Influence of Social Capital on Adaptation to Climate Variability and Vulnerability in Farming Households in Chamwino District, Tanzania

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Abstract

Adaptation to climate variability results from an interplay of livelihood capitals. These capitals (social, financial, physical, human and natural) prevail within climatic and non-climatic conditions. Vulnerability to climate variability intensifies when people are socially disadvantaged. The study assessed the influence of social capital on farming households' adaptation to climate variability and vulnerability using two villages in Chamwino District, Dodoma Region. A cross-sectional research design was employed, whereby data was collected from 160 randomly selected households using a questionnaire. In addition, data was collected from 32 focus group participants and 5 key informants. Findings show that a farmer's adaptation strategy can influence the accumulation or depletion of capital to adapt to climate variability. In addition, poor farming households (23.12%) have limited livelihood capitals thus, creating adaptation failure and reliance on less paid agricultural adaptation-based contracts to adapt to climate variability. A chi-square test results show no association between poor households' adaptation strategies and their income ($p>0.05$). Therefore, it is concluded that adaptation is not one size fits all; availability of livelihood capital within the household defines the context of adaptation. Therefore, it is recommended that to absorb the vulnerability in adaptation to climate variability, there should be an active and sustained engagement of public and private stakeholders with the local community in prioritizing the adaptation needs of all socio-economic groups to enable them adapt to climate variability.

Keywords: Adaptation, climate variability, farming household, social capital, vulnerability

Introduction

There is substantial evidence that temperatures and rainfall are changing in many parts of the world hence a significant concern to Tanzania. The country has experienced the inter-annual variability of temperature, seasonal rainfall patterns and extreme weather events which has affected the agriculture sector to a large extent (NAPA, 2007; Rowhani *et al.,* 2011; Kashaigili *et al.,* 2013; Lukali, 2021). The sector is vulnerable to water shortage, drought, desertification, land-use change, degradation with dangerous ramifications for communities' food security, livelihoods and wellbeing (FAO, 2019, Kandji *et al.,* 2006).

Generally, the livelihoods of farmers encompass income-generating activities as well as social institutions, intra-household relations, and mechanisms of access to resources through the life cycle (Ellis, 1998). Therefore, for farming households to sustain decent livelihoods in drylands, they require adequate capabilities to enhance their effectiveness to deal with such conditions and available opportunities. Moreover, social capital in such cases can be used by farming households to widen choices in adaptation strategies to increase access to resources. Moreover, diverse livelihood strategies encountered reflect how individuals, households, and groups negotiate among themselves with their communities, markets, and society to improve their well-being or reduce their vulnerability (Valdivia and Quiroz, 2003). According to (Pierce *et al.,* 2001; Fischer *et al.,* 2002; Zhang *et al.,* 2008; Acosta *et al.,*

2013) poverty rates, changing socio-economic, political circumstances, environmental degradation and population growth have been reported as significant challenges to adaptation strategies. Consequently, these challenges create additional layers of complexities to farmers.

In Dodoma Region, resources such as land and water have been extensively degraded due to unsustainable use which has been made worse by the area's recurrent droughts and climate variability (Shechambo *et al.,* 1999). Generally, the degradation of resources for agriculture is the main challenge in drylands. According to Liwenga (2008) farming households use local innovations in water management such as sandy river cultivation as an adaptive strategy in the drylands. Farmers in Chamwino District have been employing several adaptation strategies to reduce the impacts of drought and unpredictable rains in the district. However, most of these strategies do not seem to improve farmers' productivity and reduce their vulnerability and poverty to farmers. According to Berry and Townshend (1973) land use in the district is closely linked with the culture and social systems. Nonetheless, the above adaptation challenges do undermine farmers' adaptive capacity in terms of poor livelihood outcomes, becoming vulnerable and pushing households further into poverty (Liwenga, 2008). The driving force for poverty, in this case, is the failure to anticipate, prepare for, and respond to adverse future impacts (Tschakert *et al.,* 2014).

Furthermore, the conceptualization of vulnerability depends on the understanding of individuals and their social dimensions (Wolf, 2011). Therefore, prevailing conditions of vulnerability in adaptation are highly context-specific, and socio-economic characteristics, social networks and local knowledge play a significant role in shaping adaptation strategies (Eriksen *et al.,* 2005; Inderberg *et al.,* 2014). Thus, a key question is to what extent vulnerability patterns evolve when embedded with social capital in adaptation to climate variability. Therefore, the paper focuses on assessing social capital and how the same is associated with vulnerability and climate variability adaptation strategies.

Conceptual Framework

Assets-based model of farming households

Generally, maintenance of poor farmers' livelihoods needs under conditions of adaptation strategies are based on existing resources. Nonetheless, their choices have to be economical. The Asset-based model enables one to assess farming households by looking at the flow of the total stock of natural, social, human, physical and financial assets. Moreover, the flows of these resources and outcomes are central to sustaining and improving farming systems (Pretty, 1999). Asset-based model (ABM) has been used as a conceptual framework because it focuses on how farms, rural livelihoods and communities accumulate assets and transform them to produce positive or negative functions. The positive functions accumulate natural, human and social capital base over time and therefore sustain the farming system making households less vulnerable. The negative functions reflect the depletion or run-down capitals (natural, human and social) and leave less for the next adaptation, thus creating vulnerability. Furthermore, the model has been chosen for the study because it directly links the flow and accumulation of assets in agriculture which supports adaptation to question whether the existing vulnerability in adaptation to climate variability had been connected with the depletion of the natural, social and human capital.

Materials and Methods

Description of the study area

The study was conducted in Chamwino District, Dodoma Region, the country's driest region (Shechambo *et al.,* 1999), and is frequently hit by drought every four years (Matari, 2007). The District is located between Latitudes 6°5'54.7656 - 6°5'.9128 S and Longitudes 36°2'16.6812 - 36°2.278 E. Recurrent droughts and climate variability are significant causes of crop failure and recurrent food insecurity (NAPA, 2007). Moreover, the frequency of drought occurrence has been increasing within Chamwino District, triggering low agricultural productivity and profitability in addition to environmental degradation (Gowing *et al.,* 2003; Liwenga, 2008; Nikusekala *et al.,*

2016).

Research design, sampling procedure and sample size

The study employed a cross-sectional design. Data were collected once from 160 farming households to assess existing social capital used in adaptation to climate variability in the study villages. The choice of this design was guided by the fact that it allows one to describe two or more groups of variables concerning a particular characteristic or characteristics at one point in time (Machin and Campell, 2005; Kothari, 2004).

A multi-stage sampling technique was applied to select the study district, wards and villages. At the district level, Chamwino District was chosen out of the seven districts of Dodoma Region. Chamwino District was selected as it is the driest compared to the other districts (less weather favoured) hence, farmers have developed diverse and locally adapted farming systems (URT, 2012). Two wards were selected from the district, i.e. Dabalo and Fufu, because of location differences (Chamwino District has two main agro-ecological zones) to capture the different adaptation strategies within the district. Dabalo ward is located to the North where rainfall ranges between 550 and 650mm per year while Fufu in the South receives on average 400mm of rain annually. Thereafter, the study chose one village from each ward, hence two villages for the study.

The study's sampling frame was all farmers in the selected villages. At the village level, stratified sampling was used to choose farming households for interview. Each hamlet's farmers were selected from each hamlet capture those with and without capital but, involved in adaptation activities. Dabalo Village has 1884 households while Fufu Village has a total of 660 farming households. Therefore, the study sample included 5% of farmers' households from Dabalo village and 10% of the household of farmers from Fufu Village for the interviews. According to Guy *et al.* (1998), a sample should form 10% for population sizes between 101 - 1000 and 5% for population sizes between 1001 – 5000. Based on the above, a total of 160 farming households were interviewed, 94 and 66 farmers from Dabalo and Fufu Villages, respectively.

Data Collection

The techniques used to collect data were household surveys, Focus Group Discussions (FGDs), Key informant interviews (KIIs) and observation. A pre-structured questionnaire with close and open-ended questions was used to allow collection of both quantitative and qualitative data. Four FGDs, two from each village were conducted with eight participants each. Furthermore, six Key Informants involved the District Commissioner, District Agricultural Officer, District Livestock Officer, two village chairpersons and three farmers from different resource use committees were interviewed.

Data Analysis

Statistical Package for Social Sciences (SPSS) version 20 was used to analyse quantitative data. Frequency was used to identify adaptation strategies conducted by the household of farmers. Chi-square was used to associate the relationship between the income of the households and adaptation strategies done. Qualitative data from the FGDs and KIIs were analyzed using content analysis. The codes were created according to the thematic aspects on the research questions. Data were ordered according to the household's socio-economic group (the well-off, moderate well-off, and the poor) and assets used in adaptation strategies and location where an adaptation strategy is conducted.

Results and Discussion

Adaptation strategies for surveyed households

Study findings (Table 1) show the existence of six main adaptation strategies in both villages, namely keeping and selling livestock, businesses, planting drought-tolerant crops, irrigating vegetables, engaging in skills-based activities and casual labour activities. The differences in adaptation strategies were captured through socio-economic groups and villages (Dabalo has five groups while Fufu has four groups) as shown in Table 2. For example, in Dabalo Village, the availability of a dam facilitates irrigation farming, particularly for

vegetables. Fufu Village is located along the Dodoma-Iringa road; farmers engage more in non-farming activities as part of their adaptation to climate variability.

the main adaptation strategies conducted by farmers are crop farming, livestock keeping and business. Liwenga (2003) also noted that the Gogo people live in a harsh dry environment,

Table 1: Households adaptation strategies to climate variability

Adaptation strategies	Villages		Total
	Fufu (n=66)	Dabalo (n=94)	
	Percent	Percent	Percent
Planting drought-tolerant crops	22.7	31.9	28.1
Skills based activities	4.5	8.5	6.9
Casual labour	24.2	22.3	23.1
Keeping and selling livestock	16.7	13.8	15
Businesses	24.2	12.8	17.5
Irrigation	7.6	10.6	9.4

Table 1 further shows planting drought-tolerant crops was the number one strategy done over a quarter (28.1%) of farmers because yields of the drought-tolerant crops were the superior even at current climate variability and growing conditions. The four main drought-tolerant crops cultivated in the study villages were sorghum, groundnuts, sunflower and sim sim. During KII, it was reported that sorghum is produced by 80% of households because it serves as food and a cash crop. Similar observations have been reported by Lema and Majule (2009) that but still they have given great priority to farming as their major means of survival.

It was observed during the FGD's that the involvement of the poor farmers in this adaptation strategy was to take care of the livestock as casual labourers. The moderately well-off farmers reported engaging in multiple adaptation strategies and so employed other farmers, especially the poor farmers to support accomplishing adaptation activities. However, to secure the contract, one must use social capital as a pre-condition. Attributes of social

Table 2: Adaptation strategies of socio-economic groups of farmers by villages

Village	Socio-economic groups of farmers				
Dabalo Village	**The well-off**	**The moderate well-off**			**The poor**
	"Tajiri ng'ombe"	**Business**	**Farmers**	**Small businesses**	**Poor farmers**
Adaptation/ Strategies	Livestock keeping – more than 1 000	Selling crops, own shops and money lenders	Agro-pastoralist, irrigation farming and fishing	Food vendors and crop cultivation	Casual labour
Fufu Village	**The well-off**	**The moderate well-off**		**The poor**	
	"Wagoli"	**Business**	**Farmers with capital**	**Farmers without capital**	
Adaptation strategies	Livestock keeping – more than 3000	Selling crops and livestock,	Agro-pastoralist, irrigation farming	Casual labour	

capital used were reciprocity, connectedness, exchanges and trust. Observation by Mpuya (2012) confirms that households with fewer productive assets have limited capabilities to participate in off-farm activities to earn a living. Ferreira and Lanjouw (2001) reviews show that opportunity-led strategies involve the wealthier rural household with sufficient asset endowments that decide to diversify their livelihood to increase returns on their assets. Chi-square test results show no significant association between adaptation strategies and increased household income (X2 (1, N=37), p>.423). The chi-square test results in Table 3 show that adaptation strategies and income are independent, meaning that there is no significant association between practised adaptation strategies and increase in income among the poor households working as casual labourers. According to Dulal *et al.* (2010) adaptation outcomes depend upon the livelihood strategies that the poor undertake. Thus, understanding the poor's endowments and entitlements is crucial to better understand the vulnerabilities of farmers.

their planting dates from the end of November to the end of December to the first week of January. Planting within these dates at least guarantees survival of maize whereby the maize plant is 1 foot tall by the end of February. Their local experience reported that if the rain comes back, a one-foot maize plant can recover and produce more efficiently when the rain returns compared to a taller plant. Figure 1, shows the average maximum temperature of twelve months in a year for 20 years in the Dodoma Region. On average January, February, March, November and December are the hottest months which are the onset of agricultural seasons in the area. Furthermore, Elias (2014) evidenced a trend of temperature increase in the Dodoma Region, temperature in the study area increased from 23°C to 24°C (1961-2014) indicating an increase of 1°C. These findings collate with Mdee (2022) that the number of hot days increase relative to that of cold ones in the semi-arid climate.

Figure 2 shows the annual rainfall of the Dodoma Region with an average of 578 mm and

Table 3: Relationship between income and adaptation strategies of poor households

	Value	df	Asymp.Sig. (2-sided)
Pearson Chi-Square	37.000a	36	.423
Likelihood Ratio	35.893	36	.474
Linear-by-Linear Association	5.107	1	.024
N of Valid Cases	37		

Interaction between livelihood, social capital and adaptation to climate variability

Households engage primarily in crop production and livestock keeping, hence, they are mainly agro-pastoralists. The district experiences a long dry season and a short wet season of less than four months characterized by low and unpredictable rainfall (Liwenga, 2009). For example, the FGD in Dabalo Village, reported the decrease in the amount of rain, increase in temperature and occurrence of short rainfall seasons with long dry periods to be their primary challenge. In addition, the FGD participants reported an extended dry period of more than three weeks reported to occur in February. Consequently, maize growers in Dabalo Village reported adapting by changing

a coefficient of variation of 24.6%. The annual minimum and maximum rainfalls were 289 mm in the year 1969 and 1117 mm in the year 2020, respectively. Figure 2 shows a significant decrease in rainfall amount for five consecutive years (2013 to 2017). In such years, livelihood is difficult without adaptation strategies. There have been other similar studies in the area indicating irregular rainfall intensity in semi-arid areas of Tanzania (Hamisi, 2013; De Paola *et al.* (2014); Elias, 2014).

Furthermore, the difference in adaptation strategies employed by farmers was also influenced by either bad or good years. Bad years are those of low rainfall below the average amount and are characterized with short rainfall seasons while good years represent years with

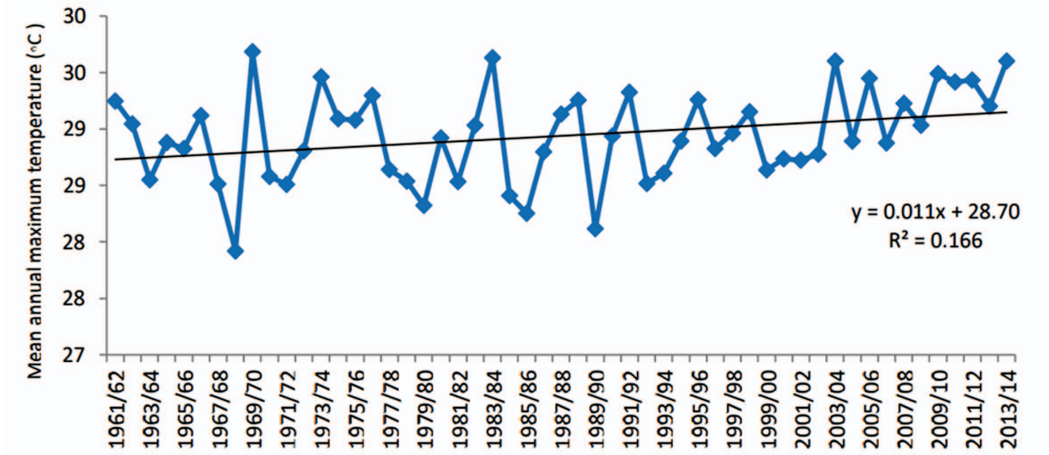

Figure 1: Mean maximum Temperature for Dodoma for 50+ years

Source: Temperature and rainfall characteristics in Dodoma Region (Elias, 2014)

the average amount of rainfall. It was also pointed out during the FGDs that during the years where rain is not enough, adaptation strategies are driven by social capital. Thus, trust, standard rules, connectedness, exchanges, reciprocity and social institutions were used by socio-economic groups to support adaptation in farming and livelihoods. To secure a contract one has to use his/her social capitals attributes. However, the use of social capital in adaptation has both positive and negative functions.

Generally, two issues emerged from the analysis:

(i) Trust, connectedness and exchanges as the basis for adaptation and

(ii) Social capital and vulnerability

Trust, connectedness and exchange as a basis for adaptation

Farmers during the FGDs, defined trust as "the relationship between farmers coupled by treating each other honestly and being reliable to assigned activities during adaptation". And connectedness "as the state of being close as friends or relatives, assisting each other to accomplish certain adaptation strategies." These relations in social life lubricate cooperation in adaptation. Moreover, the dynamic nature of the climate constrains resource availability; thus, poor farmers use social capital as a channel towards adaptation. It was evident from the data collected from the households and the FGDs that trust was held by the poor who belong to the

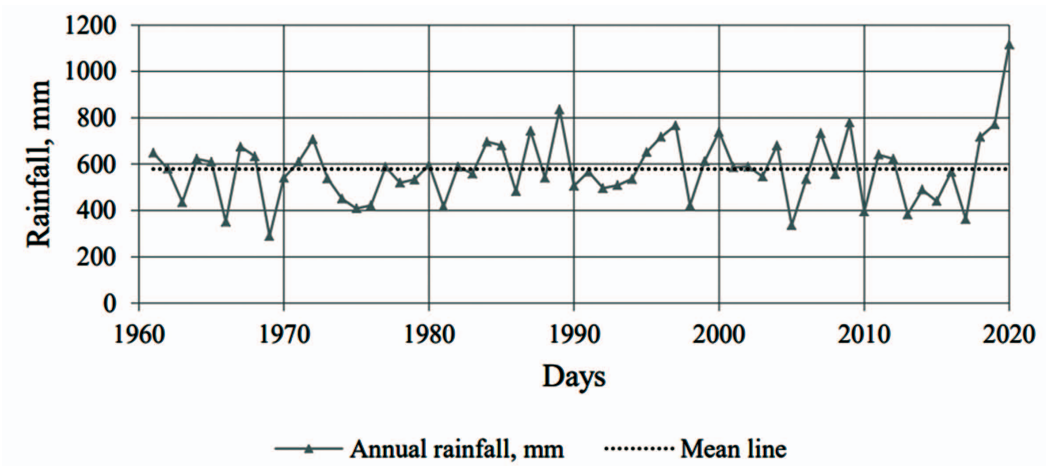

Figure 2: Mean maximum Rainfall for Dodoma for 50+ years

Source: Rainfall Characteristics in Dodoma (Mdee, 2022).

lower social-economic group as a commodity using it as a security to activate adaptation tasks of other socio-economic groups.

Livestock keeping and irrigation of vegetables were the main adaptation strategies that employed trust and connectedness as elements of social capital. For example, in Fufu Village, adaptation through livestock keeping was of two types; those who give low-income families livestock to tend within the village and others outside the village. Moreover, during the household surveys, it was observed that poor farming households kept large numbers of cattle and when asked how they got them, some mentioned owning nothing while others said to own a few. Livestock kept within Fufu Village include pigs. Poor households took one pig from the owner; feed it for the whole year and when these farrowed, they were compensated by being given half of the piglets. However, the burden of providing them was not easy for poor households since several pigs were observed moving around the village, feeding on grasses and whatever found in the surroundings.

Keeping cattle near mountains has been taken by farmers as a good adaptation strategy because of the availability of grazing areas. Trusted poor households and relatives were given livestock to take care of far-away from the village, near the mountains. However, cattle numbers have been increasing and during the FGDs several challenges were reported by the livestock caretakers. For example, shortage of grass during the dry season forced them to walk long distances from the mountains to faraway places. Some went to Iringa via Mtera Dam, Kiteto and Kondoa. The yearly payment for taking care of the cattle ranged between TZS 50,000/= and 70,000/= plus weekly food provision every week in Fufu Village while in Dabalo Village it was reported to be TZS 120,000/= plus three goats per year and a few households said they got their payment from selling milk. Nonetheless, according to the FGDs, animals were facing disease challenges, and some died due to drought. The above may have been due to traditional keeping livestock with no or very little access to veterinary services.

Exchanging tomatoes with sorghum outside the village represented another adaptation strategy carried out by those farmers practising irrigation and poor households. The poor took tomatoes without paying for them upfront from the farmers to trade the same in nearby villages in exchange for sorghum. Generally, farmers practising irrigation use trust to select whom to give the vegetables for the exchanges outside the village. One tin (20litres) bucket of tomatoes was exchanged for one and a half tins of sorghum during the high season for tomatoes. One tin of sorghum had to be paid back to the vegetable farmer and the remaining half was taken by the poor farmers for food or selling. Three to five tomatoes were exchanged for one kilogram of sorghum during the low tomato season. Generally, poor households dedicated a substantial amount of time to this activity since they had no other activity or source of income open to them to establish their adaptation activities.

The amount of sorghum collected by farmers involved in irrigation farmers during the exchanges was sold during intense food shortages in the dry season. One tin of sorghum was sold at between TZS 7,000/= to 10,000 while the average price was around TZS 3,000/= and TZS 4,000/=. The price differences indicate the benefits the farmers got. The poor were primarily engaged in drought-resistant activities connecting them with barter trade (buying through exchange) since they could not afford transactions.

Social capital and vulnerability

The distinction between positive and negative functions of social capital forms the integral vulnerability context of farmers. It was revealed during the FGDs that, positive functions of social capital were observed mainly with livestock owners in the study villages. Due to the networks established in the villages they could engage in multiple adaptation strategies such as businesses. According to Eakin (2005) having connections across socio-economic groups creates flexibility in their diversification and adaptation strategies. In addition, Osbahr *et al.* (2010) argues that only households that regularly invested in networks were able to take part in risk-averse livelihood strategies for

survival.

Livestock keeping in the two villages was among the main adaptation strategy. Households with livestock at times do not cultivate crops while others reduce their farm size, since they can sell several livestock to buy the food needed by the households while poor households have no options other than searching for casual labour opportunities as their adaptation strategies. Nonetheless, some poor households rely on already established adaptation activities and are devoted to moving far away from their settlements and with their families to take care of the livestock far away. According to literature (Ribot *et al.,* 1996; Agrawal, 2009; Afifi *et al.* (2014) group characteristics are often closely related to vulnerability. The group characteristics can be correlated with principal means of livelihood, skill level, reliability of income, wealth, landholding size and geographic location to natural resources, transportation, and marketing infrastructures. Valdivia and Quiroz (2003) argue that even during average rainfall, the low-income families experience depletion of assets because they are less diversified. Therefore, they are more exposed to climate variability impacts. The poor households who were employed to take care of the livestock far from the villages were lacking social services such as schools, and children were forced to help their parents look after the livestock. They also mentioned lack of some essential services such as shops, hospitals, and markets and losing social networks and neighbours was a significant challenge.

Informal crop loans were mentioned during the FGDs in Dabalo to be important in their adaptation to climate variability. Vulnerable and poor farmers mostly requested crop loans. One participant from one of the FGDs said:

"Money was availed to the poor farmer depending on the size of the farm and sometimes assessment of the amount of produce the farmer normally gets after harvest. After the harvest, the loan providers fix the crop price and take an amount of the product equal to the amount of money loaned as payback. In most cases what remains to the poor farmer is less than what the household has paid for the loan" (FGD Participant, Dabalo Village, Chamwino District).

It was further revealed that the challenges of crop loans and less rain had pushed farmers to adapt by the cultivation of sim sim and sunflowers, which have a reasonable price compared to maize or sorghum. However, KIs reported that farmers were cultivating sim sim in the mountains because of fertile soil and good prices at the market. One of the key informants at Dabalo Village said that: since village bylaws restrict farmers from cutting trees in the mountains, the farmers are looking for fresh farms outside the village. Moreover, observations show that the Dabalo Village Mountains had open patches due to agricultural activities.

There is a clear distinction that social capital is an asset to livelihood and adaptation activities and it functions differently between the poor and non-poor. Although poor farmers are taking part in adaptation processes/ activities, the benefit is minimal, thus making them more vulnerable despite maximizing their social capital investments. Hence, having social capital alone does not ensure a positive function (benefits) from adaptation strategies but, instead relates to access to all other resources such as economic resources, technology, infrastructures and institutions for a farmer to adapt and reduce vulnerability.

Conclusions and Recommendations

It can be concluded that social capital has an important role in adaptation to climate variability both positively and negatively. Entirely, social capital influences farmers to gain adaptive capacity through the accumulation of capitals while weakening social networks, and trust is reflected as a negative gain. Given the multiple stressors of farmer's vulnerability, many factors have framed adaptation processes. The social context can exacerbate different pathways causing vulnerability and only certain groups like the poor farmers are highly affected. In addition, when certain groups of farmers are doing multiple adaptation strategies; the poor farmers are employed as casual labourers and end up doing coping strategies.

Based on the study's findings and conclusion, two recommendations are made.

First, there is a need to evaluate options for enhancing adaptation strategies, especially for poor farmers. Among the options could be the provision of necessary resources for adaptation to absorb vulnerability to climate variability. Strengthening markets for cash crops cultivated and vegetables could help to enhance adaptation through farming in rural areas by adding value and benefits to the adaptations strategies they are engaged. Second, Chamwino District Council, NGO's and other institutions should work in partnership with the local community to prioritize the adaptation needs of every socio-economic group and provide assistance such as agricultural loans and implements to enable them to adapt to climate variability.

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References

Acosta-Michlik, L. (2013). Intervulnerability assessment: shifting foci from generic indices to adaptive agents in assessing vulnerability to global environmental change. Report on a project of the Advanced Institute on Vulnerability to Global Environmental Change.

Afifi, T., Liwenga, E. and Kwezi, L. (2014). Rainfall-induced crop failure, food insecurity and out-migration in Same-Kilimanjaro, Tanzania. Climate and Development 6(1): 53-60.

Agrawal, A. (2009). Local institutions and adaptation to climate change. In: social dimensions of climate change: Equity and vulnerability in a warming world. (Edited by Norton, A. and Mearns, R.) Washington, DC. pp. 173-198.

Berry, L. and Townshend, J. (1973). Soil Conservation policies in the semi-arid Regions of Tanzania: A Historical perspective. The Bureau of Resource Assessment and land Use Planning (BRALUP), University of Dar-es-Salaam, Tanzania, Research Monograph No.1.

De Paola, F., Giugni, M., Topa, M.E. and Buchignani, E. (2014). Intensity-Duration-Frequency (IDF) rainfall curves, for data series and climate projection in African cities. SpringerPlus 3(1): 1-18.

Dulal, H.B., Brodnig, G., Onoriose, C.G.,and Thakur, H.K. (2010). Capitalizing on Assets: Vulnerability and Adaptation to Climate Change in Nepal. World Bank, Social development working paper No 121. 23pp.

Eakin, H. (2005). Institutional change, climate risk, and rural vulnerability: cases from Central Mexico. World Development, 33: 1923–1938.

Elias, M.H. (2014). Recent temperature and rainfall characteristics in Dodoma Region. *Ghana Journal of Geography,* 13(1): 2021 pages 63-80.

Ellis, F., (1998) Household Strategies and Rural Livelihood Diversification. *Journal of Development Studies* 35(1): 1-38.

Eriksen, S., Brown, K. and Kelly, P.M. (2005). The dynamic of vulnerability: locating coping Strategies in Kenya and Tanzania. *Geographical Journal,* 171(4): 287-305.

FAO. (2019). The State of Food and Agriculture 2019: Moving forward on food loss and waste reduction. Rome. ISBN 978-92-5-131789-1.

Ferreira, F. and Lanjouw, P. (2001). Rural non-farm activities and poverty in the Brazilian North East. World Development 29(3): 509-528.

Fischer, G., Shan, M. and Veltithuizen, H. (2002). Climate change and agricultural vulnerability. IIASA special report on the world summit on sustainable development, Johannesburg.

Gowing, J.W., Young, M.D.B., Hatibu, N., Mahoo, H.F., Rwehumbiza, F. and Mzirai, O.B. (2003). Developing improved dry land cropping systems for maize in semi-arid Tanzania. Expl Agric 39: 293-306.

Guy, D.M., Carmichael, D.R. and Whittington, O.R. (1998). Audit sampling: An

introduction. John Wiley & Sons, Inc. New York.

Hamisi, J., (2013). Study of rainfall trends and variability over Tanzania, Postgraduate Diploma in Meteorology, University of Nairobi, Nairobi, Kenya.

Inderberg T.H., Eriksen S., O'Brien K. and Sygna L., (2014). Climate change adaptation and development: Transforming paradigms and practices, Routledge, London.

Kashaigili, J.J., Levira, P., Liwenga, E., and Mdemu, M.V. (2013). Analysis of climate variability, perceptions and coping strategies of Tanzanian coastal forest-dependent communities. Available at http://suaire.suanet.ac.tz:8080/xmlui/handle/123456789/302

Kandji, S.T., Louis, V. and Mackensen, J. (2006). Climate change climate and variability in Southern Africa: Impacts and adaptation in the agricultural sector. UNEP & ICRAF.

Kothari, C.R. (2004). Research Methodology: Methods and Techniques. Dharmesh Printers; New Delhi, India.

Liwenga, E.T. (2003). Food insecurity and coping strategies in Semi-arid areas: The case of Mvumi in Central Tanzania. Thesis submitted for PhD degree at the Stockholm University, Sweden. 189pg.

Liwenga, E.T. (2008). Adaptive livelihood strategies for coping with water scarcity in the drylands of central Tanzania. *Journal of Physics and Chemistry of the Earth,* 33: 775–779.

Liwenga, E. T. (2009). Livelihood diversification and implications on dry land resources of central Tanzania. *African Journal of Ecology* 47: 142-146.

Lukali, A,A., Osima, S.E., Lou, Y. and Kai, K. H. (2021). Assessing the Impacts of Climate Change and Variability on Maize (*Zea mays*) Yield over Tanzania. Atmospheric and Climate Sciences 11(3)2021.

Machin, D. and Campbell, M. J. (2005). Design of Studies for Medical Research. John Wiley and Sons. Chichester (1, 9, 16).

Matari, E. (2007). Effects of some meteorological parameters on land degradation in Tanzania. In: Climate and Land Degradation. Sivakumar, M.V. K. and Ndegwa, N. (Editors). Springer International, Switzerland. 153-166pg.

Lema, A.M. and 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, 206-208.

Mdee, O.J. (2022). Evaluation of Rainfall Extreme Characteristics in Dodoma Urban: A Central Part of Tanzania. *International Journal of Environment and Geoinformatics* 9(3).

Mpuya, M.R. (2012). Disparate Coping Strategies for Gendered Effects of Drought: A Call for re-examination of Gender Roles and Harmful Traditions in Central Tanzania. *International Journal of Disaster Resilience in the Built Environment* 3(3), 283-302.

National Adaptation Plan for Action (NAPA), (2007). Disaster and Risk Profile: United republic of Tanzania. Government Printers, Tanzania.

Nikusekela, N.E; Mgale, Y.J. and Msaki, M.M. (2016). Farming Related Factors Contributing to Agricultural Productivity in Smallholder Farmers in Dodoma Municipality: A Factor Analysis Approach. *Imperial Journal of Interdisciplinary Research* 2(6):62-71.

Osbahr, H., C., Twyman, W. Adger, N. and Thomas, D.S.G. (2010). Evaluating successful livelihood adaptation to climate variability and change in Southern Africa. Ecology and Society 15(2):27.

Pierce, S.L.G., Mbwaga, A.M., Lamboll, R.I., Riches, C.R., Press, M.C. and Scholes, J. D. (2001). Farmers, farms and physiology: An integrated Approach to Striga research. BCPC International Congress Report. 5pg.

Pretty, J. (1999). Can Sustainable Agriculture Feed Africa? New evidence on progress processes and impacts. *Journal of Environment, Development and Sustainability* (1): 253–274.

Ribot, J.C., Magalhaes, A.R. and Panagides, S. S. (Eds) (1996). Climate variability, climate change and social vulnerability in the Semi-

Arid tropics. Cambridge University Press, UK.

Rowhani, P., Lobell, D.B., Linderman, M. and Ramankutty, N. (2011). Agricultural and Forest Meteorology Climate Variability and Crop Production in Tanzania. Agricultural and Forest Meteorology 151(449-460).

Shechambo, E., Sosovele, H. and Kisanga, D. (1999). Rethinking natural resource degradation in Semi-arid Sub-Saharan Africa: The case of Semi-arid Tanzania. ODI, Dar-es Salaam, Tanzania.

Tschakert, P., Dietrich, K., Tamminga, K., Prins, E., Shaffer, J., Liwenga, E. and Asiedu, A. (2014). Learning and envisioning under climatic uncertainty: An African experience. Environment and Planning 46(5): 1049-1068.

United Republic of Tanzania (URT) (2012). Risk, Vulnerability and Capacity Assessment Report for Chamwino District Council. Prime Minister's office - Regional Administration and Local Government Authorities. Dar-es-Salaam, Tanzania. 561pp.

Valdivia, C. and Quiroz, R. (2003). Coping and adapting to increased climate variability in the Andes. A paper presented at the American Agricultural Economics Association Annual Meeting, July 27-30. Montreal, Canada

Wolf, J. (2011). Climate change adaptation as a social process. In: climate change adaptation in developed nations: From theory to practice, advances in global change research. (Edited by Ford, J.D. and Berrang-Ford, L.).

Zhang, Y., Chen, Z., Zhu, B. Luo, X., Guan, Y. and Guo, S. (2008). Land desertification monitoring and assessment in Yulin of Northwest China using remote sensing and geographic information systems (GIS). Environmental Monitoring and Assessment 147(327–337).