Smallholder farmers pathway to resilience: achieving food security through adaptation strategies in Southern Highlands of Tanzania

Brown Gwambene* and Emma Liwenga

Building smallholder farmers’ resilience is essential to the sustainability of food security interventions. Being food secure alone is not enough, as disasters, including climate related extremes can quickly wipe out hard won development gains. Climate variability is an immediate challenge affecting the economy and poses threats to agriculture production and food security for smallholder farmers in rural communities. The livelihoods of people who depend on climate sensitive agricultural resources are particularly vulnerable. This study used a survey method to envisage adaptation strategies in agricultural production of smallholder farmer so as to increase resilience and create opportunities for increasing food security and environmental sustainability. The results indicated that more frequent and severe extreme climatic events, especially drought and heavy rainfall pose challenges to agricultural production and on ensuring food security in the area. To deal with such climate related extreme events, farmers develop different adaptation measures. Although farmers’ adaptation measures may not succeed completely, they form the basis of solutions to extreme events and disaster preparedness. It suggested that, addressing the threat posed by climate change will require better quantification of the problem, greater attention for prioritizing which production systems are vulnerable, and a redoubling of land and water management efforts. Climate change is occurring within a background of other global challenges, such as population growth, urbanization, land and water use, rural-urban migration, and biodiversity depletion. Thus, efforts to adapt to the impact of climate change should do so in a manner that is consistent with these broader development issues.

Keywords: Smallholder farmers, Resilience, Food Security, climate change, adaptation and livelihood strategies

INTRODUCTION

The need for livelihood diversification strategies to improve food security and adaptation to anticipated climate change has been increased in smallholder farmers of Tanzania as in most developing countries, particularly in South Asia and sub-Saharan Africa. Low adaptability capacity of smallholder farmers increased challenges and reduced agricultural production. Reduced production leads to higher food prices and increasing food insecurity, particularly for rural families who are net buyers of food (CARE International, 2011; Gwambene, 2011). People’s ability to maintain food security in the face of climate change depends significantly on their adaptive capacity. Notably, Adaptive capacity influenced by access to and control over important resources, such as information and knowledge on climate change, natural resources such as land and water for agriculture, and opportunities for earning a sustainable income (CARE International, 2011; IIED, 2012).

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Climate change and variability are placing additional stress and increased vulnerability, which limit capacity to adapt to changes occurring in agricultural production (Nkomo et al., 2006; Gwambene, 2011; Kangalawe, 2012; Nyunza & Mwakaje, 2012). Smallholder farmers are particularly vulnerable to such changes, which reduce productivity and negatively affect their weather-dependent livelihood systems (Ngigi, 2009).

According to CARE International brief on climate change (2011) a recent study on the future of food and farming identified six key drivers of change affecting the global food system. Such drivers include a growing global population; changing diets, an increase in demand for resource- intensive meat products; food system governance, including globalization of markets, subsidies and trade restrictions; competition for resources (IIED, 2012; Word Bank, 2013), particularly land, water and energy; consumer values and ethics; and the impacts of climate change. Most Sub-Saharan Africa countries are particularly vulnerable to climate change because of limited adaptive capacity as a result of widespread poverty, recurrent droughts, inequitable land distribution and dependence on rain-fed agriculture (Ngigi, 2009). The combined effects of these pressures will mean increasing numbers of people at risk of food shortage in the future.

Smallholder farmers are using and testing out different crop diversification strategies, including the use of drought tolerant indigenous seed varieties and crop rotation, legume intercropping methods to improve soil fertility (Gwambene, 2011; Dakishoni, 2013). Achieving food security for all requires a coordinated effort that incorporates preventive, promotional, protective and transformative measures (CARE International, 2011; FAO, 2013; World Bank, 2013). Preventive measures aim to help people avoid food insecurity, and include social insurance systems such as savings groups, as well as risk management measures such as crop diversification. Promotional measures aim to reduce vulnerability to food insecurity by enhancing incomes and capacities. Protective actions are relief measures, required when preventive and promotional measures fail. Underpinning these three with an emphasis on participatory education through farmer experimentation, farmer-to-farmer teaching and improving extension services to increase awareness on climate change and adaptation strategies are paramount. Such measures would need to enhance flexibility, resulting in a net benefits for agriculture production and environmental sustainability (Ngigi, 2009; Gwambene and Majule, 2010; Government of Kenya, 2013).

There is an urgent need to strengthen smallholder farmers innovation systems to address food insecurity, promote resilient livelihoods to ensure adequate food availability and access; improving utilization with a focus on enhancing stability through vulnerability and risk reduction and management. To minimize sensitivity to climate change, African economies should be more diversified, and agricultural technology should optimize water usage through efficient irrigation and crop development (Ngigi, 2009; Tumbo et al., 2008; Gornall et al., 2012). Increasing agricultural productivity, climate resilience and sustainability, particularly for smallholder farmers (for example, by promoting climate smart agricultural practices, restoration of degraded soils and agricultural biodiversity is among the important options (Gwambene, 2012; FAO, 2013). Adaptation looms must incorporate actions targeted at climate-resilient livelihoods and disaster risk reduction, as well as addressing the underlying causes of vulnerability. In many contexts, strategies to reduce vulnerability to climate change also increase food security.

MATERIALS AND METHODS

Descriptions of study area

This paper used a survey method undertaken in the southern highlands of Tanzania between 2010 and 2013. The study was conducted in three agro-ecological zones that include the lowland, midland and highland zones in Rungwe district. The zones have different characteristics in terms of climate, soil, terrain and biophysical environment that differentiate agricultural production. The District is located in the Southern highland of Tanzania and lies between Latitudes 830’ and 930’ South and Longitudes 335 and 345 East with an altitude range rising from 770 to 2,265 meters above sea level (MASL) (Gwambene, 2011). The district was selected due to its agricultural potential within its vertical landscape gradient with diverse characteristics, which allow the production of a number of crops. For a long time, the district has been a basket of food supply for the country. The District also experienced changes in crop yield in the past 20 years that acknowledged the importance of climate variability that had effects on crop production (Gwambene, 2011). This provides the basis on climate variability and its implication on livelihood.

The highland zone, which rises to an altitude of 2000 - 2865 MASL, experience high rainfall ranging between 1500 mm to 2700 mm per annum and experience cold condition throughout the year, its temperature range between 5°C - 18°C. The area is suitable for agriculture and the main crops grown are Irish potatoes, maize, and pyrethrum. The middle zone lies within altitude of 1400 – 2000 MASL. The zone experiences cold temperature ranging between 16°C - 28°C and receive an annual rainfall between 800 mm to 2200 mm. The soil is good for agriculture and livestock keeping. The main crops grown include tea, coffee, cardamom, beans, bananas, groundnuts, maize and paddy. The lowland zone lies in the southern part of the district at an altitude of 772 - 1500
MASL with an average rainfall ranging between 900 mm and 1200 mm per annum. The temperature is generally hot ranging between 20°C - 30°C. The area is suitable for cultivation of rice, maize, beans, cocoas, and bananas.

Sampling techniques and sample size

Given the nature of the study purposive and random sampling techniques were employed. The combination of the two sampling techniques was important to assure the accuracy of the results. In order to have efficient and representative sample, the study covered three selected villages of the district covering the highland, middle and lowland zones. Random and purposeful sampling techniques were used in the selection of wards and villages for study. In each agro-ecological zone, one ward was purposefully selected and in each ward one village was picked at random. This study was therefore carried out in three villages: Kapulampunguti village in the lowland zone, Kikota village in midland zone, and Mbeye I village in highland zone. Then, the required information was collected from the elements within each selected village. The main technique for data collection were review of relevant literature, focus group discussions, field observations, household survey with a structured questionnaire, semi-structured interviews with key informants within the selected project areas, districts and in the study wards and villages. A total of 147 households were randomly selected from the total households of the study villages to which the structured questionnaire was administered. In each study village one FGD meeting of 10 to 18 representatives based on gender, age and socioeconomic situation was carried out. 14 Key informants representative in all villages, wards and district were chosen for their knowledge or distinctive point of views they have in the community. In addition to key informant interviews, in-depth interviews were conducted during the household survey. These interviews aimed at gathering additional information from respondents on issues of interest regarding the study.

Material and methods

To acquire accurate and detailed information, combinations of both qualitative and quantitative approaches were used in the assessment of the agricultural dynamics and climate variability in Rungwe district. The qualitative methods established the knowledge and experience with the Climate variability implications and related challenges on livelihood; spatial and temporal changes in agricultural production, food security and response strategies while the quantitative method provided the percentages and statistical information. Based on the nature of the study and its objectives, quantitative method was employed at a household level whereby a closed and open-ended questionnaire administered to sample households, with face-to-face interview being the main approach used. Qualitative design involved key Informant Interviews (KII), and Focus Group Discussions (FGD) coupled with field observations. KII and FGD were guided by semi-structures questionnaires. The use of two approaches facilitated the triangulation and validation of information collected through various methods.

The choice of research method was based on the type and quality of information required, socioeconomic setting, time frame and resources available. Information collected was biophysical, weather and socioeconomic and cultural. In order to enhance the smooth running of the study secondary information were reviewed from various documents on what others have done and form a background of the study. The main focus was on the agricultural production challenges in ensuring food security and prospects in relation to climate variability, adaptation measures and other stresses to livelihood and agricultural production. Moreover, a detailed analysis of smallholder farmers' adaptation strategies, options and mitigation measures were undertaken.

The data collected from different sources and methods were edited, coded, tabulated, compiled, processed and analyzed using different techniques. Quantitative data were compiled and analyzed by using Statistical Package for Social Sciences (SPSS) version 20 and Microsoft Excel software. The qualitative data were analyzed during and after data collection using content analysis, factor analysis, as well as cluster analysis. The qualitative data from key informant interviews, focus group discussions, household interviews and observations were examined and presented in summary form and the results were displayed in the form of tables, bar charts and figures, before descriptions.

RESULTS AND DISCUSSION

Climate variability implications and related challenges

Increased occurrence of extreme weather events such as floods, droughts, and strong wind significantly affects agricultural production. For farmers, extreme rainfall events disrupt growth and destroy crops, while changes in temperature alter cropping patterns and suitability of the crops and increased the occurrence of diseases and insect pests. The results revealed that climate variability and land exhaustion were the main challenge in crop production reported during focus group discussions and key informant interviews. Other production challenges were land shortage, insect pests, the high price of inputs (fertilizers) that increase production cost, unreliable market, and lack of product knowledge. Figure 1 indicates the crop production challenges in southern highland of Tanzania.
Changing in rainfall patterns and higher temperatures have forced farmers to shorten the growing season and switch to more expensive hybrid crops. Frequent droughts and floods are eroding assets and knowledge, leaving people more vulnerable to climate variability and food shortage. These changes, with increased fluctuations, are expected to cause many shifts in food production, as most crops are sensitive to changes in climate conditions, which include alterations in temperature, moisture, and carbon dioxide level. Furthermore, major climate changes and variability influence populations of beneficial organisms and pests and alter their effective roles in agricultural ecosystems. Climate change and variability (expressed through shortage of rainfall and drought), land exhaustion (mainly reported in lowland and midland zones), and use of chemical fertilizer (reported in middle and highland zones).

Weather and climate are important factors in crop production. Understanding the effects and impacts of climate variability on agriculture is critical in formulating strategies and adaptation options to minimize adverse consequences. A general shift in the agro climatic zones and change in the cropping patterns calls for farmers to adhere to improved agronomic practices and better crop management. For example less and erratic rainfall received in lowland and middle land areas, irrigation and drought resistant varieties is required to substitute moisture losses due to increased evapo-transpiration. In addition, fluctuating rainfall in lowland and midlands zones induces the need for irrigation to buffer the negative impacts on agricultural production during dry periods. The major adaptation options need to include diversifying into multiple crops, intercropping, mixed crop-livestock systems, switching from rain-fed to irrigation. This will need to have efficient and effective irrigation systems including good strategies for rainwater harvesting for agricultural production.

**Agricultural production challenges in ensuring food security**

The results indicated that more frequent and severe extreme climatic events, especially drought and heavy rainfall pose challenges to agricultural production and food security in the area. It was revealed that most farmers in rural areas are buying food due to changes in productivity that was reported to being a result of increased climate variability and land exhaustion in the area (Gwambene, 2011). In general, food security is partly linked with the incomes of the people that is used for buying food. Further, it was reported that, the better off in terms of income are less vulnerable to food shortage. In the context of changing climate, farmers faced the challenge of increasing crop productivity and income for purchasing food and other basic need items. Thus, efforts to increase the rural non-farm incomes will have a positive effect on food security and nutrition. Therefore, to raise people's income to such a level that they can afford to purchase enough food or produce more food for the whole year is among the challenges of increasing food security and resilience for smallholder farmers.

The food shortage in the study area is experienced mainly between December and March in low land, December and February in middle land, and January and February in the highland zone. Unlike in the central zone of Tanzania in Rungwe district only few farmers experience food shortage and most of food shortage is in lowland where there is an increase of drought frequency. It was further revealed that in most cases food shortage for most
Table 1. The main causes of food shortages

<table>
<thead>
<tr>
<th></th>
<th>Low land</th>
<th></th>
<th>Middle land</th>
<th></th>
<th>Highland</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Drought</td>
<td>52</td>
<td>92.9</td>
<td>30</td>
<td>50.0</td>
<td>16</td>
<td>51.6</td>
</tr>
<tr>
<td>Low temperature</td>
<td>35</td>
<td>62.5</td>
<td>25</td>
<td>41.7</td>
<td>8</td>
<td>25.8</td>
</tr>
<tr>
<td>High temperatures</td>
<td>21</td>
<td>37.5</td>
<td>24</td>
<td>40.0</td>
<td>9</td>
<td>29.0</td>
</tr>
<tr>
<td>Shortage of Labour</td>
<td>15</td>
<td>26.8</td>
<td>9</td>
<td>15.0</td>
<td>4</td>
<td>12.9</td>
</tr>
<tr>
<td>Strong winds</td>
<td>19</td>
<td>33.9</td>
<td>9</td>
<td>15.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Lack of social networks</td>
<td>12</td>
<td>21.4</td>
<td>9</td>
<td>15.0</td>
<td>2</td>
<td>6.5</td>
</tr>
<tr>
<td>Too much rain</td>
<td>18</td>
<td>32.1</td>
<td>4</td>
<td>6.7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Floods</td>
<td>9</td>
<td>16.1</td>
<td>4</td>
<td>6.7</td>
<td>7</td>
<td>22.6</td>
</tr>
<tr>
<td>Low soil fertility</td>
<td>12</td>
<td>21.4</td>
<td>5</td>
<td>8.3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Crop pests and diseases</td>
<td>8</td>
<td>14.3</td>
<td>5</td>
<td>8.3</td>
<td>2</td>
<td>6.5</td>
</tr>
<tr>
<td>Low household income / lack of assets</td>
<td>20</td>
<td>35.7</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Loss of livestock</td>
<td>10</td>
<td>17.9</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Overselling of crops</td>
<td>9</td>
<td>16.1</td>
<td>1</td>
<td>1.7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Livestock diseases</td>
<td>7</td>
<td>12.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Laziness</td>
<td>13</td>
<td>21.7</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>9.7</td>
</tr>
</tbody>
</table>

Lack of purchasing power to ensure adequate nutrition and pay for essential human need increase vulnerability. Although everyone in the community is vulnerable to climate change and variability, the poor are most vulnerable, because they have very few assets to rely on and/or livestock to sell and fewer livelihood alternatives. Among these, the worst are women, children and the aged due to their inability to migrate and look for alternative sources of livelihood. A widespread and severe household food insecurity occurs in many farming systems in a rural area of developing countries due to their low adaptive capacity (Gwambene and Majule, 2010; Gornall et al., 2012). Safe and health use of food deteriorates as the poor farmers switch to monotonous diets which lack essential micronutrients.

Ensuring food security at the scene of climate variability and the increasing environmental changes is among the greatest adaptation challenges in the developing world. This will need to focus on increasing food crop production and distribution and understanding the complex nature of food security. The academic community is in the position to spearhead the generation of information and the development of innovative and improved technologies to adapt to future situations, and to enhance the climate resilience of vulnerable communities. Such factors will need to include crops and livelihood diversification in addition to the adoption of high yielding crop varieties and intensive agricultural production for the success of adaptation strategies, enhancement of the adaptive capacity and increase climate resilience in farming communities.

**Smallholder farmers’ adaptation strategies and options**

Farmers have various strategies to sustain and maintain production, which is important for their livelihoods. The study revealed that people responded differently to climatic events in their environment based on their adaptive capacity and environmental resources availability. The strategies used to deal with current climate variability and extremes often produce benefits as well as form a basis for coping with future anticipated change. Adaptation is critical and of concern among the smallholder farmers where vulnerability is high because of low ability to adapt. Adaptation strategies help farmers achieve their food, income and livelihood security objectives (Tumbo et al., 2008; Gornall et al., 2012). Farmers have reduced the potential damage by making tactical responses to climate variability and changes. Even though farmers’ adaptation measures may not succeed completely, they form the basis of solutions to extreme events and disaster preparedness. The adaptation strategies use included crop diversification; using different crop varieties; varying the planting and harvesting dates; increasing the use of irrigation; increasing...
the use of water and soil conservation techniques, shading, shortening the length of the growing season; and diversifying from farming to non–farming activities. Other adaptation options available to farmers include varying planting dates; using different crop varieties, fertilizers and pesticides; practicing soil and water conservation. Also strategies such as small scale irrigation, use of agriculture extension services, growing different types of crops on different land units and water harvesting are used. The measures used to deal with climate variability impacts is indicated in Figure 2.

The results indicate that different measures are employed in dealing with climate changes and variability in agricultural production. Some of the strategies like crop diversification serve as an important form of insurance against climate variability and food shortage. Diversification reduces the risk of complete crop failure since different crops are affected differently and also can be used to modify the length of the growing season. In addition, important intervention suggested for improving crop productivity, which include improvement of access to input subsidies, knowledge on the use of fertilizer, extension services, environmental management and commercialization of farming activities. Other interventions mentioned are improvement of irrigation farming and capital and implements.

The study revealed the importance of promoting the practice of organic agriculture, particularly in areas vulnerable to extreme weather conditions, such as drought, flooding, and water logging. Organic agriculture increases soil organic matter content, and hence higher water holding capacity and this makes crops more resistant to drought conditions. Appropriate crop production technologies and strategies that may include modifying the cropping system or crop combination, or crop rotation and adjustment in cropping calendar form important adaptation option. For successful adaptation it is important to consider the decision on crop varieties to be planted, taking into account the seasonal climate forecasts for the growing season. The reflection should be on understanding the crops that require less water, that can make use of available soil moisture and give reasonable yield.

Adjustment to alternative farming systems was suggested for improving agricultural productivity... Such adjustments include promoting indigenous knowledge, change planting dates, increasing irrigation to boost crop production in selected areas, drip irrigation for specific areas and reducing reliance on maize as a staple food by growing early maturing and drought tolerant crops such as cassava, sweet and round potatoes. Other practices involve crop rotation practices, use of integrated crop and pest management; make better use of climate and weather data, weather forecasts, and other management tools as shown in Figure 3. Such practices will need the creation of awareness on the negative effects of climate variability, sustainable water management to boost food crop production through irrigation, strengthening early warning system, follow standard agronomic practices and promoting annual and short term crops.
It was further suggested that, addressing the threat posed by climate change require better quantification of the problem, greater attention for prioritizing which production systems are vulnerable, and a redoubling of land and water management efforts. At the farm-level adaptation strategies need to emphasize on the critical role of improving access to weather information, providing information through extension services and the means to implement adaptation measures. Provision of information that allows individuals and communities to protect their lives, property and ensure their livelihood and food security are imperative for proper and effective adaptation strategies. These require a considerable awareness raising among actors to capacitate the ability to interpret and use the results. Such intervention will help to reduce vulnerability, food insecurity and increase resilience.

CONCLUSION AND RECOMMENDATIONS

In reducing vulnerability there is a need to mainstream climate variability and adaptation in education, such as the integration of climate risks in local agriculture and natural resources development planning and comprehensive land use plans. This will form the base for addressing other global challenges, such as population growth, urbanization, land and water use, rural-urban migration, and biodiversity depletion. Understanding adaptive capacity and adaptation strategies at the local or community level are critical in ensuring sustainability of agricultural productivity and towards achieving food security and environmental sustainability. Multiple scale actions are needed to promote agricultural production opportunities and adaptation measures with more effort in turning knowledge into practical applications. These need to consider the involvement of all key stakeholders for sustainability and for scaling-up (from farm to the community) and scaling-out (from one location to another). More awareness creation on climate variability, agricultural production, utilization of economic incentives, development of appropriate and new technologies and adaptation measures are requisite for increasing resilience among smallholder farmers. Such measures include improving access to agricultural inputs and proper use, increasing investment in yield, market information, diversification opportunities, improvement technology such as irrigation, climate smart agriculture and agroforestry technologies. In addition, provision of education on record keeping among farmers to remember necessary information and activities at the household/farmers level is among the important option. Farmers need to have specific measurement for their harvest that will help them to understand and quantify of their productivity, production trend and production cost and benefits. This will improve access to adequate food supplies and production for income generation to alleviate poverty, improve natural resource management and reduce vulnerability to environmental stresses and food shortage.
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Accepted 14 July, 2016.


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