An Investigation of Grapevine Farmers' Climate Change Awareness: A Case of Dodoma Region, Tanzania

Felix Yohana Mahenge & Abiud Lucas Kaswamila
Department of Geography and Environmental Studies,
University of Dodoma
P.O. Box 259, Dodoma -Tanzania
Corresponding author; Email: fmahenge2018@gmail.com

Abstract

Lack of awareness owing to insufficient access to climate information is one of the factors contributing to farmers' failure to adapt to climate change. The awareness of grapevine farmers about climate change was investigated in Dodoma, Central Tanzania. The study involved 248 respondents. Data were collected through questionnaires and document reviews, and analysed through inferential and descriptive statistics using the International Business Machines Corporation-Statistical Product and Service Solutions (IBM-SPSS) software. Findings revealed that age, education, sex, and access to climate information sources influenced grapevine farmers' awareness of climate change. Climate change awareness was higher among grapevine farmers who had access to climate information and education; and males were more aware than females. As for the age group, the elderly was substantially more aware ($p = 0.02$, at 5% confidence level) than the youths. Radio, indigenous knowledge, and friends were the most important sources of climate information. To improve grapevine farmers' awareness of climate change, the findings suggest strengthening grapevine farmers' access to education services; improving collaboration with development practitioners, including the Tanzania Meteorological Agency and the media; improving farmers' access to climate information; and focusing on sharing and transferring climate-related knowledge, skills, and experience among diverse groups.

Keywords: *Education, climate information, grapevine farmers, Tanzania*

Introduction

Climate change is the world's most pressing environmental problem. It poses a serious threat to the world's security and prosperity. Climate change has direct effects on the economy,water resources, weather events, health, desertification, sea level rise, as well as political and social stability issues (Aid, 2006;Intergovernmental Panel on Climate Change [IPCC], 2001;Omambia& Gu, 2010). In Tanzania, climate change has had an impact on water resources, and food and energy production. Projections show that the impact of climate change will worsen agriculture, hydropower, and livestock production by 2050, thus risking the livelihoods of many Tanzanians (Said et al., 2019).

Climate change impacts are exacerbating disasters in most disaster-prone countries. Therefore, increasing climate change awareness at the local level is critical. It has been noted that understanding the awareness of the community about climate change aids in the planning and implementation of climate change adaptation (Shahid, 2015). Awareness is a key factor for adopting new practices. Shahid and Piracha (2010) reveal that awareness of climate change has a significant positive contribution to people's adaptive capacity. Based on that understanding, the United Nations' Millennium Development Goals included environmental awareness to highlight the dangers of climate change and global warming to humanity (Sultan et al., 2016).

According to Mahenge (2016) understanding various aspects of farmers' lives, such as their level of climate change awareness and the adaptation strategies they use to combat the effects of climate change, is necessary for a successful intervention aimed at increasing their resilience to climate change. These issues determine the level of intervention required to enable farmers to respond positively to climate change. The purpose of this study was to better understand the level of awareness, knowledge of the impact of climate change, factors influencing awareness, and access to climate information among grapevine farmers in Dodoma, Tanzania. These factors are thought to be critical for interventions aimed at improving the capability of farmers to adapt to climate change.

Literature Review

The main concept of the study is the awareness of climate change. The key variables include the levels of awareness of climate change; knowledge of the

impact of climate change; access to climate information; and factors influencing awareness of climate change. According to Hagger and Chatzisarantis (2007), awareness is the extent to which people are aware of the stimulus triggering a process. Bulgurcu et al. (2010) define awareness as the overall knowledge and understanding of potential issues. Kreuter and Wray (2003) view awareness as the extent to which a message stimulates cognitive activity. Goel et al. (2012) have also defined awareness as knowledge about an event or the ability to recall things. These definitions build a basis for this study, which regards awareness as the consciousness, understanding, and knowledge of the farmers about the impacts of climate change on grapevine production.

Based on the main concept of the study (awareness) and its key variables (levels, knowledge, access to information, and factors influencing awareness), this study was grounded in some constructs of theories which depict awareness as leading to action, including the Theory of Planned Behaviour (TPB), and Social Cognitive Theory (SCT). These theories aid in explaining how awareness leads to behaviour changes (Wathuge & Sedera, 2021).

Theory of Planned Behaviour (TPB) was developed by Icek Ajzen in 1991. It predicts an individual's intention to engage in a specific behaviour at a specific time and place. It posits that an individual's behaviour is driven by their behaviour intentions. It further states that behavioural achievement depends on motivation (intention) and ability (behavioural control). The three key constructs of TPB include an individual's attitude toward behaviour, subjective norms, and perceived behavioural control (Frawley, 2017). In climate change awareness studies, TPB may inform the role of knowledge in influencing individuals' attitudes towards the intention to implement climate actions such as adaptation and mitigation. The TPB, therefore, guided the researchers in selecting the variables that were used to determine the grapevine farmers' level of awareness about climate change, and examine grapevine farmers' knowledge of the impacts of climate change. However, TPB is criticised for being unable to take into consideration the influence of environmental factors on a person's intention to perform a behaviour. This necessitated the inclusion of SCT in the study.

The Social Cognitive Theory (SCT) was first developed by Stanford psychologist, Professor Albert Bandura, in 1960. He reviewed the theory in 1977 and 1986

(Schunk & DiBenedetto, 2020). The SCT describes the influence of individual experiences, the actions of others, and environmental factors on individual behaviours. The operational components of SCT include attention, retention, production, and motivation. This construct informs the study of the way an individual selects sources of information, remembers the observed information, reconstructs the memories of the observations, and opts to perform or not perform the observation based on the results. SCT is critiqued for its assumption that changes in the environment perpetually cause changes in an individual's behaviour, but this may not always happen. However, the SCT helped researchers to identify variables for assessing the farmers' knowledge of the impacts of climate change, examine the sources of climate information accessed by grapevine farmers, and identify the predictors of awareness of climate change during the construction of questionnaires.

Knowledge of the Impacts of Climate Change

Climate change has emerged as one of the most serious environmental dangers, with dire global consequences for human and ecological systems (Nigatu et al., 2014). Many of the causes of climate change are anthropogenic in nature, resulting from lifestyles, consumerism, and decisions that pollute and exploit resources in an unsustainable manner (Abatzoglou & Williams, 2016; Abatzoglou et al., 2019). Carbon dioxide (CO2), methane (CH4), nitrogen dioxide (N2O), and chlorofluorocarbons (CFCs) are important human atmospheric pollutants as greenhouse gases (Somerville,2012).

Climate change has devastating consequences for development sectors such as agriculture, energy, tourism, and fisheries (Coffinet et al., 2018). Ecosystems may collapse as a result of climate change (Grimm et al., 2013). Due to their limited landholdings and lack of resources to cope with climate change, small-scale farmers would suffer the most (Ochieng et al., 2016; Raghuvanshi & Ansari, 2017). Poor rural households, who rely on agriculture and natural resources for a living, endure a disproportionate share of the negative effects of climate change (Raghuvanshi&Ansari, 2017).

Studies confirm the occurrence of climate change and its impacts on Tanzania natural resources and agriculture sector (Coffinet et al., 2018; Lukwale & Sife, 2017). Climate change has a greater effect in central Tanzania, which has semi-

arid conditions. Unreliable and low rainfall, deteriorating soil fertility, agricultural pests and illnesses, and livestock diseases are among them (Kihila, 2018). These consequences have a significant influence on the economic performance and livelihoods of people that rely on rain-fed agriculture.

Contradictory understanding of the impact of climate change may pose significant challenges in addressing it (Hare, 2003). Yeoman and McMahon-Beattie (2006) acknowledge that policymakers must have a good grasp of the impact of climate change in order to differentiate the truth from misconceptions. Local communities may choose appropriate adaptation if they have a clear understanding of the impact of climate change (Haynie & Pfeiffer, 2012).

The Level of Awareness of Climate Change

African societies are aware of the changing weather patterns yet are misled about global climate change (Ochieng& Koske, 2013). The low level of climate change awareness in Africa is due to a lack of awareness initiatives, poverty, and political chaos. As a result, these countries do not prioritise climate change issues (United Nation Framework Convention on Climate Change [UNFCCC], 2007).Several studies have been conducted to investigate farmers' awareness of climate change. Ado et al. (2019) show that farmers' access to climate information influences their awareness of climate risks. Twinomuhangi et al. (2021), Sarkar and Padaria (2016), and Idrisa et al. (2012) reveal that farmers become aware of climate change through climate-related phenomena, such as increased temperature, reduced agricultural production, and increased crop diseases. Ochieng and Koske (2013) showed that the level of climate change awareness among primary school teachers in Kenya was low enough to necessitate capacity building to improve their quality of knowledge on climate change.

Factors Influencing Farmers' Awareness of Climate Change

The environmental communication network, which includes socioeconomic, institutional, and geographic aspects, influences farmers' awareness of climate change (Mustafa et al., 2019; Garcia de Jalon et al., 2015). Age, occupation, and education have been found to influence people's levels of awareness and knowledge of the causes of climate change (Adebayo et al., 2013). However, Adebayo et al. (2013) note that gender has no influence on awareness of climate change. Lee et al. (2015) have noted education level to be the strongest predictor of public climate change awareness.

Ajuang et al. (2016) reveal that sex, education level, and age have a significant influence on farmers' awareness of climate change markers. However, Olatumile (2013) notes that age and gender have no significant influence on awareness of climate change. Mwalukasa et al. (2018) disclose that farmers' awareness of climate change is also influenced by marital status, farm size, farming experience, radio ownership, and income. Owusu et al. (2019) add place-based variables as among the factors influencing farmers' awareness of climate change. Masud et al. (2017) conclude that socio-demographic factors influence an individual's climate change awareness.

Sources of Climate Information

Several studies show that climate information is important in determining farmers' awareness of climate change (Ado et al., 2019; Mustafa et al., 2019; Garcia de Jalon et al., 2015). Idrisa et al. (2012) reveal that extension services and friends are the most common sources of farmers' climate information. Similarly, Mtambanengwe et al. (2012) add radio, and television as among the key farmers' climate information sources.

However, Popoola et al. (2020) note that extension services have a low contribution to rural farmers' climate change knowledge. Similarly, Djido et al. (2021), and Onyango et al. (2014) show that radio, television, and local administration have little contribution to the farmers' adoption of smart agricultural practices and operational decisions. Caine et al. (2015) note that the use of mobile phones as a farmers' climate information source is still under pilot studies. Nkiaka et al. (2019) have insisted on capacity building of personnel working for Meteorological Services to improve farmers' uptake of climate information.

Most of the local communities rely on indigenous knowledge (IK) to acquire climate information for predicting future weather conditions (Mugiya & Hofisi, 2017). Meteorological, biological, and astrological indicators are the most commonly used IK to forecast local weather conditions (Radeny et al.,2019). Singh et al. (2018) ascertain that externally provided climate information has an important role in building on IK.

Farmers' ability to adapt to climate change is influenced by their level of climate change awareness (Fahad et al., 2020; Ibrahim et al., 2015). However, a number of studies on climate change (Dessu&Melesse, 2013; Kangalawe et al., 2017;

Kihila, 2018; Komba&Muchapondwa, 2012; Lupala et al., 2015; Smucker et al., 2015) have focused on understanding its impact, and mitigation and adaption techniques with little emphasis on the drivers of farmers' awareness. Where the drivers of awareness of climate change have been studied (Adebayo et al., 2013; Ochieng & Koske, 2013; Lee et al., 2015), it has been undertaken at global levels, leaving the drivers of awareness at local levels understudied. This study assessed the knowledge-based awareness of grapevine farmers on climate change in Dodoma, Tanzania, as a contribution to reducing the existing knowledge gap. Specifically, the study determined the level of grapevine farmers' awareness of climate change, examined the grapevine farmers' knowledge of climate change impacts, investigated the determinants of climate change awareness, and examined the sources of climate information accessed by the grapevine farmers.

Materials and Methods

This study was conducted in Dodoma city and the Chamwino district, both in Tanzania's Dodoma region. Hombolo, Miyuji, and Mpunguzi villages in Dodoma city were all involved. Likewise, in the Chamwino district, three villages – Chinangali II, Makang'wa, and Mvumi-mission – were involved. These study locations were chosen because they are well-known grapevine producers in Tanzania. Due to climate change, grapevine productivity has recently decreased (Kalimangasi, 2020).

The Chamwino district is characterized by mountain chains, hill ranges, and low-lying plains. The main socio-economic activities include agriculture, animal husbandry, maize milling, carpentry, and tailoring. Lowlands, hills, seasonal rivers, deep and shallow wells, and dams define Dodoma city. The main economic activities of Dodoma city are agriculture, livestock raising, and agricultural-related businesses. The study adopted quantitative approach with a descriptive cross-sectional design. The villages involved in the study were chosen by using purposive sampling technique (non-probability). The number of existing grapevine farmers was the primary requirement. Individual grapevine farmers served as sampling units, with all grapevine farmers in the study area as the target population. Because the number of grapevine farmers was estimated to be 653, the sample size was calculated using the Yamane formula using a precision level of 95%. The sample size was calculated to be 248 individual grapevine farmers. A village-based sample size, such as Hombolo (58), Miyuji (8), Mpunguzi (71), Chinangali II (82),

Makang'wa (16), and Mvumi-mission (13) were estimated and selected using the Israel formula. Individuals were recruited for the study using a simple random sampling procedure (probability) in each participant village.

Questionnaires and document reviews were used to gather information. Questionnaires were created using the study objectives as well as the two guiding theories. Theory of Planned Behaviour (TPB) aided in the identification of variables for objectives (levels of climate change awareness) and ii (knowledge of the impact of climate change), while the Social Cognitive Theory (SCT) aided in the identification of variables for objectives iii (factors influencing climate change awareness) and iv (sources of climate information). Following pilot research with 40 respondents, the questionnaires were pre-tested using Cronbach's Alpha (CA) in SPSS to verify the internal consistency of the questions. The CA value was 0.623, indicating that the questions' internal consistency was acceptable. The variables of the study are shown in Table 1.

Table 1: Variables Adopted to Assess Grapevine Farmers' Awareness of Climate Change in Chamwino District and Dodoma City

Specific objective	Variables
To determine the level of grapevine farmers' awareness of climate change	Percentage of grapevine farmers with certainty understanding of climate change
To examine grapevine farmers' knowledge of the impacts of climate change	Percentage of grapevine farmers who can reveal consequences of climate change
To investigate factors influencing grapevine farmers' awareness of climate change	Age, sex, access to information, and education level
To examine the sources of climate information accessed by grapevine farmers	Mediafor accessing climate information

Documentary review was conducted by looking for relevant published articles on Google Scholar. The article's relevance was guided by the study objectives, from which key terms were derived. Only the top 100 articles were inspected for each search, and only a few that were deemed relevant were chosen (Table 2). The purpose of the documentary review was to confirm the results of the questionnaire surveys.

The Statistical Product and Service Solutions (SPSS) software from International Business Machines Corporation (IBM) was used to analyse the data. In terms of frequencies and percentages, descriptive statistics were used to address specific research objectives. To explain the association between two categorical variables, the chi-square test was used in conjunction with cross-tabulation. Multiple response analysis was used to evaluate multiple response questions. In the case of the document review data, the analysis was carried out by determining the article's relevancy and categorising its findings according to the study's objective factors.

Table 2: Search Terms and Number of Articles Reviewed

Specific objective	Terms searched	Inspected article	Selected articles
Determining the level of awareness of climate change	Level of awareness/climate change/farmers/Tanzania/ developing countries	100	15
Examining knowledge of the impacts of climate change	Farmers/knowledge/climate/ change/impacts/Tanzania/ developing countries	100	32
Investigating factors influencing awareness of climate change	Climate change/awareness/ influence/farmers/Tanzania/ developing countries	100	24
Examining the sources of climate information	Climate change/climate/ information/sources/farmers/ awareness/Tanzania/ developing countries	100	23

Results

Demographic Characteristics of the Respondents

Sex, age, marital status, and educational level were among the demographic features of respondents (Table 3). When it came to gender, male respondents outnumbered females in both research locations. In terms of age, many respondents in Dodoma city were between the ages of 40 and 45 years, while those in Chamwino district were between the ages of 20 and 39 years. Many respondents were married in both study sites when it came to marital status. In terms of education, many respondents in Dodoma city had completed primary school, whereas many in Chamwino district had received informal education.

Table 3: Demographic Characteristics of The Grapevine Farmersin The Chamwino District and The Dodoma City, Tanzania

Locations	Sex		Age in years			Marital status				Educational level				
	(%)		(%)			(%)				(%)				
	M.	F.	20-39	40-45	45+	S	M a.	Sep.		I.		P.	S.	T.
Dodoma city (n=137)	84	16	36	50.5	13.5	6.2	91.8	2		2.6		70.5	10.4	16.5
Chamwino district (n=111)	78	22	75.6	21.5	2.9	7.4	91.4	1.2		67		20.5	5.2	7.3

Note: All responses are in percentages n=sample size M=Male F=Female S=Single Ma=Married Sep=Separated I=Informal education P=Primary education S=Secondary education T=Tertiary education

The Level of Awareness of Climate Change

The grapevine farmers were aware of climate change, with Dodoma city farmers being relatively more informed (91.8%) than Chamwino district farmers (72.9%) (Table 4). Grapevine farmers awareness differed significantly between villages, with a $p<0.05$ at the 5% confidence level. Villages levels of awareness differed as well. Grapevine farmers in Miyuji had relatively high knowledge about climate change (100%) compared to any other village in Dodoma. Farmers in Chinangali II village (Chamwino district) were also relatively high knowledge about climate change (79.3%) compared to any other grapevine farmer in other villages in the district. These differences could be explained by the study locations' various contexts (urban and rural), as recognised by the Social Cognitive Theory (SCT), which states that contextual circumstances influence individuals' knowledge, which can alter their behaviour in responding to the environment.

Table 4: Climate Change Awareness Among Grapevine Farmers in The Chamwino District and the Dodoma City, Tanzania

Locations		Aware (n=207)		Not aware (n=41)	
		Frequency	Percentages	Frequency	Percentages
	Hombolo (n=58)	47	81%	11	19%
Dodoma city	Miyuji (n=8)	8	100%	0	0%
	Mpunguzi (n=71)	67	94.4%	4	5.6%
Total frequency (Average %)		122	91.8%	15	8.2%
	Chinangali II (n = 82)	65	79.3%	17	20.7%
Chamwino district	Makang'wa (n=16)	10	62.5%	6	37.5%
	Mvumi-Mission (n=13)	10	76.9%	3	23.1%
Total frequency (Average %)		85	72.9%	26	27.1%
n=sample size	X^2=14.494	df=5	p=0.016 (significant at 5% confidence level)		

Grapevine Farmers' Knowledge of the Impacts of Climate Change

The ability of grapevine farmers to relate the challenges of grapevine production to environmental variables was used to measure their awareness of the impacts of climate change. The respondents who were aware of climate change,91.8% in Dodoma city and 72.9% in Chamwino district (Table 4), were able to mention some of the problems they believed climate change was causing. Outbreaks of pests and diseases, droughts, severe rainfall, and high temperatures were all noted as impacts of climate change (Table 5). These answers are consistent with the constructs of the Theory of Planned Behaviour (TPB), which proposes that motivation and ability, as assessed by behavioural control, drive an individual's behaviour. Grapevine farmers' capacity to connect current grapevine problems to climate change may inspire them to discover the best solutions.

Table 5: The Knowledge of Grapevine Farmers About the Impact of Climate Change on Grapevine Production in the Chamwino District and the Dodoma City, Tanzania*

Impacts	**Dodoma city (n=137)**	**Chamwino district (n=111)**
	Responses	Responses
Outbreaks of diseases	54(35.9%)	44(40.3%)
Outbreaks of pests and insects	45(30.6%)	42(37%)
Drought	17(11.2%)	17(15.7%)
Heavy rainfall	9(6.4%)	4(3.6%)
Extreme high temperature	10(6.8%)	5(4.8%)
High wind speed	2(1.2%)	0(0.0%)
Total	137 (92.1%)	111(101.4%)

Note. Numbers outside brackets are frequencies *Multiple responses
n=sample size

Factors Influencing Grapevine Farmers' Awareness of Climate Change

The grapevine farmers' awareness of climate change was identified to be influenced by their level of education, sex, and age (Table 6).

The awareness of grapevine farmers about climate change differed significantly ($p<0.5$ at 5% confidence level) between different age groups. There was an increase in awareness about climate change with the increase in the elderly. The grapevine farmers in the age group of 45+ years were relatively more (95.5%) aware of climate change than any other age group. With the level of education, there was no significant difference ($p>0.05$ at 5% confidence level) even though all grapevine farmers with tertiary education (college and university) were aware of climate change.

Table 6: Factors Influencing Grapevine Farmers' Awareness of Climate Change in Chamwino District and the Dodoma City, Tanzania

Factors	Variables	Awareness		
		Aware (n=207)	Not aware (n=41)	
Education	Informal	36(86.2%)	5(13.8%)	X^2=4.69
	Primary education	35(83.7%)	6(16.3%)	df=5
	Ordinary secondary education	31(73.7%)	9(26.3%)	p=0.383 (not significant)
	Advanced secondary education	21(50%)	21(50%)	
	College	42(100%)	0(0.0%)	
	University	42(100%)	0(0.0%)	
Sex	Male	111(85.9%)	15(14.1%)	X2=3.759
	Female	96(75%)	26(25%)	df=1 p=0.065 (not significant)
Age (years)	20 – 39	61(77.2%)	23(22.8%)	X2=6.863
	40-44	70(87.5%)	13(12.5%)	df=2 p=0.02
	45+	76(95.5%)	5(4.5%)	(significant at 5% confidence level)

Note. Numbers outside brackets are frequencies n=sample size

Farmers' awareness of climate change differed by sex, despite the fact that there was no statistically significant difference ($p>0.05$ at 5% confidence level). Males, on the other hand, were relatively more aware (85.9%) than females (75%). Individual experiences, other people's actions, and environmental circumstances all have an impact on an individual's results, according to the Social Cognitive Theory (SCT). As a result, creating an environment that encourages interaction among grapevine farmers of various educational levels, ages, and sex may increase their knowledge of climate change.

Sources of Climate Information Accessed by Grapevine Farmers

Accessing various sources of climate information that improved weather forecasts was one way for grapevine farmers to become aware of climate change. It was found that grapevine farmers had received climate information from formal and informal sources (Table 7).

Table 7: Climate Information Sources in the Chamwino District and the Dodoma City, Tanzania*

		Climate sources							
Locations		Radio	News papers	Television	Village officials	Indigenous knowledge	Agricultural Extension Services	Political leaders' speech	Friends
Dodoma city	Hombolo (n=58)	8.1	1.6	3.6	3.6	6.5	5.6	0.4	2.8
	Miyuji (n=8)	1.6	0.8	1.2	0.8	0.4	0.8	0	0
	Mpunguzi (n=71)	4.4	0.4	2.8	2.4	5.2	4	0	14.5
Chamwino district	Chinangali II (n=82)	10.9	3.6	7.3	5.6	8.9	3.6	0	2
	Makang'wa (n=13)	1.6	0	0.8	0	1.2	0	0	2
	Mvumi-Mission (n=16)	0	0	0	0	0.4	0.8	0	2
Total		26.6	6.4	15.7	12.4	22.6	14.8	0.4	23.3

Note. All numbers are in percentages *Multiple responses n=sample size

The formal sources of climate information included radio, television, agricultural extension officers, village officials, and political leaders' speeches. Similarly, the informal sources included indigenous knowledge (IK) and friends. These responses acknowledge the influence of some Social Cognitive Theory (SCT) constructs, such as individual experiences, others' behaviours, and environmental circumstances, on individual behaviour toward the environment.

Radio, friends, and IK were the most common sources of climate information (Table 6). Some grapevine farmers, on the other hand, had limited or no access to climate information sources. The sources of climate information were different in each village. Farmers in many villages acquired climate information through radio, IK, and television, with the exception of Mpunguzi, where they largely received it through friends.

Documentary review findings

Similar research either confirmed or refuted the study's findings. Table 8 summarises the articles that were reviewed and their links to the study findings.

Table 8: Reviewed Documents and their Relationship to the Study Findings

Specific objective	Articles	Relationship to the study findings
Determining the level of grapevine farmers' awareness of climate change	Komives et al. (2019); Nkoana (2020); Mustafa et al. (2019); Ado et al. (2019)	Corroborate
	Koch et al. (2007); Ochieng and Koske (2013)	Refute
Examining grapevine farmers' knowledge of the impacts of climate change	Raghuvanshi and Ansari (2017); Ajuang et al. (2016); Sogani (2011)	Corroborate
	Christian et al. (2021)	Refute
Investigating factors influencing grapevine farmers' awareness on climate change	Bizimana et al. (2014); Stamoulis and Zezza (2003); Atchoarena and Gasperini (2003); Mwalukasa et al.(2018); Owusu et al. (2019); Adebayo et al. (2013); Leeet al. (2015).	Corroborate
	Olatumile (2013); Adebayo et al. (2013); Masud et al. (2017); Christian et al. (2021); Ajuang et al. (2016)	Refute
Examining the sources of climate information	Corner (2011); Boykoff and Roberts (2007); Kihila et al. (2018); Mahoo et al. (2015); Nadarajah and Rankin (2005); Beegle et al. (2006); Bauer (2009); Bizimana et al. (2014).	Corroborate
	Idrisa et al. (2012); Onyango et al. (2014).	Refute

Discussions

The Level of Awareness about Climate Change

The findings revealed that grapevine farmers were aware of climate change. However, grapevine farmers in Chamwino district were more aware of the climate change than those of Dodoma city. Farmers' awareness also varied significantly between the research villages. Location and differences in accessing climate information and other social services may have contributed to the minor variances in awareness levels between the study sites. Miyuji, for example, is near Dodoma city centre, whereas Chinangali II is close to Chamwino town. Grapevine farmers can easily acquire climate information and educational services because of their

proximity to town centres. This finding is consistent with Komives et al. (2019) and Nkoana (2020), who found that climate awareness is influenced by access to climate information and education. The findings are comparable to those of Mustafa et al. (2019), who showed that farmers are aware of current weather patterns; and Ado et al. (2019) who revealed majority of farmers in Nigeria were aware of climate-related hazards. However, the result contradicts Koch et al.'s (2007) who found that lack of awareness among development stakeholders limit climate change adaptation. Similarly, Ochieng and Koske (2013) found that educators in Kenya had a poor level of climate change awareness. To improve grapevine farmers' awareness of climate change, the findings suggest strengthening grapevine farmers' access to formal education and climate information.

Grapevine Farmers' Knowledge of the Impacts of Climate Change

The study findings also show that, grapevine farmers who were aware of climate change identified climate change consequences as an indicator of knowledge. Pest and disease outbreaks, droughts, heavy rains, and exceptionally high temperatures are among them. The majority of these responses focused on grapevine farming as their primary occupation. The aforementioned climate change implications have been identified as creating a concern in grapevine production. These findings show that grapevine farmers were able to link climate change to grapevine production challenges. Understanding the root cause of the problems could aid them in resolving the challenges.

Raghuvanshi and Ansari (2017) found similar results, stating that the majority of farmers feel crop loss is a significant influence of climate change. The findings also support the findings of Sogani (2011), who observed that the advent of pests and illnesses owing to climate change affects the growth of specific plant species in India. Farmers in Kenya have also noted rising temperatures and decreased rainfall as evidence of climate change (Ajuang et al., 2016). However, Christian et al. (2021) found that farmers in Ghana had a better grasp of climate change from the perspective of climate-related risks such as floods, tsunamis, drought, and landslides.

Farmers' grasp of the effects of climate change on grapevine output, according to the findings, may provide an opportunity to assist them in developing adaptation measures. Controlling grapevine pests and diseases, irrigation, and soil and water conservation measures are examples of such strategies. It is suggested that the climate change adaptive capacity of grapevine farmers be enhanced.

Factors Influencing Grapevine Farmers' Awareness of Climate Change

The findings revealed that the level of climate change awareness among grapevine farmers was influenced by their education, sex, and age. However, neither education nor sex played a significant role in raising awareness. The findings differ from those of Adebayo et al. (2013) and Ajuang et al. (2016), who found that education has a significant influence on people's awareness of climate change. Similarly, Lee et al. (2015) revealed that education is the best predictor of climate change awareness. However, the findings show that increasing people's access to education services can help them learn more about climate change. As a result, grapevine farmers should have better access to educational services.

In the case of sex, males were somewhat more aware of climate change than females, although the difference was not significant. This indicates that male and female grapevine farmers had unequal access to climate information. It also implies that boys had easier access to climate knowledge than girls. The finding is similar to that of Adebayo et al. (2013) and Olatumile (2013), who revealed that sex had no significant influence on people's awareness of climate change in Nigeria. However, this finding contradicts that of Ajuang et al. (2016), who discovered that sex has a significant influence on farmers' awareness of climate change. Similarly, Bizimana et al. (2014), and Stamoulis and Zezza (2003) revealed that in developing countries, male children have better access to social services than female children. According to Atchoarena and Gasperini (2003), women in rural areas of developing nations have limited access to climate information sources. The finding suggests that gender discrepancies in obtaining social services should be actively discouraged to ensure equitable access to climate information.

The findings also showed that the awareness of climate change significantly increased with an increase in age. This implies that age and experience matter in improving climate change knowledge. The finding is similar to Mwalukasa et al. (2018), who reveal that age is among the socio-demographic factors influencing the use of mobile phones in accessing climate information. Adebayo et al. (2013) also noted that age significantly influences people's awareness of climate change in Nigeria. The finding contrasts with Christian et al. (2021), who found that aged respondents were underestimating climate risks in Ghana. Similarly, Olatumile (2013) noted that age has no significant influence on people's awareness of climate change in Nigeria. The finding suggests that, to increase grapevine farmers' awareness of climate change, the elderly should be enabled to interact with the youths in their community.

Sources of Climate Information Accessed by Grapevine Farmers

The findings showed that the majority of the grapevine farmers had received awareness of climate change through accessing climate information sources. The major sources of climate information were radio, indigenous knowledge, and friends. Many grapevine farmers had more access to the radio than to other information sources. This implies that to increase the likelihood of climate information delivery in the study area, one has to improve grapevine farmers' access to radio. Similar findings were made in Uganda, where 89% had radio access to climate change topics (Corner, 2011). Boykoff and Roberts (2007) also highlight that radio is accessible to a large number of people because it is relatively inexpensive and does not require a literate audience. These findings differ from those of Idrisa et al. (2012), who revealed that extension services are the major farmers' climate information sources in Nigeria.

Grapevine farmers also stated that friends were a key means of receiving climate information. The finding issimilar to that of Idrisa et al. (2012), who found friends among the foremost means for farmers to receive climate information in Nigeria. It was found that grapevine farmers alsolearned about climate change through their indigenous knowledge (IK). Similarly, Kihila (2018),and Mahoo et al. (2015)state that Tanzanian farmers can monitor local indications, such as plant and animal behaviours to predict rainfall. These findings suggest that grapevine farmers' interactionwith their friendsshould be increased by improving farmer visits as a means of sharing IK.

Grapevine farmers with access to electric power were accessing climate information on television. However, the high cost of obtaining a television set and decoder, operational costs, and limited access to energy hindered most grapevine farmers' access to television. The finding conforms to Corner (2011), who noted that in Uganda, just 24% of the rural respondents and 63% of the urban respondents watched television on a regular basis. This finding indicates that, to improve grapevine farmers' access to television, it is critical to strengthen their access to electricity.

A few grapevine farmers acknowledged newspapers as a source for climate information. This could be due to a lack of newspaper distribution in villages or the high cost of newspapers. The findings relate to Beegle et al. (2006), who explain that Tanzania's per capita income is low. As a result, most farmers are unable to purchase newspapers. Similarly, Bauer (2009), Bizimana et al. (2014),

and Corner (2011) point out that only literate individuals can access newspapers. Therefore, it is of paramount importance to encourage grapevine farmers to have a diversified economy to increase their income.

Similarly, a few grapevine farmers named village officials, agricultural extension officers, and government leaders' speeches as sources of climate information. These government agencies were reported to contribute little to environmental awareness building due to a scarcity of incentives for extension personnel, such as transportation and lodging. These findings contrast with those of Onyango et al. (2014), who noted that government administration contributes significantly as a farmers' climate information source in Kenya. The findings suggest a significant need for improved governance by the government of Tanzania.

References

Abatzoglou, J. T., & Williams, A. P. (2016). Impact of anthropogenic climate change on wildfire across western US forests. Proceedings of the National Academy of Sciences, 113(42), 11770-11775. https://doi.org/10.1073/pnas.1607171113

Abatzoglou, J. T., Williams, A. P., &Barbero, R. (2019). Global emergence of anthropogenicclimate change in fire weather indices. Geophysical Research Letters, 46(1), 326-336. https://doi.org/10.1029/2018GL08095

Adebayo, A., Mubi, A., Zemba, A., & Umar, A. (2013). Awareness of climate changeimpacts and adaptation in Adamawa state, Nigeria.

International Journal of Environment, Ecology, Family and Urban Studies (IJEEFUS), 3(1), 11-18. https://www.researchgate.net/profile/Abel-Adebayo/publication/235951747_

Ado, A. M., Leshan, J., Savadogo, P., Bo, L., & Shah, A. A. (2019). Farmers' awareness and perception of climate change impacts: Case study of Aguie district in Niger. Environment, Development and sustainability, 21(6), 2963-2977.https://link.springer.com/article/10.1007/s10668-018-0173-4

Aid, C. (2006). Life on the edge of climate change: the plight of Pastoralists in Northern Kenya.http://reliefweb.int/sites/reliefweb.int/files/resources/87732D4D8913559C85257225006E79

Ajuang, C. O., Abuom, P. O., Bosire, E. K., Dida, G. O., &Anyona, D. N. (2016). Determinants of climate change awareness level in upper Nyakach Division, Kisumu County, Kenya. SpringerPlus, 5(1), 1-20. https://springerplus.springeropen.com/articles/10.1186/s40064-016-2699-y

Atchoarena, D., & Gasperini, L. (2003). Education for Rural Development towards New Policy Responses. ERIC. https://files.eric.ed.gov/fulltext/ED499625.pdf

Bauer, S. (2009). The secretariat of the United Nations Environment Programme: Tangled up in blue. Managers of global change: The influence of international environmental bureaucracies,169-201.https://books.google.co.tz/books?hl=en&lr=&id=pF3RB56QMFgC&oi=fnd&pg=PA169&dq

Beegle, K., De Weerdt, J., &Dercon, S. (2006). Poverty and wealth dynamics in Tanzania: Evidence from a tracking survey. World Bank, Washington, DC.https://www.researchgate.net/profile/Kathleen-Beegle/publication/228663459

Bizimana, J.-C., Clarke, N. P., Dile, Y. T., Gerik, T. J., Jeong, J., Leyton, J. M. O., Richardson, J. W., Srinivasan, R., &Worqlul, A. W. (2014). Ex Ante Analysis of Small-Scale Irrigation Interventions in Mvomero. ILSSI Reports and Publications. https://agrilife.org/ilssi/files/2019/12/updated-mvomero-integrated-ex-ante-analysis-421_jc_ec.pdf

Boykoff, M. T., & Roberts, J. T. (2007). Media coverage of climate change: Current trends, strengths, weaknesses. Human Development Report, 2008(3), 1-53. https://www.researchgate.net/profile/Max-Boykoff-2/publication/228637999

Brown, O., Hammill, A., &McLeman, R. (2007). Climate change as the 'new' security threat: implications for Africa. International Affairs, 83(6), 1141-1154.https://doi.org/101111/j.1468-2346.2007.00678.x.

Bulgurcu, B., Cavusoglu, H., &Benbasat, I. (2010). Information security policy compliance: an empirical study of rationality-based beliefs and information security awareness. MIS quarterly, 523-548. https://doi.org/10.2307/25750690

Caine, A., Dorward, P., Clarkson, G., Evans, N., Canales, C., Stern, D., & Stern, R. (2015). Mobile applications for weather and climate information: their use and potential for smallholder farmers. CCAFS Working Paper. https://hdl.handle.net/10568/69496

Change, C. (2007). IPCC fourth assessment report. The physical science basis, 2, 580-595. http://sciencepolicy.colorado.edu/admin/publication_files/resource-2523-Alvord_ipcc.pdf

Coffinet, S., Huguet, A., Bergonzini, L., Pedentchouk, N., Williamson, D., Anquetil, C., Gałka, M., Kołaczek, P., Karpińska-Kołaczek, M., &Majule, A. (2018). Impact of climate change on the ecology of the Kyambangunguru crater marsh in south-western Tanzania during the Late Holocene. Quaternary Science Reviews, 196, 100-117. https://doi.org/10.1016/j.quascirev.2018.07.038

Corner, A. (2011). Communicating climate change in Uganda: Challenges and opportunities. Hidden Heat. https://psycnet.apa.org/buy/2011-14728-001

Dessu, S. B., &Melesse, A. M. (2013). Impact and uncertainties of climate change on the hydrology of the Mara River basin, Kenya/Tanzania. Hydrological Processes, 27(20), 2973-2986. https://doi.org/10.1002/hyp.9434.

Djido, A., Zougmore, R. B., Houessionon, P., Ouedraogo, M., Ouedraogo, I., & Diouf, N. S. (2021). To what extent do weather and climate information services drive the adoption of climate-smart agriculture practices in Ghana? Climate Risk Management, 32, 100309. https://doi.org/10.1016/j.crm.2021.100309

Fahad, S., Inayat, T., Wang, J., Dong, L., Hu, G., Khan, S., & Khan, A. (2020). Farmers' awareness level and their perceptions of climate change: A case of Khyber Pakhtunkhwa province, Pakistan. Land Use Policy, 96, 104669. https://doi.org/10.1016/j.landusepol.2020.104669

Frawley, J., Ober, R., Olcay, M., & Smith, J. (2017). Indigenous student achievement in higher education: the influence of cultural factors on self-efficacy. Journal of Australian Indigenous Issues, 20(2), 17-30.https://search.informit.org/doi/abs/10.3316/INFORMIT.149361916232183

Goel, R. K., Nelson, M. A., &Naretta, M. A. (2012). The internet as an indicator of corruption awareness. European Journal of Political Economy, 28(1), 64-75.https://doi.org/10.1016/j.ejpoleco.2011.08.003

Grimm, N. B., Chapin III, F. S., Bierwagen, B., Gonzalez, P., Groffman, P. M., Luo, Y., Melton, F., Nadelhoffer, K., Pairis, A., & Raymond, P. A. (2013). The impacts of climate change on ecosystem structure and function. Frontiers in Ecology and the Environment, 11(9), 474-482. https://doi.org/10.1890/120282

Hagger, M. S., & Chatzisarantis, N. L. (2007). Intrinsic motivation and self-determination in exercise and sport. Human Kinetics. https://psycnet.apa.org/record/2007-05407-000

Hare, W. (2003). Assessment of Knowledge on Impacts of Climate Change–Contribution. Arctic, 100(6). https://digital.library.unt.edu/ark%3A/67531/

Haynie, A. C., & Pfeiffer, L. (2012). Why economics matters for understanding the effects of climate change on fisheries. ICES Journal of Marine Science, 69(7), 1160-1167. https://doi.org/10.1093/icesjms/fss021

Ibrahim, S. B., Ayinde, I. A., &Arowolo, A. O. (2015). Analysis of arable crop farmers' awareness to causes and effects of climate change in South Western Nigeria. International Journal of Social Economics. https://doi.org/10.1108/IJSE-09-2013-0201

Idrisa, Y., Ogunbameru, B., Ibrahim, A., &Bawa, D. (2012). Analysis of awareness and adaptation to climate change among farmers in the Sahel Savannah agro-ecological zone of Borno State, Nigeria. http://www.taccire.sua.ac.tz/handle/123456789/158

IPCC, T. (2001). Climate change 2001: synthesis report. Intergovernmental Panel on Climate Change (IPCC), Geneva, Switzerland, https://www.ipcc.ch/site/assets/uploads/2018/05/SYR_TAR_full_report.pdf

Kalimangasi, N. N. (2020). Profit efficiency of smallholder wine grape farmers in Dodoma city and Chamwino district in Dodoma Region, Tanzania [Doctoral dissertation]. Sokoine University of Agriculture. http://suaire.sua.ac.tz/handle/123456789/3492

Kangalawe, R. Y., Mung'ong'o, C. G., Mwakaje, A. G., Kalumanga, E., &Yanda, P. Z. (2017). Climate change and variability impacts on agricultural production and livelihood systems in Western Tanzania. Climate and Development, 9(3), 202-216. https://doi.org/10.1080/17565529.2016.1146119

Kaswamila, A. L., &Songorwa, A. N. (2009). Participatory land-use planning and conservation in northern Tanzania rangelands. African Journal of Ecology, 47, 128-134. https://doi.org/10.1111/j.1365-2028.2008.01059.x

Kihila, J. M. (2018). Indigenous coping and adaptation strategies to climate change of local communities in Tanzania: A review. Climate and Development, 10(5), 406-416. https://doi.org/10.1080/17565529.2017.1318739.

Somerville, R. C. (2012). Communicating the science of climate change. https://repo.library.stonybrook.edu/xmlui/bitstream/handle/11401/8097/

Komba, C., &Muchapondwa, E. (2012). Adaptation to climate change by smallholder farmers in Tanzania. Economic Research Southern Africa (ERSA) working paper, 299(5), https://econrsa.org/2017/wp-content/uploads/wp299.pdf

Komives, P. M., Pilishegyi, P., Novak, N., Nagy, A. S., &Korosparti, P. (2019). The role of the higher education in the development of the agriculture. International Journal of Information and Education Technology, 9(9), 607-612. http://www.ijiet.org/vol9/1275-E143.pdf

Kreuter, M. W., & Wray, R. J. (2003). Tailored and targeted health communication: strategies for enhancing information relevance. American journal of health behaviour, 27(1), S227-S232. https://www.ingentaconnect.com/content/png/ajhb/2003/00000027/A00300s3/art00006

Lee, T. M., Markowitz, E. M., Howe, P. D., Ko, C.-Y., & Leiserowitz, A. A. (2015). Predictors of public climate change awareness and risk perception around the world. Nature climate change, 5(11), 1014-1020.https://www.nature.com/articles/nclimate2728

Lukwale, S., & Sife, A. (2017). Climate change research trends in Tanzania: A bibliometric analysis. International Journal of Biodiversity and Conservation, 9(6), 224-231. https://doi.org/10.5897/IJBC2017.1099

Lupala, Z., Lusambo, L., Ngaga, Y., &Makatta, A. A. (2015). The land use and cover change in miombo woodlands under community-based forest management and its implication to climate change mitigation: a case of southern highlands of Tanzania. International Journal of Forestry Research, 2015. https://doi.org/10.1155/2015/459102

Mahenge, F. (2016). Dry land community resilience to climate change: A case of grapevine farmers in Chamwino district and Dodoma municipality, The University of Dodoma. http://41.78.64.25/handle/20.500.12661/2117

Mahoo, H., Mbungu, W., Yonah, I., Radeny, M. A., Kimeli, P., &Kinyangi, J. (2015). Integrating indigenous knowledge with scientific seasonal forecasts for climate risk management in Lushoto district in Tanzania. CCAFS Working Paper.https://cgspace.cgiar.org/handle/10568/56996

Majule, A., Kauzeni, A., &Mujwahuzi, M. (2013). Exploring opportunities for climate change adaptation in semi-arid areas of Tanzania: A case of Nzega District in Tabora region. African Journal of Environmental Science and Technology, 7(8), 758-769. https://doi.org/10.5897/AJEST12.230

Masud, M. M., Akhatr, R., Nasrin, S., & Adamu, I. M. (2017). Impact of socio-demographic factors on the mitigating actions for climate change: a path analysis with mediating effects of attitudinal variables. Environmental Science and Pollution Research, 24(34), 26462-26477. https://link.springer.com/article/10.1007/s11356-017-0188-7

Mtambanengwe, F., Mapfumo, P., Chikowo, R., &Chamboko, T. (2012). Climate change and variability: smallholder farming communities in Zimbabwe portray a varied understanding. African Crop Science Journal, 20, 227-241. file:///C:/Users/USER/Downloads/81755-

Mugiya, D., & Hofisi, C. (2017). Climate change adaptation challenges confronting small-scale farmers. Environmental economics, (8, Iss. 1), 57-65. https://www.irbis-nbuv.gov.ua/cgi-bin/irbis_

Mustafa, G., Latif, I. A., Bashir, M. K., Shamsudin, M. N., & Daud, W. M. N. W. (2019). Determinants of farmers' awareness of climate change. Applied Environmental Education & Communication, 18(3), 219-233. https://doi.org/10.1080/1533015X.2018.1454358

Mwalukasa, N., Mlozi, M. R., & Sanga, C. A. (2018). Influence of socio-demographic factors on the use of mobile phones in accessing rice information on climate change adaptation in Tanzania. https://www/doi/10.1108/GKMC-01-2018-0006/full/html

Ngailo, J. A., Kaswamila, A. L., &Senkoro, C. J. (2007). Rice production in the Maswa District, Tanzania and its contribution to poverty alleviation. https://agris.fao.org/agris-search/search.do?recordID=GB2013203386

Nigatu, A. S., Asamoah, B. O., &Kloos, H. (2014). Knowledge and perceptions about the health impact of climate change among health sciences students in Ethiopia: a cross-sectional study. BMC Public Health, 14(1), 1-10. https://link.springer.com/content/pdf/10.1186/1471-2458-14-587.pdf

Nkiaka, E., Taylor, A., Dougill, A. J., Antwi-Agyei, P., Fournier, N., Bosire, E. N., Konte, O., Lawal, K. A., Mutai, B., & Mwangi, E. (2019). Identifying user needs for weather and climate services to enhance resilience to climate shocks in sub-Saharan Africa. Environmental Research Letters,14 (12),123003. https://iopscience.iop.org/article/10.1088/1748-9326/ab4dfe/pdf

Nkoana, E. M. (2020). Exploring the effects of an environmental education course on the awareness and perceptions of climate change risks among seventh and eighth grade learners in South Africa. International Research in Geographical and Environmental Education, 29(1), 7-22. https://doi.org/10.1080/10382046.2019.1661126

Ochieng, J., Kirimi, L., & Mathenge, M. (2016). Effects of climate variability and change on agricultural production: The case of small-scale farmers in Kenya. NJAS-Wageningen Journal of Life Sciences, 77, 71-78. https://doi.org/10.1016/j.njas.2016.03.005

Ochieng, M. A., & Koske, J. (2013). The level of climate change awareness and perception among primary school teachers in Kisumu municipality, Kenya. International Journal of Humanities and Social Science, 3(21), 174-179. https://ir-library.ku.ac.ke/bitstream/handle/123456789/12223/

Olatumile, A. (2013). Assessment of environmental professional awareness of climate change: Implication for climate change education. International Education Research. Volume, 1, 38-50. https://doi.org/10.1.1.904.3234

Omambia, C. S., & Gu, Y. (2010). The cost of climate change in Tanzania: impacts and adaptations. Journal of American Science, 6(3), 182-196. https://www.researchgate.net/profile/Ceven-Shemsanga-2/publication/267956742

Onyango, E., Ochieng, S., &Awiti, A. (2014). Weather and climate information needs of small-scale farming and fishing communities in western Kenya for enhanced adaptive potential to climate change. Proceedings of Sustainable Research and Innovation Conference, 4, 187-193. https://ecommons.aku.edu/eastafrica_eai/9/

Owusu, M., Nursey-Bray, M., & Rudd, D. (2019). Gendered perception and vulnerability to climate change in urban slum communities in Accra, Ghana. Regional environmental change, 19(1), 13-25. https://link.springer.com/article/10.1007/s10113-018-1357-z

Popoola, O. O., Yusuf, S. F. G., & Monde, N. (2020). Information sources and constraints to climate change adaptation amongst smallholder farmers in Amathole District Municipality, Eastern Cape Province, South Africa. Sustainability, 12(14), 5846. 46; https://doi.org/10.3390/su12145846

Raghuvanshi, R., & Ansari, M. A. (2017). A study of farmers' awareness about climate change and adaptation practices in India. Young (Less than 45), 45, 40-90. https://doi.org/10.11648/j.ijaas.20170306.13

Said, M., Komakech, H. C., Munishi, L. K., &Muzuka, A. N. N. (2019). Evidence of climate change impacts on water, food and energy resources around Kilimanjaro, Tanzania. Regional Environmental Change, 19(8), 2521-2534. https://link.springer.com/article/10.1007/s10113-019-01568-7

Sarkar, S., & Padaria, R. (2016). Farmers' awareness and risk perception about climate change in coastal ecosystem of West Bengal. Indian research journal of extension education, 10(2), 32-38. https://www.researchgate.net/profile/Rabindra-Padaria/publication/265944178_

Schunk, D. H., & DiBenedetto, M. K. (2020). Motivation and social cognitive theory. Contemporary Educational Psychology, 60, 101832.https://doi.org/10.1016/j.cedpsych.2019.101832

Shahid, Z. (2015). Awareness for better adaptation strategy development for climate change impacts in Pakistan. Pakistan Journal of Science, 67(4). https://web.p.ebscohost.com/abstract?direct

Shahid, Z., & Piracha, A. (2010). Climate change impacts in Pakistan: awareness and adaptation. International Journal of Climate Change: Impacts and Responses, 2(1), 119-130. https://www.cabdirect.org/cabdirect/abstract/20103334896

Singh, C., Daron, J., Bazaz, A., Ziervogel, G., Spear, D., Krishnaswamy, J., Zaroug, M., & Kituyi, E. (2018). The utility of weather and climate information for adaptation decision-making: current uses and future prospects in Africa and India. Climate and Development, 10(5), 389-405. https://doi.org/10.1080/17565529.2017.1318744

Smucker, T. A., Wisner, B., Mascarenhas, A., Munishi, P., Wangui, E. E., Sinha, G., Weiner, D., Bwenge, C., & Lovell, E. (2015). Differentiated livelihoods, local institutions, and the adaptation imperative: Assessing climate change adaptation policy in Tanzania. Geoforum, 59, 39-50. https://doi.org/10.1016/j.geoforum.2014.11.018

Sogani, R. (2011). Documentation of climate change perceptions and adaptation practices in Uttarakhand, Northern India. Beej BachaoAndolan-Save Seed Campaign, PANAP, Malaysia.

Stamoulis, K., & Zezza, A. (2003). A conceptual framework for national agricultural, rural development, and food security strategies and policies. https://ageconsearch.umn.edu/record/289082/

Sultan, S., Ajmal, M., & Lodhi, M. F. (2016). Environmental Awareness among Trainee Teachers at Tertiary Level in Pakistan: Need, Scope, Challenges and Opportunities. Bulletin of Education and Research, 38(2), 123-134. https://files.eric.ed.gov/fulltext/EJ1210312.pdf

Twinomuhangi, R., Sseviiri, H., Mulinde, C., Mukwaya, P. I., Nimusiima, A., & Kato, A. M. (2021). Perceptions and vulnerability to climate change among the urban poor in Kampala City, Uganda. Regional Environmental Change, 21(2), 1-13. https://link.springer.com/article/10.1007/s10113-021-01771-5

UNFCCC, F. (2007). Climate change: impacts, vulnerabilities and adaptation in developing countries. Bonn, Germany: United Nations Framework Convention on Climate Change. https://www.preventionweb.net/files/2759_pub07impacts.pdf

Wathuge, A., & Sedera, D. (2021). An awareness-based model to minimize the environmental damage of the internet usage: A Longitudinal Study. arXiv preprint arXiv:2111.04453. https://doi.org/10.48550/arXiv.2111.04453