Climatic Variability and Livelihood Diversification among Small-Scale Rice Farmers in Bahi Sub-basin, Tanzania

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ABSTRACT

Climate variability is a major challenge facing small-scale farmers in semi-arid of developing countries. Farmers employ various ways to cope with climate variability. However, scant information is available on livelihoods diversification to ensure livelihoods security. Livelihoods diversification is commonly acknowledged as the means to increase income. Therefore, this paper is an attempt to bridge information gap on livelihoods diversification among small-scale rice farmers in Bahi sub-basin. Analysing determinants of livelihood diversification, to better understanding farmers' strategic behaviour in the event of climatic variability, is important for formulation of development policies. Qualitative and quantitative information were collected and analysed to validate the study objectives. Regression model was used to assess factors influencing livelihoods diversification. Findings show that climate variability increases likelihood of diversification, suggesting the importance of diversification as a response to constraints imposed by climatic variability. Unfavourable rainfall made farmers likely to diversify income. However, the study concludes that farmers have low asset ownership for livelihoods diversification; farm productivity is declining due to rainfall variability and an apparent lack of public investment in infrastructure to reduce the risk of rain-fed agriculture. Therefore, there is urgency for promoting water harvesting and irrigation; increasing access to agricultural-technologies; support diversification; and skills development.

Keywords: Climate variability, adaptation, livelihoods diversification, small-scale rice farmers, rain-fed agriculture

1.0 INTRODUCTION

Climate variability is a global challenge to both sustainable livelihoods and economic development (Dawson *et al.,* 2018). Climate variability, associated with farm-income variability, is recognized as one of the main drivers of livelihoods diversification strategies in developing countries (IPCC, 2014). Studies have revealed that variability in climate and dangerous change in climatic condition that could result in excessive storms; flooding and prolonged droughts have shown considerable impacts on the locations and amenities available to the people (Christensen *et al.,* 2007; Richard and James, 2013). These extreme

events often constitute major stresses to the livelihoods diversification of the poor especially in sub-Saharan Africa.

As of recently, sub-Saharan Africa is classified as a region under pressure from climate risks and is highly vulnerable to the impacts of climate variability (Justus *et al.,* 2018; Milbank, 2018). Many areas in sub-Saharan Africa are recognized as having climates that are among the most variable in the world on seasonal and decadal time scales of which floods and droughts occur on regular basis (Milbank, 2018). These events lead to famine and widespread disruption of livelihoods security (Dawson *et al.,* 2018). For instance, estimates reported by Justus *et al.* (2018) indicate that one third of sub-Saharan African people already live in drought-prone areas and 220 million are exposed to drought each year. Many factors contribute and compound the impacts of current climate variability in sub-Saharan Africa and they have negative effects on the continent's ability to cope with climate variability (Milbank, 2018). These include poverty, illiteracy and lack of skills, weak institutions, limited infrastructure, lack of technology and information, low levels of education and health care, poor access to resources, low management capabilities and armed conflicts. The overexploitation of land resources including forests, increases in population, desertification and land degradation pose additional threats (IPCC, 2014).

Adapting to variability is determined by a number of factors often related to "wealth, technology, education, information, skills, infrastructure, and access to resources, effective governance structure and other essential management capabilities" (Justus *et al.,* 2018; Christensen *et al.,* 2007. However, poor communities in sub-Saharan Africa, especially small-scale rice farmers are known to be lacking in many of these factors, hence, increases their vulnerability to climate variability (Justus *et al.,* 2018). As climate variability is becoming more severe, the lives of the small-scale rice farmers are increasingly become jeopardised. The need to discover alternative livelihoods diversification becomes important; and an investigation into the livelihoods diversification constraints facing the small-scale rice farmers becomes also important to influence the policy makers on the ability of the farming community to adapt. This is because Richard and James (2013) contend that with the available range of conceptual tools, there will be challenges in putting adaptation theory into practice. This is because of the uncertainty factors inherent in the future climate variability and its anticipated effects (Justus *et al.,* 2018). Furthermore, is because of the difficulty in evaluating and relating adaptation measures due to time scales with respect to costs and opportunities, being interpreted locally within the "limits" of existing socio-political entities (Milbank, 2018). Therefore, given the persistent influence of climate variability, and its attendant risks on the small-scale rice farmers (Justus *et al.,* 2018); this study brought to light the livelihoods diversification of small-scale rice farmers in the Bahi sub-basin of semi-arid area in central Tanzania.

2.0 METHODOLOGY

2.1 Study Area

The Bahi sub-basin is located in south of Internal Drainage Basin (IDB). Its southern part is in the form of a lake during the rainy seasons while it becomes a swamp during the dry seasons (Bahi swamp). The Bahi sub-basin also called Sulunga Lake in Central Tanzania is located in a semi-arid area, 45km west from the capital city Dodoma. With the maximum extent of 974km² (42km long / 26km width), the seasonal lake, surrounded by fertile land, is hosting abundant bird and fish populations during their breeding period (Philemon *et al.,* 2018). Due to climatic variability, specific fauna and flora have developed that impedes small-scale rice farming (URT, 2015). Dominated by agriculture, livestock and farming, the Bahi sub-basin is threatened by anthropogenic pressures to rainfall variability (Philemon *et al.,* 2018). Therefore, the Bahi sub-basin is experiencing extreme climate variability with frequent droughts that affects negatively small-scale rice farming in the study villages of Bahi Sokoni and Uhelela that were purposively selected.

2.2 Research Design, Data Collection Methods and Analysis

The study adopted cross-sectional research design. The data collected entailed to capture the variables of the study. The variables ranged from climatic patterns, constraints to adaptation, and livelihoods diversification strategies among the small-scale rice farmers. The nature of this study necessitated the use of both qualitative and quantitative paradigm for sufficiently capture of information from 64 small-scale farmers and 10 key informants (District Agricultural Officer, Ward /Village leaders, Rice Schemes Leaders, and extension officers). The methodological positions of qualitative research are generally different from those of quantitative research; however the two paradigms are not fundamentally opposed to each other.

In determining the sample size from the villages in Bahi sub-basin with a population of 221,645 according to the census data (URT, 2012) the following formulae by Nassiuma (2002) was used:

$$\mathbf{n = (NCv) / (Cv + (N - 1) e^2)}$$

Where, n = the desired sample size, N = Target population.

Cv = Coefficient of variation (take 0.5).

e = Tolerance at desired level of confidence (0.06) at 95% confidence level.

$n = 221{,}645 \times 0.25 / 0.25 + (221{,}645 - 1)\ 0.06^2$, $n = 70$

Therefore, the sample size for the study was supposed to be 70 but only 64 respondents were selected due to information saturation. Finally, purposive sampling was applied in the selection of ten key informants.

In order to identify and analyse the determinants of households' constraints to adaptation because of climate variability, the study adopted linear regression model as shown below.

$$Y_i = \beta_0 + \beta_1(X_1) + \beta_2(X_2) + \beta_3(X_3) + \ldots + \beta_p(X_p) + e_i$$

Where: Y_i = The value of the dependent variable which measures the degree to which a ***livelihoods diversification*** may be adopted by household to manage risk depending on the

households endowments/assets, and thus on their ability to engage in profitable activities, on external factors such as the exposure to shocks.

X_1 to X_p = independent variables; β_1 to β_p = regression coefficients; β_0=intercept; e_i = Random error;

X_1=*Age of the respondent* (This variable takes accounts of the age of the household head, age plays a very important role in rural communities, in most cases, critical household and community decisions are expected to be undertaken by older people).

X_2 =*Education status of the respondent* (This variable represents the education status of the household head. It is expected that the more educated the household head is, the more informed she/he is likely to be, hence their ability to embrace information that has to do with adaptation with respect to climate variability in their environment).

X_3=*whether household members engage in income earning activities* (This variable represents the income earning activities that the respondents engage in. It was included in the model to determine the association between household shocks and their income earning activities; it is reasonable to assume that in the event of extreme shocks to households in crop production, households with other income sources might be able to better adapt than households whose livelihoods entirely depend on crop production. Hence, lack of or little alternative income earning activities could serve as constraints to adaptation in the study area).

X_4=*size of the household* (This variable measures the association between the size of household and their ability to adapt to climate variability, it is expected that the larger the household the more likely will be the adaptive capability, especially among rural household where farming practices represent major livelihoods strategy).

X_5=*whether household planted rice the last year* (Similarly, rice constitutes a major staple food in the study area, any negative extreme climatic variability that have direct impact on rice production will adversely affect livelihoods of the people in this study area. Therefore, rice, is included in the model to serve as a proxy for household shocks relating to food security).

X_6=*whether household planted sesame the last year* (Evidence from previous studies in the study area reveals that sesame is one of the major crops that support the daily livelihoods of the people in the study area. This variable included in this model in order to investigate the extent to which growing this crop relative to other crops renders the households vulnerable. It is therefore becomes very important to investigate the vulnerability of this important crop to climate variability in the study area; it is expected to serve as a proxy for household shocks relating to food security in the study area).

X_7 =*whether household planted maize the last year* (Similarly, maize constitutes a major staple food in the study area, any negative extreme climatic event that have direct impact on maize production will adversely affect livelihoods of the people in this study area. Therefore, maize, just like rice is included in the model to serve as a proxy for household shocks relating to food security)

X_8 =*whether household suffered crop failure* (This variable is included as a proxy for households' shocks resulting from extreme climatic variability e.g. extreme rainfall or extreme temperature that could portend great danger to the livelihood strategies (e.g. crop production) of the people in the study area. Since crop production is generally vulnerable to climate variability, it is expected that any extreme event resulting in flooding or droughts would affect negatively on the livelihoods of the people in this study).

X_9 =*whether household lost crop to hail/storm or heavy rainfall*

X_{10}=*household income* (It is expected that if household income is affected due to one form of shocks or the other as a result of extreme climate variability, the livelihoods diversification of the entire household may be threatened)

X_{11} =*whether household use seed varieties* (This variable will be included in the model for the purpose of investigating likely constraints to adaptation, and it represents the purchase of different seed varieties as a means of adapting to climate variability. Expectedly, households with little or no money to procure varieties of seeds would find it difficult to adapt to climate variability).

3.0 RESULTS AND DISCUSSION

3.1 Socio-economic and Demographic Characteristics of the Respondents

Table 1 shows socio-economic profile of the household heads. Greater percentages (78%) are concentrated between ages 40 to 60 and above. These age groupings has social and economic implications in the sense that are near retirement, and their respective households might become more vulnerable if there are no structures in place to cater to their livelihoods diversification coping strategies.

Table 1: General distribution of the ages of the respondents

Age groups	Frequency	Percent
30-39	4	6
40-49	34	53
50-59	16	25
60 and Above	10	16

Table 2 shows that a higher proportion of male (77%) and 23% of female were involved in this study. The major means of production (land) owned and controlled by men. The larger percentages (48.14%) of household heads in the Bahi sub-basin are single/never married. This suggests that there is a tendency for them to migrate easily in the event of serious negative shocks as a means of livelihoods diversification coping strategies. The resident status of the household heads also suggests that a large percentage (69%) have permanent resident status; it is therefore, expected that since they have what it takes to move freely within the region, migration as a means of adaptation to climate variability is a possibility.

Table 2: General distribution of marital status and sex of the respondents

Attributes	Frequency	Percent
Marital Status		
Married (formal)	5	7.31
Single/never married	31	48.14
Married (informal)	2	3.60
Divorced	4	5.96
Separated	1	1.91
Widow	21	33.07
Sex of the Respondents		
Female	15	23
Male	49	77
Resident Status of the Household Head		
Permanent resident	44	69
Temporary migrant (working/looking for work)	17	29
Temporary migrant (others)	1	0.66
Recent out-migrant	1	0.66
Recent in-migrant	1	0.66

Households in the Bahi sub-basin have access to information channels. This is because a larger percentage (98.89%) of the small-scale rice farmers households have cell phones, 86.51% have functioning Television sets, while 46.7% have access to information from Radio (Figure 1).

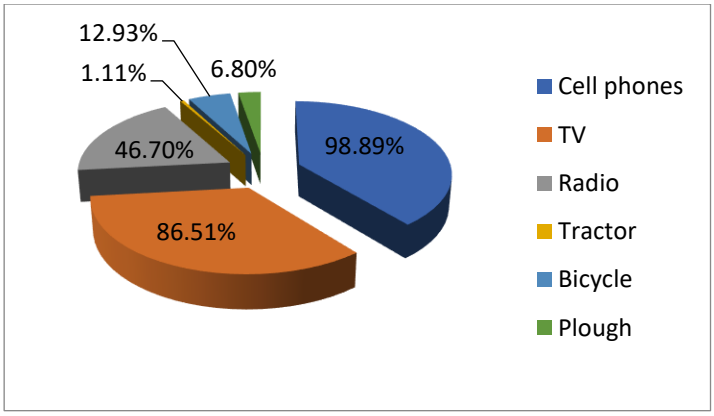

Figure 1: Assets and physical capital ownership of the household heads

Responding to climate variability in agricultural communities will be incomplete without access to weather forecasting and early warning information. The forecasts provide advance information so that farmers can adjust critical agricultural decisions, thereby improving efficiency, and enabling them to adopt the most suitable coping strategies (Hansen *et al.*, 2006). The importance of early warning systems in enhancing timely and effective responses to climate impacts is emphasised by various scholars (Houghton 2009; Karanasios, 2011). This is because preparedness to events such as violent storms, floods, and droughts is crucial in reducing vulnerability. Nonetheless, many of the promising opportunities provided by early warning and climate information have not been fully exploited (Vermeulen *et al.*, 2010). Dinku *et al.* (2014) noted that the availability and

access to such information and the ability to use it, is a serious challenge in most rural areas across the continent.

Furthermore, in terms of forecast information, Dinku *et al.* (2014) explain, "climate and weather forecasts in their current form are often ill-suited for direct use in decision-making and decision-making is often ill-suited for the use of weather and climate information". Nevertheless, farmers in developing countries as well as those in countries with a well-integrated market system have the potential to benefit significantly from weather and climate forecasts, those in developing countries as a result of their particularly high vulnerability. However, the greatest benefits may go to those farmers who have the means and resources to take the most advantage of the information technology. For smallholder farmers in Africa, and in other developing regions, these would be those farmers who could apply productivity-enhancing technologies such as improved seeds, fertilisers, and labour. Conversely, poor market development limits the demand, especially for farmer-oriented climatic information, since the options available to farmers are limited (Motha and Stefanski, 2006).

The study took the public ownership of land as a given institutional condition and examined other factors perceived as crucial by small-scale rice farmers in the Bahi sub-basin. The findings commend on how the present land tenure system in the Bahi sub-basin discourages small-scale rice farmers from migrating to other areas for seasonal employment as reported during focus group discussion. Land is an essential asset especially to farmers for farming activities since it is a major means of production. Ownership of land in rural areas considered as a symbol of wealth and so by possessing a piece of land, farmers assured of cultivating for consumption and commercial purposes. This is because Figure 2 shows that 58% of the small-scale rice farmers own 1-3 acres of land, 19% of the small-scale rice farmers own 4-7 acres while 23% own 8 to 12 and above acres.

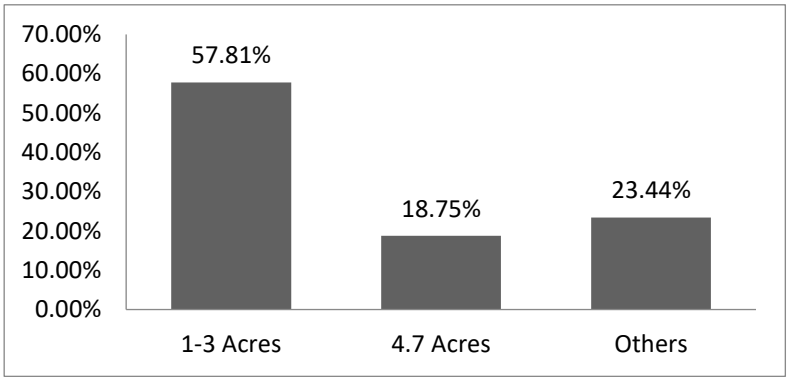

Figure 2: Household land ownership (in terms of acres)

The data show that majority of the small-scale rice farmers in the Bahi sub-basin (more than 50%) are owning 1-3 acres, this implies that small-scale rice farmers produce mainly for consumption and non or little for commercial purposes. For that matter, small-scale rice farmers quest for alternative means of livelihoods for sustaining their living and income. Increased land access for the poor brings direct benefits for livelihoods options

by contributing directly to increased households food and livelihoods security. In countries where agriculture is a main economic activity like in Tanzania, access to land is a fundamental means whereby the poor can ensure households food supplies and diversify their income. The distribution of land rights and opportunities for access to land have implications for the distribution of wealth, rates of economic growth and the incidence of poverty. The shape and direction of agricultural development affect the incomes and returns from different types of farming activity, the value of land and demands for access to land resources (Baland *et al.*, 2007).

3.2 Current Livelihoods Diversification of the Small-scale Farmers in the Bahi Sub-basin

Figure 3A shows the relative contributions of different activities to small-scale rice farmers' income in the Bahi sub-basin. About 72% of the small-scale rice farmers' households obtained income from on-farm and other sources; this is in addition to farming, implying that livelihoods diversification is widespread. Other sources of income emanated from livestock keeping, "*Bodaboda"* (motorcycles taxi), sales of charcoal and fire woods, wage labour, food vending, selling local brews, tailoring, carpentry, money lending, and land rent (Figure 3B). However, the contribution of sources other than farming to households' income is low.

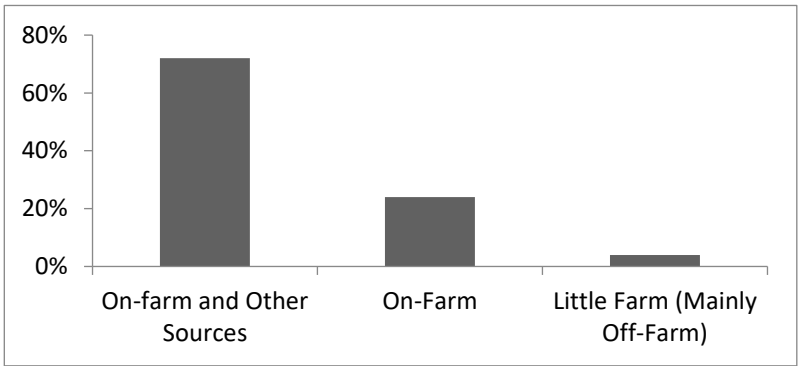

Figure 3A: Percent share of different income sources in the Bahi sub-basin

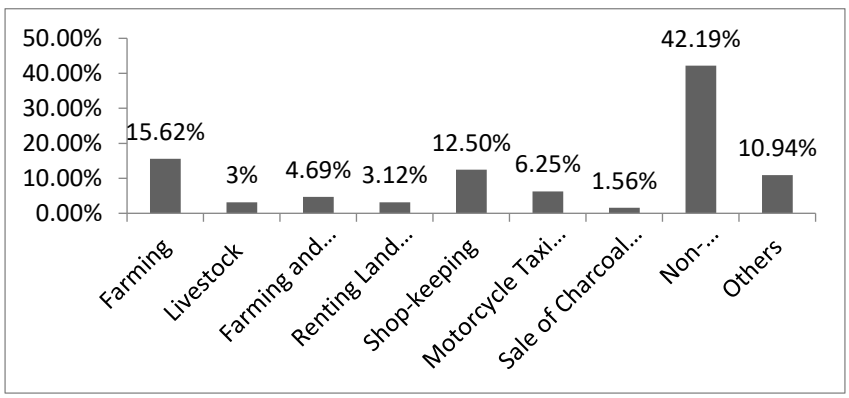

Figure 3B: Distribution of existing livelihoods diversification in the Bahi sub-basin

The high dependence on the farm as the main source of income made the small-scale rice farmers' households highly vulnerable to livelihood failure given frequent crop losses due to rainfall variability.

3.3 Key Factors Constraining Livelihoods in the Bahi Sub-basin

Figure 4A presents small-scale rice farmers' perception of the principal constraints to livelihoods in the Bahi sub-basin, of which erratic rainfall was the single highest source of risk and vulnerability for more than 43.7% of the households. The frequent drought (26.56%) is the second most serious constraint in the Bahi sub-basin. Other factors such as access to improved seeds and fertilizers (23.44%), lack of capital (1.56%), shortage of agricultural land (1.56%), and pest infestation (1.56%) are also significant problems for substantial numbers of small-scale rice farmers. In fact, most of the farm households operated under the combined impacts of most of these constraints.

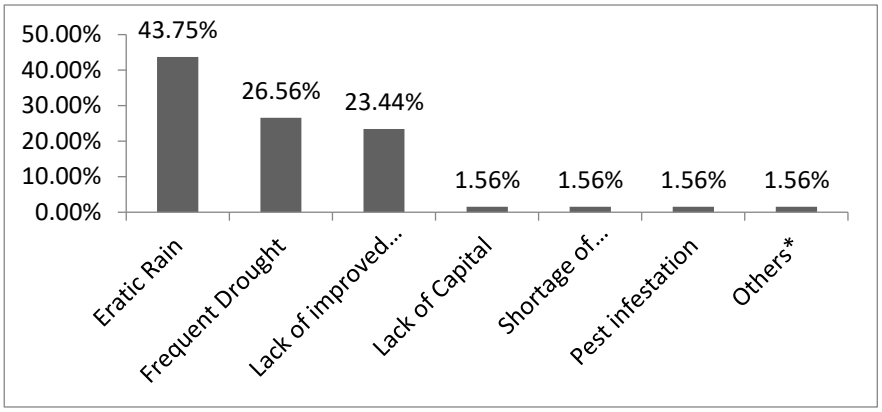

Figure 4A: Major Constraints to Livelihoods

Likewise, Figure 4B indicates that rainfall variability is the principal constraint to livelihoods in the Bahi sub-basin. Small-scale rice farmers characterised the rainfall in the area as highly irregular, inadequate, showing poor seasonal distribution, or a combination thereof. Furthermore, there is an additional problem of crops being damaged by occasional downpours; but also identified 'bad years' in which whole or part of their production was lost due to rainfall related problems.

On the other hand, crop loss due to occasional heavy rain downpours, pests and diseases were more common. From the sampled small-scale rice farmers, 51.6% reported that one of the effects associated with climate variability is inadequate harvest, which resulted to food shortage. 40.62% pointed out crop failure due to famine being among the greatest effect because of climate variability. Others included increase of pests and crop diseases (4.69%), and loss of soil nutrients (1.56%) as among the effects of climate variability.

The risk of unsatisfactory harvests or harvest loss due to rainfall failure is high, and it has actually occurred every other year. As production failed, households forced to sell valuable assets, borrow in cash or in kind, or lease out agricultural land to meet consumption needs. This significantly affected the capacity of small-scale rice farmers to meet subsequent consumption needs and retain their asset bases. The struggle to cope with recurrent food shortages and to settle previous debts has kept most households in the study area in a poverty trap.

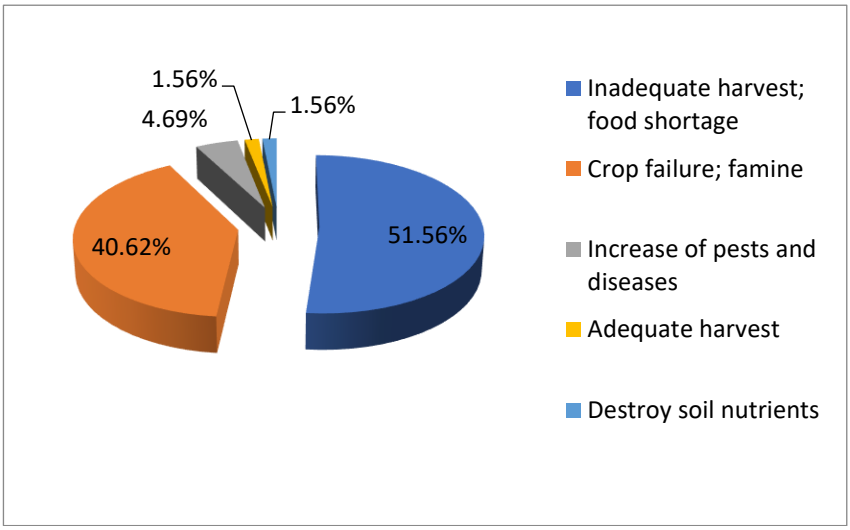

Figure 4B: Farmers' description of the effects of climate variability

3.4 Adaptation Mechanisms by Small-scale Farmers in their Farming Practices

Bahi sub-basin like other catchments in semi-arid zone of Tanzania, small- scale rice farmers adopts various farming practices as adaptation mechanisms to the effects of climatic changes. Table 3 shows adaptation mechanisms for small-scale rice farmers in the Bahi sub-basin which involved growing of drought resistant crops (Sesame and Bambara nut "*Njugumawe*") (17.19%), mixed cropping (7.81%), local irrigation schemes (34.38%), crop rotation (3.21%), fallowing (4.69%), off-farm activities (28.12%), and on-farm activities (4.69%). The local irrigation schemes, off-farm activities, and growing drought resistant crops are the most frequently used as adaptation mechanisms by the small-scale rice farmers.

Table 3: Small-scale farmers' adaptation mechanisms in farming practices

Adaptation Mechanisms	Frequency	Percentage
Growing Drought Resistant crops	11	17.19
Mixed Cropping	5	7.81
Irrigation Activities	22	34.38
Crop Rotation	2	3.12
Fallowing	3	4.69
Off- farm Activities	18	28.12
On-farm activities	3	4.69

3.5 Factors Influencing Choice of Livelihood Among the Small-scale Rice Farmers in the Bahi Sub-basin

There are number of factors affecting the livelihoods diversification in the Bahi sub-basin. Table 4 indicates that, the small-scale farmers at the Bahi sub-basin diversify their livelihoods as results of variability in climatic conditions. This is supported by positive and significantly ($p<0.01$, $p<0.05$ and $p<0.1$) on the majority of the variables.

Table 4: Factors influencing livelihoods diversification among small-scale farmers in the Bahi Sub-basin

Predictor	Std. Error	Coefficient Estimate	t-Value
(CONSTANT)	0.445	0.000	0.00^{S}
Marital Status	0.080	-3.333	-4.17***
Age of the respondents	0.006	0.000	0.00^{NS}
Household income	0.098	0.000	0.00*
Household size	0.094	1	10.66***
Whether planted sesame	0.097	0.167	1.72*
Household crop failure	0.110	0.333	3.02***
Whether planted rice	0.044	0.333	7.57***
Education	0.116	0.167	1.43*
Income earning activities	0.101	0.167	1.64*
Crop loss to heavy rain	0.121	1	8.21***
Seed varieties	0.069	0.000	0.00*

*Note: Pseudo R^2=34.36%, ***Significant at 1% level, **Significant at 5%, *significant at 10%, S significant*

According to Gebru and Beyene (2012), people make livelihood choices according to the level of their household assets or availability of infrastructure in their community. The results in Table 4 summarises the regression analysis of the factors that influenced livelihood choices adopted by the small-scale farmers. The result are highly significant ($t<0.001$), suggesting that the model has a strong explanatory power. The pseudo R^2 was 34.36%, thus confirming households' choice decision-making process attributed to fitted covariates. For instance, the coefficient of marital status is negatively and significantly ($p<0.05$) related to the probability of the household choosing livelihoods diversification strategy as their means to escape from climate variability shock.

Households income is positive and statistically significantly ($p<0.01$) in choices of livelihoods. This is because income is the major determinants of livelihoods options. There is every tendency of the household choosing a livelihoods source that generates

more income. The more income obtained from a livelihood source, the greater the probability of a household choosing it as their major livelihood option.

Likewise, educational level of the household head is positive and significantly related to the likelihoods of the household heads choosing other livelihood options. This implies that educated household heads are more likely to diversify their livelihoods options of the family. Education is expected to impact positively on farmer's decision making, since educated households are expected to be more informed and knowledgeable on the best livelihood choices. This finding is in line with that of Birkmann and Fernando (2008), who noted that education and skills up grading are powerful adaptive strategies for individual families and communities. In addition, Adi (2007) identified education as one of the determinants of livelihood choice in Eastern Nigeria. Therefore, based on the outcome of this analysis, climate variability affects the livelihoods diversification of the small-scale rice farming in Bahi sub-basin.

4.0 CONCLUSION AND RECOMMENDATIONS

According to the findings, rural livelihoods among the small-scale rice farmers in Bahi sub-basin are caught up in the trap of livelihoods insecurity. This is because asset ownership is low, household size is large, and soil fertility is declining rapidly because of climate variability. Rainfall variability is the most critical source of risk and vulnerability, with an apparent lack of public investment in infrastructure to reduce the risk of rain-fed agriculture.

Livelihoods diversification is constrained by poverty, poor access to extension services, and poor infrastructure development (irrigation scheme). As crops fail, households are forced to sell or rent out valued assets and take loans to cope with food shortages. This in time depletes household assets, limits the capacity to diversify and adapt, and impacts negatively on production activities. As a result, poverty, food insecurity and susceptibility to livelihood crises have remained part of rural life. The following are some key areas requiring policy attention;

i. Support for diversification and adaptation activities. Small-scale rice farm households are engaged in different diversification and adaptation strategies, but their activities are limited by poverty and poor access to input delivery. Access to livelihoods choices would help small-scale rice farm households to use their human and material potential to improve their wellbeing. Many small-scale rice farm households reported lack of capital being an obstacle for not engaging or expanding their income generating activities. Hence, it is essential to expand rural micro-credit facilities and make them accessible to farm households at favourable terms.

ii. Finally, promoting water harvesting and land management techniques that retain moisture in soil or minimize its loss could be the principal and prospect area for small-scale irrigation.

REFERENCES

Adi, B. (2007). Determinants of Agricultural and Non-Agricultural Livelihood Strategies in Rural Communities; Evidence from Eastern Nigeria. *J. Dev. Areas* 40 (2): 93-94.

Baland, J., Gaspart, F., Place, F and Platteau, J. (2007). 'The Distributive Impact of Land Markets in Uganda,' *Economic Development and Cultural Change,* 55(2), 283-311.

Birkmann J and Fernando N (2008). Measuring revealed and emergent vulnerability of coastal communities to Tsunami in Sirlanka. *Disasters,* 32 (1):82-105.

Christensen J H, Hewitson B, Busuioc, A and Chen, A. (2007). Regional Climate Projections. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. New York. USA.

Dawson, N. M., Mason, M., Mwayafu, D . M., Dhungana, H., Satyal, P., Fisher, J. A., Zeitoun, M and Schroeder. (2018). Barriers to equity in REDD+: Deficiencies in national interpretation processes constrain adaptation to context. *Environmental science and policy,* 88: 1-9.

Dinku, T., Block, P., Sharoff, J., Hailemariam, K., Osgood, D., del Corral, J., Cousin, R and Thomson, M. C. (2014). Bridging critical gaps in climate services and applications in Africa. *Earth Perspectives,* 1(15): 1-13.

Hansen, J. W., Challinor, A., Ines, A., Wheeler, T and Moron, V. (2006). Translating Climate Forecasts into Agricultural Terms: Advances and Challenges. *Climate Research,* 33: 27-41.

Houghton, J. (2009). ICT and the Environment in Developing Countries: An Overview of Opportunities and Developments. *Communications and Strategies,* 70(4): 39-60.

Intergovernmental Panel on Climate Change (IPCC) (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. R.K. Pachauri and L.A. Meyer (eds.). IPCC, Geneva, Switzerland.

IPCC, (2007). "Climate Change", the Fourth IPCC Assessment Report. Cambridge University Press, UK.

Justus, O., Lilian, K and Mary, M. (2018). Effects of climate variability and change on agricultural production: The case of small scale farmers in Kenya. *NJAS - Wageningen Journal of Life Sciences,* 77: 71-78.

Karanasios, S. (2011). New and Emergent ICTs and Climate Change in Developing Countries. Centre for Development Informatics Institute for Development Policy and Management, SED. Manchester: University of Manchester.

Milbank, D., Coomes, D and Vira, B. (2018). Assessing the Progress of REDD+ Projects towards the Sustainable Development Goals. University of Cambridge Conservation Research Institute, The David Attenborough Building, Pembroke Street, Cambridge CB2 3QZ, UK.

Motha, R and Stefanski, R. (2006). United States Department of Agriculture's weather and climate information system for operational applications in agriculture.

<https://rmets.onlinelibrary.wiley.com/doi/pdf/10.1017/S1350482706002532> (accessed on 20 August 2019).

Nassiuma, D. (2002). Survey Sampling: Theory and Methods. Egerton University Press Kenya.

Philemon1, W., Missanga, S. J and Ndimbo, M. (2018). Socioeconomic Activities and Their Potential Impacts on Sustainable Food Safety and Livelihood Improvement in the Bahi Wetland, Central Tanzania. *Archives of Current Research International,* 12(3): 1-9.

Richard, Y and James, G. (2013). Climate Change, Adaptive Strategies and Rural Livelihoods in Semiarid Tanzania. University of Dar es Salaam, Tanzania.

Vermeulen, S. J., Aggarwal, P. K., Ainslie, A., Angelone, C and Campbell, B. M. (2010). Agriculture, Food Security and Climate Change: Outlook for Knowledge, Tools and Action. CCAFS Report 3. Copenhagen: CGIAR-ESSP Programme on Climate Change, Agriculture and Food Security.