Vol. 1, Issue 1, 2018 *ISSN 0856-9037*

CLIMATE CHANGE EFFECTS AND PERCEIVED SUSTAINABILITY OF ADAPTIVE CAPACITY RESOURCES AMONG SMALLHOLDER FARMERS IN MANYONI DISTRICT, TANZANIA

Andrew Omari Shirima[1], Christopher P. Mahonge[2] and Emanuel E. Chingonikaya[3]

Abstract

This paper assessed climate change future effects and determined the perception of sustainability of adaptive capacity resources among smallholder farmers in Manyoni District, Tanzania. The paper adopted a cross-sectional study design. A multistage sampling was used to select four wards randomly from which two villages were randomly selected in each ward to make a total of eight villages. Using simple random sampling guided by lottery method, 30 respondents were selected from each village. The specific objectives were to identify the future climate change effects; to determine the perceived sustainability of adaptive capacity resources and to analyse the weights of perceived sustainability resources. Data collection was done through a household questionnaire survey, focus group discussion and key informant interviews. Descriptive analysis was used for analysis using SPSS. Kruskal-Wallis Test was performed to test the perception of adaptive capacity resources in relation to age. It was found that the expected future effects are: fall of grain production, acute water shortage, washing away of fertile soil, reduced motivation to cultivating, increased food insecurity and soil erosion. Furthermore, 60.4% of the smallholder farmers were found to have low perception on the sustainability of adaptive capacity resources. Based on the findings the study concludes that climate change will pose more serious effects in the future as indicated by the majority who perceive sustainability of their adaptive capacity resources to be low being more worried of these effects. Furthermore, the study concludes that, the critical adaptive capacity resources are governance and human capital. The study recommends that smallholder farmers in collaboration with the District Agricultural Department devise proactive measures to address the anticipated effects. Similarly, smallholder farmers and the local government should set plans to strengthen a more sustainable access to and use of adaptive capacity resources.

***Key words**: Smallholder farmers, Climate change, Sustainability.*

1.0 INTRODUCTION

Climate change is regarded as one of the greatest contemporary environmental challenges facing humanity due to the multi-dimensional impacts it poses (UNDP, 2004). The threat it poses to human well-being is new and its negative outcomes will interact with ongoing poverty and environmental degradation in many places, exacerbating problems and creating new types of risks (Schipper and Burton, 2009). It specifically poses significant threats to smallholder farmers in developing countries (Morton, 2007). The magnitude of impact varies greatly given the level of adaptive capacity which according to IPCC (2001) is the ability of farmers to adjust to climate change, to lessen potential damages, and to take advantage of opportunities or to cope with consequences. It is the sum of assets (tangible and intangible) such as financial, natural and

[1] *Lecturer, Department of Community Development, University of Iringa (Corresponding author: Email: andhansom@gmail.com)*

[2] *Associate Professor, Department of Policy Planning and Management, Sokoine University of Agriculture College of Social Sciences and Humanities, Sokoine University of Agriculture*

[3] *Senior Lecturer, Department of Development Studies, Sokoine University of Agriculture College of Social Sciences and Humanities, Sokoine University of Agriculture*

human assets that a system has and the diversity of livelihood a system is endowed with. Local farmers with low adaptive capacity are thought to be more vulnerable to adverse effects of climate change, which contributes to the loss of their natural resources (Eriksen *et al*., 2005; Paavola, 2008)? According to Nyong (2005) smallholder farmers in Sub-Saharan African countries are vulnerable to climate change because they lack sufficient capacity to adapt. The resources and technologies for adapting to climate change are limited and agriculture solely relies on rainfall. In Tanzania climate change poses an immense threat to about 80% of the population living in rural areas where their livelihoods depend on subsistence and rain dependant farming (URT, 2013). Drought, torrential rains, pests are some of the effects that climate change has posed to farmers in Tanzania. Farmers, who operate under subsistence conditions, smallholder farmers included, tend to be the most vulnerable. The provision of food for their dependants is an overriding priority for many of them. Regardless of the source of risk, the degree of riskiness of an action depends, in part, on the ability to predict what will happen in the future. It is important that a farmer understands risk and the sustainability of the adaptive capacities and how these affect farming (FAO, 2013). This puts the farmer in greater command the factors that influence the household, farming and livelihood systems.Studies like that of Swai *et al.* (2012) have assessed gender and adaptation practices to the effects of climate change in Bahi and Kondoa Districts and found that the majority of men and women perceived climate change and managed to identify adaptation practices. Kihupi *et al.* (2015) assessed smallholder farmers' perception of climate change in Iringa District and concluded that smallholder farmers perceived continual climate change, and it was getting worse over time. Mary and Majule (2009) and Makundi and Lyimo (2015) assessed the impacts of climate change, variability and adaptation strategies on agriculture. Documented information on the future effects and smallholders' perceived sustainability of adaptive capacity resources in Tanzania is inadequate while in Manyoni District is lacking. Filling in this gap will inform adaptation initiatives on the perception of smallholder famers with regards to adaptation and involve them in the light of their perception. This study therefore, assessed climate change projected effects and the perceived sustainability of adaptive capacity resources in the light of climate change among smallholder farmers in Manyoni District. It specifically aimed to: firstly examine the future climate change effects and secondly to assess the perception of the sustainability of adaptive capacity resources in the study area. The results from this study contribute knowledge on the contextual understanding of the perceived sustainability of adaptive capacity resources in in Manyoni District.

2.0 METHODOLOGY

2.1 Study Area

The study was conducted in Manyoni District. The District is found in semi-arid areas of Tanzania where food shortages are frequent due to unreliable rainfall (URT, 2005). The District has a unimodal rainfall pattern that rains from November to April. The long-term mean annual rainfall is 624 mm with a standard deviation of 179 mm whereas the long term mean number of rainy days is 49 in a year with a standard deviation of 15 days. Rainfall pattern in the district is unreliable. In terms of temperature, the annual mean, maximum and minimum monthly temperatures in the district are 22^0C, 24.4^0C (November) and 19.3^0C (in June) respectively (Mary and Majule, 2009). The study was carried out in four wards namely Itigi, Itigi-Majengo,

Manyoni and Mitundu wherein, two villages from each Ward were randomly selected. The selected villages were Itigi, Mitundu, Muhalala, Kipondoda, Zingilani, Manyoni, Majengo and Tambukareli. The District was selected due to the fact that it falls within the semi-arid areas of Tanzania and where their dependence on rainfall exceeds 95% (NBS, 2009).

2.3 Research design, sampling procedure, sample size and methods of data collection

A cross-sectional research design whereby data were collected at single point in time was adopted for this study. The design has a greater degree of accuracy and precision in social science studies than other designs (Casley and Kumar, 1998). Also, the objectives required collection of data to be done in a point in time. The unit of analysis for the study was a smallholder farmer household. Ward Agricultural Extension Officers and District Agricultural Officer, Village and Ward executive officers were selected as key informants because they are key persons in issues of agriculture and administration at the district levels. Using a checklist of items for discussion, qualitative data were collected from 13 key informants and 8 focus groups (consisting of 8-12 people) were obtained. Focus group discussants were chosen on the grounds of seniority in age in view that they are more vested with experience of farming, climate change scenarios and adaptation. Key informant and FGDs methods of data collection were used to gather qualitative information. Quantitative data were collected using a structured questionnaire administered to 240 household heads, 30 from each village. This number of respondents is in line with what Bailey (1998) recommends regarding the minimum sample size of 30 cases as adequate for studies where statistical data analysis is required.

2.4 Data processing and analysis

Qualitative data were analysed using content analysis techniques whereby data were categorized into themes and summarized into meaningful information. Quantitative data analysis was done using SPSS employing descriptive and inferential statistics. Using an index summated scale, perception of sustainability of adaptive capacity resources was determined. The indicators that were used were natural, governance, financial, physical, social and human capital. Indicators of sustainability of adaptive capacity resources were assigned points and all the points were summed up to get the overall scores. The cut-off point for each level was based on the dispersion of data by setting three intervals for the three categories to segregate respondents into those with lower, moderate and high perception on the sustainability of adaptive capacity resources. Mean percentage of resources was sought to determine the hierarchy of adaptive capacity resources among the smallholder farmers. This was done by dividing average scores with the total score of all resources times a hundred.

The Kruskal-Wallis Test was performed to test the hypothesis that perception of adaptive capacity resources was the same in all ages namely: lower age (20-40 years), middle age (41-50 years) and older age (51 years and above) at $p \leq 0.05$. This test is a non-parametric test which was appropriate for comparing ordinal data when the groups compared are more than two (McCrum-Gardner, 2008). Age was chosen on the grounds that age of the head of the household represents experience in farming hence a higher probability of perceiving climate change as they are exposed to past and present climatic conditions over the longer perspective of their life span (Ishaya and Abaje, 2008). The mean perceived sustainability of each resource was obtained by

dividing the scores of individual resources (capitals) by the total score of all resources times a hundred respectively to determine the smallholder famers' hierarchy of resources.

3.0 RESULTS AND DISCUSSION

3.1 Smallholder farmers' projected climate change effects

Table 1 presents smallholder farmers expected future effects. These are the anticipated climate change related threats that are expected to affect smallholder farming. An enquiry into the possible future effects was done aiming at establishing the position in which smallholder farmers have placed themselves in the light of these effects and the adaptive capacity resources they are endowed with. Using multiple responses, 94.2% of the respondents asserted that the major possible future effect is reduced motivation to grow crops. This is partly caused by the continued crop failures due to climate stressors including drought. The implication of reduced motivation to cultivate can result in severe food shortages and severe hunger as long as households depend on farming but have limited income generation sources with which they can diversify their livelihood. This situation will induce the government to provide food aid to the households which again is not a sustainable solution.

This view was also expressed in focus group discussions whereby some farmers reported to have had no harvest at all for a number of seasons; this had impaired their motivation to grow crops. In relation to this finding, 93.8% of the respondents reported more severe fall in grain production as the future effect. In a discussion with the participants in focus groups, it was noted that smallholder farmers were worried of the continued climate change and variability and its aftermath. This was reported by discussants in Majengo village that showed signs of despair. They reported to have surrendered their fate to God and to the government. They were aware that government support had not been sustainable because such support could only be provided for a limited time. This finding was confirmed by the District Agricultural Officer who remarked that:

> *"… in spite of the fact that general data shows that crop yield has increased, many individual smallholder farmers occasionally fail completely to harvest the minimum for their household subsistence feeding; this happens especially to those that do not grow drought resistant crops as instructed by the government coupled with seasonal crop destruction by destructive birds".*

This finding is in line with the prediction of IPCC (2014) that showed that global change in climate, combined with increasing food demand, would pose large risks to food security globally. Acute shortage of water is another expected future effect that was identified by 93.8% of the respondents. This was reported to have already started manifesting itself in the study area as some discussants were also concerned about shortage of water for domestic use and for their livestock, implying that the situation will be more severe in the future, given the continued climate change. It was further reported in focus group discussions that the in rainfall and its variability would severely affect water sources such as streams that are dependent on rain water and boreholes as a result of decreasing underground water. Expected water shortage as a result of climate change is also reported by IPCC (2014) which project reduction of renewable surface water and resources in most dry subtropical regions. The study further found that reduced soil

fertility is another possible future effect. About 91.2% of the respondents identified reduced soil fertility. During key informants and focus group discussions, it was learned that this effect is attributed to increased wind that sweeps away the top soil which is more fertile, as well as torrential rains resulting in floods that wash away the top soil, thus affecting farming negatively. This situation will lead to land degradation causing lower yields, crop damage and failure. The signs of these future effects have already started to happen. It was also observed that a large portion of land in the study area is bare, hence it is exposed to the effects of erosion during rain seasons and top land appeared to have been swept away by wind during dry seasons. During focus group discussion, smallholder farmers were of the view that projected effects (though they were already evident) would be more severe in the future given the limited access to resources and the reliance on rain dependent farming among smallholder farmers. This view was also confirmed by the District Agricultural Officer who remarked that:

> *"… despite the current measures that are taken by the government to minimize and address climate change related effects, there is a need to devise more sustainable measures that will be used to address the expected challenges that are expected to be more severe among smallholder farmers".*

Table 1: Respondents' views on projected climate change effects (n=240)

Projected climate change effects	Responses	
	N	Percent of Cases
Fall of grain production	226	93.8
Acute water shortage	226	93.8
Washed away fertile soil	225	92.9
Reduced motivation to cultivating	226	94.2
Increased food insecurity	221	92.1
Soil erosion	228	91.2

Note*: Multiple responses*

3.2 Projected climate change effects in relation to perceived sustainability of adaptive capacity resources

Table 2 presents findings on the views of the respondents on the future effects based on their perception of sustainability of adaptive capacity resources. The respondents' view on the future effects in the light of their perception of sustainability of adaptive capacity resources revealed that majority of those with low perception (compared to those with moderate and high perception) project fall of grain production, acute water shortage, erosion of fertile soil, reduced motivation to grow crops, increased food insecurity and soil erosion as future effects. This is caused by the fact that smallholder farming households depend entirely on rain fed farming, a situation that exposes them to more effects.

Table 2: Respondents view on the projected effects in relation to levels of sustainability (n=240)

Projected effects	Categories of Sustainability		
	Low %	Moderate %	High %
Fall of grain production	60.4	3.6	36.0
Acute water shortage	60.0	2.7	37.3
Erosion of fertile soil	58.3	3.6	38.1
Reduced motivation to cultivating	58.8	3.5	37.6
Increased food insecurity	59.7	3.2	37.1
Soil erosion	61.6	3.2	35.2

3.3 Perceived sustainability of adaptive capacity resources

The study intended to determine the perception of sustainability of adaptive capacity resources among smallholder farmers. Smallholder farmers were aggregated into those with low perception (15 to 22.4 scores), moderate perception (22.5 to 30 scores) and high perception of sustainability of adaptive capacity resources (31 to 45 scores). The results in Table 3 indicate that 60.4% of the interviewed smallholder farmers have low perception on the sustainability of adaptive capacity resources, 36.2% belong to high perception and 3.3% belong to moderate perception. The obtained mean score is 31.3, implying that majority of the smallholder farmers have low perception on the sustainability of adaptive capacities, meaning that the adaptive resources that they are endowed with will not certainly suffice them to meet the current adaptation needs and those of the future, given the constant change in climate.

Table 3: Perceived sustainability of adaptive capacity resources (n=240)

Sustainability	Scores	Frequency	Percent
Low Sustainability	15-22.4	145	60.4
Moderate sustainability	22.5-30	8	3.3
High sustainability	31-45	87	36.2

3.4 Comparison between age groups with respect to perception of sustainability of adaptive capacity resources

The Kruskal-Wallis Test was performed to test whether perception of adaptive capacity resources is the same in all ages, namely lower age (20 to 40 years), middle age (41 to 50 years) and older age (51 years and above) at $p \leq 0.05$. The results in Table 4 show that there is no statistical significant difference between age groups on the perception of sustainability of the adaptive capacity resources (χ^2 (2) = 0.384, p = 0.825), with 45 median for all the ages. The study involved smallholder farming household heads and therefore suggesting insignificant difference in the perception of sustainability of adaptive capacity resources. This is partly caused by the fact that the surveyed households were living in a similar rural setup which results in uniformity of perception regardless of age. It is also caused by the fact that in the traditional rural settings Manyoni being one, regardless of age, as soon as someone gets married he ascends to the level of elders hence sharing knowledge and perception of realities that come across them.

Table 4: Household responses on perception of sustainability of adaptive capacity resources (n=240)

Age categories	n	Median	Chi-square	Degree of freedom	P-Value
Younger age	93	45	0.384	2	0.825
Middle age	61	45			
Older age	86	45			

3.5 Analysis of the weights of perceived sustainability of adaptive capacity resources

The study intended to determine weights of the perceived sustainability of adaptive capacity resources. The results in Table 5 indicate that social capital scored 7.9%, governance 6.8% while financial capital scored 6.8% and physical capital 6.4%. The Social capital was measured by two sub indicators namely gender equality and social networks scored 7.9%. In focus group discussions, smallholder farmers explained the importance of social networks which were normally formed in terms of informal social groups. It was noted that informal social groups that involved revolving funds in an informal setup is dominant among smallholder farmers women being more active than their men counterparts due to the fact that they are vested with most of household expenditures. These groups are said to have been formed for mutual assistance and revolving funding. Social groups were said by focus group discussants to be a haven for most people especially women who, in turn take care of their families and farming. This finding implies that smallholder farmers embrace social capital as a livelihood strategy and hence perceiving it as a sustainable resource for adaptive capacity. A similar study that was carried out in Ghana by Egyir *et al*. (2015) found inadequate adaptive capacity in the area being due to low level social capital. Adger (2003) and Armitage (2005) report that social capital facilitates collaboration and cooperation between local and non-local actors in times of stress and the effective delivery of management efforts to cope with threats to resources and resource users. Social capital can also be used to generate material interventions directed at reducing vulnerability to climate change or background stressors, as well as to generate institutional modifications to address both climate stress and background stress (Pelling and High, 2005).

Governance was ranked second with 6.8% and was measured by five sub indicators namely: accountable leadership, inclusion, coordination, equity (fair rules) and responsiveness. This finding implies that the existing governance mechanisms are being perceived to be more sustainable. This may have been caused by the existing government intervention on climate change such as insistence on drought resistant crops, food aid in times of severe shortage and pests control systems by the government as well as extension services. Griffith *et al.* (2009) report that good adaptive governance determines the way power and authority are exercised, how decisions are made and how the community and stakeholders have their say.

In focus group discussions, it was reported that the government had been informing farmers on the best farming practices as well as taking stiff measures against concurrent climate change calamities such as floods and birds pests (*quelea quelea*[4]). They also reported to have been accessing government food aid in times of food crisis and extension services though in a limited

[4] *It is a genus of small passerine birds that belongs to the weaver family Ploceidae, confined to Africa*

extent. Along this assertion, the Manyoni District Agricultural Officer reported to have used helicopters to spray pesticides to rescue farms that were invaded by destructive birds. This finding further implies that smallholder farmers regard existing governance mechanisms as important and sustainable machineries for enhancing adaptive capacities and adaptation to climate change. Financial capital that was measured in terms of access to income and diversified income generating activities also scored 6.8%.

Table 5: Mean perceived sustainability of each resource (n=240)

	Capitals	Total scores	Average score per adaptive capacity category	Mean percentage per each category (%)
Human capital	Climate change knowledge	369	575.6	5.5
	Voluntary adaptation	613		
	Flexibility to adapt	745		
Social capital	Gender equality	862	822	7.9
	Social networks	782		
Physical capital	Farming facilities	675	667	6.4
	Transport facilities	659		
Financial capital	Access to income	736	707	6.8
	Diversified income generating activities	678		
Natural capital	Land ownership	633	633	6.1
Governance	Accountable leadership	688	710.4	6.8
	Inclusion	680		
	Coordination.	624		
	Equity (fair rules)	817		
	Responsiveness	743		

4.0 Conclusions and Recommendations

4.1 Conclusions

It is the conclusion of this study that smallholder farmers identified future effects that face smallholder farmers elsewhere are also found in the study area and are happening now, namely fall of grain production, acute water shortage, erosion of fertile soil, reduced motivation to cultivating, increased food insecurity and soil erosion. These are also projected to be more severe in the future, given the limited access to resources and reliance on rain dependant farming among smallholder farmers. It is also the study's conclusion that the majority of smallholder farmers have low perception on the sustainability of adaptive capacity resources, meaning that, with time, resources for adaptive capacity will not meet the needs of the present and future generations, hence a serious threat to future adaptation to climate change. Furthermore, the study concludes that, social and governance capital were very important in the hierarchy of adaptive capacity resources.

4.2 Recommendations

The study recommends that smallholder farmers, in collaboration with the District Agricultural Department, to devise pro-active measures such as using improved agricultural practices for example conservation agriculture, planting in trenches and mulching as well as construction of

manually dug water pans to store water for use during drought seasons. It further recommends that smallholder farmers and the local government set plans to strengthen a more sustainable access and use of adaptive capacity resources aiming at having sustainable adaptive resources for sustainable adaptive capacity. In addition the study recommends that, governance practices be strengthened so as smallholder farmers are well organised for a more sustainable mobilisation of the available resources; notably those that were perceived as being more sustainable such as social and financial capitals.

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