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The Determinants of Grapevine Farmers' Adaptive Capacity to Climate Change in Dodoma-Tanzania

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Abstract: ***The socio-economic livelihoods of grapevine farmers can partly be improved through their ability to avert the impacts of climate change circumventing grapevine production. Grapevine farmers' ability to cope with climate change is determined by the application of adaptation strategies which minimize impacts on grapevine production. However, the influence of grapevine production factors on grapevine farmers' adaptive capacity to climate change is not well known. This compelled to carry out a study on key factors of grapevine production and their influence on grapevine farmers' adaptive capacity to climate change in Dodoma, Tanzania. Cross-sectional research design and mixed research approaches were adopted. Purposive and random sampling procedures were employed. Data were collected through a questionnaire survey, focus group discussions, interviews, observations, and documents review. Quantitative data were analysed using IBM-SPSS software while the qualitative data were analysed through content analysis. Findings showed that grapevine famer's adaptive capacity to climate change was mainly determined by the farmers' access to: skills on grapevine production and adaptation, financial capital, water sources, land ownership, market, and grapevine production infrastructure. Farmers' adaptive capacity to climate change was observed promising by family land ownership, availability of Agricultural Research Institute (ARI)-Makutupora, and Microfinance Institutions, and existence of other sources of income. Farmers' adaptive capacity was affected by inadequate skills on grapevine production and adaptation by the Agricultural Extension Officers (AEOs), unreliable grapevine market with more petty traders buying grapevines at low prices, unreliable rainfall, and poor grapevine infrastructure. This informs the agriculture policy makers to address these aspects that influence grapevine farmers' adaptive capacity to climate change. It is recommended that: Central Government (CG) and local Governments (LG) should train the AEOs on grapevine production, LG should facilitate farmers to join SACOSS, and CG and LG should improve grapevine infrastructure.***

Keywords: Adaptive capacity, climate change, grapevine farmers, grapevine production factors, Dodoma

1. Introduction

Numerous studies (IPCC, 2001, Stern, 2007; Cohen *et al.*, 2007; Kolmannskog, 2008) show that greenhouse gases (GHGs) such as carbon dioxide (CO_2), methane (CH_4), nitrogen dioxide (N_2O), and chlorofluorocarbons (CFCs) have been increasing in the atmosphere due to natural processes and human activities. Increase in the concentration of GHGs has caused rise in the amount of heat from the sun withheld in the earth's atmosphere. Increased heat has further led to the enhanced greenhouse effect, resulting in global warming and climate change (IPCC, 2007). As a result, extreme events such as tropical cyclones, heat waves, floods, droughts and heavy precipitation are expected to rise even with relatively small average temperature increases (Meehl *et al.,* 2007). The consequences of climate change threaten the worlds' food and water security, public health, natural recourses and biodiversity (McCarthy *et al.*, 2001). Developing countries have been more vulnerable to the impacts of climate change due to fewer resources to adapt and high dependence on rain-fed agriculture (Tol and Yohe, 2006). Vulnerability to climate change differs within developing countries and among the groups of people least able to cope with. Semi-arid areas are the most vulnerable due to low and unpredictable precipitation, high temperatures and high rates of evapotranspiration (Kidanu *et al.*, 2009; Bryan et al., 2009).

The impact of climate change is inevitable even if communities exert efforts to reduce the emissions of GHGs due to high residence time in the atmosphere of the existing GHGs (Yohe, 2003; Thomas and Twyman, 2005; Bryan et al., 2009). This makes the adoption of adaption measures obligatory. Adaptation can reduce vulnerability by making semi-arid communities able to adjust to climate change, modeling potential damages, and helping to cope with adverse consequences (IPCC, 2007). The current rate of climate change is feared to exceed the limit of adaptation in Africa (Adger and Vincent, 2005; IPCC, 2007, cited in Stringer et al., 2009). Poor performance of adaptation options by the community is also attributed to lack of appropriate knowledge of the causes, the effects, and likely future changes and their complexity; poor knowledge about adaptation options, lack of ability to assess options and low capacity to implement suitable interventions (Frankhauser and Tol, 1997).

Chamwino District and Dodoma Municipality are popular in production of semi-arid related crops such as millet, sorghum and grapevine. These crops form the main livelihood options as a source of food and cash income. Grapevine, which used to be the main source of income for most farmers in these areas, has been experiencing a decline in production (Budotela, 1995; Liwenga, 2003,) due to market and climate related challenges. There is an indication from several studies (Jones *et al.*, 2005, Jones and Alves, 2012) that

grapevine agriculture is sensitive to climate. There is evidence (Fraga, 2013; Urhausen *et al.*, 2011) that temperature and moisture regimes are among the primary climatic elements determining areas suitable for growing grapevines.

Interventions from the government and other development practitioners are necessary in order to increase the grapevine farmers' adaptive capacity to climate change in Chamwino District and Dodoma Municipality. Farmers' adaptive capacity decides their ability to make use of available pools of adaptation strategies. However, to have successful interventions, understanding determinants of grapevine farmers' adaptive capacity to climate change is crucial. It can help, from the beginning, to know areas for, and levels of interventions needed to enable farmers respond to climate change. This study analysed factors which determine the ability of grapevine farmers to withstand the impacts of climate change. The study focused on establishing factors determining grapevine production and, how those factors influence grapevine farmers' adaptive capacity under climate change regimes.

2. Conceptual Framework

The conceptual framework (Fig.1) is explained based on the three interrelated variables; independent, intermediate, and dependent variables following their cause-effect relationship. The independent variables are described by the determinants of grapevine production where in the literature (Gregory and Edward, 2003; Lorenzo et al., 2012; and Liberio, 2012) include both agronomic and non-agronomic factors. However in the study area the factors of grapevine production operate under climate change regimes (regarded as intermediate variables in this study). The factors of grapevine production may further directly or indirectly influence grapevine farmers' adaptive capacity (regarded as dependent variables in this study) which can be measured in terms of grapevine productivity and the status of farmers' livelihoods. Therefore, at this climate change era, grapevine farmers must appropriately abide by the factors of grapevine production while taking on board the adaptation strategies (that offset the impacts of climate change) so as to strengthen their adaptive capacity. In the study area, the determinants of grapevine production and how they are influenced by climate change to moderate grapevine farmers' adaptive capacity were studied.

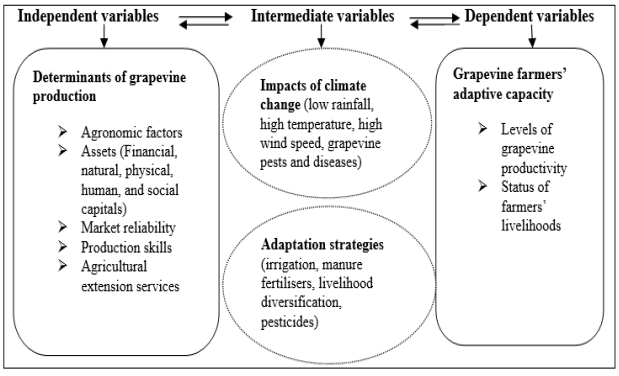

Figure 1: Conceptual Framework
Source : Researcher's own construct

3. Methodology

This study was conducted in Chamwino District and Dodoma Municipality located in Dodoma region, Tanzania. The main economic activities in these areas are mainly agriculture, livestock keeping, and engagement in commercial and industrial sectors. The food crops grown include sorghum, maize, and cassava while the cash crops include grapevines, sunflower, simsim, groundnuts, bulrush millet, and paddy.

Data were collected using several methods to triangulate information and ensure data validity and reliability. These included questionnaire survey, focus group discussions (FGDs), key informant interviews (KIs), documents review, and participant observations. A total of 248 grapevine farmers were involved in the study as primary stakeholders who were obtained from the village grapevine farmers' register through proportionate random sampling. Questionnaires were pre-tested before use to ensure their appropriateness. FGDs involved male-elders, female-elders, male-youths, and female-youths, each comprising of 8 members. This number was manageable and sufficient enough to give the required data as suggested by Stewart and Shamdasani (1990). The KIs involved agricultural and livestock officers, and Agricultural research officers. These people were thought by the researcher to be knowledgeable and to have experience on the subject matter. FGDs and KIs enabled exploration of grapevine farmers' insight opinions and views on factors determining grapevine production. Photographs on different grapevine production infrastructure were taken during participant observations.

Both qualitative and quantitative research techniques were adopted during data analysis. In contrast, qualitative data were analysed through content analysis while quantitative data were edited, coded and analysed using SPSS to produce descriptive statistics to generate frequencies and percentages which were presented through tables and figures. Photograph based findings obtained from personal observations were interpreted, narrated in-texts, and presented as plates.

4. Findings and Discussion

4.1 Knowledge on Factors Influencing Grapevine Production

The knowledge of grapevine farmers on the factors influencing grapevine production was investigated. The factors mentioned by the farmers were agronomic and non-agronomic. Likewise, different key informants (KIs) (Agriculture and Livestock Development Officers for Dodoma Municipality and Chamwino District, and the Director for ARI-Makutupora) were probed on the factors influencing grapevine production. The factors mentioned by the KIs were the application of pesticides to control pests and diseases, application of manure to improve soil fertility, grapevine production skills, and adherence to good grapevine management practices. These factors were similar to those mentioned by the farmers.

4.1.1 Agronomic Factors

The responses on agronomic factors influencing grapevine production varied from one village to another in the study area (Table 1). However, soil fertility, soil moisture content,

and application of pesticides were generic. According to grapevine farmers, grapevine production requires good fertile soils throughout its life and sufficient soil moisture content during planting. However, soil moisture content is reduced much by climate change which requires the farmers to control it through irrigation. They further argued that less soil moisture content is required during fruiting to enable sugar formation. In addition, they argued that if soil moisture content is high during fruit formation, sugar dilution may occur resulting into lowering sugar content. These arguments are similar to Lorenzo et al. (2012) who noticed soil moisture content to be important during grapevine blooming stage. Gregory and Edward (2003) also pointed out that good internal drainage of soil is the most critical criterion for a vineyard soil.

The application of pesticides is undertaken for the purpose of controlling grapevine pests such as mealybugs, termites, and aphids which spread fungal and bacterial diseases. The resurgence of grapevine pests and disease was said to be alarming in the study area due to climate change. It was also noted that grapevine pests and disease control added overhead costs to grapevine farmers.

Selection of good rootstocks was also said to be an important management practice that determine vigour of the plant which, in turn, influences resistance to pests and diseases. Preparation of trenches in the study area is normally done before planting the grapevine rootstocks to improve soil structure, water holding capacity, and aeration. Trench sizes are normally 90 cm x 90 cm with a row reaching 80m long depending on the size of the farm. Lorenzo et al. (2012) point out that good preparation of trenches facilitates the availability of potential volume of soil which can be explored by grapevine roots.

Weeding, spacing and pruning in the study area are normally done to avoid competition of soil nutrients and water to reduce plant stresses. Gianessi (2009) also affirms that weeds compete with crops for nutrients, space, light, and water, thus reducing crop yields. Most of the farmers were using a recommended spacing of 90 cm x 90 cm which gives a population of 12,346 plants/ha. As for pruning, this allows penetration of sunlight for the grapevine plant to undertake optimal photosynthesis processes.

Table 1: Agronomic factors influencing grapevine production in Chamwino District and Dodoma Municipality*

Agronomic factors	Dodoma Municipality (%)			Chamwino District (%)			Total (%)
	Hombolo (n= 58)	Miyuji (n= 8)	Mpunguzi (n= 71)	Chinangali II (n= 82)	Makang'wa (n=13)	Mvumi-Mission (n=16)	
Pesticides	22.6	2	27.4	19.8	4.4	2.8	**79**
Fertile soil	22.6	3.2	30.2	21.8	6.5	4	**88.3**
Soil moisture	20.2	3.2	29.4	23.8	3.6	3.6	**83.8**
Weeding	5.2	1.2	11.7	4.8	5.2	3.6	**31.7**
Pruning	4.4	1.2	5.2	6	4	2.8	**23.6**
Trenches	3.2	0.8	12.9	5.2	1.6	0.4	**24.1**
Trellis	4	0	2	0.8	1.2	0.8	**8.8**
Spacing (cm)	0.4	0	8.9	0	0	0	**9.3**
Good rootstocks	0.8	1.2	0.4	0	0	0	**2.4**

*Multiple responses cm = centimeter n = sample size

Trellising serves as a framework for training and supporting the vines (Lorenzo et al., 2012; Gianessi, 2009). The components of trellis include wooden or metal bars, strong end-post design (anchored or braced), and high-tensile galvanized steel wire (high cordon, low cordon, and Geneva double curtain). The type of components to be used by farmers depends on one's financial capital. The trellis must be strong enough to support large crops and withstand high wind speed. Grapevine training system adopted in the study area as recommended by ARI at Makutupora is known as high cordon training system which manage vegetative vigour by positioning the shoots downward that naturally reduces shoot vigour while exposing fruits to sunlight. High cordon training system has been identified as good grapevine production technology which enables the first harvest to be done within 18 months.

4.1.2 Non-agronomic factors

The non-agronomic factors influencing grapevine production in the study area were mentioned to be financial capital, market reliability, production skills, and agricultural extension services (Table 2). Reliable market encouraged the farmers to continue producing grapevines in many ways. For example, it made it possible sales of the grapevine at competitive price and, in turn, the farmers got profit. Financial capital can empower farmers to afford costs of adaptation strategies (preparation of large trenches, irrigation, pesticides, manure), and grapevine agricultural management practices (rootstocks, preparation of trellis, weeding and pruning, harvesting, and transportation of grapevine fruits). Provision of agricultural extension services was reported to be important for training and guiding farmers on proper farming methods through demonstration plots. Liberio (2012) found that the increase in frequency of contacting extension agents increased adoption of farming innovations.

Table 2: Non-agronomic factors influencing grapevine production in Chamwino District and Dodoma Municipality*

Non-agronomic factors	Dodoma Municipality (%)			Chamwino District (%)			Total (%)
	Hombolo (n = 58)	Miyuji (n= 8)	Mpunguzi (n= 71)	Chinangali II (n= 82)	Makang'wa (n=13)	Mvumi-Mission (n=16)	
Financial capital	5.2	0.4	13.7	9.3	3.2	2.8	**34.6**
Market reliability	3.6	0	3.2	4	0	1.6	**12.4**
Production skills	1.2	0	2	2	0.4	0	**5.6**
Agricultural extension services	0	0.8	0	0	0	0	**0.8**

*Multiple responses

4.2. The influence of grapevine production factors on farmers' adaptive capacity

4.2.1 Farmers' grapevine market and prices

Most of the grapevine farmers responded that there was no reliable market for their grapevine (Table 3). This affected their income that could be invested into climate change adaptation strategies. Mvumi-Mission, Mpunguzi, Makang'wa and Hombolo were the villages with significant market challenges compared to Miyuji and Chinangali II. Miyuji was reported to benefit from being located within Dodoma town, while Chinangali II was favoured by the

presence of farmer based organisation (FBO) known as Chamwino, Chinangali II, Bwigili, Machali, Makoga, and Mlebe Agriculture and Marketing Cooperative Societies (CHABUMA AMCOS) which has a role to organise the grapevine farmers while searching for grapevine markets.

Despite the argument for unreliable grapevine market, farmers claimed to have been selling their grapevines to various buyers (Table 4). Major grapevine buyers were petty traders and CETAWICO. Petty traders were buying grapevines in all villages as they were easily available following grapevines in the farms. Petty traders normally act as middlemen who suppress farmers' efforts through low price they pay to farmers. This was made some of the farmers claim that there was poor market reliability. This conforms to Mahmoud *et al.*, (2003) who noticed cashew nut farmers in Mtwara, Tanzania, to sell their produce to intermediate traders. This was putting buyers in a strong bargaining position while weakening the farmers' ability to negotiate prices. Temu and Temu (2006) have also noted that poor access to the produce market is a major challenge for horticultural products in Sub Saharan Africa.

Table 3: Farmers' perception on grapevine market reliability in Chamwino District and Dodoma Municipality

Districts	Villages	Market Reliability (%)	
		Yes	No
Dodoma	Hombolo (n = 58)	8.6	91.4
	Miyuji (n=8)	25	75
	Mpunguzi (n =71)	1.4	98.6
Total		**5.8**	**94.2**
Chamwino	Chinangali II (n=82)	14.6	85.4
	Makang'wa (n= 16)	6.2	93.8
	Mvumi-Mission (n=13)	0	100
Total		**11.7**	**88.3**

It was noted that CETAWICO was buying grapevines from Chinangali, Hombolo and Makang'wa. CETAWICO is easily accessed by the farmers from Hombolo because the factory is located at that village and the reasons for buying credible grapevines from Chinangali II was its existing farming contract with CHABUMA AMCOS. Other grapevine buyers have been Dar-Es-Salaam market, UDUNI (one of the supermarket investors in Nairobi, Kenya), and KATO (one of the wine industry investors in Dodoma Municipality, Tanzania). All of the FGDs reported serious grapevine market challenge where the major expected buyers such as KATO and CETAWICO were not buying all of the grapevines and there were always delayed payments.

During the KI interview, the Director of ARI at Makutupora also pointed out some challenges on grapevine market where he said there was no organised market for grapevine fruits and most of the existing grapevine buyers were private who failed to pay farmers in time. He suggested for the formation of FBOs. Likewise, the Acting agricultural development and livestock officer for Dodoma Municipality recommended the Government to facilitate grapevine farmers to access reliable market for their produces through formation of FBOs, and encouraging farmers to form Savings and Credit Cooperative Societies (SACCOS).

Table 4: Grapevine markets in Chamwino District and Dodoma Municipality*

Market	Dodoma Municipality (%)			Chamwino District (%)			Total (%)
	Hombolo (n = 58)	Miyuji (n = 8)	Mpunguzi (n = 71)	Chinangali II (n = 82)	Makang'wa (n=13)	Mvumi-Mission (n=16)	
Petty traders	23.1	4.1	28.2	25.4	6	5.2	**92**
CETAWICO	3.6	0	0	10.9	0.4	0	**14.9**
KATO	0	0	0	0	0	0.4	**0.4**
Dar- Es-Salaam market	0.4	0.4	0	0	0	0	**0.8**
UDUNI Supermarket-Kenya	0.4	0.4	0.4	0	0	0	**1.2**

*Multiple responses

4.2.2 Grapevine farmers' access to grapevine production skills

The major sources for receiving grapevine production skills were identified to be farmers' friends, Agricultural extension officers (AEOs), and seminars conducted by ARI-Makutupora (Table 5). Other sources were parents, an expatriate from Italy and seminars conducted by the World Vision. These sources had a role to facilitate the farmers to get knowledge and skills for practicing adaptation strategies such as different grapevine production innovations.

The AEOs were offering extension services in Mpunguzi, Hombolo and Chinangali II. As regards to ARI-Makutupora, it was offering agricultural adaptation skills in Chinangali II, Hombolo and Mpunguzi. Seminars provision by ARI-Makutupora was also acknowledged by the members of FGDs in Hombolo, and ARI-Makutupora as KI. The ARI-Makutupora also confirmed that the Institute was disseminating their research findings to the farmers through farmers' annual festivals (held on 8th August each year) and organised trainings. Collective actions through farmers based organisations in Chinangali II and Hombolo might have also encouraged ARI-Makutupora to conduct these seminars. Mwaseba et al. (2006) have explained that ARIs are the sources of innovation which can be transferred to the farmers either directly or through AEOs.

Table 5: Sources for grapevine production skills in Chamwino District and Dodoma Municipality*

Sources	Dodoma Municipality (%)			Chamwino District (%)			Total (%)
	Hombolo (n = 58)	Miyuji (n = 8)	Mpunguzi (n = 71)	Chinangali II (n = 82)	Makang'wa (n=13)	Mvumi-Mission (n=16)	
Farmer friends	11.7	0	15.3	18.1	6	11	**62.1**
Agricultural extension officers	9.3	1.2	20.6	5.6	0	0	**36.7**
Parents	3.6	0.4	9.7	1.2	0.4	0	**15.3**
Seminars by Makutupora-ARI	6.9	1.6	6	10.1	0	0.8	**25.4**
Expatriate from Italy	0.8	0.4	0	0	0	0	**1.2**
Seminars by World Vision	0	0	0.8	0	0	0	**0.8**

*Multiple responses

As for the quality of agricultural extension services provided, the overall results showed that many grapevine farmers (66.1%) were satisfied (Fig. 1) while about 33.9% of the farmers were not satisfied due to the fact that a number of AEOs had general agricultural skills but lacked specific

skills on adaptation strategies with regards to grapevine production. This argument was also supported by the Agricultural officers for Chamwino and Dodoma Municipality. Nambiro et al. (2010) and Glendenning et al. (2006) explain that agricultural extension services can be enhanced through well trained staff on specific crops.

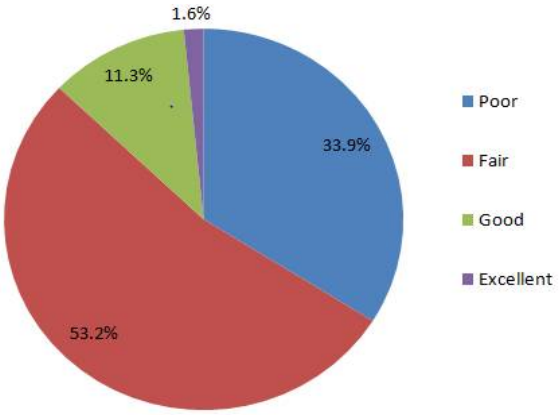

Figure 1: The quality of Agricultural extension services provided in Chamwino District and Dodoma Municipality

4.2.3 Grapevine farmers' access to the financial capital

Financial capital is important for the grapevine farmers as it enables them to afford the cost of climate change adaptation strategies, thereby increasing adaptive capacity. Hence, grapevine farmers' accessibility to financial capital was investigated by examining the availability and performance of financial institutions. This included Savings and Credit Cooperative Societies (SACCOS), and Microfinance Banks. There were five SACCOS identified to be available in the study area (Table 6). The major SACCOS were FUNE /CHABUMA AMCOS (28.6%), MWASHITA (17.7%), and HOZEM (11.7%). Farmers in Hombolo and Chinangali II had access to many SACCOS compared to other villages. Grapevine farmers in Hombolo had access to HOZEM, UWAZAMAH and MWASHITA while Chinangali II grapevine farmers had access to FUNE/CHABUMA AMCOS, UWAZAMAH and HOZEM. Mpunguzi had access to MWASHITA and UWAZAMAH while Makang'wa and Miyuji had access to UWAZAMAH and TIGO respectively. Hombolo and Chinangali II had significant number of grapevine farmers who were members of the SACCOS compared to other villages.

Table 6: Saving and loan groups in Chamwino District and Dodoma Municipality*

SACCOS	Dodoma Municipality (%)			Chamwino District (%)		Total
	Hombolo (n = 58)	Miyuji (n= 8)	Mpunguzi (n = 71)	Chinangali II (n = 82)	Makang'wa (n=16)	
FUNE /CHABUMA AMCOS	0	0	0	28.6	0	**28.6**
UWAZAMAH	7.3	0	1.2	0.4	0.4	**9.3**
MWASHITA	0.8	0	17.7	0	0	**18.5**
HOZEM	11.7	0	0	0.4	0	**12.1**
TIGO	0	0.4	0	0	0	**0.4**

*Multiple responses

However, most of the farmers were not members of SACCOS (Table 7). The presence of FBOs (UWAZAMAH and HOZEM for Hombolo, and CHABUMA AMCOS for Chinangali II) encouraged more farmers to join SACCOS. Meanwhile, Makang'wa and Mvumi-Mission in Chamwino District had no grapevine farmers with membership in any SACCOS due to lack of awareness. The reason for some of the farmers in other villages not joining the SACCOS was due to lack of leadership skills and financial management ethics on SACCOS. During the FGDs in Mpunguzi grapevine farmers complained on the poor leadership from UWAZAMAH. The same has been noted by Swallah (2009) where Rural SACCOS had weaknesses in financial management. However, the role of SACCOS in reducing people's poverty has been acknowledged by Swallah (2009), and Levine (1997).

Table 7: Grapevine farmers membership to the Saving and Credit Cooperative Societies in Chamwino District and Dodoma Municipality

Districts	Village	Membership to SACCOS (%)	
		Yes	No
Dodoma	Hombolo (n=58)	43.1	56.9
	Miyuji (n=8)	12.5	87.5
	Mpunguzi (n=71)	14.1	85.9
Average		**23.2**	**76.8**
Chamwino	Chinangali II (n=82)	73.2	26.8
	Makang'wa (n=16)	0	100
	Mvumi-Mission (n=13)	0	100
Average		**24.4**	**75.6**

As for the Microfinance banks, the overall results showed that most of grapevine farmers were receiving loans from CRDB bank. It was noted that one of the conditions for the farmers to access loans was a membership to a certain SACOSS. Chinangali II in Chamwino District had the highest number of grapevine farmers who accessed loans from CRDB bank, followed by Mpunguzi in Dodoma Municipality due to the presence of SACCOS (FUNE for Chinangali II, and MWASHITA for Mpunguzi). Ngorora (2008) noted SACCOS to be important for business and investment growth as they lead to capital accumulation. However, Sacerdoti (2005) noted the absence of collateral and high risk associated with rainfed agriculture to be major constraints for the farmers to access financial services from the Micro finance banks.

4.2.4 Grapevine farmers' access to the natural capital

The grapevine farmers' access to the natural capital was investigated through their access to the sources of water, and land. The generic water sources for grapevine production were rainfall and bore holes (Table 8). Other water sources included shallow wells and dams. The grapevine farmers depended on more than one water sources even though rainfall was dominant.

High reliance on rainfall indicates that the grapevine farmers in the study area are vulnerable to climate change. POST (2006) also observed that 90% of Sub-Saharan Africa is dominated by rain-fed agriculture with the remaining percent 10% accounting for irrigation. Unreliable water due to reliance on rainfall has made farmers to look for other

sources such as bore holes, dams (Plate 1), and shallow wells as coping strategies. These alternative water sources have enabled the farmers apply improved irrigation systems (e.g. from bore holes and dams; Plate 2) and traditional irrigation systems (e.g. from the seasonal shallow wells). According to Hussain and Hanjra (2004), irrigation agricultural systems can lead to farmers' high incomes.

Table 8: Sources of water for grapevine production in Chamwino District and Dodoma Municipality*

Water sources	Dodoma Municipality (%)			Chamwino District (%)			Total (%)
	Hombolo (n=58)	Miyuji (n=8)	Mpunguzi (n=71)	Chinangali II (n=82)	Makang'wa (n=16)	Mvumi-Mission (n=13)	
Rainfall	14.1	2.4	18.1	20.6	6	5.2	**66.4**
Dam	21	0	0.4	0.4	0.4	0.4	**22.6**
Bore holes	0	2.4	1.2	31.9	0	0	**35.5**
Shallow wells	0.8	0.8	16.9	4	0	0.8	**23.3**

*Multiple responses

Plate 1: A dam as one of water sources for grapevine production in Hombolo (**Photo by:** Author, August 2016)

Plate 2: Grapevine production through drip irrigation technique from bore holes at Chinangali II (**Photo by:** Author, August 2016)

As for the land ownership, findings (Table 9) showed that a great proportion of land was owned by the family (52.4%) and individual farmers (46.8%). There were few grapevine farmers who had rented the land (0.8%). These findings imply that there was an opportunity for the farmers at the family level to strengthen their adaptive capacity to climate change as they could access credit from the financial institutions in case they could have acquired title deeds to act as collaterals. Land titling and registration is known to strengthen tenure security. UNDP (2006) has estimated that more than 90% of the rural population in Africa access land through customary tenure systems in which some of the states do not recognize.

Table 9: Land ownership for grapevine production in Chamwino District and Dodoma Municipality

Land Ownership	Dodoma Municipality (%)			Chamwino District (%)			Total (%)
	Hombolo (n=58)	Miyuji (n=8)	Mpunguzi (n=71)	Chinangali II (n=82)	Makang'wa (n=16)	Mvumi-Mission(n=13)	
Individual	11.3	2	8.5	17.7	2.8	4.4	**46.8**
Family	11.7	1.2	20.2	14.9	3.6	0.8	**52.4**
Rented	0.4	0	0	0.4	0	0	**0.8**

Munguzwe and Jayne (2014) have pointed out that enhancing land tenure security and access to land through land markets for rentals and sales are among the elements of agricultural development and poverty reduction strategies in Africa. Findings on land status (Fig. 2) used for grapevine production based on soil fertility showed that most (98%) of the grapevine farmers were satisfied with the status of land used for grapevine production.

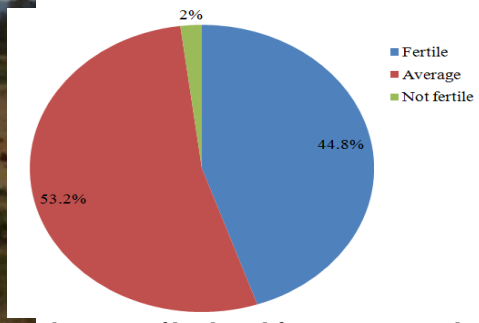

Figure 2: The status of land used for grapevine production in Chamwino District and Dodoma Municipality

The techniques used to improve soil fertility were application of farm yard manure from cattle, sheep and goat they were keeping, and compost manure (Table 10). Engagement in other farm income generating activities such as raising food crops (e.g. maize, white millet, legumes) made it possible for farmers to form compost manure from crop residues. These techniques are part of climate change adaptation strategies in the study area as before they used to improve soil fertility through industrial fertilisers.

Table 10: Ways used to improve soil fertility in Chamwino District and Dodoma Municipality*

Soil improvement techniques	Dodoma Municipality (%)			Chamwino District (%)			Total
	Hombolo (n=58)	Miyuji (n=8)	Mpunguzi (n=71)	Chinangali II (n=82)	Makang'wa (n=16)	Mvumi-Mission (n=13)	
Farm yard manure	16.5	3.6	14.9	26.6	1.6	2	**65.2**
Industrial fertilisers	14.1	2.4	4.4	19.8	0.4	0	**41.1**
Compost manure	6	2	21	11.7	6.9	5.2	**52.8**
None	80.2	8.1	102.8	107.3	23.4	19	**340.8**

*Multiple responses

4.2.5 Grapevine farmers' access to the physical capital

The key physical capitals which were investigated for grapevine production included the status of irrigation infrastructure, fruit storage facilities, and roads. Good status of the infrastructure was considered to strengthen farmers' adaptive capacity to climate change. The assessment on grapevine irrigation infrastructure (Table 11) was based on three Likert scale categories (i.e. good, satisfactory, and poor).

Table 11: Status of grapevine irrigation infrastructure in Chamwino District and Dodoma Municipality

Districts	Villages	Status of Grapevine Irrigation Infrastructure (%)			
		Good	Satisfactory	Poor	N/A
Dodoma	Hombolo (n=58)	22.4	58.4	13.8	5.2
	Miyuji(n=8)	12.5	62.5	25	0
	Mpunguzi(n=71)	4.2	15.5	60.6	19.7
	Chinangali II (n=82)	30.5	59.8	9.8	0
Chamwino	Makang'wa(n=16)	6.2	6.2	87.5	0
	Mvumi-Mission(n=13)	0	0	100	0
Average		**12.6**	**33.7**	**49.5**	**4.2**

Findings varied from one village to another. For Chinangali II, the overall findings showed that many grapevine farmers (90.3%) were pleased with the irrigation infrastructure due to the fact that they had newly made grapevine irrigation infrastructure facilitated through Chamwino District. The challenge was only the poor coordination on the use of water and the periodical maintenance of the pumping equipment after breakdowns (Plate 3). Financial contribution from the farmers to forfeit the maintenance cost and the technical skills were challenges in Chinangali II. Likewise, many grapevine farmers (80.8%) in Hombolo were pleased with the status of the irrigation infrastructure due to the presence of Hombolo dam on which the irrigation canals have been well developed throughout the grapevine growing season. However, there was also poor coordination on their periodical maintenance of the distribution chambers (Plate 4) once the breakdown occurred.

Plate 3: One of the water pumping stations at Chinangali II (**Photo by**: Author, August 2016

Plate 4: Water distribution chambers for irrigation canals in Hombolo (**Photo by**: Author, August 2016)

As for Miyuji, many grapevine farmers (75%) were satisfied with the irrigation infrastructure, while 25.0% were not due to the fact that irrigation in this village depended on the farmers' efforts as there was no government assistance. The farmers had to drill their own bore holes and use water pumps for drip irrigation. Drip irrigation requires highly developed skills which was a challenge to some of the farmers. Likewise, many grapevine farmers (60.6%) in Mpunguzi were not pleased with the irrigation infrastructure while 19.7% of the farmers did not apply improved irrigation systems due to their reliance on rainfall. However, some of them were using traditional irrigation methods by carrying water using buckets from shallow wells. This was also the same for Mvumi-Mission and Makang'wa which dependent on rainfall.

As for the grapevine fruit storage facilities, all of the respondents reported to have been using crates to store their grapevine fruits before they sold to the buyers (Plate 5). Majority (98.2%) of the grapevine farmers reported to have poor (Table 12) grapevine storage facilities while few farmers from Hombolo and Chinangali II were satisfied. This was due to the fact that Hombolo and Chinangali II are close to CETAWICO which, during harvesting, the company have been providing crates to the farmers for storing and carrying the fruits to the factory immediately.

Table 12: The status of grapevine fruit storage facilities in Chamwino District and Dodoma Municipality

Districts	Villages	Grapevine storage facilities (%)		
		Good	Satisfactory	Poor
Dodoma	Hombolo (n=58)	1.7	5.2	93.1
	Miyuji (n=8)	0	0	100
	Mpunguzi (n=71)	0	0	100
	Chinangali II (n=82)	1.2	2.4	96.3
Chamwino	Makang'wa (n=16)	0	0	100
	Mvumi-Mission (n=13)	0	0	100
Average		**0.5**	**1.3**	**98.2**

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Plate 5: Crates for storing grapevine fruits in Hombolo (**Photo by:** Author, August 2016)

The fact that most of the farmers were not satisfied with the status of grapevine storage facilities is because there was no chance to wait for the market after harvesting due to poor storage facilities. This weakened the farmers adaptive capacity to climate change as lack of good storage facilities could lead into damage of grapevines. Sofralik (2001) and Kader (2006) suggest the use of cold chain techniques to store and transport grapevine fruits. These storage techniques give chance for the farmer to wait for the market and prevent postharvest damage from fungi, bacteria, and birds. Mahajan et al. (2010) also recommend the use of cold stores and fumigation with sulphur dioxides (SO_2) to prevent postharvest quality losses of grapevine fruits and getting premium prices in the market. The use of gaseous ozone has been shown to prohibit ripening of grapevine fruits while in storage and prevent mold and bacterial growth in a cold storage environment (Palou et al., 2003). The farmers in the study area lacked all of these technologies for handling grapevine fruits.

The status of roads in the study area (Table 13) showed that Miyuji, Mpunguzi and Chinangali II had good roads while Hombolo, Makang'wa and Mvumi-Mission had poor roads. The villages which claimed to have poor roads were due to the fact that their roads were made of earth materials and there was lack of timely maintenance during the rainy seasons. Poor roads could weaken the grapevine farmers' adaptive capacity to climate change because they are impassable during the rainy season, causing high grapevine transaction costs at the market. According to Mutebile (2013), poor roads have the effects of lowering farm gate prices of agricultural produces. Villages which reported to have good roads had tarmac roads which were passable throughout the year. Miyuji, for example, was favoured by its location as it is within Dodoma town.

Table 13: Status of roads for grapevine transportation in Chamwino District and Dodoma Municipality

Districts	Villages	Status of Roads (%)		
		Good	Satisfactory	Poor
Dodoma	Hombolo (n=58)	7	13	80
	Miyuji (n=8)	98	2	0
	Mpunguzi (n=71)	95	3	2
	Chinangali II (n=82)	97	2	1
Chamwino	Makang'wa (n=16)	2.5	2.5	95
	Mvumi-Mission (n=13)	8	2	90
Average		**51.2**	**4.1**	**44.7**

4.2.6 Grapevine farmers' access to other sources of income

The major other sources of income in the study area were cultivating of both cash and food crops for selling, and keeping animals (Table 14). Other sources of income included small businesses, formal employment, fisheries, artisanship, motorcycle transport, and food vending. There were minor differences on the access to other income generating activities from one village to another. For example, grapevine farmers in Hombolo and Miyuji engaged more in raising cash crops, while in Mpunguzi and Chinangali II they engaged more in keeping animals. Likewise, the grapevine farmers in Makang'wa and Mvumi-Mission concentrated themselves in raising food crops.

These findings imply that more emphasis had been given to cultivating food crops to facilitate supply of basic needs (e.g. foods) in which people should eat first so that they can engage themselves in other socio-economic activities. Food crops also increase income of the farmers in the sense that the money which could be used to buy foods can be saved. Furthermore, nowadays, excess food crops can also be traded (sold) directly to increase the farmer's income for other expenditure. On the other hand, the fact that many grapevine farmers engaged more in cultivating other cash crops was to build their financial capital which could be re-invested in other businesses, including grapevine production. This is supported by Tanui et al. (2013) who have explained that as the smallholder farmers have poor access to credit; sources for income diversification into non-farm and off-farm activities help them to provide the required capital for increasing farm productivity. The case of grapevine farmers to engage on other sources of income can be referred to as diversification which acts as an adaptation strategy to the changing circumstances whereby the income from grapevine farming can also be re-invested into other socio-economic activities. Ellis (1998) has explained that diversification may occur as a deliberate household strategy or as an involuntary response to crisis which can be used as a safety net for the rural poor and as a way of accumulation for the rural rich. The World Bank (2007) has argued that to ensure alternative sources of livelihood for the rural poor, activities in the non-agricultural sector need to be enhanced as most of rural non-farm activities tend to be linked directly or indirectly to local agriculture.

Table 14: Other sources of income for grapevine farmers in Chamwino District and Dodoma Municipality*

Other Sources of Income	Dodoma Municipality (%)			Chamwino District (%)			Total (%)
	Hombolo (n=58)	Miyuji (n=8)	Mpunguzi (n=71)	Chinangali II (n=82)	Makang'wa (n=16)	Mvumi-Mission(n=13)	
Cultivating other cash crops	10.9	1.6	2.8	9.3	0.4	0.4	**25.4**
Cultivating food crops	12.9	1.2	8.9	15.7	3.6	1.6	**43.9**
Small businesses	2	0	7.3	10.9	0	0	**20.2**
Keeping animals	7.7	1.6	11.3	16.5	1.2	1.6	**39.9**
Artisanship	0.8	0	0	0	0	0.4	**1.2**
Formal employment	0.4	0	0.4	1.2	0.4	0	**2.4**
Fisheries	1.2	0	0	0	0	0	**1.2**
Cultivating horticultural crops	1.2	0	5.2	2.8	0.8	2.8	**12.8**
Motorcycle transport service provider	1.2	0	0	0	0	0	**1.2**
Food vender	0.8	0	0	0	0	0	**0.8**

*Multiple responses

5. Conclusions and Recommendations

Findings from this study showed that the major factors for grapevine production were categorized into agronomic and non-agronomic. The generic agronomic factors were soil fertility, soil moisture content, and application of pesticides. Likewise, the non-agronomic factors for grapevine production were identified to be availability of capital, market, grapevine production knowledge and skills, and agricultural extension services.

The influence of grapevine production factors on farmers' adaptive capacity showed that the major farmers' grapevine markets were petty traders who could pay the farmers a price they were not satisfied. Low grapevine prices led to low farmers' income which was weakening grapevine farmers' adaptive capacity to climate change. The grapevine farmers were accessing grapevine production knowledge and skills through ARI at Makutupora, the farmer's parents and friends, and the AEOs from Dodoma Municipality and Chamwino District. Most of the grapevine farmers were accessing financial capital from CRDB, friends, and other sources of income. As for the natural capital, the farmers were using water from Hombolo dam, deep wells, and shallow wells as adaptation strategies following the shortage of rains. Most of the farmers owned their land as an individual or a family which was a good opportunity to use it for accessing financial capital from microfinance banks. As for access to the physical capital, most of farmers had poor grapevine fruit storage facilities which were weakening their adaptive capacity. Likewise, most of farmers had improved road infrastructure which was strengthening their adaptive capacity to climate change. Farmers from Hombolo, Chinangali II, and Miyuji had improved irrigation infrastructure while in Mpunguzi, Mvumi-mission and Makang'wa farmers had poor irrigation infrastructure. Improved grapevine infrastructure strengthened farmers' adaptive capacity to climate change as opposed to the poor ones.

These findings inform the agriculture sector policy makers of addressing aspects that have been identified influencing grapevine production and farmers' adaptive capacity to climate change. The findings also inform the Division of Environment in the Vice-President's office of the United Republic of Tanzania (URT) that in implementing adaptation strategies proposed for agriculture sector in the National Adaptation Programme of Action (NAPA) (URT, 2007), it is imperative to give priorities to the identified aspects influencing grapevine farmers' adaptive capacity to climate change.

It is also recommended for the grapevine farmers to acquire more adaptive capacity to climate change; CG and LGAs should train the AEOs on grapevine production and its associated adaptation strategies, CG should increase and disburse ARI-Makutupora budget for disseminating research findings to the farmers and AEOs, LGAs should facilitate farmers to join SACOSS for securing loans from the same SACCOS and microfinance banks, and CG and LGAs should improve irrigation, grapevine storage, and road infrastructure for grapevine production.

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