Chapter

Pulses Farming; An Adaptive Strategy to Climate Change in Arid and Semi-Arid Regions: A Case Study of Itigi District in Singida Region, Tanzania

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Abstract

The study assessed pulses farming as an adaptation to climate change in semi-arid areas. FGD, Household Questionnaires, Key Informant Interview and Observation were used to collect primary data from four study villages; Itigi, Ipande, Damweru and Kitopeni. A total of 106 heads of households were involved in the study through questionnaires and quantitative and qualitative data were analyzed statistically and through content analysis technique respectively. Cereals among maize, millet and sorghum have lost their economic significance among farmers while pulses including chickpea, lentils and beans are potentially currently cultivated by more farmers. Climate change effects such as shifting and shortening of rainfall season and increasing drought have contributed to the decline of cereal crop yields. Specifically shifting of rainfall season and drought interaction vitally influence the decline of cereal crop yields, $F(1, 99) = 198.770$, $p = 0.000$ and the same causes have led to the adoption of chickpea and lentils farming in the study area as shifting of rainfall season was statically significant to the adoption of pulses farming, $X2 = 9.138$, $df = 2$, $p = 0.010$ and drought was, $X2 = 106.000$, $df = 3$, $p = 0.000$ as the pulses are found adoptive drought condition and shortened rainfall season. This has enhanced food and nutrition assurance to farmers, increased household income and farmers' livelihood.

Keywords: pulses farming, adaptive strategy, climate change, arid and semi-arid, Tanzania

1. Introduction

The world today is environmentally challenged by the emerging threats of climate change and variability [1]. The IPCC's Assessment Report 5 has shown the likely climate change impact to have affected greatly agricultural production, particularly in the tropics while enhancing food insecurity and malnutrition in several tropical countries [2, 3]. Tropics, semi-arid and arid regions are considered more vulnerable to climate change effects due to the population nature being exposed to drought and their livelihood source [2]. Furthermore, communities in these regions are largely depending in nature for livelihood, while they are geographically as well socially and economically at disadvantage [4]. Climate change has been affecting agriculture sectors in multiple ways including alteration of agro-ecological zones due to changes in temperature and rainfall, drought stress particularly in areas natured with semi-arid tropics including sub-tropics and flooding [5]. Adaptation strategies for climate change and its associated disasters are crucially important for sustaining the livelihood resilience for communities that are agriculture dependents [6]. Climate change extreme outcomes outlining increases heat and drought during the crops growing season enhances the decline of the top ground biomass and impactful loss of soil nutrients in which impacts largely agricultural production and soil healthy [2]. Adaptation and mitigation strategies differ depending on the local context specifying strategies that are effective to the area regarding the technical, social, natural, financial, physical capital and readiness of the people [6]. In alleviating the severity of climate change impacts adoption of adaptation strategies becomes a core value in agriculture and food production in general [7].

Most rural dwellers depend on agriculture as main the source of economic gains in which the sector is most vulnerable to climate change impacts [7, 8]. Poverty severity among rural dwellers poses difficulties to farmers in such areas in creating resilience to adaptation to climate change impacts [7]. Several adaptation strategies globally have been developed including the growing of new crops adaptive to climate stress, change of sowing time and others [7]. An adaptation to the changing climate impacts the cultivation of pulses globally has been growing and mostly the grown pulses include soybeans, dry pea, lentil and chickpea which are largely and globally grown in semi-arid areas [9]. These pulse crops have been much preferred due to their suitability in responding differently in the growing season's rainfall and temperature patterns as well pulses tend to increases cereal production when grown in rotation [9]. In several regions pulses have been grown in rotation with maize, wheat and rice while in some areas are intercropped with other crops such as marigold, sunflower, mustard, and coriander [10]. Pulses have been assuring global food security and enhancing the affordable attainment of protein among poor rural societies in which the level of protein contained in chickpea is estimated to be the same as the protein offered by meat [11]. It is globally within the context of climate change; pulses have shown a promising role in meeting world protein demand and food security [12]. Also, when intercropped or rotated, pulses have ensured the attainment of food varieties and increased soil productivity through nitrogen fixation [10]. Chickpea are mostly preferred recently due to their ability of the root trait variability in stress tolerance [11]. FAO has considered prioritizing the production of pulses as among strategies in meeting Sustainable Goal 2 through building resilience in agriculture [11]. Under climate change impacts, pulses particularly chickpea and lentils respond positively as an outcome of fertilization effects due to elevated CO_2 related to the lowering of leaf stomata conductance and a decreasing rate of transpiration leading to enhanced water use efficiency [13]. To respond to the impacts of climate change, the adaptation strategies have been developed in different areas including semi-arid areas of Tanzania where one among them is the cultivation of crops which are drought tolerant and those with short maturity period [14]. This study aimed at assessing the rate of pulses specifically chickpea farming adoption as adaptation measures to the impacts of climate change in semi-arid areas.

2. Materials and methods

This study was conducted in Itigi District (**Figure 1**) found in Singida region, Tanzania. Four villages were involved in the study in which chickpea farming has

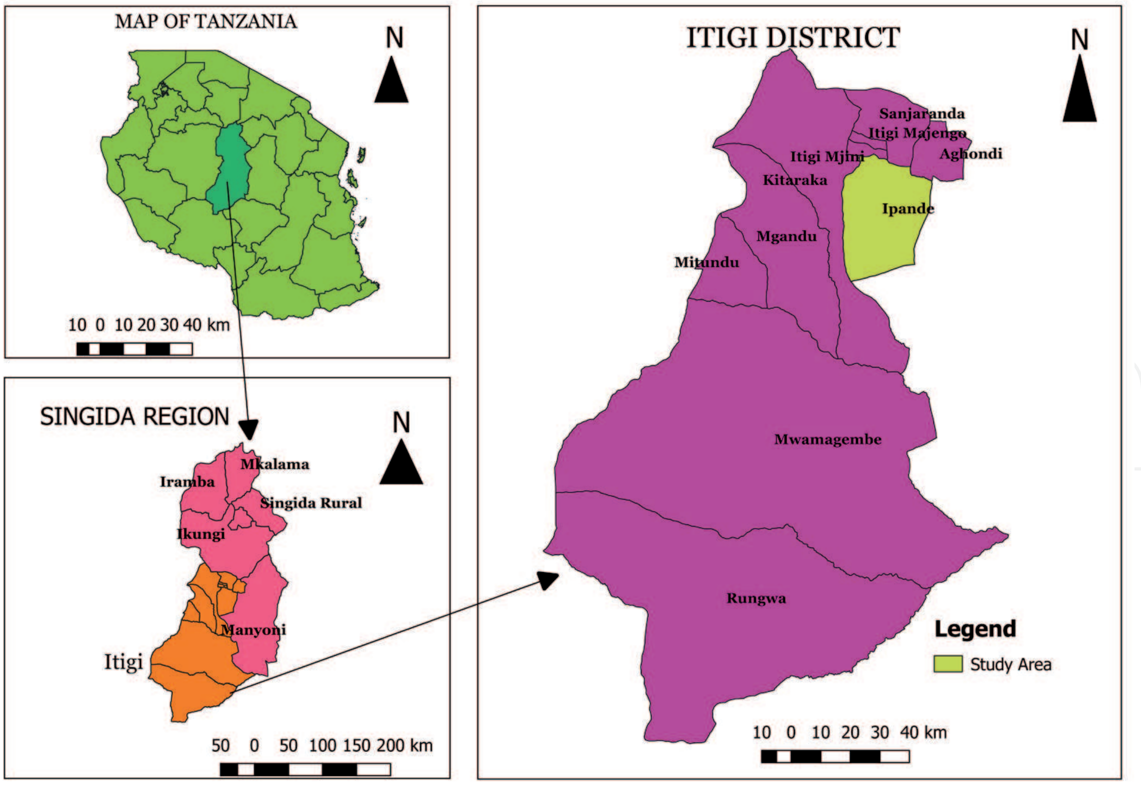

Figure 1.
Map showing the study villages. Source: AMUCTA Geography Unit.

been a dominant crop farming activity and the villages included Ipande, Damweru, Kitopeni and Itigi. Itigi district is found in coordinates 5°42′ S and 34°5′ E while topographically its altitude above the mean sea level is between 1244 m and 1300 m. Itigi is a semi-arid area experiencing low rainfall and shorty rain season which annually it receives rainfall ranging amount of 500–700 mm and normally experiences one drought season after every four years [15]. The minimum temperature is experienced during the night reaching 15°C while the maximum day temperature being 20°C during the rainy season while during the dry season being 30°C [16]. Sandy soils, grayish brown sands and black cracking soils characterize the soil dominance in the area [6]. Itigi is natured with seasonal streams which normally dry after the rainfall seasons. Based on the last census, Itigi district has a total population of 101,364 people males being 50,801 people and females being 50,563 people which when compared to the consecutive census (2002 and 2012) the population is rapidly growing threatening natural resources including land, water and forest resources found in an area [17, 18]. In terms of vegetation the study area is covered with of thickets famously named as Itigi thickets which are endemic to Itigi covering one-fifth of the total district area and miombo woodland with a variety of miombo species which are in danger due to excessive harvesting [19]. Gypsum deposits in the plains of Itigi offer employment to several dwellers particularly during the dry seasons [20].

The study used both quantitative and qualitative methods. Both primary and secondary data were used in the study. One hundred six households were engaged in the study where the sample was attained with the use of Israel sample calculation formulae [21] with the use of a set of prepared structured questionnaires. Two focus group discussions were conducted each having seven members and each included members from two close villages. Key respondents including agricultural officers, village local authorities were engaged through Key Informant Interview while collected information was ensured through transect observation. Data collected were coded in SPSS and analyzed through Chi Square technique to check the relationship between variables at $p > 0.05$ while the General Linear Model (Univariate Analysis of variance) was used to check the effect of two or more independent variables on one dependent variable.

3. Results and discussion

3.1 Socio-economic characteristics of respondents in the study villages

Assessed socio-economic parameters were sex status of respondents, education level, occupation and age of respondents (**Table 1**). The study involved both men and women whereby 63.2% were male and 36% were females which reflect the African cultural families that mostly are headed by men. The education level of respondents was as well reflective of African rural areas' situation in which most respondents had primary education (66%) followed by those who have not attended formal education (26.4%). The study involved more respondents aged above 36 years (74.5%) as are the ones matured enough to recall changes and variations of the climate in the study area and among them 24.5% were aged above 60 years who could easily assimilate the current climatic condition about agricultural activities compared to the past decades. 97% of respondents depend only on agriculture (crop farming and livestock) as a source of income and livelihood while only 3% are employed as local government authorities and other government sectors. During the dry season normally most of the people living in these villages are engaged in small-scale gypsum mining in which is normally becomes a main source of livelihood during the dry season.

3.2 Farming systems and crops grown in the study area

Several farming systems exist in the study villages where 61.3% of respondents are practicing crop farming while agro-pastoralism is practiced by 37.7% of respondents and agroforestry is practiced by 0.9% of respondents. Both cash crops and food crops including cereal and pulses (**Table 2**) are grown in the study area including cereals, root crops, pulses and oilseed crops. Cereals grown include maize and millet/sorghum while sunflower and groundnuts are the grown oil seeds and nuts. On the side of pulses include chickpea, beans, cowpeas and lentils.

Category		Frequency	Percentage (%)
Gender	Male	67	63.2
	Female	39	36.8
Age	18–35	27	25.5
	36–60	53	50
	60+	26	24.5
Education	Informal education	28	26.4
	Primary education	70	66
	Secondary education	7	6.9
	Higher learning	1	0.9

Table 1.
Socio-economic characteristics of respondents.

Category		Frequency	Percentage (%)
Crops are grown in the study villages	Cereal crops	59	55.7
	pulses	47	44.3
	Both cereal and pulses	59	55.7
Farming systems existing in the study village	Crop farming	65	61.3
	Agro pastoralism	40	37.7
	Agroforestry	1	0.9

Table 2.
Farming systems and crops are grown in the study area.

Maize is grown as the main source of food for farmers and the community around while sunflowers, chickpeas and lentils are grown as cash crops for commercial purposes.

In the four study villages (i.e., Itigi, Ipande, Damweru and Kitopeni), farmers have changed the type of crops particularly cereals they have been growing in the previous 10 years to grow cereal crops while some of them have adopted the farming of pulses in their respective farmland by reducing the farmland they have been using to grow cereal crops or they have expanded their farms (**Table 3**). Also, root crops particularly cassava, farmers have been declining their production due to their destruction imposed by wild animals particularly pigs and elephants which are suspected to be from the nearby game reserve.

3.3 Influence of climate change on the change of crops grown in the study area

The study identified impact of climate change has been a great driver to farmers in abandoning the growth of cereal crops and adoption of the growth of pulses particularly chickpea and lentils in which chickpea has gained more potentiality among the farmers due to its adaptive nature to drought. 100% of respondents agreed to have experienced impacts of climate change in their areas including change of rainfall reasons, increased drought and increased temperature as well as reduced raining season. 90.6% of respondents claimed the rainfall season to have changed while the remaining percentage (9.4%) were not aware of this shifting season in which the awareness on the changing of climate season was influenced by the age of respondents (X^2 = 24.358, df = 4, p = 0.000) whereby all the respondents claimed to have low awareness of the shifting rainfall season were aged between 18 and 30 years old. Formerly the rainfall season was starting in midst of November ending in the early of May but currently, the rainy season begins at the end of December ending at the end of March and in a few years early April.

Abandoned crops to adopt pulses farming			Adopted pulses		
Crops	Frequency	%	Crops	Frequency	%
Millet/sorghum and maize	48	45.3	Chickpea and lentils	106	100
Cassava	64	60			
Cotton	106	100			

Table 3.
Changed and adopted crops in the study villages.

The period of drought has extended as formerly it was from the late of May to early November while currently it starts from early of April to the midst of December. Also, the occurrence of insect pests was mostly noticed in which was more distractive to crops during the sunny days and when raining no insects were noticed. The trend of insect pest is increasing from year to year and the cereals particularly maize yield loss are more occurring due to these insects mostly army-worms and earwigs in which from 2015 to 2018 cereals production was rapidly declining due to farm crops attach caused by such pest insects. Increasing of temperature is currently experienced during the day and longer than the intensity experienced formerly. Few existing seasonal streams and dams are observed to dry earlier contrary to the formers decades in which they used to last to at least few days after the end of the rainfall season.

The impacts of climate change have significant contribution in the change and adoption of crops grown in the study area (see **Table 2**). 65.1% of respondents claimed to have changed/adopted the farming of pulses due to climate change impacts. Change of rainfall pattern has caused a loss of cereal crop yields for about 45.3% while increased drought is accounted for the loss of 47.2% of cereal crop yields. Shifting of rainfall season has a significant relationship with the declining of cereal crop production, $F (1, 99) = 27.710$, $p = 0.001$. Also, the drought caused a significant decline in the cereal production $F (1, 99) = 21.721$, $p = 0.041$. The interaction of shifting rainfall season and increased drought has significantly caused a loss of cereal crop yields, $F (1, 99) = 198.770$, $p = 0.000$.

The pulses that are mostly cultivated in the study area due to climate change are chickpea and lentils. Chickpea is grown by 100% of respondents. Statistically, the increase of drought has a significant relationship with the adoption of pulses farming in the study villages $X2 = 106.000$, $df = 3$, $p = 0.000$ and the shifting of rainfall season was found significantly to have caused the adoption of pulses farming in the study $X2 = 9.138$, $df = 2$, $p = 0.01$.

3.4 Impact of pulses farming in farmers' livelihood under climate change

Pulses in the study areas have become the main sources of income among community members in the study areas. Farmers have been selling chickpea and lentils to attain other basic needs. Income generated through chickpea has been used to buy enough food adequate to meet the demands of the household annually. Currently, most of the farmers are living in more improved houses (housed built with bricks) compared to formerly used huts. The income is as well used to send children to schools and in attaining their basic needs such as clothes and getting medical services in case of. Though few, some of the farmers are using income, generated through pulses farming to buy motorcycles, tractors for farming and cows for pulling plough.

3.5 Challenges to pulses production in the study areas

Although pulses seem to be alternative crops for semi-arid agriculture under climate change threats, still there are some challenges particularly in the study areas are posing difficulties to attain improvements in pulse crops production. Inaccessibility of improved seeds and lack of awareness of existing improved chickpea and lentil seeds among farmers has been a huge setback in which none of the farmers were found aware of the existence of improved varieties of seeds particularly of chickpea and lentils; therefore, all farmers in the villages are still using traditional seeds and seeds infected by bruchids.

Existing pests in the study area affecting chickpea including Rhizoctonia bataticola (dry root rot), Helicoverpa armigera (Gram pod borer) and collosobruchus chinensis (Bruchids) in which 95% of respondents identified such pests to cause a significant loss of their crop yields. These insect pests seem less responsive to numerous insecticides and pesticides used by farmers in these semi-arid areas. Poor storage facilities favour the harvest and seeds attach by bruchids (Collosobruchus chinensis) which lead to the great loss of harvests in the study villages. 93.6% of respondents claimed seeds loss due to bruchids attaches to their local storage facilities. Furthermore, seeds affected by bruchids are always observed to have been easily attached by other insects and diseases due to soil pathogens particularly when rotated with cereals consecutively in the same farming season.

The crops particularly chickpea and lentils are not included as among crops given first in national policy therefore farmers are not getting agricultural subsidies making difficulties in meeting financial demands for growing chickpea and lentils crops. Among others, minimal agricultural extension services, use of poor farming tools mostly hand hoes for cultivation due to lack of mechanization and a low level of agricultural awareness among farmers still pulls down the efforts of farmers in increasing pulses yields in their farmlands.

Poor farmers' perception of the fertility level of the soil where pulses are grown affects much pulses production. Pulses particularly chickpea is normally grown in vertisols (dark clay soil) in the all study villages which has a low level of phosphorous in which farmers perceive that the vertisols is always fertile as having a dark color making none of the farmers apply fertilizer in their farms but contrary to the demand of the crop which does well when the soil has a high level of phosphorous. Therefore, despite the ability of the pulses in nitrogen fixation, a low level of other soil nutrients among phosphorus and calcium limits the production of pulses in the study areas.

4. Conclusion

Climate change effects including drought, low rainfall, shifting of rainfall season and the increasing temperature still affects greatly agricultural production in terms of quality and quantity in several agro-ecological zones greatly in semi-arid and arid regions. These incidences have been leading to food insecurity and the dangers of malnutrition among rural communities in semi-arid areas. Several adaptation strategies have been developed including local ones and modernized ones such as climate and soil friendly agronomic activities, use of improved seeds and cultivation of short-season crops and drought adoptive crops. Farming of pulses and in particular chickpea is found effective to reduce the impacts of climate change effects particularly in semi-arid areas. This is due to the crop's ability to sustain the harsh climatic condition including drought and shortened rainfall season. Currently improving the adaptive behavior of the crop to resist the effects of increased insect pests as an outcome of climate change is very vital as will enhance crop productivity, ensure farmers availability of food security and nutrition, as well increase farmers household income in semi-arid regions in which its dwellers are more vulnerable to climate change impacts. More studies are needed particularly on insecticides and pesticides which are suitable for such localities. Improvement of other agricultural services including training farmers on better agronomic practices that are climate and soil friendly in attaining sustainable pulses production and soil productivity under climate change particularly in those arid areas and semi-arid areas.

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Declaration of conflict of interest

The author wishes to declare no conflict of interest to report.

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