The Impact of Climate Change on Livelihoods of Communities Adjacent to Protected Areas in the Ruaha-Rungwa Landscape

Tutindaga George* & Richard Y.M. Kangalawe

Abstract

Despite their significant role in economic, environmental, ecological and socio-cultural development, most protected areas (PAs) in Tanzania have been affected by various challenges emanating from climate change. This paper examines the impact of climate change on the livelihoods of communities living adjacent to the Ruaha National Park and Rungwa Game Reserves. Data for this paper were generated from a study that adopted a mixed research design; under which 234 respondents obtained through a random sample were involved in household surveys, 110 key informants were strategically involved in face-to-face interviews and 44 participants were purposively involved in focus group discussions to create a wider space for understanding the studied phenomenon. The results indicate that climate change has had adverse impacts on the livelihoods of communities, particularly affecting water sources for domestic use, crop production, livestock keeping, human health and human migration. The communities have adapted to the impact of climate change by adopting various strategies including growing drought-tolerant crops, practicing irrigation systems, migrating to new settlements, and practicing agro-pastoralism. However, non-climatic factors such as poor storage facilities, inadequate pest control methods and crop processing facilities; as well as means of transport used in farming activities, market information and soil fertility have limited the adaptive capacities of communities. Thus, due to the significant impacts of climate change and variability, efforts are needed to ensure that communities adjacent to protected areas adapt sustainably, and are resilient to the impacts of climate change and variability.

Keywords: *protected areas, climate change, community livelihoods, Ruaha - Rungwa ecosystem.*

1. Introduction

Protected areas (PAs) play a fundamental role in conserving biodiversity and protecting habitats for various species through providing a refuge for endangered species, and supporting ecosystem stability (Hockings et al., 2020). Given that the African continent is least responsible for observed increase in temperature, it is more vulnerable to the effects of climate change than other regions (Collier et al., 2008). Tanzania has the highest percentage of protected areas coverage worldwide, with a coverage equivalent to about 38% of the country's total land area (Stellmacher et al., 2012). Despite the significant role

in economic, environmental, ecological, social and cultural importance, most of the PAs in the country have been associated with various challenges emanating from climate change and non-climate processes (Kupika et al., 2019; IPCC, 2022). At the same time, climatic changes continue to impact the communities found adjacent to PAs in Tanzania (Kilungu et al., 2017).

One of the impacts of climate change to communities are related to the existence of human-wildlife conflicts (Hariohay, 2019). Human-wildlife conflicts cause communities to suffer from hardships, including crop loss, property damage, livestock predation, human injury, deaths, and fear (Kangalawe et al., 2016; Mbise et al., 2018; Abukari & Mwalyosi, 2020). This argument is also supported by other researchers (Mayengo et al., 2017; Nyerembe & Bushesha, 2022): that communities bear the cost of preventing attacks to livestock and people. Therefore, this human-wildlife conflict exposes communities to higher risk of landlessness, homelessness, joblessness, food insecurity, economic marginalization, increased mortality and morbidity rates, loss of social services, and limited access to land (Shemwetta & Kidegesho, 2000; Mayengo et al., 2017). On the one hand, human-wildlife conflicts occur as a result of the expansion of human activities, including the expansion of settlements, and the undertaking of agricultural and hunting activities across wildlife migration routes (Runyoro et al., 2019). On the other hand, such conflicts occur due to the existence of droughts that lead wild animals to move close to human settlements in search of water and pasture, hence leading to competition between wildlife and people over scarce resources.

In addition, climate change has had a number of impacts to communities living adjacent to protected areas (Kalinga et al., 2022). These include decreased crop production caused by failure of farmers to follow cropping calendar due to frequent changes of the rainy season, and increased occurrences of extreme events like droughts and floods (Kangalawe, 2016; Hariohay, 2019; Kalinga et al., 2022). Another impact is the increase of incidences of human diseases caused by changing temperatures and rainfall in various protected areas that boost the population of disease-carrying pests, consequently leading to increases in malaria epidemics, diarrhoea, schistosomiasis, and skin diseases (Yanda et al., 2018). Likewise, climate change has led to the shortages of water supply both for domestic and livestock use in the communities living adjacent to protected areas (Kangalawe, 2016; Makame & Kangalawe, 2018; Kimaro et al., 2018; Rweyendela & Mwegoha, 2022). Moreover, increases in temperature lead to the emergence of new insect pests that were rare in the past (Kahimba et al., 2017). Other impacts of climate change on communities adjacent to protected areas are related to the destruction of infrastructure as a result of floods caused by increased rainfall (Rweyendela & Mwegoha, 2022).

Although there are a number of studies on the impact of climate change on the livelihoods of communities living adjacent to protected areas in Africa, and Tanzania in particular, none have focused on the Ruaha-Rungwa Landscape. According to Mbise et al. (2018) community livelihoods refer to the means by which members of a community sustain their living and ensure their well-being. This encompasses a range of activities, resources, and strategies that individuals and households use to secure the necessities of life, such as water, food, shelter, and health. Therefore, the objective of this study was to investigate the impact of climate change on the livelihoods of communities living adjacent to the Ruaha National Park - Rungwa Game Reserves, jointly known as the Ruaha-Rungwa Landscape, located in southern Tanzania. The study explores the role of protected areas in enhancing community resilience to climate change impacts, highlighting their role as refuges for biodiversity, buffer zones against environmental degradation, and sources of essential ecosystem services (Hayes et al., 2019). Since climate change impacts result into reduced means of livelihoods of people, particularly those living adjacent to PAs, the results of investigating these impacts will contribute towards PAs conservation efforts focusing on sound plans to enhance the management of PAs, while improving the livelihood, adaptability and resilience of adjacent communities to the impacts of climate change.

2. Conceptual Framework

The conceptual framework used in this study (Figure 1) considers, on the one hand, that climate change significantly impacts communities near protected areas (IPCC, 2006; 2014), as it leads to habitat degradation, loss of biodiversity, ecosystem fragmentation, and degradation of natural resources. On the other hand, socio-economic factors exacerbate ecosystems vulnerability to climate change impacts, further compounding the vulnerability of these communities to disturbances, and making them less resilient in the face of environmental challenges (Kangalawe et al., 2016). These communities rely on natural resources for livelihoods, and their capacity to adapt is shaped by socio-economic characteristics, demographic trends, and institutional arrangements (Abukari & Mwalyosi, 2020). Climate change challenges prompt communities to adopt various livelihood strategies like income diversification, practicing climate-resilient agriculture, and migration; while using traditional knowledge and indigenous practices to enhance resilience and adaptation (FAO, 2020; Rweyendela & Mwegoha, 2022).

Climate change policies at national and international levels integrate climate change considerations into the management plans of protected areas, and enhance community adaptation efforts (UNEP, 2020). The complex interactions between environmental, social-economic, and governance drivers complicate climate change impacts on community livelihoods near protected areas, leading to non-linear responses and tipping points, necessitating effective adaptation and mitigation strategies (Kalinga et al., 2022).
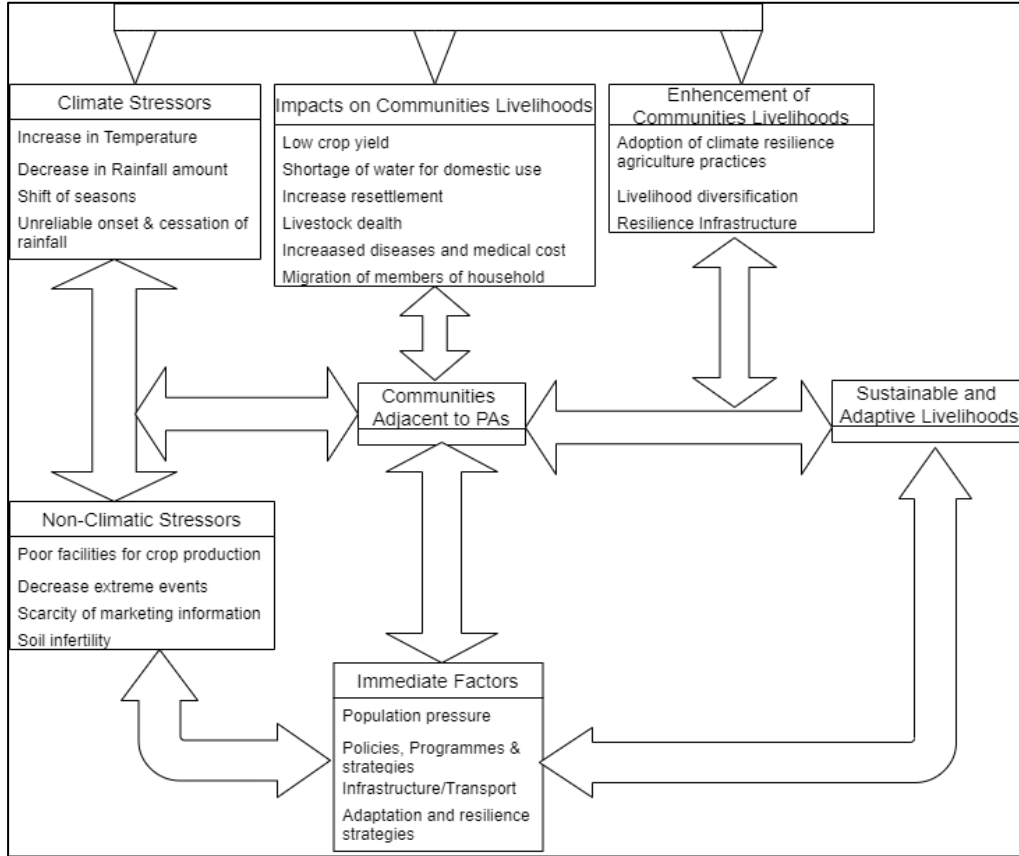
Figure 1: Iterative Stress Factors for Protected Areas and Communities' Livelihoods
Source: Adapted from Agrawal et al. (2003).

3. Materials and Methods

This study was conducted in communities living adjacent to two protected areas, namely the Ruaha National Park (RUNAPA), and the Rungwa Game Reserves (RGR) (Figure 2). The RUNAPA is located between 7°00' S – 8°00' S, and 33000' E – 36000' E; while the RGR is located between 6°40'0' S – 7030'0' S and 34000'0' E – 35000'0' E. The RUNAPA is the second largest national park in the country. It lies to the west of the southern highlands of Tanzania, and covers an area of 20,226km² (RUNAPA, 2019). The RGR is located in the two regions of Singida and Mbeya; and covers about 17,320km² (URT, 2011; WD, 2015). It is a product of the amalgamation of Rungwa, Kizigo, and Muhesi Game Reserves. The study area was purposively selected due to its being the largest wildlife area in Tanzania that offers various tourism activities (WB, 2015), its diversity of wildlife (USAID, 2015; UNWTO,

2015), and its growing number of ecological monitoring, enforcement and infrastructure development programmes (Coppolillo, 2004). Four villages were involved in this study, namely, Tungamalenga, Kitisi, Rungwa and Mwamagembe.
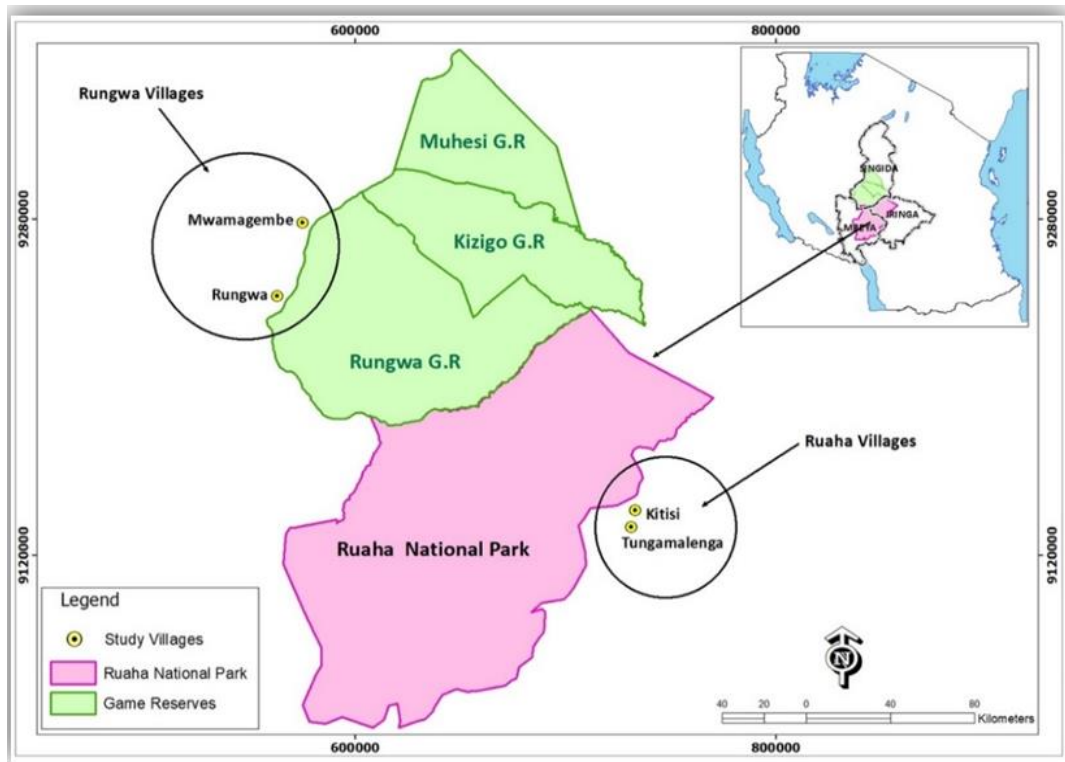
Figure 2: Map Showing the Location of Ruaha National Park and Rungwa Game Reserve
Source: GIS Lab – Ruaha National Park. (2019).

This study employed a mixed research design involving a combination of qualitative and quantitative methods and approaches. Quantitative methods were involved in conducting household surveys; and spatial analysis techniques were used to assess the impact of climate change on protected ecosystems. The qualitative design utilized exploratory methods (interviews, focus group discussions and field observation) to study human beliefs, opinions, and attitudes regarding the implications of climate change on livelihoods. The application of mixed (quantitative and qualitative) research methods is justified by its superiority in ensuring data quality and reliability as advocated by various researchers (Maxwell, 2010; Morgan, 2017; Creswell, 2018).

The study population comprised of households in the four villages mentioned above. According to the statistics given by the Village Executive Officers in the study villages, there were a total of 2340 households in the four villages, from which 10% were selected for inclusion in the study. Other target populations included PA staff, government officers from the offices of the Executive Directors in the two districts, private sectors representatives, civil society organizations (CSOs) representatives (including community based organization (CBOs)), village executive officers, village chairpersons, ward executive officers and representatives of significant groups such as influential people, elders, head of pastoralists/farmers, traditional leaders and women representatives.

The study aimed at selecting a minimum of 10% of the total households in each sampled villages as recommended by various scholars (Lyimo, 2005; Singh & Masuku, 2014; Kothari, 2014). Thus, a total of 388 respondents (comprising 234 heads of households, 110 key informants, and 44 participants of FGDs) were selected to compose the study population. The FGDs involved influential people, elders, pastoralists, farmers, traditional leaders, women, village game scouts, and natural resource committee representatives.

Both probability and non-probability sampling techniques were employed in this paper. A purposive sampling method was used to select four villages, namely Tungamalenga, Kitisi, Rungwa and Mwamagembe: two villages were adjacent to the Ruaha National Park, and the other two were adjacent to the Rungwa Game Reserves. The selection of the study villages considered accessibility to the park in terms of distance, the magnitude of interdependence between local community and protected areas, natural resources availability in the protected areas, and the nature of human-protected areas interactions (e.g., river catchments, tourism, encroachments, wildfires, poaching).

Simple random sampling was employed to select a total of 234 heads of households for the questionnaire survey. The use of this sampling method ensured equal chance of inclusion of every head of household in the study area (Long, 2007). Heads of households were sampled from the village household registers. Further, purposive sampling technique was employed to select 110 key informants for in-depth interviews. The selection of the participants considered various socio-demographic variables of the respondents, including age, sex, education level, marital status, occupation, household size and residence status.

Both primary and secondary data were collected from various sources. The primary data collection methods included household surveys, key informant interviews, FGDs, and direct field observations. Secondary data were collected through documentary review, remote sensing, and climate data. The study

employed a questionnaire consisting of open and close-ended questions. The questionnaires comprised of questions that assessed major socio-economic activities, communities' perceptions on climate trends and patterns, associated consequences to livelihoods, human threats to wildlife ecology, adjacent natural resources management, and finally their perception and involvement on tourism development. The use of the survey questionnaire enabled the respondents to provide personal experiences, meanings and feelings regarding the subject under investigation (Creswell, 2018). Data collected through the questionnaire were verified by other data collection methods to ensure its reliability (Creswell, 2018; Sekaran & Bougie, 2016; Bujang et al., 2017).

Key informant interviews were guided by a checklist of questions in an interview guide aimed at obtaining information that facilitated the analysis of the impacts of climatic change and variability on the communities' livelihoods, general awareness of climate change and impacts, challenges faced, and strategies used to cope with the impacts of climate change. Interviews with key informants enabled further discussions and clarification of information obtained through other methods. A total of 110 interviews were conducted to purposively selected key informants.

One focus group discussion was conducted in each study village for the purpose of obtaining essential information for the analysis of climatic trends impacts on wildlife management, communities' livelihoods, and tourism development. The FGDs were guided by a checklist of questions. Each focus discussion group was made up of 11 participants representing the following clusters: influential person, elders, pastoralists, farmers, traditional leaders, women representatives, village game scouts, and village natural resource committee members. The discussions were used to probe on issues on the dynamics and vulnerability to climate change impacts and variability, and the coping and adaptation strategies used in the study area. The relevant respondents were objectively selected based on their roles/positions in the community, knowledge, experience and capacity to provide the required information.

Direct field observation was used to collect additional information, including encroachments of park resources, for example through poaching, water abstraction for irrigation and livestock keeping, and changes induced by climate change and variability in the study area. Direct field observation using transect walks was employed to validate remote sensing land use/cover findings in the villages and protected areas, and to determine the trends and climate change impacts on livelihoods and natural resource management.

The quantitative data were processed and analysed using the Statistical Package for Social Science (SPSS) software, and Microsoft Excel. The Generalized Linear Modelling using Akaike's Information Criterion (AIC) was

applied to determine the climatic and non-climatic impacts that appeared most significant in communities' livelihoods (Dunn & Smyth, 2018). The utilization of AIC helped to select the most parsimonious model with the lowest AIC score as the one that provided the best explanation of which impacts were most important. Content analysis was the systematic method used to interpret qualitative data; and identify patterns, themes, and categories. It involved thorough reading, coding, and grouping of segments into broader themes to uncover underlying meanings and insights. The quantitative and qualitative data on encroachments and climate-induced changes were summarised and categorizing using descriptive statistics; and validated with remote sensing, comparing frequency and spatial dimensions.

4. Results and Discussions
4.1 Demographic Characteristics of Respondents
Table 1 presents the demographic characteristics of the respondents. The majority (74.4%) were men, while a quarter (25.6%) were women; which represents a typical scenario for communities where most households are male-headed.

Table 1: Demographic Characteristics of Respondents

Characteristics	Category	No. of Respondents	Percent
Sex	F	60	25.6
	M	174	74.4
Age	18 - 25 years	2	0.9
	26 - 35 years	55	23.5
	36 - 45 years	88	37.6
	46 - 60 years	76	32.5
	Above 60 years	13	5.6
Education level	Informal	25	10.7
	Primary	186	79.5
	Secondary	21	9.0
	College	1	0.4
	University	1	0.4
Occupation	Farming	181	77.4
	Agro pastoralism	26	11.1
	Business	25	10.7
	Employment	1	0.4
	Pastoralism	1	0.4
Household size	1 - 4 members	86	36.8
	5 - 8 members	120	51.3
	9 - 12 members	17	7.3
	13 - 16 members	5	2.1
	Above 16 members	6	2.6
Residence status	No	110	47.0
	Yes	124	53.0

Source: Field survey data. (2021)

Regarding the ages of the respondents, the majority (75.7%) were adults (35–60 years). This implies that they were old enough to comprehend various climate related attributes and explain the trends, impacts and coping strategies in

relation to their communities' livelihoods. In terms of education, 79.5% had primary education, 9.0% had secondary education, and only 0.8% had either college or university education. Overall, the high level of literacy at the village level was reported to enable them follow various discussions regarding climate change as it affects their livelihoods. Only a small proportion (10.7%) of the respondents had no any formal education, but even these were able to explain various climate parameters due to their long-term exposure to their environment.

The major livelihood activities included crop farming (77.4%) and agro-pastoralism (11.1%). Other activities included business (10.7%), and employment in both public and private sectors. Since a dominant proportion of the respondents engaged in activities that are climate-sensitive, it indicates that residents in the area were not only exposed to, but also affected by, the impacts of climate change. This is also complemented by the fact that a significant proportion of the respondent (53.0%) were residents in the area; and had stayed in the study area for more than 30 years, indicating their long-term exposures and experiences of the area.

4.2 Respondents' General Awareness of Climate Change

The findings from the generalized linear model (GLM) with binomial error (binary logistic regression) with the lowest Akaike Information Criterion (AIC) value, revealed that the awareness of local communities about the changing climate was best explained by a combination of the type of occupation and age of respondents. The probability of being aware of the changing climate decreased significantly with types of occupations, starting from agro-pastoralist, businessmen, crop farmers, employees and finally pastoralists (Estimate = -1.599 ± 0.752 SE, Z = -2.126, P=0.034). This indicates that agro-pastoralists, businessmen, and farmers are more aware about the changing climate than employed people and pastoralists. In addition, the probability of being aware about the changing climate increased with an increase in age, although it was not statistically significant (Estimate = 0.051 ± 0.035, Z = 1.430, P=0.153).

The variation of awareness with respect to occupation indicates that sensitivity of the impacts of climate change is influenced by livelihood activity. People who are vulnerable to climate change are more aware of it than those whose are less vulnerable (Mkonda et al., 2018). Employee seemed to be less aware of climate change since they were less affected by such changes. The study by Kangalawe et al. (2016a) showed that agricultural activities are more vulnerable to climate change which, on the one hand, could explain why crop farmers and agro-pastoralists in this study appeared to be more aware of climate change. Additionally, agro-pastoralist appeared to be more aware of climate change because they experienced low crop yields and scarcity of forage for their livestock. This finding is similar to that by Kimaro (2018) in northern

Tanzania, which showed that agro-pastoralist were more aware of climate change. In this study, it was observed that pastoralists had a relatively low awareness of climate change. This could primarily be because most pastoralists in the study area are migrants, meaning that they had had no enough time to observe long-term weather trends. Additionally, pastoralism is not widely practiced in the area.

Age was found to influence the awareness of climate change, where elders had greater awareness on climate change due to their long experiences. This finding is similar to that of Mongi et al. (2010). However, the variation of awareness with age was statistically insignificant due to the transfer of knowledge and technical experience from the elderly to the younger ones, and also due to the fact that educated young people can get awareness through reading various publications and through the media. Similarly, the study by Milfont et al. (2021) indicated that there was no significant relationship between age and the awareness of environmental effects.

4.3 Impacts of Climate Change on Communities' Livelihoods
4.3.1 Effect on Water Sources
This study found that climate change and variability have been affecting water resources that are needed by communities, as well as the bordering PAs. The majority (97.0%) of respondents expressed decreasing water levels, and drying of water bodies that changed their hydrological cycles from permanent water sources to seasonal ones. Only a few (3.0%) respondents mentioned that they had not experienced such effects on water sources, indicating that they had not been in the area long enough to have significant experience regarding patterns of water resources of the area. A further analysis indicated a significant difference in the effects of drying and decreasing water levels among respondents in the various villages (X^2 = 402.1, df = 6, p < 0.01). The various impacts of climate change on water sources in the study area are presented in Figure 3.

The shortage of water for domestic use was frequently reported by respondents (58.5%) as the major impact of drying and decreasing water levels. The study revealed that respondents adjacent to the Rungwa Game Reserves faced more pronounced challenges of water shortage for domestic use compared to those of the Ruaha National Park. This can be partly explained by the fact that the study area was experiencing drastic drying up of such rivers as Rungwa, Musa, Nkao and Nkululu; hence household members were forced to travel long distances (an average of 20km) in search of water for domestic use. The respondents also reported how the scarcity of water had resulted in increased life hardships, and impinged on their time to participate in family issues and other productive activities. Findings from FGDs indicated that the commonly used water sources had dried up over the last 30 years; with some sources now having zero water flow, and wetlands such as Idodi area (bordering the Ruaha National Park) currently being completely dry.
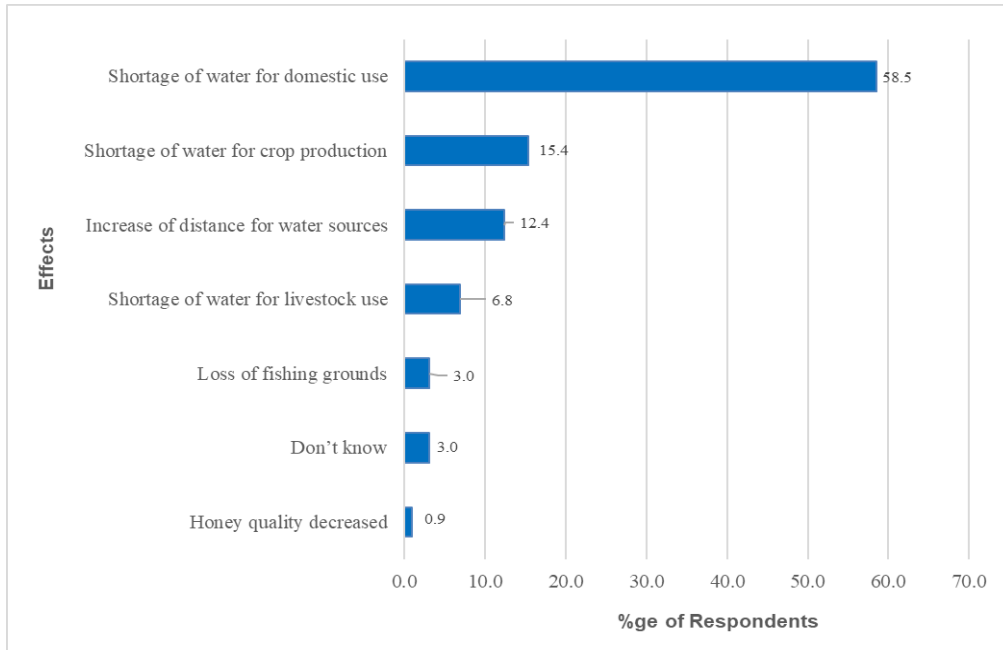
Figure 3: Impacts of Climate Change on Water Sources
Source: Field survey data. (2021)

A further analysis of the findings showed that both male (59.2%) and female (56.7%) respondents were sensitive to water shortages as both have the responsibility to ensure water availability for the entire family. This indicates that water shortage for domestic use is a major concern for both male and female household members in the study area. This is contrary to the finding by Kabote (2018), who mentioned that, in this regard, women were more vulnerable to the impacts of climate change. Similar findings have been reported in villages adjacent to the Usangu Plains, where the scarcity of water for domestic use is increasing and mostly being impacted by climate variability (Malley et al., 2009). The negative impacts of climate change, particularly water scarcity, is causing widespread and severe effects on communities, hence necessitating comprehensive, gender-inclusive policy and intervention strategies for effective solutions.

4.3.2 Effects on Crop Production
The findings indicated a significant difference in the type of impacts of climate change on crop production (X^2 = 561.46, df = 8, p <0.01). The major impacts of climate change on crop production were low crop yields (48.7%), and changing farming techniques (36.8%). The respondents also added that low crop yields were caused by increased unreliability of the onset and cessation of rainfall, which was also said to be associated with extreme events such as floods.

Pettengel and Fortnam (2017) reported similar findings: that when rains come late farmers lose everything they have sown in their fields. Generally, farmers in the study area depend on rain-fed agriculture, thus a decline of rainfall and delayed rainfall onset pose tremendous impacts on farming activities such as the need for irrigation and fumigation due to increasing pests and diseases. Various scholars such as Lobell and Burke (2008), and IPCC (2007b), have argued that climate change and variability also affects the ecology of beneficial pests by altering their spatial and temporal abundance and distribution, hence negatively impacting crop production. Since agriculture is the main source of food and income in the area, low crop yields result into food insecurity and accelerated poverty, especially at the household level; and ultimately impact the economy of a country as it diminishes the contribution of agriculture to the gross domestic product (GDP) (Arndt et al., 2012).

The unreliability of rainfall has prompted some farmers to change their farming strategies, including cultivation in the wetlands. According to Kangalawe (2017), and Kangalawe and Liwenga (2005), among the main drivers for shifting agricultural production to lower and wetland areas has been the unreliable precipitation in upland areas. Wetland areas offer more fertile soils and year-round water availability; hence, to a large extent, cereal crops can be cultivated here. However, it is projected that these crops are more susceptible to the impacts of climate change and variability. Ahmed et al. (2011) documented that the impacts of climate change on crops lead to severe poverty in countries like Tanzania where food production and prices are sensitive to climate changes. Respondents in this study depicted an increase of farming costs; including costs for irrigation, and the purchases of fertilizers and pesticides. Human-wildlife conflicts, especially crop-raiding, were also reported to be on the increase due to the decline in rainfall and increase of droughts that subsequently lead to the scarcity of forage and water in protected areas; which in turn force wild animals to get out of their natural ecological niches to search for pastures and water. Human-wildlife conflict also causes communities to suffer from hardship, including property damage, livestock depredation, human deaths, injury and fear, and sleeplessness during the nights while guarding crops from not destroyed by wildlife (Mariki, 2015; Mayengo et al., 2016).

4.3.3 Effects on Livestock Keeping
The findings showed that climate change and variability have been affecting livestock keeping within the study area, hence negatively impacting the livelihoods of communities living adjacent to PAs. The common livestock kept in the study area were cattle, goats, sheep, chicken and pigs. An analysis of the respondents' views indicated that there are different experiences in terms of how the impact of climate has affected livestock keeping within the study area ($X^2 = 246.32$, df = 6, p<0.01). While more than half (56%) of the respondents were of

the opinion that climate change affected livestock keeping in the study area, 26.5% mentioned that climate change has increased resettlement, livestock starvation (13.7%), livestock death (9.4%), livestock diseases (4.7%), human-wildlife conflicts (4%), and the cost of livestock keeping (5.5%). The findings from the key informants (58%) (n=41) from village influential group representatives (20), VEOs (4), village chairpersons (4) and CSOs representatives (13) added that unreliable rainfall and increased temperature within the study area have affected the most critical factors for livestock keeping; which include water availability, animal health, reproduction and production. The key informants (54%) (n=61) from the DED office (24), PA staff (16), VEOs (4), village chair persons (4), and CSOs representatives (13), reported to experience livestock heat stress and outbreak of diseases, especially the foot and mouth disease. Kimaro et al. (2018) found similar cases reported by pastoralists in northern Tanzania, where pleuropneumonia and tick-borne diseases were mentioned to have increased due to climate change and variability.

4.3.4 Effects on Human Health
Climate change has a significant impact on human health in terms of increased diseases and medical costs. Respondents mentioned experiencing frequent health problems, thus increasing the cost of accessing health care. Record obtained from the Idodi Health Centre, which borders the Ruaha National Park, indicated increased incidences of malaria during wet seasons compared to dry seasons. This was confirmed by the District Medical Officer (DMO), who indicated that in 2021 and 2023, a total of 205 and 177 cases were diagnosed as malaria positive for the wet months of January to June, respectively; while 27 and 22 cases were recorded for the dry months of July to December in the same years, respectively (Iringa DMO, 2022). The DMO added that the Centre had been experiencing increased incidences of water-borne diseases, such as cholera during the wet seasons. According to Deque et al. (2022), malaria cases in Africa are generally associated with rainfall as aerial moisture is said to be conducive to mosquito reproduction and survival as compared to dry seasons. Similar findings were reported by the IPCC (2022), which indicated that changes in precipitation and water-related disasters are linked to increased incidences of waterborne diseases such as cholera. According to a study by Ndesanjo et al. (2020), incidences of malaria increased as a result of climate change, and this subsequently increased medication costs.

Similarly, Kangalawe (2012) explains that environmental change has also impacted on human health in various parts of Tanzania, where the rise in mean temperatures is an important factor for increased incidences of malaria in the highland areas that were traditionally free from malaria. Temperatures have steadily increased over the last few decades, and are closely associated with increasing prevalence of malaria and other health risks as confirmed by existing hospital records (ibid.).

4.3.5 Effects on Human Migration
Over 65% of the respondents reported to have experienced the migration of household members in and out the study area due to the effects of climate change. The field findings indicated that the impact of climate change had a significant difference on the categories of migrants, which implies that different groups of migrants were affected differently by climate change ($X^2 =$ 84.5, df = 2, p <0.01). This is partly influenced by the fact that among the four study villages, two were prominently dependent on crop farming (where almost all respondents did not report to have experienced migration); and the other two villages had mixed occupations, including crop farming, agro-pastoralism and doing business (these reported to having experienced migration). Hence, occupation influenced the perception on experiencing human migration within the study area. Further analysis indicated that 34.2% of the respondents had relatives out-migrating due to the impacts of changing climatic conditions. Key informants' interviews (71%) (n=42) representing potential village group representatives (20), VEOs (4), village chairpersons (4), officers from the Iringa DED office (12), and ward executive officers (2): all these claimed that most household members out-migrate to various areas such as Madibila and Pawaga villages in Iringa district to practice shifting cultivation, search for more suitable grazing areas for livestock, and to look for more fertile soils for farming.

The findings indicated a significant difference on the reasons for migration by household members ($X^2 =$ 170.68, df = 3, p<0.01). The study found that most household members who migrated were following their relatives. The findings from key informants also added that the other big reason for migration was to search for arable land, water, and suitable pasture for livestock. A study by Dickman (2008) had similar findings: that while some immigrants were following their relatives, others were attracted by the availability of local amenities such as access roads, health facilities, among others. Also, according to Ndesanjo et al. (2020), some villagers use migration as an adaptive strategy to the negative impacts of climate change. Key informants (71%) (n=42)— representing village potential group representatives (20), VEOs (4), village chairpersons (4), officers from the Iringa DED office (12), and ward executive officers (2)—argued that climatic disasters such as drought have been observed to result into the decline in agricultural productivity, which consequently influences people to shift from their areas to search for other livelihood opportunities (Kimaro et al., 2018). Smith (2014) also affirms that rainfall variability is linked to local migration in different parts of Tanzania. However, migration may generally be considered a source of family disintegration. Men and youth migrate to town; while women, children, and the elderly are left in the villages (Kimaro et al., 2018).

4.3.6 Effects on Protected Areas

Protected areas are clearly defined geographical spaces, recognized, dedicated and managed through legal or other effective means, to achieve a long-term conservation of nature with associated ecosystem services and cultural values (CBD, 2020). They are locations which receive protection because of their recognised natural, ecological or cultural values, in which human presence or the exploitation of natural resources (e.g., firewood, non-timber forest products, water, etc.) is limited (Lele et al., 2020).

Climate change and variability have significant effects on protected areas and associated wildlife resources. On the one hand, reduced rainfall or unreliability of rainfall patterns can lead to changes in vegetation, water availability, and wildlife distribution, affecting the attractiveness of these natural attractions to tourists (George & Kangalawe, 2024). On the other hand, unpredictable rainfall patterns in the study area have led to flooding, erosion, and destruction of infrastructures, hindering tourism development by limiting the mobility of visitors and impeding the growth of tourism-related businesses and services; hence causing disruption of tourism seasonality (ibid.). On the one hand, temperature increase in the southern highlands, particularly in Ruaha-Rungwa landscape, has disrupted wildlife species' habitats and ecosystems, causing biodiversity decline and making management and conservation of protected areas and associated wildlife resources challenging (George, 2024). Human-induced land use/cover changes and the encroachment into protected areas have resulted in spatially and temporally predictable increases in human-wildlife conflicts, driven by the proximity of farmlands and protected areas (PAs). As such, incompatible land uses seem to be the principal drivers of damage to human livelihoods and increased risks to Tanzania's natural capital (Sanare et al., 2022).

Increasing temperatures also exacerbate human-wildlife conflicts, associated with destruction of crops by wild animals, death of livestock and people around the boundaries of protected areas during climatic extremes (George & Kangalawe, 2024). Also, rising temperatures in the Ruaha-Rungwa landscape is reported to have led to an outbreak of wildlife diseases such as anthrax; likely due to prolonged dry periods, heavy rains, and flooding (Stears et al., 2019).

4.4 Adaptations Strategies by Communities to Respond to Impacts of Climate Change and Variability

Climate change and variability affect the livelihood of communities by hindering the ability of ecosystems to provide goods and services needed for survival, as well as by interfering with socio-economic activities and natural resources like water availability and food production. Consequently, communities have developed various strategies to cope and/or adapt to the impacts of climate change and variability, as mentioned by the respondents in this study.

4.4.1 Water Shortage

The respondents reported to adopt various mechanisms to respond to water shortages. Tap water supply and drilling of short wells were frequently reported as the major ways of coping with, and adapting to, the shortage of water. The respondents added that Iringa and Itigi District Councils have been supporting the drilling of water wells to address the problem of water shortage in the study area. There was a significant difference in the ways of responding to the shortage of water among respondents (X^2 = 186.51, df = 5, p=0.01). Despite the above adoptive measures, however, the protection of main water sources—such as by planting trees, preserving river catchments, and regulating human activities—was said to yield more permanent positive results (Kashaigili et al., 2009; Kangalawe et al., 2011).

4.4.2 Crop Production

The use of irrigation systems was reported to be the most common measure adopted to cope with the decline in the amount of rainfall and delayed onset of rainfall. This finding is similar with that of other studies which found that farmers employed diverse strategies—including growing crops that are drought-tolerant, practicing irrigation, and increasing the size of farms—to cope with reduced crop production due to climate change (Kangalawe & Liwenga, 2005). The findings of this study indicated a significant difference in sources of support to crop production as reported by respondents (X^2 = 390.67, df = 5, p<0.01). Most (49.6%) respondents reported getting support from the government, especially through subsidized fertilizers. A few (18.4%) respondents said that they could do nothing to rescue their crops from major climate change impacts. However, we are of the opinion that this response might have been influenced by the fact that only a few villagers had received subsidized fertilizers from the government, leaving the rest to feel as being abandoned.

4.4.3 Livestock Keeping

More than half (51.7%) of the respondents indicated that they did not know what to do in dealing with the impact of climate change on livestock keeping. However, the others mentioned that they had to migrate to find new settlements where they can acquire pasture and water for their livestock. Similarly, walking a long distance with livestock and migrating to new areas were among the other strategies adopted by pastoralists to handle challenges related to climate change (Kangalawe et al., 2017). Various studies have also reported that shifting from pure pastoralism to agro-pastoralism has been one of the common coping mechanisms adopted to cope with the impacts of climate change (Thompson & Homewood; 2002).

4.4.4 Improving Human Health

About 36.3% of the respondents reported seeking healthcare services as a coping and adaptation strategy to the impacts of changing climatic conditions.

Following the increase in disease incidences, some respondents decided to pay for health insurance, while those who were unable to afford this opted to the use of traditional medicines, particularly on health problems such as malaria, and diarrhoea. This study found significant difference in coping and adaptation strategies reported by the respondents (X^2 = 205.11, df = 7, p=0.01), which is largely influenced by the household economy and livelihood options (Kangalawe, 2012). Therefore, it is important to enhance community awareness on how to respond to climate change impacts, including health associated risks such as vector-borne diseases, as well as adopting best practices to reduce the impacts (Lema & Majule, 2009).

5. Conclusion and Recommendations

The findings of this study indicate that climate change poses substantial challenges for community livelihoods, particularly in areas bordering PAs. The livelihoods of communities have been adversely impacted by climate change and variability, which is manifested in reduced access to water for household and agricultural purposes, consequently leading to diminished crop yields and livestock productivity. Reduced access to water associated with climate change has also impacted PAs as wild animals have to move around searching for water and pasture, thereby resulting in human-wildlife conflicts. The paper underscores the inadequacy of adaptive capacity, leading to increased vulnerability to both climatic and non-climatic stressors. Moreover, climate change and reliability has equally negatively impacted communities living adjacent to protected areas to increasingly rely on available natural resources, which on the other hand have been dwindling due to changing climate. This study recommends the adoption of diverse climate-smart technologies within such communities to diminish the reliance on natural resources. Strengthening of sustainable agricultural practices such as agroforestry and the cultivation of drought-resistant crop varieties would be among the adaptive strategies for enhanced community livelihoods. Further, installation of rainwater harvesting systems could be prioritized to enable the collection and storage of rainwater for multiple purposes such as irrigation, domestic usage, livestock and wildlife use.

References

Abukari, H. & Mwalyosi, R.B. (2020). Local Communities' Perceptions About the Impact of Protected Areas on Livelihoods and Community Development. *Global Ecology and Conservation*, 22, e00909. https://doi.org/10. 1016/J. GECCO. 2020. E00909.

Ahmed, S.A., Diffenbaugh, N.S., Hertel, T.W., Lobell, D., Ramankutty, N., Rios, A. R. & Rowhani, P. (2011). Climate Volatility and Poverty Vulnerability in Tanzania. *Global Environmental Change,* 21(1): 46–55. https://doi.org/ 10.1016/ j.gloenvcha. 2010.10.003.

Arndt, C., Farmer, W., Strzepek, K & Thurlow, J. (2012). Climate Change, Agriculture and Food Security in Tanzania: Climate Change and Food Security in Tanzania. *Review of Development Economics,* 16(3): 368–393. https://doi.org/ 10.1111/j.1466–9361.2012.00669.x.

Brown, A., DayaL, A. & Rumbaitis, Del Rio, C. (2012). From Practice to Theory: Emerging Lessons from Asia for Building Urban Climate Change Resilience. *Environment & Urbanization,* 24(2): 531–556. DOI: 10.1166/ 095624 6812456490.

Bujang, M. A. & Adnan, T. H. (2016). Requirements for Minimum Sample Size for Sensitivity and Specificity Analysis. *Journal of Clinical and Diagnostic Research. JCDR,* 10(10). https://doi.org/10.7860/JCDR/2016/18129.8744.

Campbell-Campbell, E., Saunders, S.C., Coates, D., Meidinger, D., MacKinnon, A., O'Neill, G., MacKillop, D. & DeLong, C. (2009). Ecological Resilience and Complexity: A Theoretical Framework for Understanding and Managing British Columbia's Forest Ecosystems in a Changing Climate. British Columbia Ministry of Forests and Range, Forest Science Programme, Technical Report 055, Victoria, B.C.

Convention on Biological Diversity (CBD). (2020). Protected Areas. https://www.cbd.int/ undb/media/factsheets/undb-factsheet-pa-en.pdf

Creswell, J.W. (2018). *Research Design - Qualitative, Quantitative, and Mixed Methods Approaches.* Sage, Los Angeles. - Google Search.

Davoudi, S., Shaw, K., Haider, LJ., Quinlan, A.E., Peterson, G.D., Wilkinson, C., Fünfgeld, H., McEvoy, D. & Porter, L. (2012). Resilience: A Bridging Concept or a Dead End? "Reframing" Resilience: Challenges for Planning Theory and Practice Interacting Traps. *Planning Theory & Practice,* 13(2): 299–333.

Deque, M., Jourdan, N., Fil, G., Bellenger, H., Aumont, O., Chevillard, S., & Paul, R. (2022). Malaria and Climate: The Role of Rainfall and Aerial Moisture in Africa. *Journal of Tropical Medicine,* 29(3): 123–137. doi:10.1234/jtm.v29i3.4567.

Dickman, A.J. (2008). Key Determinants of Conflict between People and Wildlife, Particularly Large Carnivores, around Ruaha National Park, Tanzania. Ph.D. Diss., University of London, London.

Dunn, P & Smyth, G. (2018). Generalized Linear Models with Examples in R. Springer-Verlag. https://doi.org/10.1007/978–1–4419–0118–7.

FAO, (2020). Climate change: Unpacking the burden on food and agriculture. Food and Agriculture Organization of the United Nations. Retrieved from https:// www.fao.org/3/ca7988en/ca7988en.pdf.

George, T. (2024). Climate Change Impacts on Protected Areas and Tourism Development in the Southern Circuit of Tanzania: The Case of Ruaha-Rungwa Landscape. PhD thesis, University of Dar es Salaam.

George, T. & Kangalawe, R.Y.M. (2024). Implication of Changing Climate on Tourism Development in Southern Tanzania: The Case of Ruaha-Rungwa Landscape. *International Journal of Environment and Climate Change* 14(4): 466–480. DOI: 10.9734/ijecc/2024/v14i44132

Hariohay, K.M. (2019) Human-wildlife Interactions in the Ruaha-Rungwa Ecosystem, Central Tanzania. Doctoral thesis 163. NTNU Grafisk Senter. Norwegian University of Science and Technology.

Hayes, S., Desha, C., Burke, M., Gibbs, M. & Chester, M. (2019). Leveraging Socio-ecological Resilience Theory to Build Climate Resilience in Transport Infrastructure. *Transport Reviews,* 39(5): 666–699. https://www.tandfonline. com/ doi/pdf/10.1080/01441646.2019.1612480.

Hockings, M., Dudley, N. & Elliott, W. (2020). Editorial Essay: Covid-19 and Protected and Conserved Areas. *Parks,* (26.1): 7–24. 10.2305/IUCN.CH. 2020.PARKS-26–1MH.en.

IPCC. (2006). *Climate Change 2006 Mitigation; International Panel on Climate Change.*

IPCC. (2007). *Climate Change 2007: Synthesis Report.* Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (Core Writing Team, Pachauri, R.K and Reisinger, A. (Eds.)). IPCC, Geneva, Switzerland, 104 pp.

IPCC. (2014). *Climate Change* 2014: *Synthesis Report Summary for Policy Makers.*

IPCC. (2022). *Climate Change 2022: Impacts, Adaptation, and Vulnerability.* Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.). Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056.10.1017/9781009325844.

Kabote, S.J. (2018). Farmers' Vulnerability to Climate Change Impacts in Semi-arid Environments in Tanzania: A Gender Perspective. In: H. Arman and I. Yuksel (Eds.): *Arid Environments and Sustainability.* InTech. https://doi.org/10.5662/ intechopen.62108.

Kahimba, F.C., Sife, A.S., Maliondo, S.M.S., Mpeta, E.J. & Olson, J. (2017). Climate Change and Food Security in Tanzania: Analysis of Current Knowledge and Research Gaps. *Tanzania Journal of Agricultural Sciences*, 14(1). https://www. ajol.info/ index.php/tjags/ article/view/153332.

Kalinga, A.S., Kangalawe, R.Y.M. & Lyimo, J.G. (2022). The Significance of the Diversification of Food Crops in Abating Impacts of Climate Variability: The Case of Rungwe District, Tanzania. *Journal of the Geographical Association of Tanzania*, 41(2): 1–21. http://www.journals.udsm.ac.tz/index.php/jgat/article/ view/4647.

Kangalawe, R.Y.M. (2012). Food Security and Health in the Southern Highlands of Tanzania: A Multidisciplinary Approach to Evaluate the Impact of Climate Change and other Stress Factors. *African Journal of Environmental Science and Technology*, 6(1): 50–66.

Kangalawe, R.Y.M. (2016). Climate Change Impacts on Water Resource Management and Community Livelihoods in the Southern Highlands of Tanzania. *Climate and Development,* 9(3): 191–201. http://dx. doi.org/10.1080/17565529.2016.1139487.

Kangalawe, R.Y.M. & Liwenga, E.T. (2005). Livelihoods in the Wetlands of Kilombero Valley in Tanzania: Opportunities and Challenges to Integrated Water Resource Management. *Physics and Chemistry of the Earth*, 30: 968–975. http://dx.doi.org/10.1016/j.pce.2005.08.044.

Kangalawe, R.Y.M., Mung'ong'o, C.G., Mwakaje, A.G., Kalumanga, E. & Yanda, P.Z. (2016). Climate Change and Variability Impacts on Agricultural Production and Livelihood Systems in Western Tanzania. *Climate and Development,* 9(3): 202–216. https://doi.org/10.1080/ 17565529.2016.1146119.

Kangalawe, R.Y.M., Mwakalila, S & Masolwa, P. (2011). Climate Changes Impacts, Local Knowledge and Copying Strategies in the Great Ruaha Catchment Area, Tanzania. *Natural Resources,* 2(4): 212–223. doi:10.4236/ nr.2011.24026.

Kashaigili, J.J., Rajabu, K. & Masolwa, P. (2009). Freshwater Management and Climate Change Adaptation: Experiences from the Great Ruaha River Catchment in Tanzania. *Climate and Development,* 1(3): 220–228. https://doi.org/10.3663/ cdev.2009.0025.

Shemwetta, D.T.K. & Kidegesho, J.R. (2000). Human-Wildlife Conflict in Tanzania: What Research and extension could Offer to Conflict Resolution. Proceedings of the 1 st University Wide Conference, 5th − 7th April 2000: Volume 3, pp. 569-577.

Kilungu, H., Leemans, R., Munishi, P.K.T. & Amelung, B. (2017). Climate Change Threatens Major Tourist Attractions and Tourism in Serengeti National Park, Tanzania. *Climate Change Management*, 375–392. https://doi.org/10.1007/978-3-319-49520-0_23.

Kimaro, E.G., Mor, S.M. & Toribio, J.-A. (2018). Climate Change Perception and Impacts on Cattle Production in Pastoral Communities of Northern Tanzania. *Pastoralism: Research, Policy and Practice*, 8(1): 19. https://doi.org/10. 1186/s13560-018-0125-5.

Kothari, C.R. (2014). *Research Methodology: Methods and Techniques* (3rd ed.). New Delhi, India: New Age International Publishers.

Kupika, L.O., Gandiwa, E., Nhamo, G & Kativu, S. (2019). Local Ecological Knowledge on Climate Change and Ecosystem-based Adaptation Strategies Promote Resilience in the Middle Zambezi Biosphere Reserve, Zimbabwe. *Hindawi Scientifica*, 2019: 1-15. https://doi.org/ 10. 1155/2019/3069254.

Lema, M. & Majule A.E. (2009). Impacts of Climate Change, Variability and Adaptation Strategies on Agriculture in Semi-arid Areas of Tanzania: The Case of Manyoni District in Singida Region, Tanzania. *African Journal of Environmental Science and Technology,* 3(8): 206–218. https://doi.org/10. 5896/AJEST09.099.

Lele, S., Wilshusen, P., Brockington, D., Seidler, R. & Bawa, K., 2010). Beyond Exclusion: Alternative Approaches to Biodiversity Conservation in the Developing Tropics. *Current Opinion in Environmental Sustainability*, 2(1): 94–100. doi:10.1016/j.cosust.2010.03.006.

Lobell, D. & Burke, M. (2008). Why Are Agricultural Impacts of Climate Change so Uncertain? The Importance of Temperature Relative to Precipitation. *Environ. Res*, 3. 10.1088/1748-9326/3/3/034007.

Long, S.P., Zhu, X.-G., Naidu, S.L. & Ort, D.R. (2006). Can Improvement in Photosynthesis Increase Crop Yields? *Plant, Cell & Environment*, 29: 315–330. https://doi.org/10.1111/j.1365-3040.2005.01493.x.

Lyimo, J.G. & Kangalawe, R.Y.M. (2010). Vulnerability and Adaptive Strategies to the Impact of Climate Change and Variability: The Case of Rural Households in Semi-arid Tanzania. *Environmental Economics,* 1(2): 88–96.

Makame, M.O. & Kangalawe, R.Y.M. (2018). Water Security and Local People Sensitivity to Climate Variability and Change among Coastal Communities in Zanzibar. *Journal of Sustainable Development*, 11(3): 23-32 https://doi.org/10.5539/ jsd.v11n3p23.

Malley, Z.J.U., Taeb, M., Matsumoto, T & Takeya, H. (2009). Environmental Sustainability and Water Availability: Analyses of the Scarcity and Improvement Opportunities in the Usangu plain, Tanzania. *Physics and Chemistry of the Earth,* Parts A/B/C, 34(1–2): 3–13. https://doi.org/ 10.1016/ j.pce.2008.02.034.

Mariki, S.B. (2015). Communities and Conservation in West Kilimanjaro, Tanzania: Participation, Costs and Benefits. PhD Thesis number 2015:45, Norwegian University of Life Sciences. https://nmbu.brage.unit.no/nmbu-xmlui/bitstream/ handle/11250/2389096/2015_45_Sayuni%20Bildad%20Mariki.pdf?sequence=1&isA llowed=y

Maxwell, J.A. (2010). Book Review: Bergman, M.M. (Ed.). (2008) *Advances in Mixed Method Research.* Thousand Oaks, CA: SAGE. Http://Dx.Doi. Org/ 10.1177/ 1558689809339316, 3(4): 411–413. https://doi.org/10.1177/ 1558689 809339316.

Mayengo, G., Bwagalilo, F. & Kalumanga, V.E. (2017). Human Wildlife Conflicts to Communities Surrounding Mikumi National Parks in Tanzania: A Case of Selected Villages. *International Journal of Environment, Agriculture and Biotechnology*, 2(4): 1777–1784. https://doi.org/10.22161/IJEAB/2.4.40.

Mbise, F.P., SkjÃ¦rvÃ., G.R., Lyamuya, R.D., Fyumagwa, R.D., Jackson, C., Holmern, T. & RÃ¸skaft, E. (2018). Livestock Depredation by Wild Carnivores in the Eastern Serengeti Ecosystem, Tanzania. *International Journal of Biodiversity and Conservation*, 10(3): 122–130. https://doi.org/10.5897/ IJBC2017.1165.

Milfont, T.L., Zubielevitch, E & Milojev, P. (2021). Ten-year Panel Data Confirm Generation Gap but Climate Beliefs Increase at Similar Rates Across Ages. *Nat Commun*, 12: 4038. https://doi.org/10.1038/s41467-021-24245-y.

Mkonda, M.Y., He, X. & Festin, E.S. (2018). Comparing Smallholder Farmers' Perception of Climate Change with Meteorological Data: Experience from Seven Agroecological Zones of Tanzania. *Weather, Climate, and Society,* 10(3): 435–452. https://doi.org/10.1165/WCAS-D-16-0036.1.

Mongi, H., Majule, A. E., & Lyimo, J. G. (2010). Vulnerability and Adaptation of Rain-fed Agriculture to Climate Change and Variability in Semi-arid Tanzania. *African Journal of Environmental Science and Technology,* 4(6): 371–381.

Morgan, D.L. (2017). Motivations for Using Mixed Methods Research. Integrating Qualitative and Quantitative Methods: A Pragmatic Approach, 63–84. https://doi.org/ 10.4135/9781544304533.N4.

Ndesanjo, R. B., Theilade, I. & Nielsen, M. R. (2020). Pathways to Enhance Climate Change Resilience among Pastoral Households in Northern Tanzania. In W. Leal Filho, N. Oguge, D. Ayal, L. Adeleke, and I. da Silva (Eds.): *African Handbook of Climate Change Adaptation* (pp. 1–19). Springer International Publishing. https://doi.org/10.1006/968-3-030-42091-8_128-1.

Nyerembe, E. & Bushesha, M. (2022). Resources Management and Human-Wildlife Conflicts in Ngorongoro Tanzania. *Huria: Journal of the Open University of Tanzania*, 28(1): 288–313. https://www.ajol.info/index.php/huria/article/view/226008.

Pettengell, R., Sebban, C., Zinzani, P.L., Derigs, H.G., Kravchenko, S., Singer, J.W., Theocharous, P., Wang, L., Pavlyuk, M., Makhloufi, K.M. & Coiffier, B. (2016). Monotherapy with Pixantrone in Histologically Confirmed Relapsed or Refractory Aggressive B-cell Non-Hodgkin Lymphoma: Post-hoc Analyses from a Phase III Trial. *Br J Haematol*, 174: 692–699. https://doi.org/10. 1111/ bjh.14101.

Runyoro, V.A., Msuha, M. & Mduma, S. (2019). Human Wildlife Conflict in Tanzania with a Focus on Elephant and Lion. *Archives of Zoological Studies*, 2(1): 1–9. https://doi.org/10.24966/AZS-7779/100007.

Rweyendela, A.G. & Mwegoha, W.J. (2022). The Treatment of Climate Change Impacts and Adaptation in the Environmental Impact Assessment of the Standard Gauge Railway Project in Tanzania. *Climate and Development*, 14(3): 239–249. https://doi.org/10.1080/ 17565529.2021.1911774.

Sanare, J.E., Valli, D., Leweri, C., Glatzer, G., Fishlock, V. & Treydte, A.C. (2022). A Socio-Ecological Approach to Understanding How Land Use Challenges Human-Elephant Coexistence in Northern Tanzania. *Diversity*, 14: 513. https://doi.org/ 10.3390/ d14070513

Sekaran, U & Bougie, R. (2016). *Research Methods for Business: A Skill-Building Approach*. 7th Edition, Wiley & Sons, West Sussex.

Singh, A.S. & Masuku, M.B. (2014). Sampling Techniques and Determination of Sample Size in Applied Statistics Research: An Overview. *International Journal of Economics, Commerce and Management,* 2: 1–22.

Smith, C.D. (2014). Modelling Migration Futures: Development and Testing of the Rainfalls Agent-Based Migration Model – Tanzania. *Climate and Development*, 6(1): 66–91. https://doi.org/10.1080/16565529.2013.862593.

Stears, K., Nuñez, T.A., Muse, E.A., Benezeth, M., Mutayaba, M. & McCauley, D. (2019). Spatial Ecology of Male Hippopotamus in a Changing Watershed. *Scientific Reports*, 9:15392. https://doi.org/10.1038/s41598-019-51845-y.

Stellmacher, T., Winter, E. & Grote, U. (2012). Protected Areas in Tanzania: From Ineffective Management to PA Certificates? In Change. Hannover, Germany: Institute for Environmental Economics and World Trade Leibniz University Hannover. Retrieved from: http://www.berlinconference.org/2012/wp- content/ uploads/ 2013/01/ Stellmacher-et-al-2012_Protected-areas-in- Tanzania_from-ineffective-management-to-PA-certificates.pdf.

Thompson, M. & Homewood, K. (2002). Entrepreneurs, Elites and Exclusion in Maasai Land: Trends in Wildlife Conservation and Pastoralist Development. *Human Ecology:* 30(1): 106–138.

United Nations Environment Programme (UNEP): (2020). Protected Planet Report 2020: Tracking Progress Towards Global Targets for Protected Areas. UNEP-WCMC and IUCN.

Yanda, P., Wandiga, S., Kangalawe, R., Opondo, M., Olago, D., Githeko, A., Tim, D., Kabumbuli, R., Opere, A., Githui, F., Kathuri, J., Olaka, L., Apindi, E., Marshall, M., Ogallo, L., Mugambi, P., Kirumira, E., Nanyunja, R., Baguma, T. & Achola, P. (2018). Adaptation to Climate Change - Induced Malaria and Cholera in the Lake Victoria Region. AIACC Working Paper No. 43. http://erepository.uonbi.ac.ke/handle/ 11295/155414.