable management. Through Google search the author of this article found that there are several Open and Distance Learning (ODL) institutions around the world that offer courses related to renewable energy education. These courses can range from short certificate programs to full-fledged degree programs. Several Universities offering these programmes including; The Open University (OU) - United Kingdom, Penn State World Campus – USA, UNISA - University of South Africa, Massachusetts Institute of Technology (MIT) – USA, The University of California, Berkeley Extension – USA, African Virtual University (AVU), Indira Gandhi National Open University (IGNOU) – India and the Open University of Tanzania (OUT).

In Tanzania, the Open University of Tanzania (OUT) is the largest and most well-known ODL institution in the country, accredited by Tanzania Commission for Universities (TCU) which is the regulatory body responsible for accrediting and overseeing universities in Tanzania. In addition, Sokoine University of Agriculture being a conventional university also offers some ODL programs in agriculture-related fields, catering to the needs of individuals interested in agricultural education.

The Open University of Tanzania being ODL institution its delivery modes are accessible to all in need of education, flexible and give freedom to its learners to study on their own pace whenever they are. Its learning platforms have digital materials, web-links to access E-resources. Field practical, projects and research activities also consider students' convenient times and places. Face to face sessions, are conducted at regional and coordination centres to enable student study whenever they want.

3.2 Contribution of ODL to Renewable Energy Education

The Open University of Tanzania is a fast-growing institution in terms of enrolling undergraduate and postgraduate students. University offers various certificates, diplomas, bachelor degrees, and master and doctorate degrees in various disciplines since its inception in 1994. The university operates through 27 regional centers spread throughout Tanzania Mainland and its islands Unguja and Pemba in Zanzibar, as well to other countries. The University has well established faculties, institutes and directorates offering degrees and non-degree programmes through blended mode. Additionally, The University hosts three centres namely the ACDE Technical Committee in Collaboration (ACDE TCC), UNESCO Chair, and University Teaching and Learning Services Unit (UTLS). As a university, in addition to teaching, its academic members also conduct research and consultancies in various fields of study that touches the surrounding communities in general (OUT Facts and Figures, www.out.ac.tz).

The Faculty of Science Technology and Environmental studies offer bachelor degree in energy resources since 2016 where students from various angles of the country have been enrolled and studied the course. This course was designed to prepare students for their professional works in energy sector and physical environment. It is aimed to provide knowledge and understanding in aspects of

nature and practical experiences in energy resources. It also trains students in problem solving and entrepreneurship in energy fields, communication and computer skills. Graduates of this programme should be able to work as technologists and researchers in energy industry (Faculty of Science Handbook, 2021/2022). The programme contents cover among others; the topics related to renewable energy resources such as; solar energy, wind energy and other non-conventional energy resources like hydropower, biogas and geothermal energy (Table 1).

Table 1: Bachelor of Science (Energy Resources): Course Contents

Course Code	Course Title	Lecturer Hours	Total Credits	Core/ Elective
OFC 017:	Communication skills	35	10	Core
OCP 100:	Computer Studies	35	10	Core
OPH 111:	Fundamental Physics	105	30	Core
OPH 112:	Electromagnetism I and II	70	20	Core
OPH 211:	Statistical Thermodynamics	70	20	Core
OPH 212:	Mathematical Physics	70	20	Core
OPH 320:	Physics Practical's	70	10	Core
OMT 111:	Mathematical Analysis	70	20	Elective
OMT 114:	Probability and Statistics	70	20	Elective
OMT 223:	Computer Programming	35	10	Core
OPH 213:	Optics	70	20	Core
OPH 214:	Earth Physics	70	20	Core
OPH 311:	Fundamentals of Material Science	35	10	Core
OPH 312:	Physics of the Atom	70	20	Core
OPH 313:	Quantum Theory of Solids	70	20	Core
OPH 314:	Digital Electronics	70	20	Core
OMT 221	Numerical Methods	35	10	Elective
OPH 215	Analog Electronics	70	20	Elective
OPH 322	Solar Energy	70	20	Core
OPH 323	Environmental Physics	70	20	Core
OPH 324	Wind Energy	70	20	Core
OPH 325	Nuclear Energy	70	20	Core
OPH 326	Non-conversional Energies	70	20	Core
OPH 330	Energy Resources Practical	70	10	Core
OPH 331	Energy Resources Final Project	35	10	Core
OME 312	Entrepreneurship course	70	20	Elective
	TOTAL		450	

Source: FSTE Student Handbook, 2022

From Table 1, one can note that the Open University of Tanzania offers courses related to renewable energy technologies at undergraduate level. However, there is no postgraduate programme related to energy issues. The content covers general physics courses as required by professionals in energy sector as proposed by US Bureau of Statistics... Renewable energy courses are covered at level 3 of bachelor degree with a total of 100 credits out of 450 (22.2%) credits

offered under this programme. However, the small percentage of specific courses related to renewable energy is questionable on if will truly enable students to acquire enough skills required for energy expertise. The author is of the opinion that the university should consider for more inputs and specifying the course contents towards improving the programme.

The renewable energy sources covered under this program as per faculty handbook include solar energy, wind energy, nuclear energy and other non-conventional energy such as tidal and bioenergy with their associated practicals and project writing. Solar energy technologies are learned to create awareness on the use of thermal energy and solar electricity. It plays a great role in reduction of greenhouse effects and in environmental conservation. Through this programme graduates acquire knowledge and skills to design and install thermal energy and photovoltaic systems for different applications. Wind energy topic aims to provide knowledge on the current status and future prospects of wind energy technologies; technical aspects of the devices used to measure wind speed and wind direction. The topic also covers the fundamentals of wind turbines technology particularly wind rotors; theories behind it, designs and their performances and environmental benefits of wind energy and their related challenges. Students of this programme are exposed to the practical and research skills on energy technologies; entrepreneurship and business plan. The practicals are designed to equip learners with capabilities in the fields of small business enterprises and entrepreneurship development (FSTE Student Handbook, 2022).

The current bachelor degree in energy resources can only accommodate few candidates who qualify for taking the courses based on the small number of students with science background. This can be testified by the experience with the Open University of Tanzania, Figure 1 shows that over the last twenty-nine years of its operation (i.e. 1994 to 2021/22), the University has about 43.2% of enrolled students pursuing degrees in Education; 17.5% in Law; 13.8 % in Business Management; 17.0% in Arts and Social Sciences; and 8.5% in Sciences (OUT Facts and Figures; 2021/22).

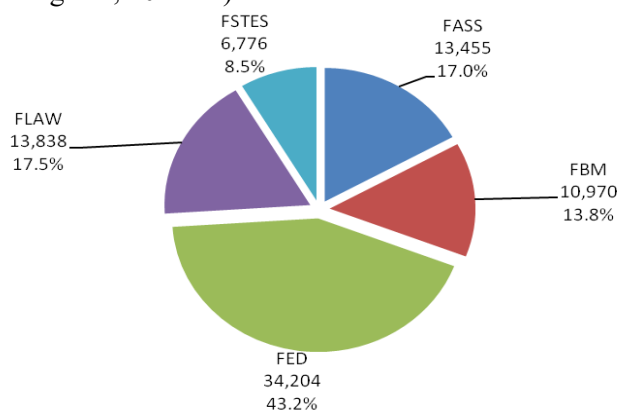


Figure 1: Percentage of Undergraduate Degree Students Admission in the Faculties
 Source: OUT Facts and Figures 2021/20022

From Figure 1 it shows that though the Open University gives room for entire population to access education only a small segment of a population is eligible to acquire specific courses related to energy, limited by having a science background. However, the potentiality of ODL still remains that the institution can still design for short courses for capacity building for energy professionals' particularly renewable energy. The Open University of Tanzania through Institute of Continuing Education has proposed some demand driven short courses that aims at building the capacity of human resource engaged in public and private sectors in Tanzania. These short courses target business community members, public institutions leaders, non-governmental organizations, Local Government Officials, and the general public. Others are the Professionals, Executives, and Mid-level managers who wish to develop particular skills or re-tooling through a lifelong learning paradigm. These short courses are expected to provide knowledge and skills related to; leadership and governance, project formulation and evaluation, and professional skills in data analysis and interpretation (OUT Facts and Figures, 2021/2022). In addition to technical skills energy professionals also needs to have some basic skills in project management, finance, marketing, and entrepreneurship, especially when starting or runs renewable energy business or consultancy. Currently the Open University of Tanzania offers the on-demand oriented short courses to cater for various professional needs and to qualify those in need. The professional courses currently available fall under various disciplines including, business studies, ICT, education, economic development and social sciences. However, there is nonexistence of skills-oriented courses related to renewable energy to cater for professional needs and in-job training for capacity building. The author concurs with several writers who suggested for the universities to consider programmes that meet the energy market demands

The Open University of Tanzania has invested in the use of ICT in its teaching and research. The Vice Chancellor of The Open University of Tanzania in RSP 2023-26 declares that OUT has recorded impressive achievement in various areas including the application of ICT in online teaching and learning. This is in line with other writers like Hoque *et al* (2022), Jennings and Lund (2011), Bhattacharya (2011) Bhattacharya in this study, who advocate the use of ICT in teaching and learning in today's digital era. The use of ICT in ODL system, open rooms for students to do independent study; this is possible through access to online materials where learners are enriched through different sources and exposed to the world.

The Open University of Tanzania has adopted a blended mode of delivery where both face-to-face, online interaction and E-learning is used. Moodle platform is the E-learning platform to access online forum discussions where instructors interact with students; announcements, assignments, and assessments are accessible to all registered stakeholders wherever they are. In addition to e-learning platforms OUT also operates through regional centres and coordination

centres at district levels. Currently Tests and exams are done at regional and district levels, but in near future planned to be done online, all these aims at bringing support services closer to clients. These services are accessible wherever a student is and not bound to geographical locations (OUT Prospectus 2022, www.out.ac.tz).

3.3 Challenges facing ODL System in offering Programmes

Various challenges have been addressed by institutions offering its programmes through online mode. OUT for instance, through difference staff meetings and teaching experiences through Moodle platforms, has tabled the following;

- Internet connectivity challenged by low bandwidth at HQ, which lowers its performance in the course of online classes. This is also associated to unreliable power supply particularly in rural settings. Additionally, is network infrastructure that requires constant upgrading to cater for dynamic needs of the IT industry. This can be a general challenge to online delivery modes, particularly in developing world.
- Negative perception of stakeholders on online learning affected by traditional paper-based learning particularly to aged learners who facing some difficulties in adopting digital technologies

Suggested Solutions include;

- Government to strengthen the capacity of power supply by promoting of the use of alternative energy technologies particularly renewable energy resources like solar and wind systems. Also improving fibre optic to increase bandwidth for maximizing the efficiency of internet connectivity.
- Stakeholders' awareness campaigns should be conducted to minimize negative perceptions on ODL systems
- OUT to consider offering of short courses which are more skills oriented to meet the market demand for energy sector

4.0 CONCLUSION AND RECOMMENDATIONS

The author conquers with other writers that renewable energy education is vital to meet the need for public awareness and knowledge, expertise in renewable energy technologies. Additionally, there is a need to look for training innovations and structure the programmes that meet the public at large. ODL mode of delivery, despite of some drawbacks noted in their programme contents, still stands a better chance to meet the need, as it is accessible and flexible to the larger population. ODL Institutions have the potentiality to expand its operations to a large geographical coverage hence research and consultancy activities to a larger population. It is recommended that; ODL institutions like OUT to conduct needs assessment and review their programmes regularly to ensure they meet the REE demands of the public at large. This will help to explore energy related problems, training needs, technical expertise requirements and recommend for

alternatives to policy makers to ensure appropriate policies and strengthen the infrastructures required for training needs.

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Farmers-Pastoralists Perceptions on Climate Change in Mvomero District, Tanzania

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Abstract

This study investigated the perceptions of farmers and pastoralists regarding climate change in Mvomero District, Tanzania. Data was collected using questionnaires, interview, Focus Group Discussions and documentary literature review. A total of 391 heads of households were surveyed, and 26 key informants were interviewed constituting four Village Chairpersons, four Village Executive Officers (VEOs), four Heads of Village Security Committees, four Village Agricultural and Livestock Officers (VALOs), four Ward Executive Officers (WEOs), the District Executive Director (DED), and the Officer Commanding District of Police (OCD). The study aimed to underscore local perceptions of climate change, identifying the impacts on agricultural practices, and evaluating adaptive strategies employed by the study communities. The findings revealed that both farmers and pastoralists perceive climate change as a significant threat to their livelihoods. Adaptation strategies implemented include altering planting dates, diversifying crops, improving water conservation techniques and integrating livestock with crop farming. Despite these efforts, several barriers to effective adaptation persist, including limited access to climate information, inadequate financial resources and insufficient support from local government and extension services. The study emphasizes the need for tailored interventions that enhance adaptive capacity and resilience. Policy recommendations include improving access to timely and accurate climate information, strengthening local institutions, and promoting community-based adaptation strategies.

Keywords: Adaptive strategies, climate change, farmers, pastoralists, perceptions, Mvomero District, Tanzania

1.0 INTRODUCTION

Climate change poses significant challenges to and pastoral systems with its effects in the regions heavily relying on natural resources for their livelihoods. In Mvomero District, Tanzania, both farmers and pastoralists experience increasingly unpredictable weather patterns, prolonged droughts and extreme rainfall events. These climatic changes exacerbate competition for scarce resources such as land, pasture and water, heightening tensions and conflicts over land and water use (Msangi, *et al.*, 2016). Despite the clear evidence of climate change and its impacts, there remains a critical gap in understanding how local communities perceive these changes and the strategies they adopt to

cope with. Farmers and pastoralists, whose livelihoods depend directly on natural resources, offer unique and essential perspectives on the shifts in climate patterns. These perceptions influence their adaptive strategies, which can either mitigate or exacerbate the impacts of climate change and resource-based conflicts (Jeckoniah *et al.*, 2015).

Recent studies indicated that perceptions of climate change among farmers and pastoralists vary significantly, shaped by socio-economic status, access to information, and traditional knowledge systems (Detges, 2020; Nyong & Fiki, 2021). However, there is limited empirical data on these perceptions in the specific context of Mvomero District. This lack of localized understanding impedes the development of effective, culturally appropriate adaptation and conflict resolution strategies. Globally, the impacts of climate change are well-documented through scientific data and long-term observations. Phenomena such as changes in rainfall and wind patterns, drought conditions, extreme storms, temperature fluctuations, rising sea levels, and desertification have been recorded in various parts of the world (Twinomugisha and Mushy, 2019). Understanding local perceptions of climate change, particularly among rural communities, is crucial for developing effective adaptation strategies and mitigating conflicts arising from environmental changes.

In Tanzania, studies have shown that farmers and pastoralists are increasingly aware of changes in weather patterns, although their responses and adaptations differ significantly (Mwangi & Dohrn, 2019). The study by Kashaigili *et al.* (2021) found that most farmers in Mvomero District recognize climate change as rising temperatures and irregular rainfall patterns. These changes negatively affect crop yields, water availability, and soil fertility, which are very crucial for agricultural practices. Addressing barriers such as limited access to information and resources is essential for supporting sustainable agricultural practices in the district.

Similarly, Msuya *et al.* (2020) highlighted that, pastoralists in Mvomero District exhibit high levels of awareness regarding climate change, noting increased frequency of droughts and unpredictable weather patterns. Pastoralists perceive climate change as adversely affecting livestock health, pasture availability, and water resources which is a key component of their livelihoods. The study underscores the need for flexible land use policies to accommodate pastoral mobility and for strengthened conflict resolution mechanisms to reduce tensions between pastoralists and farmers as Mhache (2019) noted in his paper. Mzuna *et al.* (2022) conducted a comparative analysis of farmers' and pastoralists' perceptions and adaptation strategies in Mvomero District. Their findings revealed that while both groups are aware of climate change and perceive it as a significant threat to their livelihoods, the specific impacts and perceived severity vary. Both groups acknowledged that climate change exacerbates land use

conflicts, especially during drought periods when competition for water and grazing land intensifies.

The implications of these studies for the current research highlighted the importance of understanding different perceptions and adaptation strategies of farmers and pastoralists to inform the development of integrated and context-specific policies. Collaborative efforts between these groups, supported by effective governance, are essential for enhancing resilience and reducing conflicts. Addressing challenges such as limited resources, inadequate support, and land use conflicts which requires a comprehensive approach that integrates local knowledge and fosters sustainable resource management.

This study aims to address this gap by exploring the perceptions of climate change among farmers and pastoralists in Mvomero District, Tanzania. By examining how these communities understand and respond to climate change, the research provides insights into the drivers of land use conflicts and informs policies and interventions designed to enhance resilience and promote sustainable resource management. The primary objective of the study is to assess farmers' and pastoralists' perceptions of climate change in Mvomero District. The research framework focuses on several key areas: factors influencing perceptions, impacts on livelihoods, adaptation and mitigation strategies, and the institutional and policy frameworks that shape responses to climate change.

2.0 METHODS AND MATERIALS

2.1 The study area

This study was conducted in Mvomero District in Morogoro Region. Morogoro Region is one of the regions in mainland Tanzania lying between Latitude 5° 00' 58" and 10° 00' 00" South of the Equator, and Longitude 35° 00' 25" and 35° 00' 30" East of Greenwich meridian. The region is among the major agricultural producer region in the United Republic of Tanzania bordered by Tanga and Manyara Regions to the North, Coast Region the East, Dodoma and Iringa Regions to the West and Ruvuma and Lindi Region to the South (MRIP, 2022). Other districts of Morogoro region include Morogoro municipal and Morogoro rural Districts, Kilosa, Kilombero, Ulanga, Malinyi, and Mikumi Districts. Mvomero District is geographically located between Latitude 6° 8' 49" and 6° 26' 00" South of the Equator, and Longitude 37° 32' 00" and 37° 35' 49" East of Greenwich Meridian (MDCIP, 2022). Mvomero District has diverse ecological zones that support both farming and pastoralism. This district provides a representative sample for studying the perceptions of climate change among different land use groups.

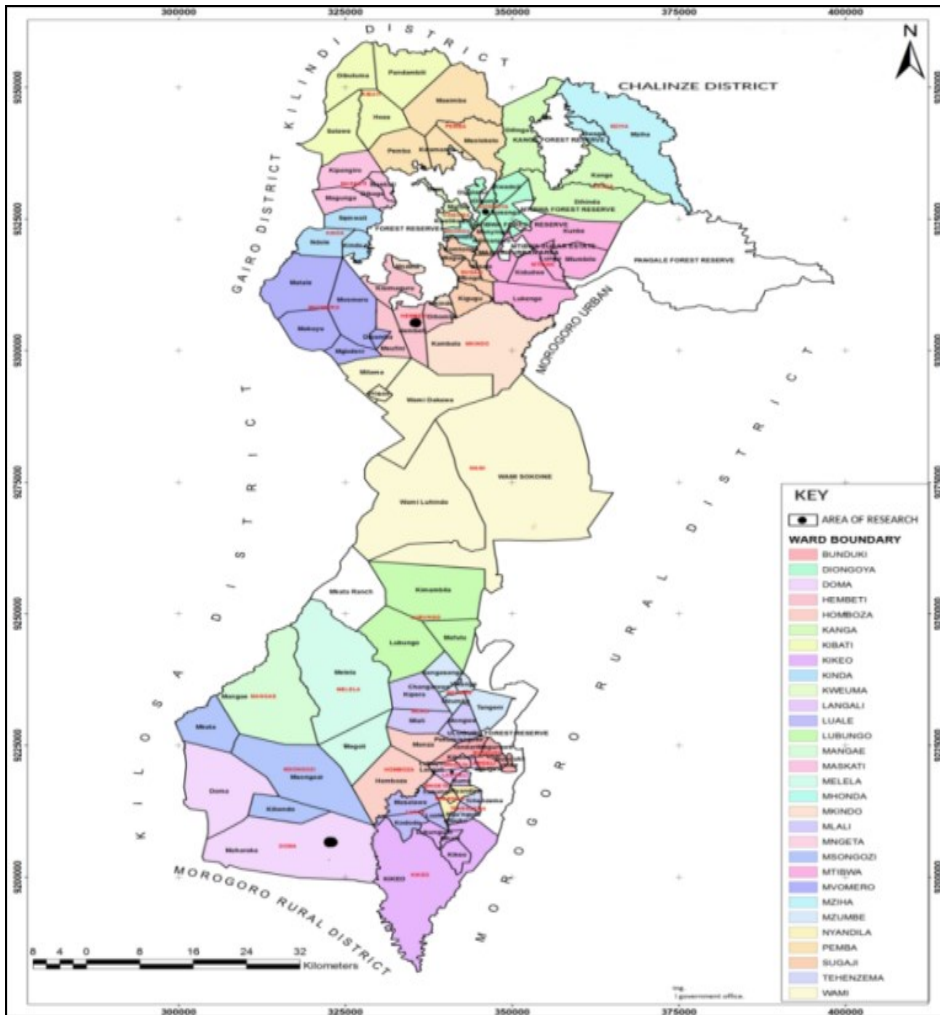


Figure 1: Map of Mvomero District showing the Study Area

Source: Mvomero District Council Investment Profile, 2022

This study adopted a cross-sectional research design, in which data were collected from four villages which consists Doma, Langali, Diongoya and Hembeti. Both qualitative and quantitative approaches were used in data collection and analysis. The study population included 16,675 head of households in which 391 heads of households were randomly selected and 26 key informants were purposively selected for inclusion in the sample of the study. In this study, data were collected using various methods for triangulation purposes; hence key informants' interviews, focus group discussion, questionnaire, documentary review and field observation methods were employed. The interview method used to collect data from 26 key informants that involved four Village Chairpersons, four Village Executive Officers (VEO), four Heads of Village Security Committees, Four Village Agricultural and

Livestock Officers (VALO), Four Ward Executive Officers (WEO), the District Executive Director (DED), and one Officer Commanding District (OCD).

FGDs engaged community members, specifically head of households from farmers and pastoralists to sit in groups for discussions to explore shared experiences and perceptions of climate change, where four group discussions were conducted in Doma, Langali, Hembeti and Diongoya, one group for each sample village. Questionnaire items were administered to 391 heads of households to gather quantitative data on climate change awareness, perceived impacts, and adaptation strategies. The researcher prepared and placed the questionnaire to heads of households from farmers and pastoral communities from the four village of Doma, Langali, Hembeti and Diongoya. The documentary review was done by analyzing existing reports and records on climate change awareness, perceived impacts, and adaptation strategies so as to contextualize the study findings.

Observation method involves a systematic walk within a defined transect in the given area of interest and people so as to observe environmental condition, asking different questions, listening and looking to natural environmental features (De Zeeuw and Wilbers, 2004). Through observation the researcher collected information on observable impacts of climate change such as flooding, drought condition, erratic rainfall, soil acidity, and features of desertification. Also, the researcher observed some effects climate change to the environment which spark to the land use conflicts such as dried grazing, loss biodiversity and hunger, size of farms destroyed during the fights and number of crops destroyed. Data was processed and analyzed quantitatively through descriptive statistics using Statistical Package for Social Sciences (SPSS) version 20. Qualitative data was translated and categorized data in several themes and sub-themes basing on objective of the study. The data from in-depth interviews were transcribed and analyzed by thematic content analysis

3.0 RESULTS AND DISCUSSION

3.1 Perceptions of Climate Change in Mvomero District

This study sought to understand how farmers and pastoralists perceive climate change in Mvomero District. Respondents were asked about their awareness of changes in climate, such as temperature increases, prolonged droughts, and irregular rainfall. The study found that both farmers and pastoralists are not having knowledge that climate has been changing. Therefore, they could not adapt easily to climate change effects; whose adverse outcomes would catch them unprepared. They reported experiencing unpredictable weather patterns, prolonged droughts, and reduced water availability. These changes have led to a decrease in agricultural productivity and pasture quality, intensifying competition for available resources. Respondents also were asked where did first hear about climate change such as media platforms, Education Institution, Community meeting groups and multi-platform approach. The study found that

mostly of the respondents (45%) they heard through media platforms, (32%), heard through education institutions, 13% through community meetings and groups, while 10% heard via multi-platforms approach.

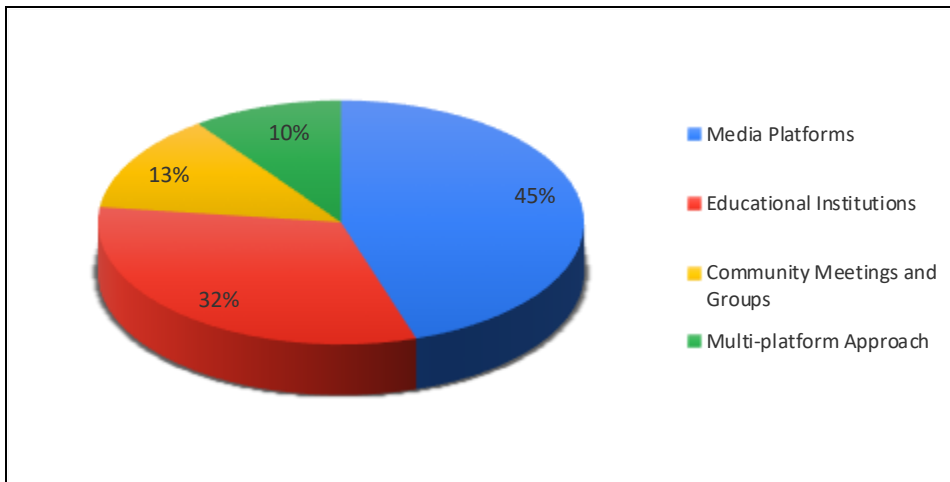


Figure 2: Perceptions of climate change in Mvomero District

Source: Field survey data, 2024

3.1.1 Perception of rainfall and temperature between pastoralists and farmers

Both farmers and pastoralists reported noticeable changes in climate patterns. They observed a decrease in rainfall and an increase in temperatures over recent years. The majority of farmers and pastoralists recognized the adverse effects of climate change such as increased temperature and prolonged droughts. These changes directly affected their livelihoods by reducing the availability of water and grazing land. Result on maximum and minimum temperature and rainfall amount were computed. Linear line was used to indicate the rainfall and temperature data.

There is a consensus among both farmers and pastoralists that temperatures are increasing, leading to more intense and prolonged dry conditions. These harsher conditions have resulted in diminished pasture quality and water shortages, adversely affecting both farming and pastoral activities. Results of temperature for 10 years from 2013-2023 indicates positive trends which implies that there was fluctuation in temperature. The increase in the temperature; indicated an increase in temperature especially in January and February, the months where by the recorded temperature was always high. The increase of temperature has a great impact on pasture resource whereby during periods of high temperature, pastoralist community does not get water, they move from one place to another in search of water as they move, they graze in the agricultural land and conflict erupts (Mhache, 2017). If we can solve the water problem, pastoralists will have enough water and limit their movement to search water. This is in line with other

studies which show that, during the dry season the conflict between farmers and pastoralist is likely to occur due to shortage of water and pasture as shown by low rainfall and the decline in quantity and quality of available feeds (Mhache, 2017; 2019).

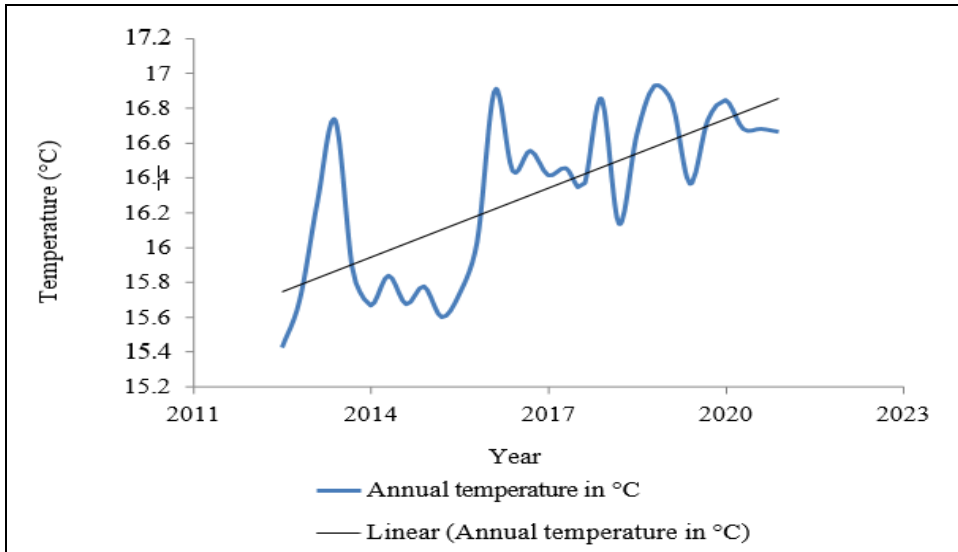


Figure 3: Showing temperature fluctuation

Source: Field survey, 2024

The majority of respondents perceived a decrease in rainfall in Mvomero District. This perceived decline has been linked to reduced water availability for crops and livestock, exacerbating competition for these scarce resources. It was shown that there has been a decrease in rainfall by about 4% especially in the present years. Water is very crucial for vegetation growth as it increases the amount of moisture in the soil. Insufficient rainfall results to the death of plants as well as negatively affecting pasture growth. In Tanzania, the fluctuation in rainfall can be dated back to 1960 where there was observed a decline in rainfall at an average rate of 2.8 mm per month and 3.3% per decade (TCAR, 2020). Regarding the rainfall pattern, majority of the respondents 77% declare that rainfall have decreased in terms of amount and timing. During focus group discussion, it was noted that currently Mvomero District rarely receives short rains commonly known as Vuli. This was confirmed by a Maasai elder saying that:

“We have not received the Vuli rains since 2021....we are depending on single rain per year like our neighbors in Gairo District” (Key Informant/ Hembeti Village, November, 2024).

Also added by saying:

“Rainfall is very crucial for pasture growth as it increases the amount of moisture in the soil. Insufficient rainfall results to the drying up and

retardation of vegetation". (Key Informant/ Hembeti Village, November, 2024).

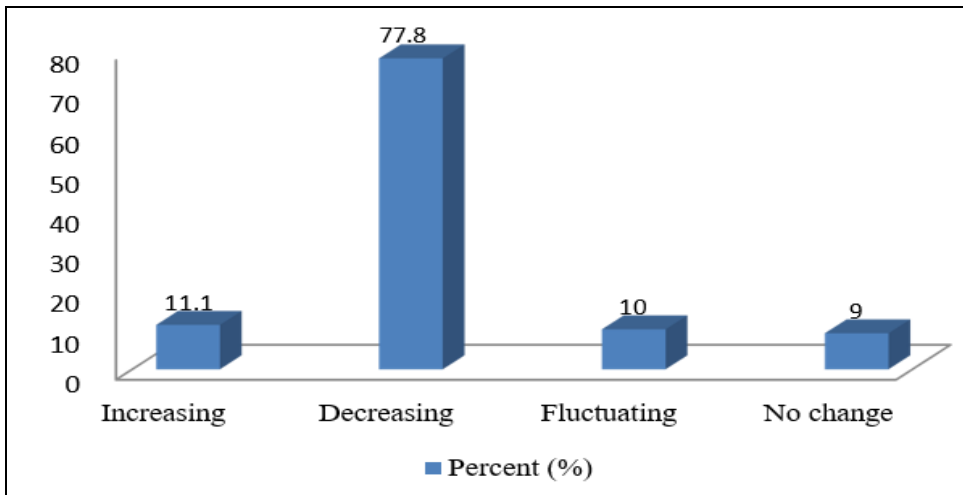


Figure 4: Showing decreasing rainfall in Mvomero District

Source: Field survey data, 2024

Osofsky (2021) found that, the number of animals died due to long drought that led to inadequate pastures. Figure 6 shows some of pastoralist's cows feeding on crops plants during drought in Mvomero district which lead to the conflict between farmers and pastoralist. The study revealed that majority of the respondents 77.8% commented that, rainfall has decreased over time, indicating that the amount of rainfall was insufficient for their uses; which makes pastoralist to be more vulnerable due to their dependence on rainfall. Ceven *et al.* (2020) agreed that in 2019, the Vuli, short rains were very poor in many regions including areas where the rains are usually plenty, like Kilimanjaro region. Also Thornton *et al.* (2019) supported that African countries are vulnerable to the impact of climate change due to overdependence on rainfall for crop and livestock production.



Figure 5: Pastoralist feeding cows on crop during critical pasture loss in dry season at Hembeti Village, Mvomero District

Source: Researcher, 2024.

Key informants further argued that:

“Rainfall was not only scarce but rather erratic. They reported that, for some decades, rainfall has been starting from November to March, but since 2015, the rainfall season has changed. It comes very late and one cannot tell exactly when it may commence. This variability affected several planning schedules and consequently growth of natural pastures. Reduced amount and scarcity of rainfall in Mvomero District have been said to cause shortage of feed for livestock which lead to frequently conflict between farmers and pastoralist” (Key Informant/ Hembeti Village, November, 2024).

Minority of the respondents 11%, claimed that there was an increase in rainfall, whereby 10% responded that rainfall has been fluctuating. This is in line with a study by Cabeza et al. (2020) who explained that semi-arid areas are also characterized by unpredictable differences in total rainfall between and within years. Pasture is very crucial to pastoralists' areas, as the only resource used to feed their livestock. The decreased amount of rainfall most likely may leads to reduction of pasture resource, which influence the pastoralists to graze their cows on agricultural land. Respondents noted that rainfall patterns have become more unpredictable, with delays in the onset of the rainy season and a reduction in the total amount of rainfall. This unpredictability complicates planning for planting and grazing, leading to decreased grazing and farming land hence lowering agricultural productivity.

3.2 Perceptions of Rainfall and Temperature according to Meteorological Data for the Past 30

According to Tanzania Meteorological Agency (2024), Mvomero District has experienced notable climatic changes over the past three decades. Analysis of climate data over a 30-year period revealed a linear increase in temperature by 0.02% and a decline in precipitation by 3%. The mean annual rainfall in Mvomero District varies geographically, ranging from 500 to 600 mm in the western parts to 800 to 1,000 mm in the eastern regions.

Temperature data indicates that the district experiences a hot season lasting approximately 1.9 months, from January 15 to March 13, with average daily high temperatures above 92°F (33.3°C). The hottest month is February, with an average high of 93°F (33.9°C) and a low of 75°F (23.9°C). The cool season spans about 3.5 months, from May 2 to August 18, with average daily high temperatures below 87°F (30.6°C). July is the coolest month, averaging a low of 67°F (19.4°C) and a high of 86°F (30°C). These climatic shifts align with local perceptions of climate change, as both farmers and pastoralists in Mvomero District have reported increased temperatures and decreased rainfall, adversely affecting their agricultural practices and livelihoods (TMA, 2024). Table 1 summarizes historical meteorological data from the Tanzania Meteorological Agency (TMA).

Table 1: Historical meteorological data from the Tanzania Meteorological Agency

Element of weather	Period	Trend/ Change	Perceived changes
Rainfall	Past 30 years	Decrease of ~3%	Average annual rainfall declined over the study period; spatial variability exists with lower totals in western areas (500–600 mm) and higher in eastern parts (800–1,000 mm).
Temperature	Past 30 years	Increase of ~0.02%	A gradual rise in mean annual temperatures has been recorded, with more frequent high-temperature events reported during the hot season.

Source: Tanzania Meteorological Agency, 2024

The Table 1 highlights that over the last 30 years, Mvomero District has experienced a slight increase in temperatures along with a modest decline in rainfall. These trends mirror local perceptions, where farmers and pastoralists note hot conditions and less predictable rainfall patterns. The reduction in rainfall and rise in temperature pose challenges for agriculture particularly for communities reliant on rain-fed farming prompting shifts in practices such as altering planting dates and diversifying crops. However, limited access to detailed climate information and financial resources remains a barrier to effective adaptation.

3.3 Perceived Causes of Climate Change

In Mvomero District farmers and pastoralists have identified several perceived causes of climate change, primarily focusing on observable environmental changes. The findings from this study revealed that, community attributes climate change to the increased frequency of unfavorable climatic events, such as reduced rainfall, elevated temperatures, and unpredictable onset of rainfall seasons. These perceptions are based on first hand experiences with shifting weather patterns that directly impact agricultural productivity and livelihoods. The community's observations align with broader regional studies, which have reported similar indicators of climate change, including rising temperatures and altered precipitation patterns.

3.4 Perceived Impacts of Climate Change between and among the Pastoralists and Farmers

Both groups have experienced significant adverse effects due to climate change. Farmers report reduced crop yields and increased crop failures, while pastoralists face declining livestock productivity due to poor pasture and water scarcity. These challenges have intensified competition over land and water resources, leading to frequent conflicts between the two groups. Many community members perceive climate change as a major factor contributing to these land use conflicts, as shrinking resources force farmers and pastoralists into closer competition.

The study found that majority of the farmer's respondents (41%) declare that change is caused by environmental and human impact, (38%) of the farmers' respondent change noticed is prolonged drought, (13%) extreme weather events and lastly (8%) change noticed is irregular rainfall. Also, majority of the pastoralist (48%) claimed that change noticed is prolonged drought, (22%) of the pastoralist respondents change noticed is extreme weather events and minority of the pastoralist respondents (10%) reported that change noticed is irregular rainfall

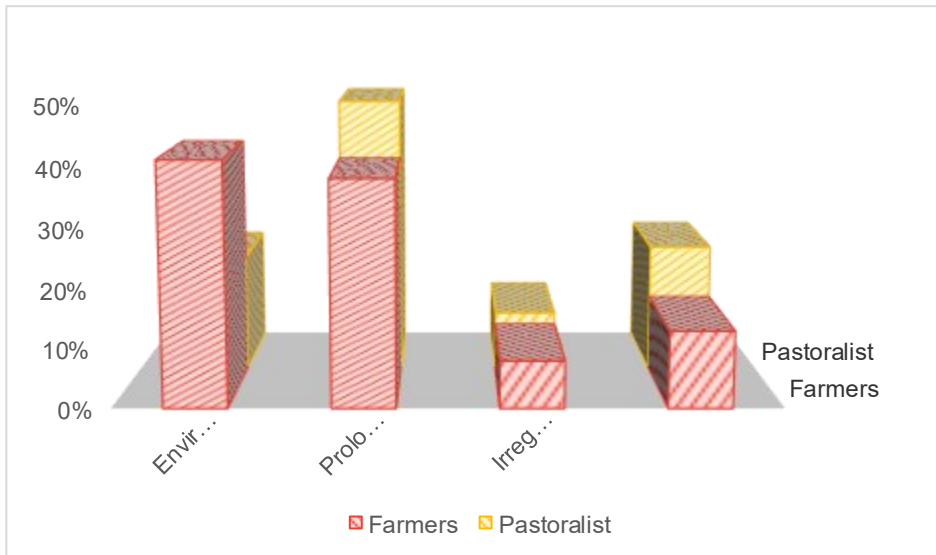


Figure 6: The perceived climate change

Source: Field survey, 2024.

4.0 CONCLUSION AND RECOMMENDATION

The perceptions of climate change among farmers and pastoralists in Mvomero District reflect a growing awareness and concern over its impacts. While farmers and pastoralists have developed various adaptation strategies, significant barriers remain. Effective adaptation requires a collaborative approach involving government, NGOs, and the communities themselves. Future efforts should focus on enhancing access to climate information, financial resources, and capacity-building initiatives to support sustainable adaptation practices. Both groups perceive climate change as a major factor influencing resource availability, particularly grazing land and water. The movement of pastoralists in search of these resources often results in conflicts with farmers, who see their crops damaged and land encroached upon. Additionally, the absence of formal land-use plans and land titles exacerbates these conflicts. The impacts of these conflicts are far-reaching, ranging from the destruction of property and infrastructure to the loss of life.

Both farmers and pastoralists have employed coping strategies to mitigate these challenges, including livelihood migration, diversification and participation in

trade. However, without long-term solutions to address the root causes of these conflicts, such as climate change and resource scarcity, the situation is likely to worsen. As mitigation measure to solve the land use conflict escalated by climate change, the government of Tanzania and other stakeholders should opt the following; promoting climate-resilient agriculture whereby farmers should be encouraged to adopt climate-resilient farming practices, such as irrigation and agroforestry. Government and non-governmental organizations should provide training and resources to support these initiatives. Another measure is to enhance conflict resolution mechanisms by creating local committees that involve both farmers and pastoralists in conflict resolution; this will help de-escalation of tensions. Also, strengthening land-use planning and policy involving implementing clear land-use policies that delineate farming and grazing zones will help to mitigate land use conflicts. This should include issuing formal land titles to both farmers and pastoralists to reduce disputes over land ownership. However, investment in sustainable water management systems is crucial. The formation of water user groups and the construction of water reservoirs can help mitigate the effects of drought and reduce competition over water resources. This study contributes to the growing body of knowledge on climate change perceptions and adaptive responses in rural Tanzania. It underscores the importance of understanding local contexts and involving community members in the development of sustainable adaptation strategies.

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Linking Local and Scientific Knowledge in Climate Change Adaptation in Semi-Arid Area: A Case Study of Igunga District, Tanzania

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Abstract

Climate change poses threats to semi-arid biomes worldwide that calls for global efforts to combat its effects through adaptation and mitigation practices. Recent studies recognized the importance of including Indigenous and Local Knowledge (ILK) and Scientific Knowledge (SN) in research on climate change impacts and adaptation. This paper explored indigenous knowledge on climate change impacts and adaptation and its relation to scientific knowledge in semi-arid areas, Igunga District, Tanzania. The study adopted a mixed methodology combining qualitative and quantitative approaches including household questionnaires survey, key informant interviews and field observations. The study found out evidence of pronounced climate change impacts in Igunga District from the scientific literature and local reports. The findings highlighted that, there is extensive overlap between information derived from local and scientific knowledge systems. And that about 96% of respondents in the study area uses their ILK in predicting weather and adaptation to climate change impacts. Majority of the respondents reported the associated climate change impacts with erratic rainfall, increase of temperature and frequent prolonged droughts. Overall, our results suggest that cross information of indigenous and scientific should be used to develop local community coping and adaptation strategies to climate change. The study concludes by suggesting inclusion of ILK in policy formulation for climate change adaptation and risk management.

Keywords: *Indigenous and Local Knowledge, Scientific Knowledge, Climate change, Climate Change impacts, Adaption, Semi-arid area*

1.0 INTRODUCTION

Climate change exacerbating violent storms, heat waves, prolonged drought and flood have brought severe risks to local communities in sub-Saharan Africa (Nyadzi et al., 2021). Predictions indicate that climate change is expected to increase the frequency and severity of its effects globally (IPCC, 2019). Semi-arid areas are expected to experience much severe consequences of drought. Persistency of droughts in the semi-arid areas are anticipated phenomenon under current and future climate change that caused greatest serious threats to water availability, food security, and indigenous local livelihoods (Liwenga, 2008; Mkonda, 2018; Mdemu, 2021). Water scarcity is pointed as one of the drought-induced impacts which causes several environmental challenges in rural areas

(Pamla et al., 2021). Thus, adaptation is seen as a feasible choice in reducing the vulnerability related with anticipated negative impacts of climate change (Nyong et al., 2007). For a long period of time, local communities have developed indigenous knowledge that helps them to cope with environmental changes. The local communities and indigenous people hold knowledge on practices such as agriculture, fishing, hunting, foraging and the use of medicinal plants (Ajibade and Eche, 2017). These communities developed long-term ecological knowledge base on managing the impacts of climate change, predicting, anticipating or responding to weather and seasonal climatic changes (Abu et al., 2019). This knowledge enables communities to make decision regarding climate variability, other related changes and problems (Zvobgo et al., 2022; Walter et al., 2022). For instance, livestock management is widely used as indigenous and local knowledge (ILK) in farming systems across communities in Africa. Likewise, an early-warning system is also used as an indicator of the quality of the rainy season (Mapfumo et al., 2016).

Adaptation on an individual or household scale includes activities done by individuals such as the use of local indicators, risk assessment, and planting season. On the contrary, adaptation at community scale includes communal activities such as ritual practices, traditionally managed method, and community-wide rules for resource management and tradeoff (Kangalawe et al., 2011). They take such measures after recognizing indicators in nature. For example, the Peach tree flowering and the first rains in August indicate the proximity of summer (Basdew et al., 2017). Thus, farmers can identify these indicators much in advance due to generations of using the same indigenous knowledge. They then plan the well-being of their crops or livestock based on the weather they are expecting. The locals feel that this is especially important as indigenous knowledge is not vulnerable to external forces. Indigenous knowledge communication and applications are largely unaffected by the challenges faced by scientific forms of knowledge (Basdew et al., 2017).

Knowledge systems including Indigenous and local knowledge are accepted as a 'major resource' for climate change adaptation but ILK has not been applied regularly in adaptation efforts and have often been ignored in policy, research, academic and public discourses (Petzold et al., 2020). Despite this negligence, Indigenous peoples themselves have long acknowledged the significance of their knowledge systems for handling changes in their natural environments (Ford et al., 2020). Thus, the Intergovernmental Panel on Climate Change (IPCC) and part of the scientific community have called for greater inclusion of indigenous and local knowledge in adaptation interventions and environmental management. Indigenous and local knowledge constitute complex knowledge systems embracing biological and ecological dynamics, practice shaping environmental use and management and their socio-cultural dimensions. While attempts have been made to integrate Indigenous knowledge into science

knowledge in environmental assessment and resource management, still science knowledge remains to be valued over indigenous knowledge (Abu et al., 2019).

However, recent discussion about the collaboration and exchange between ILK and scientific knowledge systems can occur suggest that knowledge pluralism has the potential for enabling transformative change through partnership between knowledge holders (Orlove et al., 2010). Previous adaptation studies in Tanzania and East Africa, focus most on indigenous knowledge, rather than investigating how indigenous knowledge can be integrated with scientific knowledge in adaptation approaches to climate change impacts in semi-arid areas (Elia et al., 2014). Consequently, the environmental knowledge of indigenous people living in semi-arid settings including Igunga District is scarcely recognized in the adaptation literatures (Elia, 2014; Basdew, 2017). This study thus aims to examine the relationships between indigenous-science knowledge in adaptation in semi-arid area, Igunga district. This will offer valuable insights that can inform policy and decision makers on adaptation strategies to climate change impacts that links indigenous and scientific knowledge.

2.0 MATERIALS AND METHODS

2.1 Study Area

This study was conducted in semi-arid area of Igunga District, Tabora Region, Tanzania. The district is located between latitude $10^{\circ}00' - 08^{\circ}40'$ South and longitude $35^{\circ}10' - 37^{\circ}10'$ East (Figure 1).

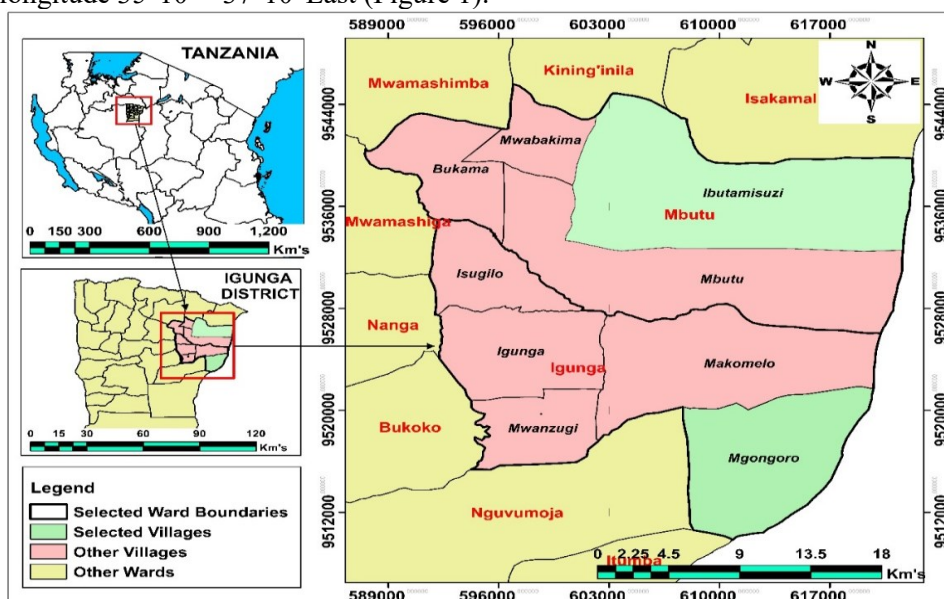


Figure 1: Geographical location of the studied villages in Igunga District, Tanzania
Source: Authors, 2024

Igunga District is largely dominated by plain land, characterized by semi-arid conditions with a long dry season and receives relatively low rainfall. Due to this, the district is one of the driest districts in the Region. The main livelihood of the indigenous is largely agro-pastoralism which is sensitive to climatic shocks. This kind of livelihood is a rain-fed dependant. This implies that the livelihoods of the communities have been under strain because all indigenous people in the study area are reliant on the provision of natural resources and that agricultural remain the predominant sources of indigenous sustenance. Given such facts, it was then thought selecting this district could yield informative results than elsewhere in Tabora Region. Within this study area, researchers purposively selected two villages that are most vulnerable to climate risks and semi-arid agro-pastoral livelihood activities variation. In this concern, Ganyawa and Mgongoro villages were selected aiming at obtaining the extent on how ILK is being used in adaptation.

2.2 Data Collection

Researchers used a mixed research method to address the study's objectives. A mixture of qualitative and quantitative research methods was adopted to collect primary data in order to identify cases with a lot of information and capture different points of view. Researchers collected (i) secondary data from the scientific literature (ii) and meteorological data. To ensure comparability between scientific data and local information, researchers asked for individual reports of change over the last 30 years. In this paper data were collected using questionnaires, interviews, observations and documentary literature review.

Questionnaire survey employed structured and semi-structured questions to obtain household responses. The questionnaires were administered face to face to the head of the household as the sample unit. The sample size was derived from the Krejcie and Morgan, (1970) where the sample size was determined from the table depending on the population available in selected villages. Sampling involved purposive and random methods to gain a wide range of local indigenous people awareness. In this way, 35 households from Ganyawa village representing 8.8 % out of 398 total households in the village, and 35 households from Mgongoro village representing 8.10% out of 432 total households in the village were selected.

Key informant interviews are meant to interview a selected group of people who are likely to bear specific information, ideas and insights on the issue at hand (Nyeme, 2010). Key informants included in this study are indigenous elders at least 50 years old and above, village leaders, agricultural and environmental officers. Two key informant interviews were conducted one in each study village, with the aim of sympathizing with climatic changes observed in the area over 30 years in regard to indigenous knowledge, and comprised both male and female elders. Field observations involved walking in the study area with GPS

taking some coordinated of some features and take photo of various place and climatic events.

Secondary data refers to information collected from published or unpublished sources (Kothari, 2004). Major sources of secondary data in this study involved reviewed scientific literature and the data from the Tanzania Meteorological Agency (TMA), [http://: climexp.knmi.nl/](http://climexp.knmi.nl/) for rainfall and temperature data. Other secondary data sources were documentary reports on trend of precipitation, drought and temperature from Igunga District Council, various stakeholders, and non-governmental organizations.

2.3 Data Analysis

Different methods were employed in this section to analyses data. Descriptive statistical analysis was used for household survey data. The interviews were auto taped, transcribed, coded and finally edited and analyzed. Qualitative data collected edited and classified based on specific objectives. Also, quantitative data were edited, coded and entered in Statistical Package for Social Science (SPSS) computer software SPSS version 20. Data obtained through interviews were analyzed according to report objectives. Analysis through SPSS included descriptive summaries, percentages, frequencies and cross tabulation which were presented in tables, charts, figures and graphs. Moreover, TMA meteorological data taken from 1970-2022 were analysed using descriptive statistics of annual rainfall and temperature using MS Excel and plotted using R software. The results were presented in figures and graphs.

3.0 RESULTS AND DISCUSSION

3.1 Indigenous and Local Knowledge on the Climate Change

Local communities in Ganyawa and Mgongoro villages have observed numerous climate driven changes indicators in their environment over the last 30 years. The seven indicators most frequently reported by the respondents from the questionnaire survey data are; (1) disappearance of some flora and fauna is among of the sensitivity observed by 18%, (2) a shortage of water reported by 28%, (3) an increased in the frequency of extreme droughts (45%), (4) increase in temperatures (14%), (5) unpredictable rainfall reported by 12%, (6) increase in animal mortality reported by 6% and, (7) increased pests and diseases by (25%). These indicators have resulted to death of livestock; poor crop yields due to shortage of water and pasture for livestock affecting local communities' livelihoods. In depth discussion with elders, it was found that, in 1960's rains used to be heavy, frequent and throughout the year, and agro-pastoralism was consistent. April used to be the maximum peak of rainfall where one could not get out of household for several periods a day. Additionally, every household engaged full in agro-pastoral activities and food was abundant. But current April is one of the driest months in the area and rains can no longer be predictable ever. Elders further clarified that, several of the observed changes started in around 1970's, and started to get little worse in 1980's and intensified in the

1990's. Furthermore, there is predominant drying of water sources, and decline of flow volumes in rivers such as river Mbutu that discharges its water into Ganyawa plains where the Taturu ethnic agro-pastoralists reside (Figure 2). The following extract from one of the interviews with a respondent in Ganyawa on 05th May 2024 provides as sense of practice:

"We are primarily pastoralists. But recently we have adopted agro-pastoralists in order to cope with changes in our natural environments. During prolonged droughts, livestock are dying of shortage of water, pasture and disease. In the past, River Mbutu stayed with water throughout the season. Pastures were available and little diseases. In recent times, the situation has changed and became worse than before"



Figure 2: Part of dried Mbutu River shared by Mgongoro and Ganyawa villages,
Source: Photo by Author on May, 2024

However, key informants had further to say that, the study area is harshly affected by uneven rainfall where previously rainfall was well-known to commence on October to December and march to early June, nevertheless now days it is undefined. They further reported that, there are now changes especially increase in frequency of dry spells during rainy season, high temperature, late onset and earlier cessation of rainfall hence worsens pasture availability for animals, water shortage. Through field observations, drying up of rivers, streams, ponds, wells, wetlands that formerly used to flow in high volumes was observed; and this was associated with prolonged droughts. Forest resource which was much dependable during harshly weather conditions has been affected at great extent. Furthermore, the indigenous agrees to have contributed to climate change and variability as they carry various socio-economic activities, whereby 89% of local communities agreed that climate change is the outcome of environmental degradation in common and poor agricultural practices were informed and non-socio-economic activities by 11%. Cutting trees down for charcoal and preparation of new land for crop production were reported to the causative for their environmental changes.

3.2 Local Perceptions and Meteorological Measurements on the Climate Change Trends

Perception is the course of realizing awareness of understanding of sensory information. What one perceives is a result of interplays between past experiences one's culture (Mdemu, 2021). Though there is diverse perception on climate change and variability, through their local knowledge, majority of informants agreed 100% that changes in climate is real. Findings from household survey reveal that, 98.4% of respondents perceive that temperature amounts have been increasing extremely in their environment, 1.6% considers no changes in temperature patterns. Key informants reported that, temperature patterns have changed at both spatial and temporal scales. In addition, the general view of many respondents was that temperatures have been increasing steadily over since 1990's. According to the analysis of the meteorological data analysed from 1970-2022 it indicates there was a consistent upward trend of temperature in the study area indicating increased temperature (Figure 3).

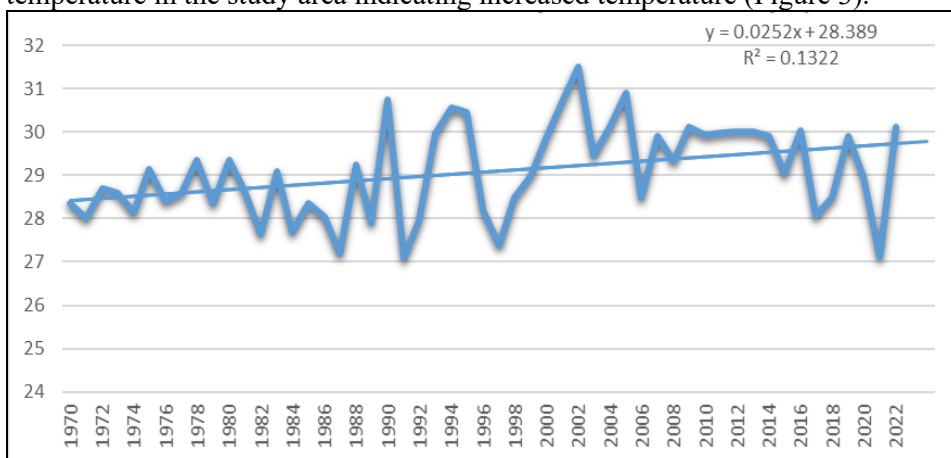


Figure 3: Mean Annual Temperature from 1970-2022 of the Igunga District

Source: Authors, 2024

3.2.1 Perceived Rainfall Trends

To grasp the extent of climate change in terms of rainfall in relation to the most observed climate events in the study area was important, in establishing the impacts of climate change on households' economic activities. Analytical results indicate that, 88% of respondents have observed at great extent a drop in the number of rainy seasons linked with late start and early cessation. On the other hand, 12% confirmed that, the seasonal rainfall distribution was unpredictable accompanied with dry spells. Key informants agreed that, the start, duration, distribution and amount of rainfall in the study area had changed tremendously since 1970s to current and had become unpredictable. This state has made cropping and pastoral activities more challenging to make decision. Rainfall erratic is increasing year to year causing negative effects on agricultural production, thus food insecurity. In a situation, according to informants one cannot predict it with confidence. Also, rainfall amount has been decreasing

progressively since 1990's and its impacts have been felt to have constant unsuccessful agricultural production and water scarcity in the study area. According to the analysis of the meteorological data analyzed from 1970-2022, it indicates there was rainfall variability from year to year and decreasing trend of rainfall amounts that correlates with respondents' views (Figure 4).

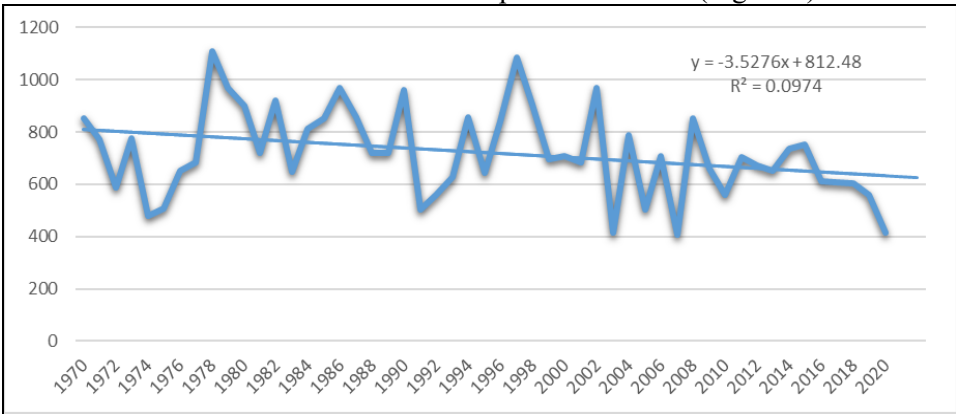


Figure 4: Mean Annual Rainfall from 1970-2022 of the Igunga district
Source: Author, 2024

3.2.2 Perceived Trends on Drought Incidences

Drought is a recurrent phenomenon in semi-arid areas of Tanzania including Igunga District. Majority of respondents from both villages agreed that, drought events have become more frequent than before by 12.2% and has occurred at least every 1 to 2 years, 63.7% of household's respondents argued that, droughts has occurred every 2 to 3 years. Yet, 11.5% of respondents claimed that, drought incidences have occurred from 3 to 4 years and 4 to 5 years agreed by 8.6% (Figure 5).

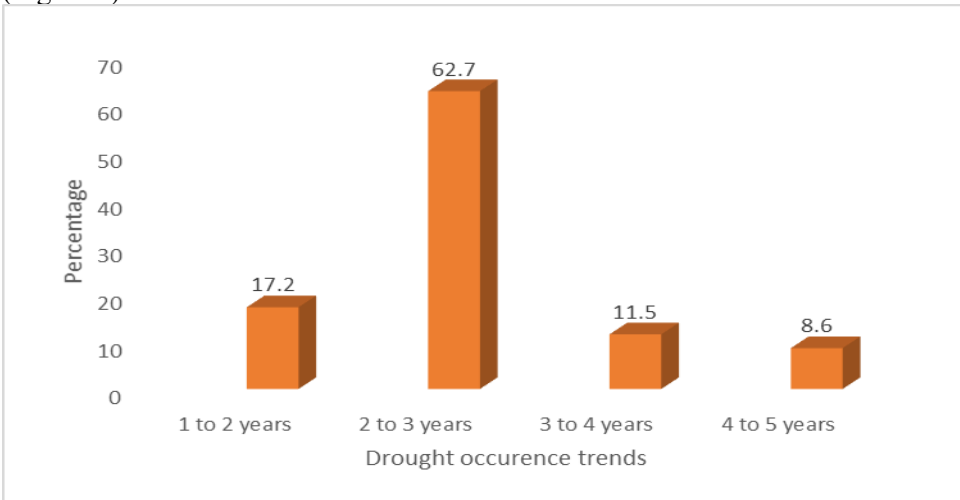


Figure 5: Percentage of Respondents on the Drought Incidence in Igunga District
Source: Authors, 2024

According to key informants' information, droughts and prolonged dry spells have affected the study area at various times throughout the history and it is now more repeated than previously and it is not a new event to them. Key informants explained in detail that, the area is getting drier because of increased drought frequency where slight normal, moderately dry and severe droughts were experienced in the study area in the year between 1977 and 2023 in the study area. It was reported further that, drought seems to be the major cause of the drying up of rivers, streams, ponds, swamps, shallow wells, food insecurity, animal mortality, extinction of some indicators and inability for ILK to perform effectively.

3.3 Indigenous and Local Knowledge on Climate Adaptation

Households were probed of their coping and adaptation experience on climate change in the study area. The results show that, local communities have invented and developed certain long-term immediate traditional techniques and approaches using knowledge transmitted orally and in practice of coping and adaptation strategies without any sophisticated equipment such as traditional animals and plant varieties by 46%, planting timely 23%, water conservation 15%, soil improvement practices 8%, migration 4%, controlling pest and disease 2% and food preservation 2%.

3.3.1 Traditional Animals and Plant Varieties

In order to be resilient to climate vulnerabilities, it was found that, indigenous have relied most on the traditional animals and plant varieties which are to somewhat resistant to local changing conditions, pests and diseases and maintain food security at households. These information merge with respondents' perception during deep discussion with key informants explained that, animals are the commonly extensively used as indicators for coping and adapting to climate such as ants' appearance at various places, different birds. They added that, behaviors of domesticated animals are good signs to them for understanding. For example, cattle, goats and sheep jumping when entering and coming out in the herd kraal from and to grazing respectively. During night hours, they seem to be violent, at the same time donkeys shouting out. This habitually often occurs in mid-September to October, indicating good rains and pasture for coming season. But when these animals' behavior does not happen in line with outing running speedy for grazing indicate that there will be dry season taking long time. In case of wild animals like insects, appearance and gathering of various ants, grasshoppers in large groups, termite starting molding soil on top of the tunnel, birds flying high above the sky, songs played by and rebuilding nests few weeks or days before the beginning of rainfall indicates good season is going to prevail, in contrast with such behavioral features, indicate little rainfall along with dry seasons. Frogs are too used to indicate good season or bad. This is when the croaking of frogs is heard in September to December and during rainy season, but when this kind of behavior not experienced or little, indicate poor season. During rainy seasons, disappearance

of these animals' behaviors marks the end of rainy, new season of prolonged drought, dry spells or winter develops.

On the other hand, numerous native tree species offer environmental benefits as well as multiple economic uses. Some of them are soil properties, and contribute to the environmental sustainability. Native trees play a well-recognized role in maintaining and improving agricultural production by protecting water sources, stabilizing soil, improving soil fertility and water retention. The value of trees in general, as stabilizers, enhancers and indicators of the environment is well-known by indigenous people. Key informant went further by insisting that, in the study area there are dominant native trees locally known as Migunga (Nilotica, Malifera, Albida and Tortilis- thorns and non-thorns acacia) and miduguyu (Balanites Aegyptiaca-simple thorned torchwood) and other plants are used in weather prediction, coping and adapting to harshly changing environments. These native plants are mostly distributed in the study area tolerant to range of conditions including droughts and dry spells (Figure 6).



Figure 6: Different natural acacia (Indicators) used in weather prediction in the study area

Source: Authors, 2024

The bark, root, the gum bark and fruits of Acacia and balanites Aegyptiaca(miduguyu) trees are used for curing coughing, fever, diarrhea, haemorrhage, abdominal pain and colds to human. Elders added that, gum from the balanites aegyptiaca is mixed with maize or millet porridge to cure chest complications. This kind of tree produces fruits even in dry seasons which is one of the food sources in the study area. Similarly, regular slash around farms and cleaning cattle kraal is implemented in order to prevent invasive pests and diseases.

3.3.2 Conservation of Water Sources

Water sources conservation was among of the initiatives that has been undertaken many years ago to conserve catchment areas for coping and adapting to climate variability and change. Observation was used to systematically to

walk across the study area with key informants to observe specific areas like water sources. From such observation, it was recognized that, water resources are conserved and remain the first priority for household as domestic use, livestock and brick making in the study area. Key informants were probed of their experience on water resources availability in the study area. According to IK possessed by elders stated that, in certain previous years (especially in 1970s) the duration of rain water in rivers, wetlands, ponds and swamps and the distance covered by green grasses at the banks determined the surface and groundwater availability throughout the dry season. Unfortunately, this does not take place. Rainwater in mentioned sources dry fast few weeks after the rain season ends. They explained further that, when unlike species like butterflies normally used to gather around drying water, indicate groundwater is unavailable, this is then happening almost every dry season. According to Key informants in the study villages, groundwater is less cost fully and can be pure and safe for both households and livestock. They further informed that, groundwater is tolerant to climate and environmental extremes than surface water which is directly heat by the sun and dry fast within few weeks. Interviews with experts (IGUWASA) informed that, there is extreme decrease in water resources specifically surface and of groundwater due to environmental and anthropogenic factors. Consequently, indigenous had have invented and developed traditional diverse techniques and measures to cope with water resources scarcity such as household hand-dug ponds, dug ponds at dried river beds, ponds, swamps and wetlands locally known as “lwijee”. Lwijee normally is supervised by the head of households. There was of shared village/communal pond that serves the indigenous, and protection, conservation of catchment areas and making an ox and donkey cart for searching water from distant places (Figure 7). Similarly, these findings are in line with Rutten (2005) who found that, in Kenya, during dry spells pastoralists dig shallow wells on dry water pans and dry river beds by scooping sand to access the water for their livestock and other basic uses.



(a)



(b)



(c)

Figure 7: (a) A hand-dug well at Mbutu river bed (Lwijee) (b) A hand dug pond around a household, dug during rainy season in March, 2024 (c) Catchment area conserved as a water source, now it is dry in the study area.

Source: Authors, 2024

Miscellaneous, ILK face challenges, linked with weather forecasting and climate prediction in the study area have been ineffective with poor dependability and lack of consistence due to climate variability and change. Information conveyed by elders indicate that over the recent years the indicators are becoming less dependable, and even if observed, the expected state of weather develops unlikely, for instance delayed onset of rain in the anticipated seasons or decrease in the amount of rainfall within exact season. In addition, prolonged drought has led to drying of communal ponds, shallow wells due to high rate of evaporation. However, an expert reported that, siltation, leaching and overuse of water by households during these dry seasons, are one of the reasons of water scarcity affecting human and livestock in general, the following extract from one of the interviews with an informant in Ganyawa on 08th May 2024 explained in details that:

We have and we are still depending on our forefathers ILK, but due to increase in environmental change, ILK is sometimes uncertain. This has forced us to rely largely on coping strategies rather adaptations strategies, since we have no means, facilities and knowledge on modern adaptive ways of drawing water deep from the ground. Also, we lack the capacity of collecting large amount of water during rainy season and hence we collect for daily use and not for future use.

3.3.3 Food Preservation

In the absence of rainfall and in order to adjust to harsh environmental change and its related impact on the household livelihoods, indigenous people have developed ILK measures in time of scarcity before, during and after the change in environment like selecting, storing and conserving food ways such as sun drying of meat, okra, leaves of green vegetable (locally knowns as Nkarango, Nzubho) of cowpea, pumpkins and cleome gynandra. Also, sweet potatoes are

preserved by being cooked or either, pee then being cut into small pieces and dried for future needs (locally known as mapalage/mathobholwa) (Figure 8).



Figure 8: Preparation of Sweet Potatoes (Mapalage) for Future Use in the Ganyawa Village

Source: Authors, 2024

Other crops stored are millets and maize. All these types of food are stored for 1 to 2 years in traditional food storage facility locally known as Kihenge) made of woven sticks plastered with cow dung or mud and mounted on a table-like structure. Indigenous have managed preserve cattle food to be used during pasture scarcity, such as keeping leaves and peels of sweet potatoes, groundnuts, maize stalks and the alike. They are preserved and stored on table-like structure (locally known Kichanja) (Figure 9).



Figure 9: Preserved Food for Cattle and Harvested Native Millet in the Study Area

Source: Authors, 2024

3.4 Linking ILK and Scientific Knowledge

It was imperative to grasp knowledge to what extent ILK and science have been linked in the study area and thus can be useful to other areas. In this regard, the challenges and opportunities that were noted from indigenous weather forecasting in this study, highlights link of techniques and approaches from the two knowledge as an instant and sustainable way for shared and inclusive weather forecasting in diverse local indigenous communities. The reliability and accuracy of the ILK have yet scientifically proven. But, the viability and utility value of ILK can only be enhanced when linked with scientific approached and know-how for good prediction and adaptation to changing environments. The reports from respondents indicated that 86.3% are aware of scientific weather forecasting. They further explained that, science knowledge is not applicable in predication of weather for their activities. Since, most of the weather forecasting information contains vocabularies which are misunderstandable to indigenous as many of indigenous are illiterate. And about 100% of households do not possess televisions and except few own radios, electricity poles pass through their villages and going far and there is no transformer.

Moreover, analysis of household survey indicates that, more than 92% rely on IK in prediction without scientific knowledge and 8% agreed to link the two knowledge through listening to media outlets specifically radios news on weather issues but do not understand properly due to language barriers. The IK in the study is paid little attention due to poor reliability of its indicators, promotion, no documentation, and integration with modern weather information. Some of them reported that, the main problem is the poor accessibility of modern weather information from media outlets especially radios so as to link with their IK and find a solution. Though some own radios, remoteness of their residential areas is faced with broadcasting radio waves and language used.

Indigenous perception on the linkage between knowledge system was revealed as an opportunity discuss how to best ways to deal with climate change events. Results showed that 100% of respondents are unfamiliar with existing or future initiatives to link indigenous-science knowledge. The challenges noted in the study area to why IK is not linked into science for weather forecasting seems to be constrained by poor cooperation between indigenous and science experts, every group is working on their own outcome. Informants revealed that, in order IK to work effectively, science must be closer monitoring and improving of IK and itself by taking valuable knowledge from elders and utilize it. Nevertheless, there is poor participation of elders indigenous with weather experts in weather prediction, no information sharing programmes, language barriers that impedes more clarification of the information, improving networks to assist perfect coverage of media. Inclusion elders, leaders in the whole process and establishing local weather forecast stations at village level, will aid indigenous to engage and enlightened hence science knowledge dissemination and exploitation of integrated weather forecast information.

Meanwhile, climate change still intensifies the frequency and intensity of extreme weather events, affecting indigenous livelihood activities in the study area. Due to this situation, the study focused more on how ILK and Scientific Knowledge can be together linked on food preservation and livestock protection. Hence indigenous were probed on their opinion and experiences with ILK and SK linkage. The report from the field indicates that, ILK is more suitable and applicable than SK in the study area, though scientific knowledge (SK) is head among them, but not applicable apparently, since no school farms/classroom garden preparations for smallholder farmers, seminars and workshops. However, more described on unavailability of modern food preservation facilities. Therefore, poor skills and experience for SK on food preservation.

It was asserted during key informant interviews with elder, village government representatives and other respondents that, the practice of ILK to forecast atmospheric weather conditions is significant for crop management and long-term strategies, for instance, crop planting, harvesting and preservation, avoiding costly mistakes in severe weather conditions. This reduces food and income losses due to lack of surplus to supplement households' need and ensure indigenous resilient and reliable food supply anytime. Informants added that, agro-pastoralists in the study area ILK typically lessen the death and loss of their livestock by observing biotic features such as animals' behaviors and trees characteristics. This normally indicates precipitation, climate extreme conditions and drought circumstances. Changes in their behavior and characteristics in response to change in the surrounding environment assist indigenous appropriate find water sources and grazing locations that can make livestock resistant from harsh condition. The results above suggest that, while indigenous local people can have a wide range of choices on knowledge systems to protect food and livestock depending on climate conditions and circumstances of the household, still ILK is priority number one. Despite the potential benefits of SK, it was observed that, SK is facing several challenges for its adoption as strategy for adaptation to climate impacts in the study area. These include climatic or environmental challenges and other such as social, economic and political challenges.

Basing on these enlightenments, since weather forecasting, interpretation, language barrier along with illiteracy seem a setback, in this context intervention is inevitable. It will enable them link the two knowledge systems, understand and utilize them for better weather forecasting and adaptations as well. Moreover, there are deficient studies of IK particularly in Tanzania that document and validate the effectiveness of the IK and the scientific knowledge. The linkage of these systems is imbedded in the selection of compatible indicator that is indigenous prediction indicators may or not merge with scientific indicators. On the other hand, the problem is also drawn from how the two are carried out, where indigenous people use animals' behaviours, plants, wind directions and rainbow in forecasting concentrating on the onset and cessation of the season.

Scientific experts (e.g., TMA) normally cover a large geographical area for a certain period of time in forecasting weather using meteorological indicators (especially wind and sea surface temperatures). Furthermore, Officials were probed on how IK and scientific in formulating and implementation of climate change interventions can be achieved. Reports from the study area verify that, there is division in institutions. Speaking with officials proposed that, linking the two systems there should be proper policies formulation methods to establish better environment and collaboration among non-governmental organizations, community-based organizations, governmental institutions, private sectors and indigenous. By so doing, intervention of scientific and indigenous concepts could bring bottom-up entry point for TMA, indigenous and other sectors. They further explained that, there should be more studies on IK to strategies to climate variability and change through animals and plants, keeping livestock, know better about the value of this knowledge. But this does not prevent it from linking them.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

Fundamental findings of this study and yet the global climate change is on large scale, linkage between IK and science is inevitable. This study revealed that in predicting weather and climate using indigenous knowledge in rural area had helped them to observe, perceive and recognize what is going on in their environments. Indigenous people accepted that, since their livelihoods depend on climate, noticeable changes in main variables of climate such as temperature and rainfall are real and at great extent. It was found that, indigenous people used their natural environment to forecast and decision making. Astonishingly, they have discovered and developed their own coping and adapting cultivating native food and cash crops, hand dug ponds among others. Single indicator could not provide enough information to interpret the coming weather, but multiple indicators are normally observed before arriving at a conclusion. However, approaches applied have gone through challenges, because of extinction and disappearance of some indicators (flora and fauna), frequency prolonged drought and dry spells, illiteracy and lack of modern way of predicting weather, thus altering the effectiveness of indigenous natural adaptation means. Moreover, the indigenous people rely on their ILK ways of prediction and adaptation, and scientific experts on the other hand on their own, creating gap between the two systems. A call upon the link between indigenous and scientific knowledge for better weather forecasting and data gathering is of important. It will contributions to reducing risk and vulnerability, developing resilient among indigenous people, environmental improvement, increasing economic activities and enhancing governance and institutions. The cross information of indigenous and scientific should be used to develop local community coping and adaptation strategies to climate change.

4.2 Recommendations

This study recommends the reinforcement advocacy and policy dialogue on indigenous-science knowledge related matters among and beyond the district institutions and organizations. On that, adaptation policy should be reviewed and indicate the deserved priority and importance of indigenous-science per sector, as a key entry point on the face of climate variability and change now, and in the coming future. Much as climate change and variability appears not to be a strange phenomenon in the study area and that indigenous local people have adapted to its adverse impacts. However, there should be sufficient and reliable weather forecast information by complement indigenous' autonomous responses and modern responses. In order to avoid challenges, TMA need to involve local communities in trainings and orientations before embarking on observing the selected indicators, data gathering and recording information as a way of community empowerment and maximizing acceptability of the strategy. And lastly, decision and policy makers should integrate ILK in policy formulation for climate change adaptation and risk management.

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6.0 COMPETING INTERESTS

The authors declare that they have no competing interests.

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Assessment of Solid Waste Management Practices in Hotels in Zanzibar, Tanzania

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Abstract

This study aims to examine hotel practices on solid waste management in Zanzibar Island in the United Republic of Tanzania. Specifically, the study analyses the solid waste management practices based on size and location of the hotel as well as degree of international influence. Furthermore, the study analyzes the stakeholder participation in solid waste management. A survey was conducted in December 2019 using a questionnaire to the 158 hotels in all three regions of Zanzibar obtained using stratified random sampling method. Data were collected using structured questionnaire and analyzed quantitatively using descriptive and inferential statistics. Results of the study showed that solid waste management by the hotel depends on the type of solid waste generated in which recycled was most preferred for food waste (18.4%), re-use for glass waste (23.4%), incineration for paper and cardboard waste (25.9%). Furthermore, regression analysis results showed that three variables explain practice of dumping solid waste in open space. These are contact with waste recycling firm ($p=0.09$), frequency of waste collection ($p=0.011$) and location ($p=0.75$). Hotels that have established contact with waste recycling firm are less likely to adopt open dumping, whereas high frequency of collecting waste decrease likelihood of dumping solid wastes. It has well been noted that hotel located in rural areas more likely to dispose waste in open dumping. The results also indicated that there was an association between hotel ownership (internationalization) and reduced use of plastic solid waste. Finally, the regression model was significant at 1 percent with p value of 0.001, implying that independent variables specified in the model which were hotel location and monitoring frequency correct determine whether food wastes are recycled at hotel premise or not. It can be concluded that, that management of waste is a combination of hotel related factors and external attributes that relates to regional or local administration. It is therefore recommended that local and national authorities should increase the frequency of waste collection and monitoring to enhance the sustainable waste management practices.

Keywords: Hotel industry, solid waste management, tourism, sustainability, Zanzibar

1.0 INTRODUCTION

The hotel industry is important to the world economy particularly in tourist attracting island as it contributes to economic and social development. Tourism is a major activity supporting an economic sector that is responsible for 9% of global GDP. In recent years it has seen significant growth which is forecasted to continue, especially in developing countries which have seen a rate of increase in visitor arrivals that considerably exceeds the world average (Mensah, 2020). However, tourism activities also have negative influences on solid waste management, in which solid waste is one of the most significant impacts (Kaseva & Moirana, 2010). The main waste generation sources in the hotels include the kitchen, guest rooms, public and function areas, food and beverage outlets, receiving and storage areas, offices, parks and gardens. The negative effect of hotel industry can be more significant in areas with high tourism activities such as Zanzibar.

Currently, there is no proper and effective method of waste (solid and wastewater) disposal in Zanzibar. Thus, there is inadequate national capacity to properly manage (handling, collection, disposal, recycling, reuse and treatment) solid waste and wastewater generated in the hotels. Among strategies that have been identified by the policy in waste management includes promoting public private partnership and community involvement and participation in waste management (Kaseva & Moirana, 2010).

Solid waste is regarded as one of the most adverse types of pollution. It needs to be managed in a sustainable way to reduce the overall burden on the environment. The International Hotel Environment Initiative (IHEI) (IHEI, 2002) reported that waste generation is one of the most visible adverse impacts that hotels have on the environment. The management of solid waste should be in accordance with the best principles of public health, engineering, economics and conservation of the environment. For instance, study by Taleb (2005) asserted that “the disposal of solid waste has always been a problem for the hospitality industry and for many hotel operators there is no route for recovery”. Indeed, the success of the hospitality industry worldwide depends largely on the presence of a clean natural environment (Manaktola and Jauhari, 2007). The improper management of hotel waste can contribute to the emergence of local and global problems (e.g. global warming, ozone depletion and climate change) (Mensah, 2014). Additionally, the biodegrading process causes the formation of a leachate, which has the potential to pollute underground water (Becklake, 1991).

The responsibility for the waste management on Zanzibar is on the municipality or the village council in different Shehias. Generally, all types of wastes are mixed and handled together in all steps (Blomstrand *et al.*, 2014). The municipality offers door-to-door services at a few streets in Stone Town, collection and transportation of municipal solid waste from different points and street sweeping (Blomstrand *et al.*, 2014). There are several types of collection

points, for instance open collection on the ground, collection in containers, concrete boxes, bins, wooden sheds and air-conditioned cabins at hotels (ZSDP1, 2005).

Large areas of stone town do not have access to regular collection (ZSDP2, 2005). It is estimated that 220 tons of waste is generated every day in the Stone Town area alone. About 45% of this is taken care of by the municipality. Currently the waste is taken into informal dumping areas and farm areas in the town surroundings (Figure 1). This is due to the fact that, the official dumpsite on Zanzibar was closed in December 2011) (Juma, 2012). The remaining 55% of the waste generated is collected and reused, incinerated, buried, randomly dumped, picked by bird/animals, swept away by the rain or just stay accumulated heaps in many parts of the town (Figure 1).



Figure 1: Informal dumping sites in Jambiani

To achieve hotel goal of best practice of solid waste management, effective and sustainable municipal solid waste management systems must be embraced by local authorities with appropriate organizational capacity and cooperation between numerous stakeholders in the public and private sectors actors (Henry *et al.*, 2005). However, management of MSW is most challenging compared with other types of wastes particularly in the developing world. The management of wastes in most cities of developing countries is highly unsatisfactory (Henry *et al.*, 2005).

Institutional operations regarding waste management in Zanzibar are guided by the Zanzibar Environmental Policy 2015. Specifically, on waste management, the policy state that, there is in-sufficient data for the entire area of Zanzibar (Unguja and Pemba) to estimate the amount of waste generated, but it is estimated that 260 tons of solid wastes are generated daily in Zanzibar Municipality (2017 estimate). According to this policy, over 60% of the total amount of solid waste generated (organic, inorganic, e-waste, etc) in Zanzibar are not properly managed and therefore accumulated in various area. Currently there is no proper and effective method of waste (solid and wastewater) disposal in Zanzibar. The main issue identified by the policy was inadequate national capacity to properly manage solid waste and wastewater generated in the communities. To implement this policy, the government in collaboration with private sectors and other stakeholders sought to improve waste management practices at all levels. Seven implementation strategies were identified in the policy: Promote proper and appropriate infrastructure services required for waste management (handling, reduction, collection, disposal recycling, reuses and treatment); promote proper and appropriate environmental sanitation facilities; promote public private partnership and community involvement and participation in waste management; promote public awareness on proper waste management practices, promote environmental standards and guidelines for waste management; promote cleaner production techniques to reduce waste at sources and to promote polluter pay principles (GOZ, 2013).

Furthermore, to address the problem of waste, the current Environmental Policy of 2021 requires proper legal mandate for coordination of environmental management issues under the auspices of a strong coordinating institution. The Zanzibar Environmental Act (2015) will need to be reviewed in line with policies and strategies for the effective implementation.

On the other hand, the government of Zanzibar recognizes the need for an institutional and legal framework capable of ensuring that the environmental policy is implemented and environmental management is integrated into the regular national planning process (GOZ, 2013). Also, the role of institutions responsible for environment has to be very broad, because environment issues are multi-sectoral, thus the Zanzibar Environmental Policy of 2013 has identified sixteen institutions that are responsible for implementation of environmental policy, these are institution responsible for water, non renewable natural resources, tourism, energy, fisheries, and marine resources, forestry, regional administration and local governments, health, agriculture and livestock, lands, investments, industries and infrastructure, disaster management, gender and vulnerable groups, education and academia, civil society organizations and private sectors, media and development partners. Each institution has developed policy and legislations to manage the environment including solid waste.

Zanzibar has recently passed the Urban Municipal Council Solid Waste Management (SWM) Regulations, 2019, developed by Delhi-based non-profit, Centre for Science and Environment (CSE) to ensure sustainable SWM (reference). It is the first of its kind in East Africa and is based on the 'Polluter Pays Principle'. This law expects to help Zanzibar revamp its waste management infrastructure and help to enforce SWM practices on various sectors in the island.

To date most of the work dealing with SWM has focused on the local authorities' waste management plans (Phillips *et al.*, 2002). A range of other studies have targeted small and medium sized enterprises (SMEs) to explore and assess their response to the environmental agenda but little or no attention has been paid to SWM aspects (Hillary, 2000; Revell and Blackburn, 2007). Moreover, the emphasis has been so far directed towards household waste and recycling. Yet, previous research has not provided insights into the precise challenges and/or factors that might influence the behavior of hotel operators to implement sustainable SWM practices particularly in Zanzibar. In this regard this paper examines factors influencing wastes management practices on hotel in Zanzibar. The particular concern is whether hotel related attributes of hotel size, location and internationalization determine waste management and disposal in Zanzibar. Understanding this attribute has important policy relevance

2.0 MATERIALS AND METHODS

2.1 Study Area

The study is a cross-section design with the purpose of examining the status of waste disposal and management. The study was carried out in hotels located in Zanzibar Island. Zanzibar is situated at the East coast of Tanzania. Zanzibar has several smaller islands and two main islands. The biggest island namely Unguja, followed by Pemba. Together, Unguja and Pemba have an area of 1, 666 km². Pemba alone has 988 km² with a population of approximately two million and the majority (approximately 1,500 000, census year 2022) lives on Unguja. Zanzibar has two rainy seasons; one is in shorter period (November- December) and one is longer period (March- May). The main economic activities conducted are tourism, retail, marine fishing, and peri-urban agriculture.

2.2 Study Population

The population of the study comprised of 484 hotels available in Zanzibar. The hotels were of different sizes from small to extra large depending on the number of rooms and beds. Sampling frame consisted of 243 hotels in which a total of 158 hotels were sampled for study. However, after data clearing, only 130 hotels were considered for further analysis

- Population: 484 hotels
- Distributed 243
- Sample (Returned): 158 hotels
- Usable : 130 answers

		Size groups (number of beds)					
		0-20	21-60	61-100	101-200	200+	
		micro	small	medium	large	x-large	
		hotel population by size					
	hotel population by region	295	130	28	20	11	
	URBAN	50	33	7	2	0	
	NORTH (A+B)	84	36	12	13	8	
	SOUTH	129	47	4	2	2	
	WEST (A+B)	16	8	1	1	1	
	CENTRAL	16	6	4	2	0	
		sample by size groups					
	sample by region	127	57	28	31		243
	URBAN	18	12	7	2	0	39
	NORTH (A+B)	30	14	12	13	8	77
	SOUTH	47	17	4	2	2	72
	WEST (A+B)	16	8	1	1	1	27
	CENTRAL	16	6	4	2	0	28

Figure 1: Study population

2.3 Sampling and data collection

A questionnaire survey was employed to collect data from a sample of hotels as primary data source. The main tool for data collection was a structured questionnaire, which was self-administered by hotel managers. The questionnaire contained questions relating to waste management practices of the hotels, characteristics of the hotels, and socio-demographic characteristics of the hotel managers. Prior to main survey, a pre-test was undertaken in four hotels in central urban zone. The pre-test was undertaken to address issues relating to respondent comprehension, burden and interest, respondents' tasks, questionnaire issues, sampling, as well as coding and analysis. The major issues identified with the questionnaires during the pre-test were respondents' lack of understanding of some of the questions and some requested the questionnaire to be translated into Kiswahili. The respective questionnaires were subsequently modified based on feedback from the pre-test. The actual data collection was undertaken by a team of twenty research assistants for fifty questionnaires who had received training from main researchers. To ensure a higher response rate, research assistants and researchers made personal calls to the hotels managers. In case the hotel managers were unavailable, the questionnaires were left to be collected at a future date. Hotel managers who failed to complete the questionnaire were substituted with managers of other hotels on the list to maintain the sample size of 158 hotels.

All hotels were stratified according to size in which three categories were considered, micro, small, medium, large and extra large. Random selection was then applied to each stratum and a total of 158 hotels were included in the study but after data clearing, only 130 hotels were suitable and considered for further analysis. Once a hotel was selected, the general manager was contacted for the survey. In the cases of manager's absence, hotel staff member who is well informed on waste management practice was contacted.

2.4 Data, measurements of variables and hypotheses

Three independent variables of interest were hotel size, hotel location and internationalization. The aim was to examine degree of causality between each of these and a selected waste management practice. All three variables were dummies. Since there is no consensus on measure of hotel size, number of employees, hotel ratings or number of rooms can be used as a measure of hotels size. Thus, in this study, number of hotel rooms was considered as an appropriate measure of size (Milohnic (2006),. Thus, hotel with more than 55 rooms was considered as a large hotel, and one with less than 55 rooms was termed as small hotel. Although size might reflect other indicators, e.g, number of employees, building and total investment still number of rooms give a true reflection of other attributes of hotel size. Therefore, it was hypothesized that *large hotels are notorious in terms of waste management, with significant negative environmental effect*. The share size of waste resulting from a large hotel may have management consequences. We should also be cognizant of the fact that small hotels may not pay attention to best solid waste management practices because of insufficient financial investment on environmental best practices

The second variable of interest was hotel location. Hotel location is a dummy for urban located hotel. It was hypothesized that *urban based hotel has greater preponderance of poor waste management measures*. This hypothesis is based on observation that Unguja is a small island with high population density. High density is often associated with waste accumulation in urban settings of developing countries.

The last variable of interest is internationalization. This is measured based on hotel ownership. Hotel with partnership or shareholding with non-citizenship is considered as having high degree of internationalization. An opposite category of this variable is locally owned hotels. It was hypothesized that *internalization of hotels is associated with best waste management practices*. To test the stated hypotheses, a binary logistic regression models were employed with different specification of independent variables (Table 2). Number of controls was included in the model specification based on literature review (Table 2). The selected model of choice was probability regression, which consider binary of dependent variable (s). Prior to running these causal models, descriptive statistics were employed to understand the spread and behavior of variables. In addition, chi square test was used to test the association between variable of interest and waste management practices.

Table 2: Measurement and description of variables of variables specified in the model

Variable	Definition
Contact with firms	This is a dummy variable for hotel contact with waste recycle firm, with 0=contact and 1 otherwise
Distance	Dummy variable for distance in kilometer between hotel and nearest dumping site
Frequency of waste collection	Dummy for frequency of waste collection., with value of 0 for waste collected weekly
No of permanent employee	Total number of employees in a hotel
Hotel ownership	Dummy variable for hotel ownership; 0 =hotel owned by locals, and 1 for foreign/partnership ownership
Waste collection arrangement	Dummy variables on nature of data collection arrangement. Value of 0 stand for licensed company as waste collector and 1 stand for individual /hotel staff waste collectors
Employee in waste management	Number of hotel staff with responsibility of managing waste
Size of hotel	Dummy for hotel size; 0=small hotel and 1 otherwise
Region	Dummy for rural/urban location; 0= rural, 1=otherwise

3.0 RESULTS AND DISCUSSION

3.1 Waste management practices

The results of the study, as shown in Table 3 indicate that, the waste management practice of hotels in Zanzibar depends on the type of solid waste generated in which recycling was most preferred for food waste (18.4%), re-use for glass waste (23.4%), incineration for paper and cardboard waste (25.9%). Furthermore, results indicated that encouraging guests to reduce the use material to reduce the waste being generated was less regularly undertaken. Furthermore, results indicate that solid waste were not processed in some hotel in which most of the waste were collected by the municipal council to the disposal site (93.7%) and some were handled by private individuals (1.9%), buried in the soil (1.3) and some also were collected by private companies such as ZANREC company (0.6%). On the other hand, results indicated that the most common practice regarding waste management in the municipality was the availability of collective waste containers (40.5%) where dumping of waste in roadside was also common (22.8%).

These results clearly indicate that, hotels owners are less interested in deriving anything from the wastes through reuse, recycling or recovery from the wastes that they generate; rather, they were more interested in how they could get rid of them. This explains why practices geared toward reuse, recycling, reduce and recovery were less popular.

Results of the study affirm that of previous studies that waste disposal is the most popular waste disposal method employed by hotels (Radwan et al., 2012). This is evident in the provision of dustbins for collection and dumping of waste

at landfills by the hotels and employment of the services of waste management companies like ZANREC to collect hotel wastes.

Table 3: Solid waste processes on the hotel

Item	Recycled	Re-use	Incineration	Reused for other purposes	Encourage guests to reduce waste
Glass and porcelain	17.1	23.4	10.8	8.9	7.6
Paper and cardboard	10.8	22.8	25.9	3.8	3.2
Metal	12.7	13.9	5.1	8.9	2.5
Plastic	16.5	21.5	13.9	5.7	12.7
Garden waste	17.7	10.8	17.7	15.2	1.3
Food waste	18.4	14.6	11.4	10.8	3.2
Electronic	13.3	13.9	12.7	7.6	2.7
Textile	10.8	18.4	12.7	10.1	1.3
Toxic waste	5.1	17.7	17.7	6.3	5.7

Further results of the study, as shown in Table 4, indicate that, based on the waste management hierarch model, the most frequent waste management practice of hotels in Zanzibar was at the level of reduce use ($M = 0.32$) which is the most preferred method as per WMH, however, interestingly guests were not encouraged to reduce use ($M=0.18$) probably hotel owners are not fully aware on the business benefits of encouraging to reduce production of wastes. Waste disposal by incineration which is not preferred was also a frequently undertaken waste management practice by hotels in Zanzibar ($M=0.28$). Thus, the hotels frequently practiced reduced use by hotel management and incineration while they occasionally practiced activities geared toward encouraging guests to reduce use, reuse ($M=0.22$) and recycling ($M=0.25$) (Table 4).

Table 4: Mean waste management practices

Waste management practices	Mean
Recycle	0.25
Encourage guests to reduce the use of	0.18
Incinerated	0.28
Reused for other purposes (e.g.: bricks)	0.22
Reduce use	0.32

Hotels in Zanzibar adopt different practice of solid waste management practices which include incineration, open dumping, compositing, recycling, disposal and reduce use among others.

(i) Waste disposal

Different model specification was attempted. The only model that yielded significant result is solid waste open dumping (Table 5). Waste disposal mechanism is an important criterion of assessing waste management behavior of a firm. When other solid waste handling practice were, modeled results were not

statistically significant with no intuitive statistical explanation Table 5 present binary regression results on causal factors that affect solid waste open dumping practice.

Table 5: Determinants of solid waste dumping practice- regression results

Variable	B	S. E	Wald	P values	Exp(B)
Contact with firms	-1.156	.440	6.894	.009	.315
Distance	.454	.461	.972	.324	1.575
Frequency of waste collection	-1.326	.525	6.390	.011	.266
No of permanent employee	-.001	.004	.110	.740	.999
Hotel ownership (internalization)	.713	.436	2.678	.102	2.041
Waste collection arrangement	-.560	.445	1.590	.207	.571
Employee in waste management	-.065	.061	1.111	.292	.937
Size of hotel	-.706	.492	2.054	.152	.494
Region (location)	-.765	.429	3.177	.075	.465

The dependent variable is a dummy for solid waste disposal in open dumping site. In this model it was interested in understanding the influence of three variables, which are hotel size, location and internationalization. These have been earlier (see section 2.4) hypothesized to influence solid waste management. The overall model is significant at 5 percent with probability value of 0.009. A total of 9 variables were specified in the model, in which two variables were significant at 5 percent ($p=0.05$) and one variable was significant at 10 percent (0.10). Interpretation will focus on the direction and not magnitude as this suffices for policy purpose. It is of hesitation to consider magnitude due to potential endogeneity of the model.

The variable contact with firm is negative and significant at $p = 0.009$. This implies that hotel with that have well established contact with waste recycling firms are less likely to use open spaces for dumping. In Zanzibar, it has become a familiar phenomenon for recycling of solid plastic waste, which constitutes largest proportion of wastes. There are firms that specialize in this activity such as ZANREC and some have established contact with hotels. The findings indicate that hotels with established contacts with waste recycling practices firms are unlikely to dump their solid waste.

Frequency of waste collection is negative and significant (at $p=0.11$). The shorter duration of waste collection from hotels is associated with increased likelihood of having solid waste dumped at open site. This makes sense since hotels may find it rational to dump their waste if waste waste collection is irregular. From policy perspective, it is important to have a well- managed plan of predictable waste collection to avoid environmental consequences of dumping

solid waste. Municipal waste collectors in Zanzibar often have sporadic visits, which cause accumulation of waste in hotels.

Hotel location was specified in the model to control for location specific factors. This dummy was negatively significant at $p=0.1$ and, implying that hotel located in urban areas are less likely to use open dumping sites. This interpretation makes sense since there are few open spaces congested urban areas where one can use as dumping site. Zanzibar is one of region in Tanzania with highest population density although in theory this does not support the hypothesis of poor waste management in urban located hotel, it doesn't necessarily imply that these hotels use best waste management practices. The other variable which is not significant but provides interesting discussion is number of employees in waste management section. The coefficient for this variable is negative. This implies, though loosely, that employing staff with specific task of dealing with waste has positive effect in terms of avoiding environment unfriendly practices of dumping waste in open sites. The regression analysis was also used to examine if there is any kind of relationship between hotel size and waste management behavior of hotel. The test results show no significant relationship, between these variables, with p value greater than a standard p value of 0.05. This implies that the size of hotel is not associated with hotel solid waste management. This particular finding does not corroborate another related study by Menshal (2006), in which large hotels were found to adopt best environmental practices. This indicates that, small, medium and large hotel have the same practice concerning solid waste management.

(ii) Reduced use of Solid Waste

A chi square test was performed to study association between hotel ownership (internationalization) and reduced use of plastic solid waste. Stated hypothesis is lack of association between hotel ownership and reduce use of plastic wastes. The value of the test is $p=0.03$. This result is statistically significant implying rejection of null hypothesis that claim that the two variables are independent of each other. Hence the empirical data suggest that the variables hotel ownership and reduced use of plastic wastes are dependent of each other. Hence results are significant and thus hotel ownership and reduced use are associated. It should be noted that no causality was found between these two variables with positive coefficient. Nevertheless, results in table two indicates local owned hotel are more likely to reduce use of plastic hotels than foreign owned hotel (i.e. 18 out of 60 foreign hotels reduce use, while only 10 out of 70 locally owned hotel have the same practice.

(iii) Food Waste Recycling

One of the main solid wastes with notorious environmental pollution effect is food waste. Hotel in Zanzibar generates large quantities of this waste type. Table 6 present regression results on covariates of food waste recycling.

Table 6: Determinants of food waste recycling (binary logistic regression)

Variable	B	S.E	Wald	Sig	Exp(B)
Hotel type	-.400	.551	.527	.468	.670
Location	-2.791	1.096	6.482	.011	.061
Hotel size	.524	.682	.589	.443	1.688
Monitoring frequency	-2.478	1.128	4.822	.028	.084
External support	-.250	.840	.089	.766	.779
Use of waste container	-.210	.604	.121	.728	.811
Distance to dumping site	-.360	.637	.318	.573	.698
Collection frequency	.479	.635	.569	.451	1.614
Policy statement	1.019	.627	2.637	.104	2.771
P.0.001; R =0.314					

Food waste recycling which was measure as a dummy variable (recycling =1; no recycling =0) intended to assess the manner in which solid wastes are processed on the hotel premises. Apart from recycling other waste processing procedure were reduced use, incineration, reuse for other purposes and encourage guest to reduce the use of solid waste. With respect to procession of food waste the only model that was significant was one of recycling (Table 6).

The regression model was significant at 1 percent with p value of 0.001, implying that independent variables specified in the model correct determine whether food wastes are recycled at hotel premise or not. Two variables were significant. These dummy variables for monitoring frequency and a location dummy.

Monitoring frequency is negative and statistically significant ($P = 0.03$) The variable monitoring frequency captures the frequency at which government agencies monitor the implementation of waste management. The frequency was dummy variables on whether monitoring was twice per year or otherwise, meaning less frequency of one in two or three years. Results imply that high frequency of government monitoring increase likelihood of food waste recycling. This probably may entail adoption of best environmentally sustainable practice when there is frequent monitoring of implementation of waste management practice at hotel premises. Recycling requires community involvement and social awareness to be successful. In recognition of the importance of public participation in the success of recycling programs, recycling policy and legislation need to be geared toward promoting people centered approaches to recycling with public education as the main driver towards increasing public participation (McAllister, 2015). Location was negative and significant. This implies that hotels that are located in urban areas have increased likelihood of recycling waste. This makes sense since earlier results have indicated that urban located hotel do not adopt open dumping, instead they recycle some of solid wastes such as food.

4.0 CONCLUSION AND RECOMMENDATIONS

This study aimed at unveiling key attributes that affect hotel solid waste management practices. Results generally indicate that, the key variable that is associated with solid waste management is location. Urban located hotel are less likely to adopt open dumping as a waste disposal practice. These hotels are also more likely to recycle their food waste. Our empirical evidence indicates that hotel ownership (whether locally or internationally owned) has no bearing on solid waste management. However, results give an impression that hotel with international partnership may adopt reduced use of plastic waste. Although this particular finding results from correlation analysis it may loosely imply causation between waste management and hotel ownership.

Furthermore, evidence from econometric estimation presented in our findings indicates three factors that influence solid waste open dumping practice. These are contact with waste collecting firm, frequency of waste collection and hotel location. Hotels with well-established contact with waste collecting firm are less likely to adopt poor environmental practice of open dumping. These collecting firms have desirable environmental practice of recycling some of wastes with additional economic appeal. As expected, hotel with more frequency of waste collection have reduced likelihood of adopting open dumping practice. Similarly, as far as hotel location is concerned, urban located hotel have limited space to adopt the use of open dumping practice.

From policy perspective, these findings present two relevant recommendations, firstly, it is suggested for a more targeted policy on waste management among hotels in Zanzibar. For example, since hotels in rural areas have increasing tendency for open waste dumping, then a rural based intervention may be appropriate and will be cost effective. In the same vein, hotels owned by locals should be encouraged to establish contacts with waste collecting and recycling firms. Secondly, at broader policy level, hotels should be advised by who? to establish contact with a waste collecting firm. These engagements may ensure timely waste collection and reducing temptations for solid waste dumping. Furthermore, increased community participation and introducing incentives may be some of the most effective social interventions in establishing sustainable solid waste management. With this objective, local governments should financially encourage the hotel sector and provide more effective and cheaper waste recovery services than the disposal in landfills, aiming at the reduction, reuse, and recycling of wastes.

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Human-Wildlife Interactions in the Selous: Causes, Impacts, and Management Approaches in Rufiji District

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Abstract

This paper investigated human-wildlife interactions in the Selous Game Reserve (now Nyerere National Park) employing mixed research methodologies. Three villages, Mloka, Ngarambe, and Tawi, were purposely chosen within two Wildlife Management Areas (WMAs). The data collection methods comprised ten key informant interviews, two focus group discussions in each village, a household survey of 120 participants, and a literature review. The enforcement of conservation regulations, infrastructure development, population growth, and wildlife conservation has led to a surge in wildlife in the communities, resulting in significant agricultural damage, injuries, and insecurity. The governmental agencies and investors were the primary decision-makers regarding conflict management measures, whereas the WMA actors held comparatively little influence in the decision-making process. The study identified multiple adverse effects of these interactions, including reduced access to natural resources for communities, absence of compensating mechanisms, and changes in regulations and rules. This paper advocates for more comprehensive conservation strategies that include the requirements of local communities and wildlife within the Selous Game Reserve (now Nyerere National Park).

Keywords: Human-wildlife interactions, Wildlife Management Areas, human wildlife conflicts, Selous Game Reserve, Rufiji District

1.0 INTRODUCTION

Interactions between humans and wildlife have become an increasingly critical issue in Africa's wildlife reserves, such as the Selous Game Reserve in Tanzania, which is now known as Nyerere National Park. Selous Game Reserve is an essential location for the conservation of a wide variety of wildlife species, including rhinoceroses, lions, and elephants, due to the fact that it encompasses a broad area and contains an unmatched variety of mammalian species (Gillingham, & Lee, 1999; Baldus *et al.*, 2003; Meloka & Haller, 2008; Mambo & Makunga, 2017). On the other hand, the local communities that are located in the surrounding area, particularly in the Rufiji District, are located in close proximity to the reserve's boundary, which raises ongoing worries regarding interactions between humans and wildlife. These kinds of interactions lead to conflicts that are detrimental to groups of people as well as species of wildlife.

Human-wildlife conflicts (HWC) pose substantial problems to conservation efforts, especially as global biodiversity declines, the need to develop effective

conservation measures that balance human and wildlife coexistence has never been greater. Despite the success of diverse actors' conservation efforts, most scientific findings on biodiversity conservation are unfavourable (Buscher & Fletcher 2019). According to the Living Planet Report 2020, an average of 68% of all natural creatures disappeared between 1970 and 2016 (WWF, 2020). Numerous studies (WWF, 2016; WWF, 2018; WWF 2020) have shown that biodiversity is critical to human survival on Earth.

Several factors are the key contributors to the conflicts that arise between humans and wildlife near this protected area (Swalehe and Yanda 2023; Gayo & Ngonyoka, 2025). There are a number of factors that contribute to wildlife that walks into human settlements. These factors include the destruction of habitat for agricultural land, the expansion of human settlements, and the infrastructure development. Poaching and land clearance are two examples of human-induced activities that bring these wild animals closer to humans. These activities are carried out for a variety of reasons, including the purpose of benefiting from natural resources. Manifestations of conflict include crop damage caused by animals, the slaughter of livestock, the destruction of property, and, in certain situations, the harm or death of human beings.

According to the World Wildlife Fund (WWF), mankind is destroying ecosystems and biodiversity at an unprecedented rate (WWF, 2020). This problem is a clear indication of massive socio-ecological reconfigurations of the Earth's surface known as the Anthropocene period (Buscher & Fletcher, 2019). These alterations have sparked debate in the conservation field, notably regarding biodiversity and species extinction. Resolving these conflicts requires a thorough understanding of socio-ecological systems, which has resulted in the establishment of numerous biodiversity management approaches (Buscher & Fletcher, 2019). Furthermore, these approaches reject colonial-era human-wildlife separation approaches to conservation in favour of more fair and participative ones that recognise the value of both human and ecological well-being.

The goal of this paper was to investigate the anthropogenic variables that influence human-wildlife interactions in the Rufiji District, determine their effects on communities and ecosystems, and assess the current management frameworks. It is therefore necessary to determine the causes, impacts, and management measures that can grow or decrease human-wildlife conflicts through the following questions: (i) What are the key causes of human-wildlife conflicts? (ii) How do human activities and land use changes influence the occurrence of conflicts between people and wildlife? (iii) What are the environmental, social, and economic consequences of these disagreements for local residents and wildlife populations? (iv) How do different sorts of conflicts (e.g., crop raiding, livestock predation, property destruction) differ in their origins and consequences? Understanding these characteristics can help to

facilitate the creation of solutions that will improve conflict resolution efforts in the Rufiji District and increase stakeholder participation.

2.0 THEORETICAL FRAMEWORK

This study uses political ecology as a framework to explain complicated relationships between humans and wildlife. Political ecology, which emerged in the 1970s, is an interdisciplinary approach that blends geography, anthropology, sociology, and environmental studies to explore how political-economic processes influence environmental concerns, with a particular emphasis on the effects on marginalised communities. It was heavily influenced by the work of scientists such as Piers Blaikie and Harold Brookfield, who studied how political-economic processes influence environmental outcomes and vulnerabilities (Walker, 2005; Roberts, 2020).

This paradigm is well-known for providing a comprehensive approach to ecological, political, economic, and social issues, emphasising power dynamics and recognising the dynamic nature of human-environment relationships. However, it faces challenges due to its complexity, lack of established methodologies, and tendency to focus on negative outcomes. Political ecology can provide valuable insights into human-wildlife management by assessing power dynamics, economic interests, and cultural perspectives in order to establish equitable and culturally sensitive management strategies. Since the 1970s, scholars have used the term to describe a variety of critical techniques for investigating the relationship between human cultures and the natural environment (Tetreault, 2017).

According to Blaikie & Brookfield (1987), the notion of 'political ecology' incorporates ecological factors into a complete political economic framework. This phenomenon includes the dynamic interplay between society and land-based resources, as well as interactions among various classes and groups within society (Blaikie & Brookfield, 1987). Political ecology can be described in a variety of ways, but it typically refers to empirical and research-based investigations that seek to understand the links between the state and the development of social and environmental systems. These investigations clearly take into account power dynamics and connections (Robbins, 2012).

Political ecology and politics approaches are appropriate for considering how both local people and conservationists create and enforce various types of human-wildlife interactions (Pooley *et al.*, 2017). However, different countries around the world have varying levels of resources and techniques to compromising and producing these types of human-wildlife interactions (Pooley *et al.*, 2017). These, in turn, have inspired a political ecology paradigm for conservation. Thus, the political ecology approach to conservation is offered as the finest techniques, battles, and conceptions for the long-term management of biodiversity.

Political ecology focusses on politics related to human-wildlife interactions while emphasising inclusive measures. Wild animals are thought to feel more protection in protected areas and near villages (John, 2021b; John, 2023). These two processes of balancing local communities' livelihoods and conservation generate political considerations about whose presence and rights are recognised in conservation, who/what is excluded by its interventions, and who or what benefits from conservation (Schreer, 2023). Furthermore, despite the inherent obstacles and negative repercussions of wild animals, local residents are legally prohibited from killing them in protected areas.

As a result, local communities try to resolve human-animal disputes by illegally killing wildlife (John, 2021b; Holmes, 2007). However, wild creatures are slaughtered without regard for meat, hides, horns, or other benefits, and their remains are allowed to decay (Holmes, 2007). This is because local communities want to convey a message, which would be considered overt resistance given the many political and economic obligations (Holmes, 2007). Although other techniques (such as community-based conservation) attempt to achieve this, friendly conservation focusses on social differences and the larger political ecology of these connections. As a result, friendly conservation is expected to provide the most effective ways for humans and wild animals to coexist.

The political ecology approach is recommended because it describes the power dynamics between local communities, the government, and other conservationists in managing natural resources in the Global South. Political ecology examines the politics and governance principles for the future of conservation. A friendly conservation approach, informed by political ecology and real-world examples of alternative methods to preserve nature, encourages the emergence of transformative seeds as a realistic and constructive basis for reconciling global conservation and development imperatives (Massarella *et al.*, 2023). Political ecology advocates for a political approach to conservation, involving movements, struggles, and ideas aimed at combating natural resource depletion and, as a result, improving local communities' standard of living.

3.0 MATERIALS AND METHODS

3.1 Description of the Study Area

As illustrated in Figure 1, this study was carried out in Rufiji District of the Selous Game Reserve in southern Tanzania. This reserve, established in 1982, is one of Africa's largest, spanning over 49,000 square km (Mambo & Makunga, 2017). Moreover, it was previously one of the largest wildlife reserves globally before its division into Nyerere National Park. Massawe *et al.*, (2025) state that the Selous Game Reserve was elevated to Nyerere National Park, including approximately 30,000 km². This section was established to promote tourism and conservation. Elephants, crocodiles, and hippopotamus are just a few of the spectacular animals that can be seen in the Selous, which is home to a wide variety of species. Foya *et al.*, (2023) assert that the geography of this region

encompasses several ecosystems, including miombo woodlands, grasslands, marshes, and riverine forests, which collectively sustain a significant degree of biodiversity. Rufiji District is one of several districts adjacent to the Selous Game Reserve (John, 2021a; Gillingham & Lee, 2003).

Between 2017 and 2020, the research project New Partnership for Sustainability (NEPSUS) looked into three sectors: forests, fisheries, and wildlife. This study is based on a wildlife package conducted in the northeastern area of the old Selous Game Reserve prior to its division into Nyerere National Park. Three Selous villages were chosen for this study based on the frequency of human-wildlife encounters as identified in different studies (Mtoka *et al.*, 2014; Baldus *et al.*, 2003; Gillingham & Lee, 2003) and current studies such as (Gayo & Ngonyoka, 2025; Swalehe and Yanda, 2023; Pop *et al.*, 2023). These studies cover two WMAs: Mloka is a village that makes up (Jumuiya ya Hifadhi ya Wanyamapori, Ngorongo, Utete, and Mwaseni). Ngarambe is one of the (Muungano wa Ngarambe na Tapika) MUNGATA WMA villages, and Tawi is part of the same ecosystem but not part of the WMA, despite the fact that animals can be observed in the villages.

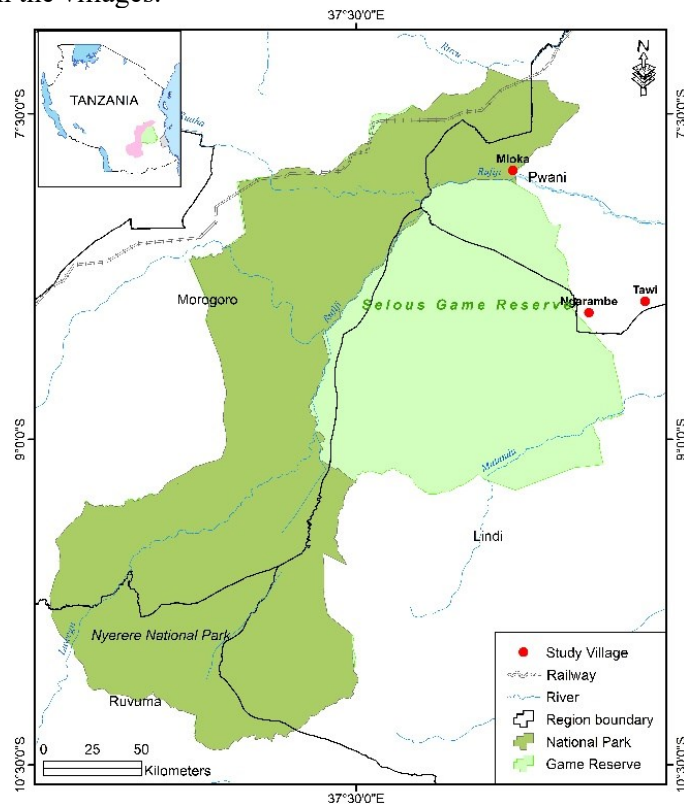


Figure 1: Map of Selous Game Reserve before it was designated to Nyerere National Park

Source: UDSM IRA-GIS LAB, 2025

3.2 Data Collection and Sampling Procedures

In this study, the sampling process was designed to gather all local perspectives from the head of households selected. The desired sample size was chosen at 40 to 50 respondents per village based on the total number of houses and the requirement to capture a variety of perspectives. As customary done in most studies, the number of households sampled from each village was slightly adjusted to reflect household subdivision and ease of access. As a result, 120 households were identified, including 40 in Tawi, 40 in Ngarambe, and 40 in Mloka. The abundance of resources counterbalanced practical constraints, allowing for a thorough examination of community opinions and experiences regarding human-wildlife conflicts. Then the village roster book was used whereby simple random sampling method was used.

The sample was computed using a random number generator to select household heads using simple random sampling methods. The study used a structured questionnaire, face-to-face interviews, and focus group discussions. Open-ended questions were also included for more explanation. The questionnaire attempted to determine respondents' incidences of crop damage, access to resources, the influence of conservation rules, and the impact of crop damage.

Two focus group discussions were held in each village, with group sizes ranging from six to nine persons, to gather varied opinions. Key informant interviews were also done with the District Game Officer, the leaders of two WMAs, and the Village Executive Officers of each village. Other key informants were interviewed, including officials from the Wildlife Division and Tanzania Wildlife Management Authority (TAWA). The key informant interviews were conducted until there was no fresh information and it was thought to have reached saturation. Focus group discussions and key informant interviews were conducted to gather information about human-wildlife conflicts, damages, and how the state dealt with the consequences.

3.3 Ethical Considerations

Before going to the communities to collect data, we needed to obtain the appropriate research clearance. Then, we notified the village leaders about the objectives and methodology of our research and requested their approval. The Tanzania Wildlife Management Authority (TAWA), Pwani Region Administrative Office, Rufiji District Council, and JUHIWANGUMWA and MUNGATA WMAs all granted approval for the study. We informed the respondents on the research purpose and requested permission to include them in our survey. We received verbal confirmation to proceed with our interview. We told them that their comments would remain anonymous while acknowledging the sources of information. The interviews and focus group discussions were recorded.

3.4 Data Analysis

To achieve a clear clutch of the findings, the data obtained from household surveys and interviews were analysed using a blend of both qualitative and quantitative methods. Conflicts of humans and animals were quantified through the collection of relevant information which was later processed through coding and input into statistical analysis programs such as SPSS version 20 and Excel for descriptive analysis. This process included frequency, percentage, and mean calculations to reveal recurring patterns and trends among the study villages.

The open-ended survey responses along with the interview transcripts provided qualitative data which were thematically analysed. These processes involve extensive and systematic coding of the data to derive themes and categories that repeatedly manifest concerning the human-wildlife conflicts and their causes, impacts, and management. The analysis was primarily inductive, making it possible for themes to arise from the data without restriction and these themes were supported by relevant quotes to demonstrate the most important ideas. Multiple researchers recording codes independently and later discussing discrepancies enhanced reliability and validity. Combining quantitative summaries with qualitative thematic insights resulted in a comprehensive understanding of the community experiences and perceptions in regard to the conflicts with animals in the studied areas.

4.0 RESULTS

4.1 Nature and Causes of Human-Wildlife conflict in the Etudy area

In Selous Game Reserve, wildlife practices and presence have a significant impact on local ecosystems and community livelihoods. While these linkages can be helpful at times, they frequently result in substantial issues such as agricultural and livestock damage, food shortages, and economic instability. Human-wildlife conflicts in Selous Game Reserve in Rufiji district have caused crop damage, habitat loss, and deaths, harming humans, wild animals, and the environment. Therefore, the locals disliked the wildlife in and around them. This harms animal conservation greatly.

This study found that local villages' proximity to the game reserve makes them vulnerable to human-wildlife conflicts and their effects. Climate change causes water shortages, deforestation, agricultural expansion, game reserve infrastructure construction, and land use changes, which lead to human-wildlife conflicts. This study has found that increasing wildlife populations in human settlements have led to a decrease in the usage of traditional wildlife protection methods, such as making loud noises. This has resulted in a rise in confrontations between humans and wildlife over the past five years (2015-2019) (Figure 2). Various forms of wildlife-related consequences include human assaults, human fatalities, agricultural harm, habitat devastation, wild animal deaths, and several others.

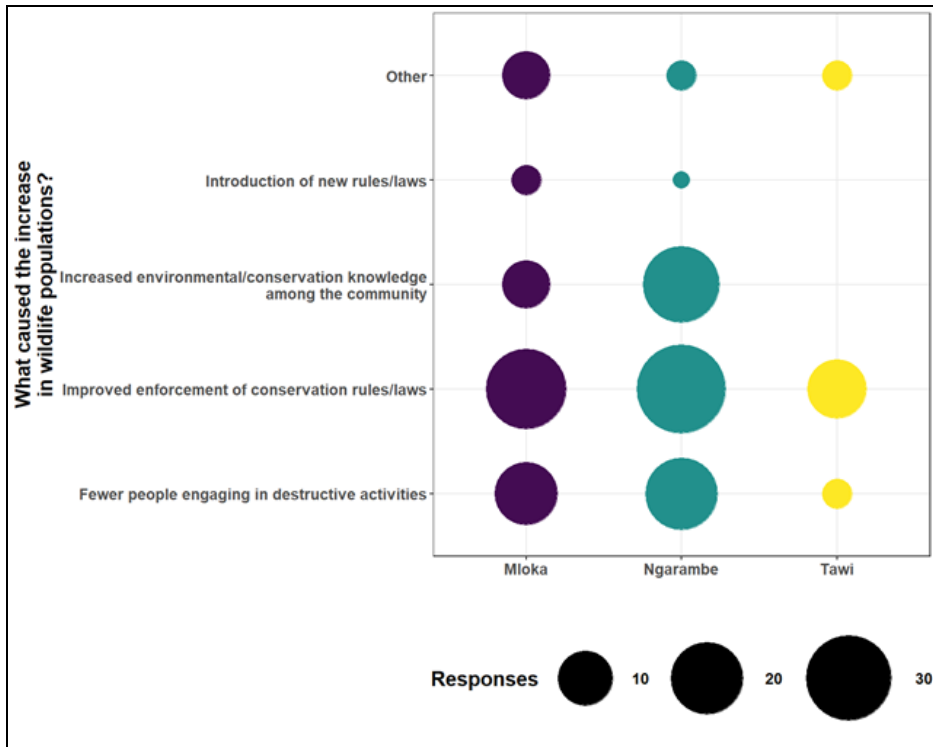


Figure 2: Local perception of wildlife population status
Source: John, 2021a

4.1.1 Crop Damage

While Selous Game Reserve has positive human-wildlife interactions, direct interactions cause conflicts because wildlife damages crops and human property. Due to population growth and the need for more space and resources to feed it, conflicts occurred. It forces humans and wildlife to live together, cross boundaries, and cause conflicts. When conflict replaced interaction, wild animals were banned from human land for interfering with human activities and damaging crops and properties. During FGDs and interviews, most respondents complained that game reserve wildlife raided cultivated land. Ngarambe village's household head supports this claim:

"An elderly woman recounted that she and other community members remained in their fields for over two months to safeguard their crops from wild animals." (Female resident, October, 2018).

Results from interviews with the villagers indicated that not all crops in the study area were affected similarly by crop raiders. Elephants, wild pigs, warthogs, and monkeys were mentioned as significant crop raiders due to their behaviour. Elephants were the most frequently reported crop predators that caused the most damage and ranked first, followed by warthogs. They damage

crops early in the morning and late in the evening, when there are no humans nearby. Humans and wildlife have come into conflict due to the fact that agricultural crops are an abundant food source for both humans and wildlife as explained during the interview:

“When I saw that, elephants had eaten my maize crops. I was anxious about relaxing, fearing that I would fall asleep and be endangered by the elephants. I, too, am concerned about the thought of confronting one, especially as a woman.” (Female inhabitant, October 2018).

Large herbivores compete for maize and sorghum in the wild. Small wild animals, such as monkeys, strive for fruits, nuts, and cereals. According to the respondents, the commodities most susceptible to raiders were maize, rice, and sorghum. As explained by the villagers, local communities sleep in the trees to protect their crops from elephants. A great deal of effort is wasted protecting crops and putting lives at risk from other predators such as snakes. However, women and children are more vulnerable to wild animal attacks than men because they cannot defend themselves as effectively.

4.1.2 Habitat disturbance

Mekonen (2020) defines habitat disturbance as the destruction of an animal's habitat by means of cutting, digging, and burning. Burning and cutting down trees in and around the game reserve constituted the majority of habitat degradation in the study area. This includes frequent fires for sesame production, tree cutting for the sale of charcoal, and the construction of shelters (field observation). In addition, tree cutting was primarily associated with a new settlement, resulting in a reduction in the area's remaining vegetation cover. This diminishes the wild animals' feeding grounds, leisure areas, and mating grounds, thereby increasing the conflict between humans and wild animals (Mekonen, 2020). Conflict can arise when wildlife intrudes into human territories in quest of resources or when human activities progressively encroach onto wildlife habitats, leading to disputes over land and resources.

4.1.3 Human attacks

Human attacks, lack of freedom of movement, injuries, and loss of life due to wild animals constitute a second significant hazard posed by wild animals to nearby human communities. The majority of attacks on humans occurred when victims were struggling on farms or defending them from crop raiders. Also, human attacks by wild animals occurred at night when local communities were fishing in Selous Game Reserve's oxbow lakes. Crocodiles and hippos attack the local communities in the neighbouring villages. More than ten persons were killed by elephants and other wild animals in the study villages between 2015 and 2018 (Focus group discussion, 2018).

In the village of Mloka, one of the villagers revealed that not everyone will return safely from prohibited fishing in the game reserve. They were either killed by wild animals or captured by game ranger patrols on occasion. Depending on the circumstances, they are fined, taken to court, or punished when discovered illegally fishing. Due to the danger and susceptibility of their livelihoods, local communities are fearful of wild animal attacks. Youth from the Mloka village blamed the government and the conservation NGOs for failing to compensate them when they are attacked by wild animals in their villages.

Tour operators can also appreciate wild animals in the village because it attracts tourists. In an interview, a Mloka village tourist resort manager said their facility hosted a leopard the night before. The leopard's presence worries locals, but it might harm humans. Wild animals in the village are likely to be treasured by clients, offering tour operators tremendous satisfaction. According to a household survey of the local community, wild animals have increased in the settlements, causing disturbances (Figure 3). Due to its location outside the Wildlife Management Area, Tawi village responded differently from Mloka and Ngarambe villages.

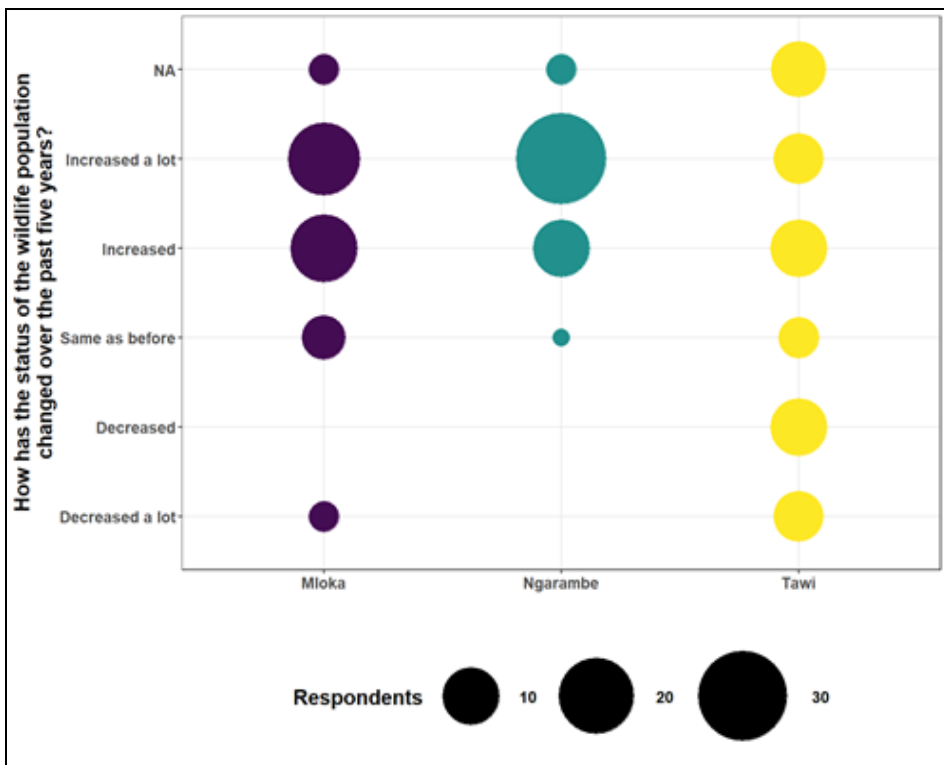


Figure 3: Local perception of the status of wildlife population

Source: John, 2021a

4.1.4 Killings of wild animals

The absence of compensation for agricultural damage as reported by Kimario *et al.*, (2020) and the killing of domestic animals makes local communities struggle to kill wild animals. This study discovered that crop raiding undermines food security and fosters wildlife intolerance in neighbouring communities. The crop damages and lack of compensation for the losses were complimented by the consolation from wildlife management authorities. For instance, the Wildlife Conservation (Dangerous Animals Damage Consolation) Regulation of 2011 permits consolation of Tsh 500,000 (approximately 214 USD) for human injury caused by dangerous wild animal attacks and Tsh 1,000,000 (approximately 429 USD) for human death (URT, 2011). Local communities are complaining that the consolation offered is insufficient to make up for the losses sustained. During a focus group discussion at Ngarambe, the men complained that the department responsible for providing consolation is taking excessively long to do so. As a result, the provided consolation is insufficient, prompting locals to engage in unlawful activity as a form of resistance.

As illustrated in Figure 4, local communities kill or injure wild animals because they are dissatisfied with how human-wildlife conflicts are resolved. Elephants, which cannot be killed, are the most frequently cited threat to humans. The game rangers chase elephants, but they eventually return and destroy food crops. Local communities access the game reserve for a variety of reasons, including illegal hunting and fishing on the Rufiji River and oxbow lakes such as Lake Siwandu, Lake Nzelekela, Lake Tagalala, and Lake Manze in Selous Game Reserve. These oxbow lakes are protected and no human activity is permitted, despite the presence of large fish. Consequently, game rangers and local communities are perpetually at odds over the preservation of fish stocks, as the local communities' primary objective is to get fish.

The Selous game reserve authority employs game rangers with formal training to patrol the reserve and prevent illegal activities such as poaching, fishing, and forest product collection (Haller *et al.*, 2008). The local communities, with their subsistence and increasingly cash crop and commercial activities, would like to continue their long-standing use of the area for agriculture and fisheries, but animal attacks and agricultural degradation are hindrances (Ponte *et al.*, 2022). At the Selous game reserve, several bodies of water, including Lake Nzelekela, Lake Siwandu, Lake Manze, Lake Tagalala, and Lake Mzizima, maintain a large stock of fish used for tourism. Numerous species of fish are catchable in the pristine waters of these locations where fishing tours are offered (Haller *et al.*, 2008). Consumption-related fishing is prohibited within the game reserve. Consequently, local communities continued to depend on agriculture for food. Similarly, Ngorima villagers consider themselves opponents of the park because soldiers and riot police are frequently employed to control them (Kachena & Spiegel, 2023).



Figure 4: Illegal kills of wild animals and tree-cutting
Source: John, 2021b

4.2 Strategies for managing human wildlife conflicts

Traditional methods of preventing human-wildlife conflicts in the communities around Selous Game Reserve in Rufiji district, such as using fire and noise to chase wildlife, have proven ineffective due to the nature of the reserve and the abundance of species. These tactics are not only temporary, but also insufficient in dealing with complex and dangerous animals like as elephants, wild dogs, and lions, which have learnt to disregard such noises. Furthermore, the increase of human activities such as farming and habitation near buffer zones around the reserve has increased tensions, causing traditional local traditions to fail to address the complex dynamics of human-wildlife conflict.

4.2.1 Traditional approaches

Prior to the establishment of a WMA in the neighbourhood of the game reserve, traditional practices were reported as methods for controlling wildlife attacks. Farmers use various methods to protect their crops from elephants, including guarding, chasing, live fencing, and traps. Local communities in the villages under study have utilised containers, drums, and empty cans to produce noise, as well as flashlights, oils, and tree ashes. Local communities learn these techniques from their ancestors, and during the focus group discussion, they reported that the WWF also attempted to teach them how to use oils, tree ashes, and ropes to surround the farm and chase away elephants. However, these techniques are antiquated and local, and they are no longer applicable because they were utilised in the past. As a result, these methods no longer frighten elephants.

4.2.2 Chasing elephants

The interview with the government officials disclosed that game rangers and village game scouts use the humane method of moving elephants without harm back to the game reserve. To try to control elephants in the study area, local

communities have shifted from cultivating food crops such as maize and sorghum to cultivating cash crops such as sesame and cashew nuts that are difficult to be destroyed by elephants. Sesame can be destroyed by elephants when they step on the farms because elephants do not eat sesame.

4.2.3 Economic incentive

The government uses economic incentives to persuade local communities to support and participate in animal conservation initiatives. Communities may be more likely to cherish and maintain wildlife habitats if they are offered financial incentives, such as revenues from eco-tourism or sustainable hunting. The income-sharing approach is also utilised to ensure that local community's benefit from the wildlife. According to an interview with villagers, few people work in lodges or hotels. Because of their unskilled employment, they are hired as guards, cleaners, drivers and gardeners.

4.2.4 Land use planning

Efficient land use planning involves the formulation and implementation of zoning regulations that achieve a harmonious stability between the preservation of wildlife and the expansion of agricultural and settlements areas. This may involve the establishment of buffer zones around protected areas and the designation of corridors for wildlife to safely traverse through landscapes dominated by human activity. Incorporating local people into strategic land use planning can potentially mitigate conflicts by proactively discouraging settlement in critical wildlife corridors.

4.2.5 Awareness creation

The interview, held at the WWF office and Frankfurt Zoological Society (FZS) in Dar es Salaam, revealed the need of educating communities about the benefits of animal conservation and the potential risks associated with human-wildlife conflicts. Implementing awareness campaigns can successfully modify attitudes and behaviours towards wildlife, fostering the establishment of harmonious coexistence by enhancing public knowledge through various means such as community workshops, educational efforts in schools, and media campaigns. Local leaders are actively involved in outreach efforts to ensure that messages are culturally appropriate and widely accepted.

Effective human-wildlife conflict resolution requires a many-sided approach that incorporates ecological, social, and economic considerations. Wildlife corridors are one of the most important techniques, as they facilitate safe animal migration while reducing contacts with human populations. Early warning systems and barrier methods, such as fencing or natural deterrents, can be employed to keep wildlife away of agricultural and human areas. Community engagement is vital; educating and involving local populations in animal conservation operations ensures that they understand the importance of biodiversity and are prepared to coexist with wildlife in a sustainable manner. Compensation systems for

wildlife-related losses can reduce economic pressures and boost community support for conservation efforts. However, the consolation supplied is not the same as compensation. Furthermore, using technology, such as GPS tracking for wildlife and AI-powered monitoring systems (Casazza *et al.*, 2023), can provide real-time data to help avoid potential conflicts.

5.0 DISCUSSION

Human-wildlife interactions and conflicts are common in different parts of the world. Though, damage to cultivated crops is a serious concern near protected areas (Naidoo *et al.*, 2019; Mekonen, 2020; Oduor, 2020; Gayo *et al.*, 2021; Montero-Botey *et al.*, 2021; Nchanji *et al.*, 2023). Elephants are one of the most dangerous animals that are very difficult to chase and control, so elephants and humans are always in potential conflicts over crops. Research conducted in and around the study area near Selous Game Reserve found that elephants, wild pigs, warthogs, and monkeys were identified as destructive animals, mainly feeding commonly on maize, sorghum, cassava, and vegetables. In the Maasai Mara ecosystem in Kenya, where human-wildlife conflicts have increased and led to the damage of food crops and human injury, a similar finding was observed in the recent study (Oduor, 2020). According to a study conducted at Cameroon's Campo Maan National Park, park wildlife regularly destroyed local farmers' crops without compensation (Nchanji *et al.*, 2023).

Politically, human activities are going on in Selous Game Reserve, and especially infrastructure development that could be among the reasons for wild animals moving to the nearby villages for water and food in the dry season. Also, Snyman (2012), Matema & Andersson (2015), Amaja *et al.*, (2016), and Frank (2016) noted that wild Animals within protected areas roamed freely outside park borders destroying crops and killing livestock and people in the villages. Other researchers argued that the increasing population of wildlife due to the current conservation efforts had stimulated human-wildlife conflicts, which occur when wild animals, especially elephants, threaten or kill people, damage crops, injure or kill domestic animals (Hahn *et al.*, 2017; Kiondo *et al.*, 2019; Stoldt *et al.*, 2020; Kiffner *et al.*, 2020).

The analysis of in-depth interviews, FGDs, surveys, and observation supports the view that local livelihoods are generally controlled by challenges of increasing wildlife in the villages, which causes human-wildlife conflicts, killings, injuries, and damage to crops. However, the survey's investigation revealed that agricultural activities are still the main livelihood activities for local communities in the Rufiji District. Also, Msuya *et al.*, (2018) reported that more than 70% of the local communities in Tanzania still depend on farming for their livelihoods. But other scholars argue that compared with the benefit attained from agricultural production, the income received from wildlife-related businesses in most communities living adjacent to protected areas is an added advantage (Mutanga *et al.*, 2017).

The government in East Africa is not well-equipped to deal with conflicts between humans and wildlife because it has failed to provide compensation for agricultural damage and injuries. For instance, according to a study on Kenya's protected areas by Van Wijk *et al.*, (2015), the incentives created through tourism businesses were intended to compensate for the costs of living with wildlife because government agencies were unprepared to handle compensation for damages caused by human-wildlife conflict. In addition, the article investigates how the challenges of co-existence could be employed to improve human-wildlife interactions in the global south. As a result, coexistence is expected to strengthen relationships between local communities living near protected areas and game reserve officials while concurrently regulating human-wildlife interactions.

The current study has adopted a recommended framework that provides a fresh and complete method to analysing and conducting environmental conservation programs. The notion comprises a holistic viewpoint that seeks to address the fundamental ecological, social, political, and economic challenges faced by both human populations and wildlife within protected areas at a worldwide level. The integration of indigenous knowledge into wildlife management practices, both within and beyond protected areas, will facilitate the accomplishment of this objective. Furthermore, it is imperative to engage local communities in the decision-making process in order to establish community-based conservation objectives (Ochieng *et al.*, 2023).

6.0 CONCLUSION AND RECOMMENDATIONS

This study on human-animal interactions in the Selous Game Reserve illustrates how complicated and nuanced conflicts between local inhabitants and wildlife in Rufiji District are. Integrating empirical data with theoretical frameworks such as political ecology provides a key perspective for understanding these interactions. The study emphasises the need for management techniques that go beyond technical fixes, focussing on social and environmental justice, eco-sustainable governance, and fair economic development all within the framework of sustainability. It challenges established conservation paradigms that frequently ignore local perspectives by stressing how population increase and restrictive policies exacerbate conflicts, emphasising the significance of incorporating traditional knowledge and community voices into policy-making processes.

Culturally sensitive and environmentally adequate policies are critical for sustaining coexistence because they acknowledge the interdependence of social and ecological systems. Furthermore, harnessing current technologies can help improve the creation and implementation of conflict resolution solutions, improving resilience in both ecological and social domains. By critically engaging with co-existence, this study proposes for a move towards more inclusive and participatory management regimes that recognise power

imbalances and prioritise co-creation of solutions. Overall, this study contributes to conservation discussions by showing how incorporating indigenous knowledge and emphasising social justice can challenge and enrich prevailing narratives, resulting in more sustainable and equitable conservation outcomes in the Selous and Rufiji Districts.

6.1 Financial Disclosures

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6.2 Declaration of Conflict of Interest

The author declares no conflict of interest

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