Trade-offs of *Dolichos Lablab* Production in the Context of the Changing Climate in Semi-arid Areas of Tanzania

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Abstract

This study sought to broaden the understanding of existing opportunities and risks for growing Dolichos lablab in the context of climate change and variability in three villages (Hedaru, Saweni and Makanya) of Same District, Tanzania, using data collected over 2 months, including oral testimony and climatic records, covering the last 58 years (1960-2018). Both qualitative and quantitative data were collected through farmers' perceptions of climate variability, and opportunities and risks for growing Dolichos lablab in the context of climate variability and change. The study employed key informant interviews, household questionnaires, and focus group discussions. Results show that most respondents have been aware of climate variability and its impacts on crop production. Meteorological data indicated that average temperature increased at a rate of 1.2 degrees Celsius (0C), whilst, rainfall has been decreasing at a rate of 0.23 millimetres (mm) over the past 34 years. Despite such changes, Pearson's coefficient correlation was deployed to test the significance of rainfall and the production of lablab. Results showed that there is a significant negative correlation (P=-0.675) between rainfall and lablab production. It was observed that when rainfall was below normal, production of crops was recorded to be high, implying that Dolichos lablab is the best crop to plant during drought conditions, due to its capacity to tolerate droughts. Findings showed further that during lower than normal rainfall, the production of lablab increased and vice versa. It was established that during excessive rainfall, lablab plant grew well, but provided low yield than during low to moderate rainfall. The study argues that Dolichos lablab is an ideal plant to grow due to its ability to withstand climatic stresses. Efforts to promote the crop will enhance adaptive capacity and improve the livelihoods of dryland farmers because it is used both as a cash and food crop.

Keywords: *Dolichos lablab*, Climate Variability, Climate change, Rainfall, Temperature

Introduction

Tanzania's economy is highly dependent on climate because a large proportion of Gross Domestic Product (GDP) is associated with climate sensitive activities, particularly agriculture. Climate variability, such as extreme drought and floods has a major implication on the country's economy (Watkiss, 2011). Arndt and colleagues (2012) estimated the impact of climate change on agricultural production in Tanzania, whereby, climate change was estimated to cause a decline in food security and an increase in poverty levels in Tanzania. The occurrence of dry-spell any time during the growing season often exposes crops to moisture stress and hence, there ensues low soil moisture to support crop growth (Watkiss, 2011). Agriculture is the backbone of most Tanzanian livelihood economies, especially in rural areas. The contribution of agriculture to the socio-economic development of Tanzania cannot be under-estimated (HBS, 2007). More than half of Gross Domestic Product (GDP) is from agriculture and the sector employs about 80 percent of its labour force. About 95 percent of the agricultural sector is rain-fed and subsistence-based (ibid.). For that reason, there are consequences of climate variability mostly experienced in rain-fed agrarian economies. An increase in temperature and reduced rainfall amount, as well as the change in rainfall patterns, would likely cause a decrease in average yields by 33 percent in Tanzania (NAPA, URT, 2007). Drought resistant crops that are adaptive to a wide range of climatic conditions like Dolichos lablab are needed as one of the adaptation strategies against climate change and variability. *Dolichos lablab* is a climatic stress crop with an ability to adapt to different climate conditions like arid, semiarid, subtropical and humid temperatures (Karanja, 2016). It is a drought tolerant crop and can withstand growth in drylands with limited rainfall as low as 400 millimetres. *Dolichos labalab* prefers rainfall above 750 mm but not above 2500 mm and cool temperatures ranging from 14 to 28 degrees Celsius (°C). It can be grown in lowlands and uplands as well as many soil types with varying pH of 4.4-7.8, but poor in wet soils (Luck, 1965; Wilson and Murtagh, 1962; Karanja, 2016).

In Tanzania, *dolichos lablab* is produced in parts of Kilimanjaro, Singida, Manyara, Dodoma, Arusha, Kilimanjaro, Tanga and Morogoro regions, and it has different market names like Ngwara and Ngwasha but the market of *Dolichos lablab* in Tanzania varies (Karanja, 2016; Magohe, 2007). Thus, there is a paucity of information regarding *Dolichos lablab* production and therefore, this study assessed opportunities and risk of growing *Dolichos lablab* in the context of rainfall variability on improving livelihood incomes and poverty reduction.

Conceptual framework

High emissions of greenhouse gases are some of the major factors, which contribute to climate variation around the globe. Emissions of greenhouse gases, especially carbon dioxide (CO_2) in the atmosphere cause climate change (IPCC, 2014). Deforestation was one among the factors influencing climatic variation because deforestation leads to change in ecological patterns of an area and human activities (greenhouse gases emission and deforestation) cause an increase in temperature and changes of rainfall pattern whereby rainfall and temperature are two key parameters influencing on agricultural production (Datta, 2013). Temperature increase and unreliable rainfall could affect the agricultural production process due to climate variability and hence, expose

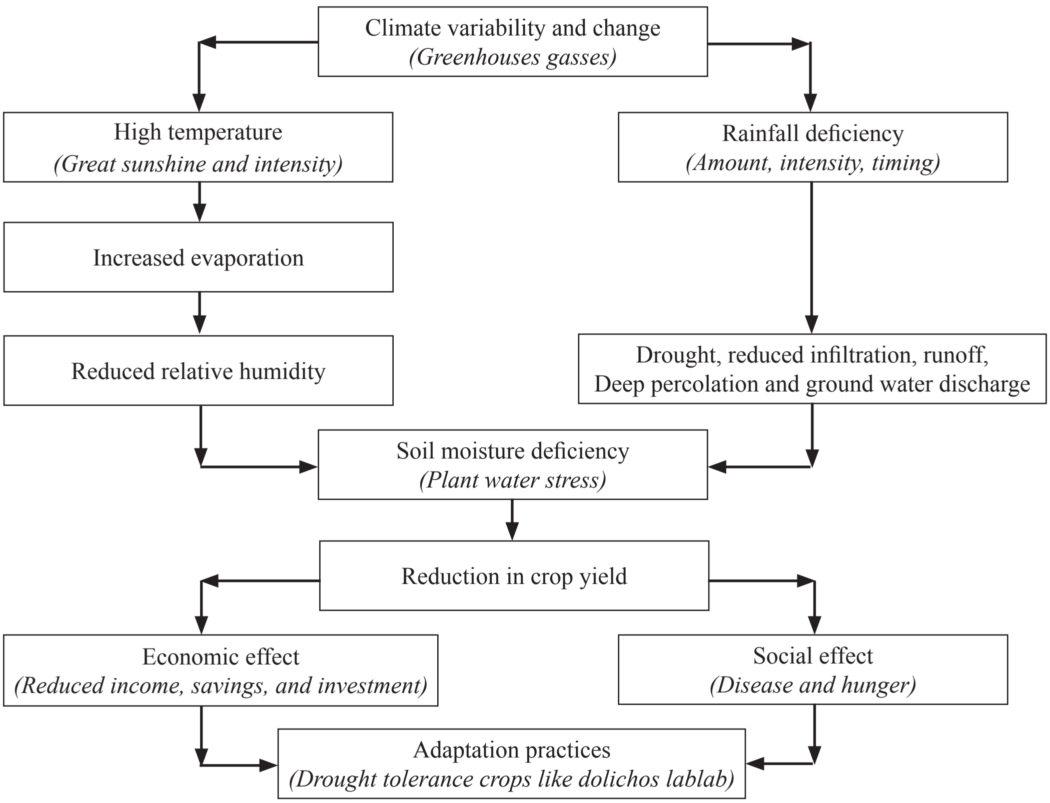

Figure 1: Conceptual framework

Source: Adapted from Food and Agricultural Organization (2007) plants to further water-stressed conditions and some plants fail to germinate as well as grow thereby leading to an increase in food insecurity (Sarker, 2012). In addition, reduction in crop yields due to climate variability has a direct effect on the socio-economic of livelihood societies, especially small scale farmers, depending on agriculture for their daily survival and their lives become highly vulnerable to poverty, hunger and diseases.

Due to the impacts of climate change and variability, farmers take a step to respond to climate change through adaptation strategies to respond with the situation and maximize production (Komba *et. al.,* 2012). Planting drought tolerant crops is one of the strategies used by farmers to cope with climate change risk and Dolichos is widely accepted to climate risk and can withstand current global climate stress and ensures socio-economic growth of livelihood communities.

Methodology

Description of the study area

Same District is geographically located between 4S – 4.45S and 37.5E–38.5E (South –Eastern). It covers an area of 5,186 kilometre squares (km^2) equivalent to 39.9 percent of the total area of the Kilimanjaro region (13,309 km^2). It has a population of 291,145, being the highest in the region. The district is surrounded by six districts, including Mwanga in Kilimanjaro region, Simanjiro in Manyara region as well as Korogwe and Lushoto both in Tanga region, and Taita as well as Taveta located in Kenya (URT, 2017).

Same District has three agro-ecological zones comprising of the upland plateau, middle plateau, and lowland plateau

The highland plateau zone is the zone that lies between 1,100 and 2,462 metres above mean sea level. Rainfall in highland zone ranges between 1250 to 2000 mm per year, while temperature ranges from 15 to 25°C. Crops grown in this zone are coffee, trees for timber, maize, bananas, beans and various fruits such as pears, pawpaw, and avocados (URT, 2017).

The Middle plateau zone is the zone that lies between an altitude of 900 metres and 1100 metres above mean sea level. This zone is characterized by rainfall between 800 to 1250 mm per year. Temperature on this middle

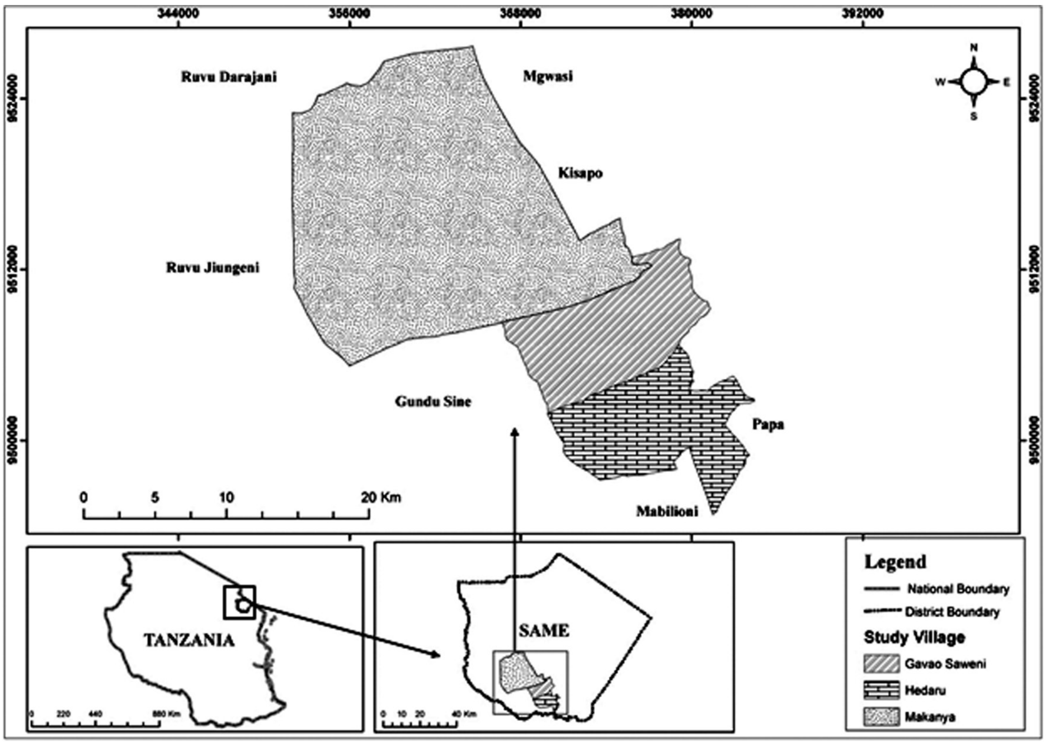

Figure 2: Map of study areas

plateau zone ranges from 25°C to 30°C. Crops grown in this zone include maize, coffee, and timber-trees (URT, 2017).

The lowland plateau zone lies between 500 and 900 metres above mean sea level and it receives rainfall between 500 and 800 mm per annum. The zone is semi-arid dominated by both crop cultivators and pastoralists. However, some crops produced are based on rain-fed agriculture, such as *Dolichos lablab*, maize, sisal, millet, sorghum, sunflower and groundnuts. Also, the zone is characterized by rapid urban settlement development (URT, 2017).

The study was conducted on three villages of Same District, namely, Makanya, Hedaru, and Saweni, which are located on the lowland plateau of Same District (Figure 2).

Research design, sample size, and sampling procedures

This study adopted a mixed research design, where both quantitative and qualitative data were collected. A list of households from the village the households register in the study villages of Makanya, Hedaru, and Gavao-saweni was used to get the sampling frame. The list was used in conducting the purposive sampling technique of the study and the total household of the study area encompassed 5975. Households are distributed as follows: Hedaru village has a total of 4410 households, Makanya has 1025 households and Saweni has 540 households. Taking into account the requirement of a sample size of 5 percent of total households, the total sample size of the study areas involved 298 households. This is a representative sample as argued by Boyde (1981) that the selected sample has to be sufficient and representative to the true population and it should constitute at least 5 percent of the population.

In addition, key informants for focus group discussions (FGDs) were purposefully selected to obtain the desired FGD participants. Factors like long experience regarding *Dolichos lablab* growing in the village and history (30 years and above) were considered for the selection of discussants for FGDs and three FGDs were conducted. Also, key informants involved people from three levels that included District level (District crops officer), Ward level (Ward agricultural officers as well as Ward executive officers) and village level (elderly aged 60 years and above who lived in the study area and *Dolichos lablab* large businesspersons).

Data collection methods

In this study, both primary and secondary data were collected, using qualitative and quantitative data collection methods. Literature show that using both methods helps the study benefit from their complementarities and thus a robust analysis of the problem under research (Green *et. al.,* 1989; Tashakkori and Teddlie, 1998). Likewise, Jick (1979) affirmed that using both methods should be viewed as complementary and not otherwise. The following sub-sections detail each method used.

Primary data

Data were collected through a household survey using a mixed open-ended and close-ended questionnaire and information about household size; age, sex and marital status were captured. Also, facts and opinions on households pertaining to opportunity and risk of growing *Dolichos lablab* in the context of rainfall variability were obtained. The questionnaires were prepared and administered to 298 household heads.

In addition, face-to-face key informant interviews formed the main source for qualitative for this study. Formal interviews were held by purposively selecting key informants in the community. Most of them were aged people with a lot of experience in *Dolichos lablab* production and rainfall variability of the areas. Also, government officials who held different positions from the district to the village levels like District Agricultural Officers helped in providing some information like data on *Dolichos lablab* production in the District, some initiatives taken to help *Dolichos lablab* farmers in the District, collaborating institute(s) in researching *Dolichos lablab* genotype and its soil suitability (agronomy) in the District. Additional information was sought to pertain to its market price and how the government helps to control markets. In addition, Extension Officers helped a lot in the provision of qualitative data in Hedaru, Makanya and Sawen villages.

Also, in-depth interviews with participants were held to recall events from the past (see also Bryman, 2008). Under this method, elderly people were asked questions concerning rainfall variability and the introduction of *Dolichos lablab* in an area as a cash crop and food crop. Six elders were interviewed. Most of them were more than 80 years old and had lived in the areas for many years.

Table 1: List of key informants

Level	Position of participant	Number of participants
District level	District Crops Officer	1
Ward level	Ward Agricultural Extension Officers	2
	Ward Executive Officers	3
Village	Village Chairpersons	3
	Village experienced farmers	6
	Dolichos lablab large businessmen	8
Total		**23**

Source: Field survey (2018).

Focus group discussion was used to gather as well as to authenticate in-depth qualitative data from farmers. Unstructured questions were used to groups that allowed participants to share their views and experiences with understanding about *Dolichos lablab* production challenges and advantages in climatic variability situations. Focus group discussion was undertaken by selecting twelve participants whereby each sub-village was represented by two members in both Makanya and Hedaru, respectively. In Saweni village, nine participants were involved in the focus group discussion. The method is good because it provided room for the generation of new ideas and helped to authenticate data (see Berg and Lune, 2012). One-hour interaction for each focus group discussion was used and participants were provided with information regarding the objectives of the study before discussions.

Sources of secondary data

Secondary data relevant to this study were obtained through reviews of both published scientific papers and unpublished manuscripts from various sources. They included books, journal articles, reports, and symposium papers. Rainfall and temperature data were obtained from the Tanzania Meteorological Agency (TMA). Daily temperature and rainfall data covering 34 years were obtained from the Same Meteorological Station located in the Same township council. The location of the station experiences the same climatic condition as the study areas because they are all located on the leeward side of the Pare Mountains in a lowland plateau and the distance from the Same station to the study areas is 30 km. Thus, data from the station provide the real picture of weather variables of the study areas. Temperature and rainfall data over 34 years (1980-2015) were analysed using the Microsoft excel program whereby linear trend lines for both rainfall and temperature were drawn to indicate the trend and patterns of such observed climatic parameters.

Data analysis plan

According to Krishnaswami (1993), data analysis involves a critical examination of the assembled and grouped information as well as ordering of data into constituent parts to obtain answers to research questions. Qualitative data were sorted and organized into thematic areas and then subjected to content analysis. Quantitative data were sorted, arranged and coded in a spreadsheet. Then they were analyzed using Statistical Product and Service Solution (SPSS) version 20 to obtain frequencies and other statistical products. Also, rainfall data and *Dolichos lablab* production data were used to test significance and Pearson's correlation coefficient was used significance test.

Results

Respondents' socio-economic characteristics age group

Findings indicated that 27.2 percent of all respondents were aged between 40 and 49 years (Fig. 3). In total, respondents with 40 years and above formed 76.5 percent of the total number of respondents, a clear pattern both in the general summary of results as well as at the village level (Fig. 3).

Taking into account the objectives of the study, having a high percentage of respondents aged 40 and above was highly appropriate in providing information about climate and the state of *Dolichos lablab* production in study areas. Therefore, respondents who filled in the questionnaire were the right persons because those aged 40 years and above formed 76.5 percent of total respondents (Fig. 3).

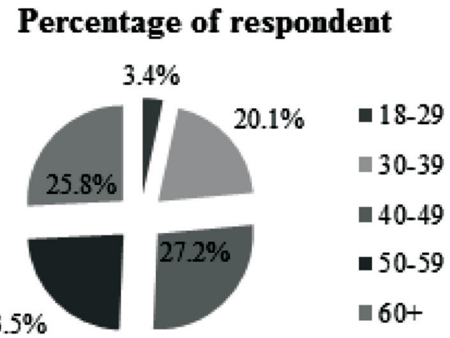

Figure 3: Age group of respondents
Source: Field survey (2018)

Household size

Half of the households had between 4 and 5 individuals, representing 50.7 percent of the total sample in the three villages (Table 2). The household with 1 to 3 individuals represented 11 percent, while 6 and above individuals in households accounted for 38.3 percent (Table 2).

Table 2: Household size

Household size	Frequency	% of respondent
1-3	33	11
4-5	151	50.7
6+	114	38.3
Total	**298**	**100**

Source: Field survey (2018)

The household size in the study areas was high (Table 2), a pattern reflected the high population growth in the study areas. Such a pattern support data from the national census of 2012 whereby the Same district recorded a high population among seven districts of the Kilimanjaro region and the average household size of the district is 4.5 (URT, 2013). At the district level, Hedaru recorded a higher population than the other villages in the study area (ibid). Therefore, the average household size in this research reflects the national statistics as per the population census of 2012. But having a large population size among households reflects that there is a high labour force at the family level in the study areas that can contribute highly to agricultural production activities.

Respondents' sex distribution

Sex composition showed that 63.1 percent of all respondents were females and 36.9 percent were males (Fig. 4). At Hedaru village, 35.9 percent were males, while 64.1 percent were females; Makanya village had 41.2 percent males and 58.8 percent females, while Saweni village had 37 percent males and 63 percent females (Fig. 4). The sex composition of respondents showed there were more women than men (Fig. 4) in all three study villages. According to the national census of 2012, Same District sex composition showed that women were in large numbers compared to men (URT, 2013). It implies that in the study areas, women are likely to provide a higher labour force in agricultural production than men. A study conducted by the Food and Agricultural Organization (FAO, 2011) revealed that females in rural areas provide the labour force in agriculture at about 50 percent.

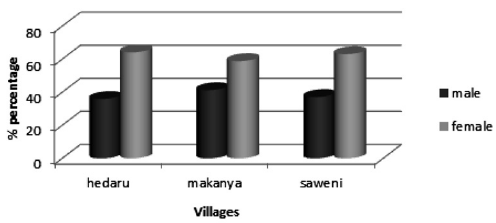

Figure 4: Respondents' sex distribution
Source: Field survey (2018)

Duration of stay in the community

Findings indicated that 60.1 percent of respondents have been living in the study area for more than 40 years and 20.1 percent lived in the study area for about 30-40 years (Fig. 5). This complied with the objective of the study that required participants with experience of climate change over 30 years, which was good because 80.2 percent of respondents were right to furnish information on how climate has changed. Furthermore, results from the study revealed that 6.7 percent of respondents lived about 20-30 years and the rest (13.1%) lived in the areas for 10- 20 years (Fig. 5). The latter groups provided information on current climatic conditions and the state of *Dolichos lablab* production in study areas.

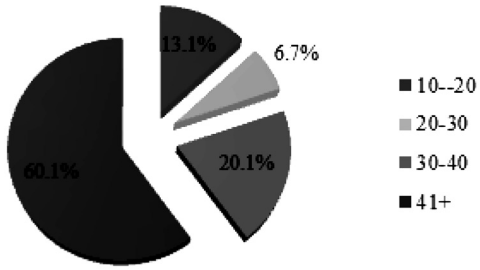

Figure 5: Respondents' duration of stay in years
Source: Field survey (2018)

Farmers' perception of climate change and impacts on lablab production

Table 3 shows that there was a high understanding among smallholder farmers that climate change and variability are happening and continuously affecting their livelihoods, which mainly depend on agriculture production. Temperature and rainfall are two weather variables reported to have changed in the study areas. Respondents also had a different perception of the cause of climate change, specifically in their local areas. Deforestation was a major factor reported by respondents to have a significant contribution to climate variability over the last 30 years plus slash and burning that ranked high on the list. Bush fires from August to September were carried out by

Table 3: Perception of climate change and climate variability by the respondent

Statement of perception	5	4	3	2	1	Score %
Climate change has a very high impact on Dolichos lablab production	85.2	14.8	0	0	0	100
Variation in climate have caused an increase in incidences of floods during the raining seasons	78.2	18.5	0	0.3	3	100
Shifts in seasonality have caused crops failure and low yield	71.8	26.5	0	0	1.7	100
Some crop varieties have no longer been productive due to prolonged droughts in the areas	12.1	83.2	2.3	0.3	2.0	100
Climate change has led to crop infestation and disease due to droughts	73.2	26.8	0	0	0	100
Climate change has led to rural-urban migration	9.4	86.2	2.7	0	1.7	100
Excessive in rainfall contributes to destruction of buildings and infrastructures	20.5	76.5	2.0	0	1.0	100
Floods do not contribute to soil erosion	9.1	11.1	0	6.7	73.2	100
Water becomes scarce and dried due to droughts and low rainfall	88.9	10.7	0	0	0.3	100
Dry spell of crops is the results of droughts	90.3	9.7	0	0	0	100
Climate variability has impact on rain fed production	91.9	8.1	0	0	0	100
Climate changes has led to deforestation	82.6	10.1	7.0	0	0.3	100
The costs of food crops are increasing because of climate change	25.8	73.2	0	0.3	0.7	100

Note: strongly agree=5; Agree=4; don't know=3; strongly disagree=2; disagree=1 livestock keepers to open areas for grazing. Thus, the vegetation of the Pare Mountains in the last decade was perceived to be changing. Such actions were suggested to be major causes of protracted drought, strong winds, and high temperatures.

Close to three quarters (73.2%) argued that climate change was affecting both agriculture and health such that some crop varieties were no longer productive in areas due to droughts like banana, which used to be cultivated in the 1980s. Few (26.8%) argued that climate change was affecting more on the agriculture sector than any other sector. Findings indicated that during the 1970s, farmers used to grow a lot of varieties under a traditional farming system called KITIVO, which means the piece of land with high fertility richness whereby most crops thrived well, unlike the recent decades. One farmer narrated that,

> *"Deforestation is very high in our areas because people cut many trees for clay bricks making and the whole lowland area, west Same District receives little rainfall and high temperatures. Such a pattern affects us in agricultural production. Besides, we are used to experience strong winds, which destroy house roofs but the status was not the same compared to the last 30 years where we did not experience such disasters."*

Results from constructed and calculated

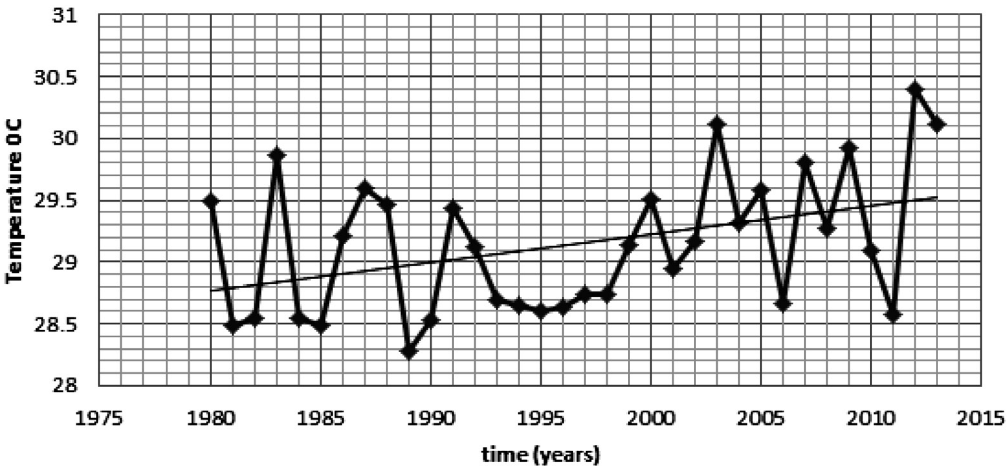

Figure 6: Temperature anomalies for Same district
Source: Tanzania Meteorological Agency (2018)

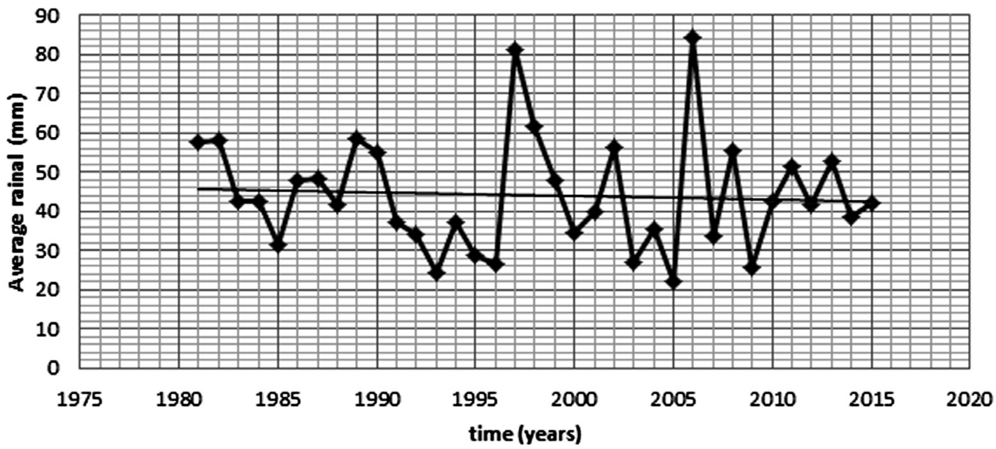

Figure 7: Rainfall anomalies for Same district
Source: Tanzania Meteorological Agency (2018)

temperature, as well as rainfall rate, showed that average temperature increased at the rate of 1.2°C and rainfall trends decreased at a rate of 0.23 mm. Fig. 6 and 7 show temperatures and rainfall trend line recorded at the Same Meteorological Station. Rainfall has been decreasing at the rate of 0.23 mm while temperature increased at a rate of 1.2°C. This shows that climate change in the study areas is happening. Such status supports respondents' views that there ensued protracted drought over the last decades and some intolerant droughts that forced people to adopt drought tolerant crops like *Dolichos lablab*.

Dolichos lablab production and rainfall trend

In testing for significance, Pearson's correlation coefficient was deployed with two-tailed methods. It was noted that there is no statistically significant relationship between *Dolichos lablab* production and rainfall in five years (Table 4). Parallel with the significance test between rainfall and *Dolichos lablab* crop production, the same data were used to draw a graph to see whether or not there was a relationship between the two parameters. It was seen that in most cases when rainfall was significantly low, the production of crops was recorded to be high. For example, in categories 4 and 5 (Fig. 8), when rainfall was little, crop production increased.

Opportunities for growing *Dolichos Lablab*

Opportunities enjoyed by *Dolichos lablab* growers included the following: the ability of *Dolichos lablab* to add soil fertility, high market prices of Dolichos, cash crop and food crop for both human as well as animals, short growing season and high productivity by harvesting three times and ensures high production of maize when incorporated together. *Dolichos lablab* has one growing cycle per year and in the study areas, it is planted during the long rainy season (*Masika*) starting from March to May. After being planted, *Dolichos lablab* grains take four months to mature and people start to

Table 4: Pearson's correlation test between rainfall and crop production

Correlations		Tones	Rainfall
Crop production (Tones)	Pearson Correlation	1	-.258
	Sig. (2-tailed)		.675
	N	5	5
Rainfall	Pearson Correlation	-.258	1
	Sig. (2-tailed)	.675	
	N	5	5

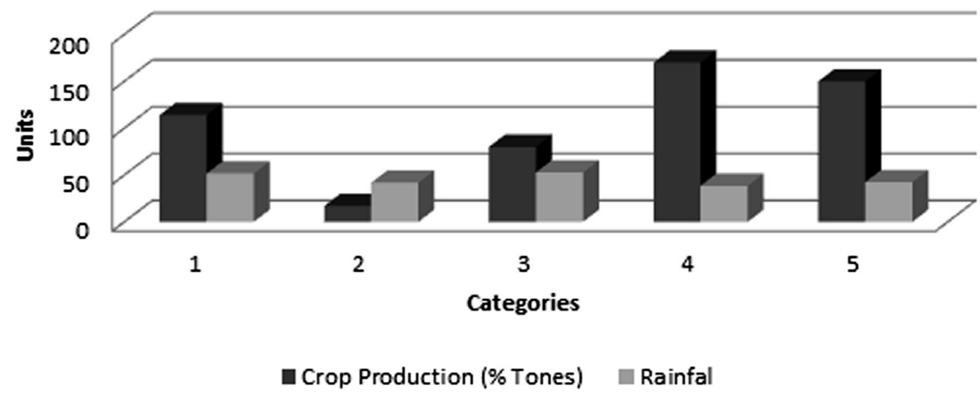

Figure 8: Comparative overview between dolichos lablab crop production (% tones) and rainfall for Same district
Source: Field Survey 2018

harvest from August up to October, depending on the planting date.

Dolichos lablab production purpose

Dolichos lablab has two grain varieties, black grain, and white cream grain. Results from this study revealed that 95 percent of respondents cultivated *Dolichos lablab* for both commercial purposes and food, 4 percent cultivated for commercial purposes only and 1 percent cultivated for consumption. Black grain was much preferred due to market demand and it was the main cash crop in the study areas. Farmers depend on *Dolichos lablab* as the main source of income. Data showed that 83.6 percent preferred to cultivate *Dolichos lablab* due to its higher market demand than other crops, 13.1 percent cultivate *dolichos lablab* due to its capacity to tolerate drought thereby ensured productivity.

The market price of *Dolichos lablab*

Despite being a suitable crop to grow in different climatic conditions, *Dolichos lablab* market price was good whereby 93 percent of respondents said that it has a good average market price, 5 percent reported moderate price and 2 percent alluded to the low price in the market. The *Dolichos lablab* market and prices have a long historical background in Same District. During interviews, elders described *Dolichos lablab* as an indigenous crop planted even in the early 1940s. *Dolichos lablab* has a good market price and out-powers cotton as a cash crop in West Same District.

> *"Since I was a child, until 1940 when I got mature, Dolichos lablab was still there and it was used as the food crop not as a cash crop until the 1970s where people started to exchange it for meat from Maasai pastoralists. By then, cotton was the main cash crop in Same District and it was highly cultivated in the district, while Mobati Company was the main cotton buyer/dealer. But from the 1980s up to the 2000s, the market price for cotton destabilized and people rejected planting cotton. Then Dolichos lablab took over after businesspersons from Kenya started to buy black grain Dolichos lablab at good prices. Thus, Dolichos lablab became our main cash crop, depending on it and cotton is no longer cultivated"* (90 years old man during interviews).

Dolichos lablab production cost

Production activities for *Dolichos lablab* in the study areas most used family labour force but some households used other forms of labour (cheap labor) in production. *Dolichos lablab* production activities involve planting, weeding, and harvesting. *Dolichos lablab* cost of production is lower than other agricultural products like maize. Furthermore, *Dolichos lablab* cultivation helps farmers in weeds because, after the vegetative stage, no weeds manage to grow. Also, the crop provides three harvesting times after maturity.

Dolichos lablab incorporated with maize

Dolichos lablab is a legume crop, which can be incorporated with maize or can be planted exclusively. In the study areas, people mix *Dolichos lablab* with maize but some plant only Dolichos. *Dolichos lablab* when incorporated with maize on the same farm, according to household data, maize productivity increases compared to when maize is planted solely. During FGD in all three villages, respondents had the same views on an increase in maize production when incorporated with maize and they mixed Dolichos with maize by using their local experience.

> *"Dolichos lablab is nitrogen fixer in nature and adds soil nutrients, which improve soil capacity to produce and it is the reason farmers in Hedaru ward do not use Agricultural fertilizers"* (Agriculture Extension Officer in Hedaru).

Risks of growing Dolichos lablab

The primary risk of Dolichos production is about pests and disease claimed by 93.6 percent of respondents. Specific weather risk conditions on the production of *Dolichos lablab* were mentioned that included drought, excessive rainfall, and temperature. During high rainfall year, 91.3 percent noted that *Dolichos lablab* gets highly affected at the flowering stage and the plant drops many pods, leading to a decline in production. On the contrary, during dry years, *Dolichos lablab* gets an intense effect on the planting stage and about 96 percent of respondents alluded to that aspect.

Discussion

Farmers' perception of climate change on crop production

Climate change and variability are major problems facing local communities in the Same District, especially the western Pare lowlands located on the leeward side of the Pare Mountains. Farmers are aware that climate change is real and had already impacted their livelihood activities. Datta (2003) revealed that climate change is a major environmental problem affecting human livelihoods in recent decades. Due to climate change, people are adopting different strategies and in the study areas, people plant *Dolichos lablab* as an adaptation crop, which tolerates climatic stress and sustains the livelihoods of societies.

Respondents were aware that human factors are highly responsible for climate variability in their localities and deforestation was the main driver, which caused climate variability compared to the past decades where the land cover was green. It is different from the recent situation due to deforestation, which is very high. People cut a lot of trees for charcoal making and many trees are used in clay bricks making. Such activities force people to cut down more trees in the study areas and leave the areas bare thereby allowing for strong winds to generate. A study conducted in Southern Mali revealed that deforestation was the source identified to cause climate change, affecting ecosystem functioning in Koutiala and Yanfolila in Southern Mali (Sanogo *et al,* 2016). But slush and burning in many parts of Western Pare lowlands are high during the dry periods, facilitating climate variability.

Most farmers perceived that climate change indicators include an increase in temperature, a decrease in rainfall and an increase in strong winds in Same District. The effect of climate variability and changes is high on both agriculture and health sectors. Same District receives bimodal rainfall from October to December (*Vuli*) and March to May (*Masika*) but due climate change and variability, people in the study areas harvest nothing during the *Vuli* rain season and rely on Masika rainfall in some years in Western Same. A study conducted in Nigeria also showed that the impact of climate change on agriculture is an issue and has significant effects on the health and livelihoods of hundreds of people in Nigeria who depend on agriculture for food as well as livelihoods (Deressa and Hassan, 2009). The impact of temperature rises and rainfall variation causes changes in people's lifestyles in the study areas. For example, people used to plant different crops like banana, sweet potatoes, and Irish potatoes in the early 1970s but due to climate variability, people have been forced to adapt to drought tolerant crops like cotton and *Dolichos lablab* from the 1980s.

Climate variability in Same District, especially on the western side causes drought in areas and warm climate (Fig. 6). Such drought has impacted people's livelihoods in western Same District because people depend on rain-fed agriculture and led to the rapid decline in crop production, especially food crop production like maize thereby causing an increase in food insecurity. Other studies revealed that due to protracted drought and unpredictable rainfall patterns, the trend of food production has been declining and the incidence of food insecurity increasing (Sarker, 2012).

The other notable aspect is that farmers had a high growing understanding of climate change and climate variability who upheld that climate change and climate variability (Table 3) continue to affect farming activities and people's livelihood mostly depending on rain-fed agriculture. Respondents understand indicators of climate change such as an increase in droughts, unpredictable rainfall patterns, shift in rainfall seasons, increase in disease, especially in crops, increase in migration, occurrences of floods and soil erosion. However, although the majority of respondents indicated to have a high awareness level their understanding of the phenomena and consequences varied significantly while their knowledge about causes was generally low.

Opportunities for growing *Dolichos lablab*

Recall, Same district receives bimodal rainfall per year and *Dolichos lablab* cultivation takes place during the long rainy season (Masika) from March to May and farmers cultivate it once per year. The plant takes four months to mature. In the study areas, the planting of *Dolichos lablab* starts in end of March to early April, depending on the onset of rainfall. *Dolichos lablab* is a drought tolerant crop and the study areas experienced different climatic stresses of drought due to rising temperatures and decrease in rainfall (Fig. 6 and 7). The crop manages to perform well and that is why farmers prefer its production due to the ability to manage climatic stresses. Other studies reported that the plant is a better drought tolerant than common beans and records showed that lablab was mostly cultivated in drier regions (Piper and Morse, 1915; Keller *et al.,* 2006). However, the study areas located on the leeward side of the Pare Mountains and experiencing strong winds together with areas located in lowland areas make them advantageous to receive/collect water from upland areas where rainfall is high and use furrows to irrigate farms during the planting stage.

West Same District experiences high climatic stresses but farmers prefer the production of *Dolichos lablab* because it is minimally attacked by the disease compared to other crops, a situation, which forces farmers to use high capital in buying agricultural chemicals. This was in line with research conducted on Dolichos lablab Floridata (1996-2012), which disclosed that *Dolichos lablab* has high grain yields and good resistance to diseases that attack more roots than beans. But due to the geographical location of study areas, farmers manage to control diseases that attack more the stem root by not directing furrows to farms when the Dolichos plant was on the vegetative stage.

Also, farmers need only one weeding after planting *Dolichos lablab* compared to others. After starting vegetation, no weed will grow on the particular *Dolichos lablab* farms. Such a scenario makes farmers start to plant maize first then after maize germination, farmers plant *Dolichos lablab* as weeds preventer. That was used as one of the strategies by farmers to control weeds in farms and reduce costs for weeding in cultivation thereby making Dolichos cultivation costs to be low in a study area. Other studies revealed that *Dolichos lablab* is used as a smother weed, lablab is a hyacinth bean, it has fast-early growth and can grow with little applied water. Thus, it can effectively suffocate weed growth and quickly provide an effective ground cover to protect soil from erosion (Sustainable Agriculture Green Manure Crops, 2002). In addition, not only weeds control but also due to high temperatures (Fig. 6) in the study areas, Dolichos effectively covers the soil and retains soil moisture after the vegetation stage because no solar radiation manages to reach the soil surface.

Lablab also has a great influence on maize production by being a legume crop. People prefer to incorporate maize with *Dolichos lablab* and the production trend of maize when mixed with Dolichos improved compared to when maize was planted solely and it was associated with the capacity of lablab on improving soil productive capacity by adding nitrogen. Lablab was the main driving force, which caused people in the study areas not to apply fertilizers in production activities. A study conducted in the humid forest of Nigeria showed that legume crops increase soil fertility and increase maize yield when mixed in the same farms rather than when maize was cultivated alone (Gbaraneh *et al.,* 2004).

Dolichos lablab managed to support household incomes in the study areas due to good market prices and made farmers highly secured with markets. Besides, farmers used to sell *Dolichos lablab* buckets up to 20,000 Tanzanian shillings (Tsh). Research conducted by Magohe (2007) described that *Dolichos lablab* has got a good market price in Kenya because it is needed by industrial biscuits, supermarkets, hotels, and nursing mothers. *Dolichos lablab* is used in improving people's livelihoods as well as household incomes and helps to reduce the poverty level to farmers. Some people's livelihood incomes depend on *Dolichos lablab* income and other respondents managed to start businesses from *Dolichos lablab* revenue. Such a pattern led people to reject the cultivation of other cash crops like cotton and preferred *Dolichos lablab* production. Another research showed that *Dolichos lablab* is an ideal crop that has contributed to the change of people's livelihoods in the Arumeru district, Arusha region and helps in poverty reduction (Ngailo *et. al.,* 2003).

Dolichos lablab cultivation in the study areas was purposely done for commercial production and food consumption. The black grain was highly demanded in the market and white cream grain was used for food consumption. White cream grains are used by people in the study areas as food and people used immature seeds to eat them by mixing them with maize (*Makande*) and also, they used to mix immature seeds with sweet potatoes. Apart from food consumption, *Dolichos lablab* in study areas is used as a commercial crop and black grain type is highly demanded in the market. This is because the black grain is highly cultivated in areas rather than white cream grain and black lablab contributes to improving household economic status. A study conducted by Ngailo and colleagues (2003) disclosed that *Dolichos lablab* has been used as an important crop in improving livelihood incomes of the community and reduces farmers' poverty level. Recent market surveys from Eastern Africa show that there are a great demand and a nice price for lablab in Kenya. The study areas are located near Kenya and thus, the pattern makes *Dolichos lablab* a strategic crop to grow due to the good availability of markets with good prices.

Dolichos lablab serves as a food crop for livestock in the study areas and it was good during summer where pasture is highly limited. Thus, *Dolichos lablab* is used as a pasture for animals until the short rain season begins. Another study showed that *Dolichos lablab* has a greater feeding value to animals, which can withstand all seasons of the year - summer and winter - hence; it is very good for filling the gap between summer and winter grazing crops and pasture (Luck, 1965). Harvesting of *Dolichos lablab* sometimes goes up to October and makes the eruption of conflicts between farmers and pastures.

Dolichos lablab production is the most preferred of all cash crops in the study areas because it is cheap and easy to cultivate as well as the fact that it helps to ensure high yields. People in study areas rejected the cultivation of cotton as cash crops because cotton cultivation costs are higher than *Dolichos lablab*. *Dolichos lablab* requires little energy both human capital as well as financial capital and also it ensures people with high production, regardless of any climatic stress happening and it makes people in the study areas prefer *Dolichos lablab* to other crops. This is in line with results revealed from a study by Wilson and Murtaght (1962) that disclosed that *Dolichos lablab* is easy to establish and process. In the study areas, most farmers use family labour in *Dolichos lablab* production activities where the labour force is high and production activities involving the planting, weeding, and harvesting all need family labour. According to HBS (2007), the Agriculture sector employs about 80 percent of the rural labour forces and contributes about half of the Gross Domestic Product (GDP).

Risks for growing *Dolichos lablab*

Despite *Dolichos lablab* being the legume crop and very good at tolerating climatic stresses like drought, the plant faces the problem of being attacked by insects, which destroy its leaves during the vegetative stage of growth. Also, during flowering, insects attack many immature pods and failing to fumigate insects will lead to a decline in good production. Therefore, to ensure high productivity, pest management is very important. Other research works showed that the plant is attacked by pests thereby reduced its production, for example, pod boring insect, leaf miners, aphids and so on (Luck, 1965; Morris and Levitt, 1968).

Dolichos lablab does not require high rainfall to maximize production. Recall, with little or low rainfall, *Dolichos lablab* production increases and excessive rainfall affects the plant on the flowering stage. It means that there are insects and disease attacks on the plants on flowering during high rainfall. Therefore, to ensure high yields of *Dolichos lablab* during high rainfall years, farmers should delay planting the plants until the end of April because when the extent of high rainfall decreases, *Dolichos lablab* starts flowering and provides pods. Other studies revealed that *Dolichos lablab* is attacked by nematodes, *Helicotylenchus dihystera* and

Meloidogyne in wet conditions (Luck, 1965). Also, it is attacked by leaf-eating insects and pod boring insects that lead to a decrease in yields (ibid).

Besides, during high rainfall or when the soil gets very wet due to water from upland and middle land areas, the plant gets big effects, especially on the stem, which causes dryness of the plant. Therefore, the *Dolichos lablab* plant requires little water after the vegetation stage. A lot of wet on the soil during vegetation, flowering, and maturation stages causes plants to dry and decline in yields. Wilson and Murtagh (1962) revealed that *Dolichos lablab* is likely attacked by numerous diseases throughout the world like in Australia, a stem rot caused by *Sclerotinia scleretiorum* may attack the plant under wet conditions and other diseases include powdery mildew and late blight, which affect *Dolichos lablab* yields.

Despite being a drought tolerant crop, during drought years, *Dolichos lablab* gets highly affected on the planting stage whereby seeds fail to germinate. *Dolichos lablab* needs rainfall during the planting stage to allow seed germination and during the vegetative stage, the plant leaves cover soil and prevent soil moisture loss and maintain it greenish and provide many pods and ensure high yields. Thus, *Dolichos lablab* could tolerate drought compared to other crops. Piper and Morse (1915) reported that *Dolichos lablab* is a better drought tolerant crop than common beans. Keller (2006) recorded that the plant was the most cultivated indigenous vegetable in the driest regions in Tanzania and was cultivated in 9 of 10 villages surveyed in Kongwa District, Dodoma region.

Conclusion

Climate change and climate variability are some of the major environmental problems affecting human life, particularly in the lowlands of Pare Mountains of Same District. Local people have a good understanding of climate variability and they have local knowledge on how to adapt to climatic stresses such as drought, unpredictable rainfall, and floods. *Dolichos lablab* is a drought tolerant crop with a high capacity of withstanding climatic stress in different climatic regions. Being a legume, *Dolichos lablab* can be used in addressing soil fertility problems, which increased worldwide due to human actions. Therefore, *Dolichos lablab* is an important crop in this era of climate change and can be used as an alternative option crop to smallholder farmers in enhancing their adaptive capacity and poverty alleviation in the changing climate.

References

Arndt Channing. William Farmer, Kenneth Strzepek, James Thurlow (2012). Climate change, Agriculture and food security in Tanzania. Review of development economic, 16(3)

Boyde, H.K., Westfall, R. and Stasch, S.F. (1981). Market research, texts, and cases. Richard, D.Illions, Publisher.

Bryman, A. (2008). Social research method. 3ed: Oxford University Press.748 pp

Bruce L. Berg and Howard Lune (2012). Qualitative research methods for social science- 8th edition, Pearson publisher

Datta, S. (2013). Impact of climate change in Indian Horticulture - A review, International Journal of Science, Environment and Technology, 2(4): 661–671

David Karanja. (2016). Pulses crops grown in Ethiopia, Kenya and United Republic of Tanzania for local and Export Market. International Trade Centre, Eastern Africa Grain Council

Deressa, T.T. and Hassan, R.M. (2009). Economic Impact of Climate Change on Crop Production in Ethiopia: Evidence from cross-sectional measures. Journal of African Economies, 18: 529-554.

Dolichos lablab floridata, [https://floridata.com/Plants/Fabaceae/Dolichos+lablab/612], site visited on 8/9/2017.

Enirisha Magohe. (2007). The marketing of lablab in Same, Tanzania. Linking local learners-impact stories

FAO (2011). Climate Change and Food System Resilience in Sub-Saharan Africa. Food and Agriculture Organisation of the United Nations, Rome.

Gbaraneh L.D., Ikpe F.N., Larbi A, Wahua T.A.T, Torunana J.M.A. (2004). The influence of lablab (*Lablab purpureus*) on grain and fodder yield of maize (*Zea mays*) in a humid forest region of Nigeria. Journal of Applied Sciences and Environmental Management 8(2): 45–50

Green, J.C, Carecelli, V.J. and Graham, W.F. (1989). Toward a conceptual framework for mixed-method evaluation designs. Educational Evaluation and Policy Analysis, 11: 255-274.

IPCC (2014), Summary for policy makers. In: Stocker, T.F., Qin, D., Plattner, G.K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V. and Midgley, P.M. (Eds.), Climate change 2013: The Physical Science Basis, Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge.

Jick, T.D. (1979). Mixing qualitative and quantitative methods: Triangulation in action. Administrative Science Quarterly, 602-611.

Keller G.D., Mndiga H, Maass B.L. (2006). Diversity and genetic erosion of traditional vegetables in Tanzania from the farmer's point of view. Plant Genet Resour 3:400–41

Komba, C. and Muchapondwa, E. (2012), Adaptation to climate change by smallholder farmers in Tanzania, Economic Research Southern Africa (ERSA) working paper 299, Environmental-Economics Policy Research Unit (EPRU), School of Economics, University of Cape Town, Rondebosch, May, 10, pp. 5.

Krishnaswami, O.R. (1993). Methodology of Research in Social Science. Mumbai, India: Himalaya Publishing House.

Luck P.E. (1965). *Dolichos lablab* available grazing crop. Queensland Agricultural Journal 91:308309.

Ngailo J.A., Kaihura F.B.S., Baijukya F.P., Kiwambo B.J., (2003). Changes in land use and its impact on agricultural biodiversity in Arumeru, Tanzania. In: Kaihura F, Stocking M (eds) Agricultural biodiversity in smallholder farms of East Africa. United Nations University Press, Tokyo, pp 145–158

Piper C.V., Morse W.J. (1915). The bonavist, lablab or hyacinth bean. Washington DC, USA. USDA Bull 318.

Sarker, A.R. (2012), "Impacts of climate change on rice production and farmers‟ adaptation in Bangladesh" A dissertation submitted in fulfillment of the requirements for the degree of Doctor of Philosophy, School of Accounting, Economics and Finance, University of Southern Queenslan

Sanogo Kapoury. Joachim Binam. Jules Bayala. Grace B. Villamor. Antoine Kalinganire. Soro Dodiomon (2016). Farmers' perceptions of climate change impacts on ecosystem services delivery of parklands in southern Mali

Sustainable agriculture, green manure crops August. 2002, SA-GM-7, University of Hawaii [https://www.ctahr.hawaii.edu/oc/freepubs/pdf/GreenManureCrops/lablab.pdf] site visited 08/08/2017

Tashakkori, A. and Teddlie, C. (1998). Mixed methodology: Combining qualitative and quantitative approaches, Thousand Oaks, CA: Sage Publications.

United Republic of Tanzania (2017). Same District Profile.

United Republic of Tanzania [nbs.go.tz› Home› Central Data Catalog› TZA-NBS-HBS-2007V01] site visited 20/8/2017.

United Republic of Tanzania (2007). National adaptation programme of action. Vice president Office, government press, Dar es salaam, Tanzania.

United Republic of Tanzania (2013). 2012 Population and housing census. National Bureau of statistic, Ministry of Finance, Dar es salaam

Watkiss, P. and Hunt, A. (2011). Climate change impacts and adaptation in cities: A review of the literature. Climate change. 104(1) pp

Wilson G.P. and Murtagh G.J. (1962). Lablab - New forage crop for the north coast. New South Wales Agricultural Gazet