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Impact of climate variability, farmers adaptation and coping strategies on coffee production in highlands of Kigoma District, Tanzania

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Abstract. *Msuya AM, Mahonge CP. 2022. Impact on coffee production of climate variability, farmers adaptation and coping strategies in highlands of Kigoma District, Tanzania. Asian J For 6: 34-42.* Worldwide, climate change and variability have raised concerns about potential changes to crop yields and production systems. This study concerns climate variability's effects on coffee production among smallholder farmers in the highland zone of the Kigoma District, the western part of Tanzania. This study specifically aimed to determine how climatic variability affected coffee production and the strategies taken to cope with the problem. Also, this study determined farmers" perceptions of climatic change and variability. The coffee production and rainfall data for thirty years (1981-2010) were used. Also, to study the trend relationship between climate change and agricultural production. Data were collected using household surveys, interviews, focus group discussions, documentary reviews, and field observations. The sampling unit was the household; 120 respondents were selected from 5 villages. First, a purposive sampling technique was employed to study wards and villages, and then 5 villages from 2 wards were selected. In each village, 24 households producing coffee were randomly selected from the village register to 120 respondents. Then, correlation analysis was used to examine the relationship between rainfall variability and coffee production in the area. In contrast, to study the effect of rainfall variability/change on coffee production, a simple linear regression was used. Both coffee production and rainfall showed a decreasing trend. However, the correlation between both trends was insignificant at a 5% probability level. Moreover, it can be concluded that coffee production was not much influenced by rainfall, given the weak correlation between rainfall and coffee production and the decreasing trend for both. Still, other factors, like a shortage of agricultural inputs such as fertilizers and pesticides, must influence coffee production in the study area.

Keywords: Climate change, coffee, purposive sampling, variability

INTRODUCTION

The first World Climate Change Conference to discuss climate change's real impacts on agriculture and other development sectors took place in 1979 in Geneva (Koo 2011). Decision makers from Federal and Regional governments, experts from research institutions and universities, practitioners from private sectors, and civil society organizations came together for plenary discussions and expert presentations on the impacts. Climate change and variability are already significantly impacting the agriculture sector, an important activity in the developing world, dominated by rain-fed crop production, and households' food security is particularly vulnerable. Hulme (1996) also stated that rain-fed agriculture is an important economic activity in the developing world. Globally, 80% of the total physical agricultural land on which 62% of the world's staple food is practiced rain-fed agriculture (FAO 2005; Bhattacharya 2008).

In recent years, several studies conducted in Tanzania have documented that climate change and variability significantly impact agriculture production. The second most vulnerable to climate change identified by NAPA (2006) was the agricultural sector. Therefore the first National Action Plan on Climate Change, which contained removal by sinks of greenhouse gases and inventory of emissions by source, helps farmers adapt to new agricultural technologies and practices. Humans depend more on agriculture for their livelihood than other economic activities. That is particularly true for small farmers in Kigoma District, whose economic well-being and food security depend primarily on farming, which has been growing coffee for over 20 years as the sole cash crop.

However, in the last 10 years, coffee production has faced severe difficulties resulting in low-yielding trees. Climate change and variability contribute to such conditions; in response, farmers have been undertaking various coping mechanisms. According to Low (2005), among farmers, several coping mechanisms include actions that agriculture agencies do not formally recognize. The coping and adaptation mechanism implications may have both negative and positive effects on coffee production.

In Tanzania, like many other African countries, the agriculture sector accounts for about half of the national income and three-quarters of product exports. In addition, it employs about 80% of the population (NAPA 2006). However, this sector in Tanzania is mostly dependent on rainwater, making it vulnerable to climate change and variability. Climate change affects the most important agricultural inputs, rainwater, and temperature (Deschenes and Greenstone 2006). Therefore, a change in rainfall has been considered to affect agriculture production in many parts of the country. A recent analysis of rainfall trends over 20 meteorological stations indicates a decrease in 13

(61.9%), whereas an increase in 7 stations (33.33%) (New et al. 2006). Furthermore, some analysis has shown decreasing annual rainfall at an average rate of 2.8 mm per month (3.3%) for a decade. The southernmost of Tanzania shows the greatest annual decreases have occurred (Mwandosya et al. 1998).

Coffee is a vulnerable crop that needs special climatic conditions to thrive and give a good harvest. Robusta and Arabica coffee varieties require agroecological areas with hot-wet or hot-temperate climates with temperatures varying between 15 and 25ºC and frequent rains of about 1,000 mm or moreper annum with two months of a dry spell (Muya 2008). Arabica coffee, common in Kigoma District, is more tolerant to low temperatures than the Robusta and sometimes could withstand temperatures below 5ºC without damage. However, the prolonged temperatures exceeding 30ºC and rains variability than the required amount are disastrous to both coffee varieties (Muya 2008). According to Rosenzweig (1996), heavy rainfall, excessive soil moisture, and flooding disrupt crop production. Also, rising temperatures could reduce and staggered flowering, different berry growths, and difficulties in managing disease and pests, lengthening the harvest and processing seasons and compromising quality. Many studies on climate change and the coffee industry (ITC 2010), indigenous knowledge in seasonal rainfall prediction in Tanzania (Chang'a et al. 2010), and research protocols to assess the impact of climate change and variability in Rural Tanzania agriculture production (Liwenga et al. 2008). However, those studies have little to address the local abilities to adapt to climate variability and its impact on Kigoma District.

Therefore, this study aimed to investigate how climate change and variability have contributed to low coffee production, which farmers have been coping with in the highlands zone of Kigoma District, Tanzania.

MATERIALS AND METHODS

Description of the study area

The research was conducted in Kigoma District, Tanzania. This area is located at about 5° S and 30° E. The district is bordered on the north by Burundi and the Kagera District, on the east by Geita County and Tabora County, on the south by Katavi District, and the west by Lake Tanganyika, which forms the border with the Democratic Republic of Congo. The total area is 45,066 m^2, of which 37,037 m^2 is land, and 8,029 m^2 is water. Figure 1 shows the study area (National Census 2012).

There were about 427,024 people in the Kigoma district; the population density was 42.4 (rural) and 1,127.0 (urban) persons per square kilometer, according to the National Census (2012). Most residents depend on agriculture for their livelihood, and a few people engaged in other activities like beekeeping, lumbering, and fishing.

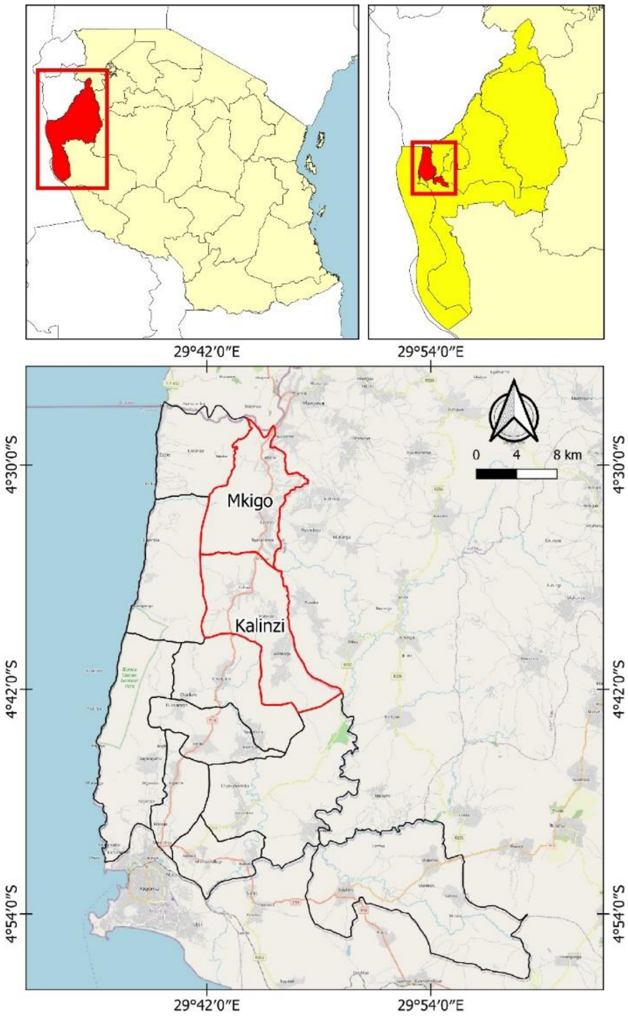

Figure 1. Map showing the study area, Kigoma District, Tanzania

Kigoma District experiences diverse climatic conditions, with annual rainfall between 600 mm and 1,600 mm, mostly distributed around and along the lake and in the highlands zone. The rainy season is in January, February, March, April, November, and December, with the most rainfall. The rainfall pattern is unimodal, with the rainy season lasting from October to May, with a short dry spell of 2-3 weeks in January or February, then a prolonged dry season. Precipitation allows a wide range of crops to be grown and is reliable for double-planting short-season crops. Lowland areas are warm for most of the year. The mean daily temperature ranges between 25ºC in December and January to 28ºC in September. Temperature varies inversely with altitude. Therefore, the lowland zone tends to be warmer than the highlands zone.

Research design

The study used a cross-sectional design, allowing in-depth data collection at one point in time from different groups of respondents (Bailey 1998). The study targeted farmers in the Kigoma District's highland zone who grow coffee. The sampling unit was the household, whereby 120 respondents were selected from 5 villages. A purposive sampling technique was employed to get the study villages and wards because not all wards produce coffee. Therefore, two wards and five villages were purposively selected. Furthermore, from the village register, 24 households producing coffee were randomly selected in each village to make a total of 120 respondents.

Preliminary visits

A reconnaissance survey was conducted to familiarize ourselves with the research site and gather general information. The main purpose was to introduce the research and the researchers to the community. So often, it takes a long time for the communities to become comfortable with strangers. They may be unwilling to answer questions because they are doubtful, then the doubt will decrease as the communities become familiar with the researcher.

Data collection methods

The household surveys and interview methods were used to collect primary data; the documentary method was used for secondary data, and this study collected qualitative and quantitative data. In gathering socio-economic data, semi-structured, closed-ended, and open-ended questionnaires were used to get information from the households. In addition, individual interviews were also carried out to get information from the farmers within the targeted households.

The questions that capture the trends in coffee crop production, climate change, and variability were used to identify changes and farmers' perceptions. Questionnaires were also administered to get information on coping and adaptation strategies to climate change and variability. In addition, the key informants were administered a checklist of questions to key informants. Conversely, secondary data on rainfall, coffee production, and temperature over 30 years (1981-2010) were collected from the district agriculture office, metrological stations, and water engineers district through documentary review. These methods are intended to collect information about climate variability's effects on coffee production and farmers' coping strategies.

Data analysis

Data from the respondents were verified and compiled, were then coded and summarized, then analyzed using Excel computer programs and the Statistical Package for Social Science (SPSS). The results were then presented using frequencies, graphs, and tables. Descriptive statistics, including frequency distribution, were computed. In addition, cross-tabulation was done to make the comparison. Furthermore, data from checklists and the researcher "s diary were analyzed by the content analysis technique, mainly transcribing information recorded in the notebooks, then clustering information into sub-themes.

RESULTS AND DISCUSSION

The major findings of the study were presented and discussed in this chapter. The first part presents the population's socio-economic characteristics of the samples, including age, marital status, education, sex, and occupation. The second part presents the rainfall trends and coffee production; the third part describes the relation between rainfall and coffee production trends; the fourth part concerns information on the local community's perception of climate variability and their adaptation and coping strategies in the highland of Kigoma District.

Socio-economic characteristics of the coffee farmers involved in the study

Socio-economic characteristics such as sex, family size, age, marital status, and education are critical to farm decisions and performance regarding climate change and variability. Respondents" education level helps in understanding the general requirements of farming and their application in the right season, while age reflects experience in farming. Marital status and sex determine farmers' responsibilities in crop production. In addition, family size gives a good labor determination on production. Table 1 shows the study area socio-economic characteristics of the sample population, whereby less than 60% of the heads of household were aged between 50 and 60 years, 35% were aged between 61 and 70 years, 3% were aged between 71 and 80 years, and 2% were aged above 80 years. About 75% of the respondents are inhabitants, and 25% are migrants, particularly from Rwanda and Burundi, neighboring countries. About 90% of the sample population resided for more than 30 years.

The sampled populations show how they are well familiar with the study area. Moreover, the household heads were 80% male, while female-headed were 20%. Regarding marital status, 92% of the respondents were married, while 6% were widows or divorced. Regarding respondents' education, about 90% had a primary school, while the others (10%) had either secondary or no formal education. Finally, regarding household size, most households had an average of 6-8 members.

Table 1. Socio-economic characteristics of the respondents (n=120) in the highland zone of Kigoma District, Tanzania

Socio-economic characteristic	Freq.	% of response
Age		
Respondents between 50 and 60	72	60
Respondents between 61 and 70	42	35
Respondents between 71 and 80	04	3
Respondents above 80	02	2
Sex		
Male	96	80
Female	24	20
Marital status		
Married	111	92
Single	02	2
Widowed	05	4
Divorced	02	2
Level of education		
Primary school education	108	90
Secondary school education	02	2
Non-formal education	10	8
Economic activities		
Coffee crop production	72	60
Both coffee crop and livestock production	42	35
Business	06	5

Trends in coffee production

Several District agricultural office documents and a report from Rumako Cooperative Union, which collects and sells all the coffee production in the Kigoma region, showed a decreasing coffee production trend over 30 years (1981-2010). The data show the maximum total annual coffee production was 736 tons in 1982, then by 687 tons in 1985 and 683 tons in 1988. It shows a considerable decrease except for a few years with an improvement in production. Figure 2 illustrates the decline of coffee production in the highland of the Kigoma District.

The Kigoma average annual coffee production for 5 years showed a decreasing trend; for example, the average coffee production from 1981 to 1985 was 676.8 tons, while the average from 1986 to 1990 was 493.8 tons.

As such, coffee productivity declined by an average of 183 tons from 1981 to 1990, data results are closely similar to farmers" perceptions of production trends. When asked about production trends, most farmers (91%) revealed that production had declined over 30 years. The average production between 1991 and 1995 was 500.8 tons, while the average production between 1996 and 2000 was 291.4 tons. In contrast, average production for the last decade, from 2001 to 2010, indicated an increase of 139.6 tons, a non-significant. The report from the International coffee organization (ICO 2006) showed that coffee production has decreased from 1,126.5 to 869.6 thousand tons annually in Africa. The production has decreased in 16 countries members of the international coffee organization but has increased in 9 countries. The coffee production trend in Kigoma following the ICO report shows a declining trend in all African countries.

Three-quarters of the farmers (75%) associated declining coffee production with non-climatic factors, such as the absence of agricultural inputs and inadequate extension services. Their views closely agree with the correlation analysis of rainfall variability and coffee production results in the study area. The coffee production trend assessment in the Kigoma District from 1981 to 2010 appears that production was good from 1981-1995 compared to the succeeding years from 1996.

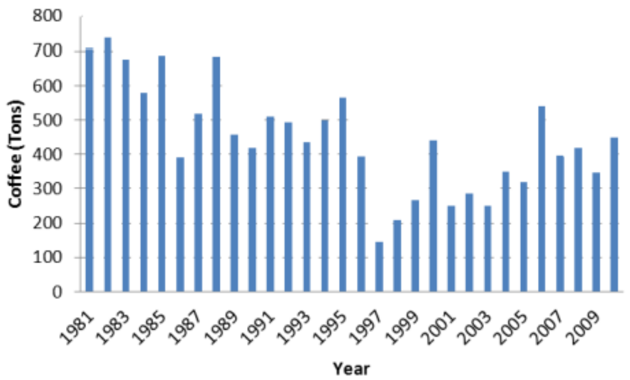

Figure 2. Coffee production trend in the Kigoma District highland, Tanzania (1981-2010)

Trends in rainfall

The rainy season in Kigoma is from October to May, and the dry season occurs from June to September. The warmest month happened in August, and the coolest month was November. Conversely, March is the wettest month, and July is the driest month. The meteorological data showed a declining trend for the last 30 years for rainfall during the rainy season between October to May, from 1981 to 2010.

Trend analysis of rainfall data (Figure 3) indicates a small variation in inter-annual rainfall. However, despite small variations in inter-annual rainfall, overall rainfall amount decreased over the years. Geographically, this area has an altitude of between 1,500 and 1,700 meters above sea level, characterized by total annual rainfall ranging from 1,000-1,600 mm. Over the thirty years (1981-2010), in 2005, 742 mm was the lowest rainfall, while the highest rainfall was 1,173 mm in 1982 ever recorded. Even though data showed that between 1981and 2010, only 11 years experienced annual rainfall of more than 1,000 mm, while 19 years experienced rainfall of less than 1,000 mm. That illustrates the fact that rainfall is less in the area.

Outside the traditional rain season, rainfall also occurred in June 1995 and July 1998 at a highly significant rate. These months traditionally fall under the dry season, which suggests splitting the season into short and long rains. The total amount of rainfall, however, at the onset of the rain season recorded in October 1981-1995 was 1,451.8 mm, while for 1995-2010 was 1,005.3 mm.

Based on the data, the number of rain days decreased from one year to another. Furthermore, starting from the 1990s, significant changes in the onset of rains tended to be delayed, with short rainfall duration associated with heavy storms. Also, rainfall was too high at the onset of rain in October 1997 compared to October of other rain seasons over thirty years. That was also reflected in local people" s perceptions; they mentioned the extreme flood event to have occurred in 1997, a clear shift in weather patterns attributed to climate variability. Anomalies graphs (Figure 4) indicate rainfall variability from January to December (1981-2010) over thirty years.

In the same way, the trends analysis of rainfall from 20 meteorological stations in Kigoma Highland District indicates a decrease for 13 stations (61.9%) and an increase for 7 stations (33.33%) (Mwandosya 1998). In Tanzania, analysis shows that areas with a unimodal rainfall pattern will experience a decrease of 5% - 15%, and a bimodal pattern will experience a decrease of 5% - 45% (Munish et al. 2006). Moreover, the IPCC report (2007) showed a decline in rainfall trend in the study area, which also showed the forecasted increasing warming in most of western Tanzania. Similarly, the International Institute for Environment and Development (IIED) also forecasted a rise in temperature between 2 and 4ºC and a decline in rainfall over western Tanzania (IIED 2009).

When asked about their views on rainfall trends, most farmers (95%) perceived an increase in temperature and rainfall change, which illustrates that drought is common in the area. However, further data verify that over 30 years (1981-2010), the last 15 years (1995 to 2010) received a minimum rainfall amount that was not experienced for the first 15 years from 1981 to 1995.

Relationship between rainfall and coffee production

The numerical data for rainfall collected at the meteorological stations were tested against data collected from District agricultural office on coffee production. The analysis of correlation was used to examine the relationship between rainfall variability and coffee production in the area. In contrast, to analyze the effect of the independent variable (amount of rainfall in millimeters) on the dependent variable (amount of coffee in tons), a simple linear regression was used. Statistically, the analysis showed a weak relationship between the amounts of coffee in tons produced and the amount of rainfall in millimeters from 1981 to 2010. The scatter plot (Figure 5) elaborates more on the relationship between the two variables.

The relationship between the amount of rainfall in millimeters and the amount of coffee in tons produced was statistically insignificant at a 5% level ($p = 0.275$). That indicates that coffee production was not much influenced by rainfall. Still, other factors must influence coffee production in the study area, like a shortage of agricultural inputs such as fertilizers and pesticides. Table 2 shows the results of the correlation analysis between the amount of coffee in tons and the amount of rainfall in millimeters.

On the other hand, a simple linear regression model was used to see the effect of an independent variable (amount of rainfall in millimeters) on a dependent variable (amount of coffee in tons). The regression analysis shows that the amount of rainfall can explain only 4.2% of total variations in coffee production. In contrast, the other 95.8% can be explained by other factors, meaning that the amount of rainfall has insignificantly impacted the amount of coffee produced (Table 3).

From Table 3 above, the result indicates that coffee production would be 192.276 tons if there were no rainfall. Conversely, the results show that if rainfall increases by a unit (1 mm), coffee production will rise by 0.263 tons, which also indicates the regression coefficients (192.276 and 0.263) all have an insignificant effect on the amount of coffee (p-values are 0.413 and 0.275, respectively). That implied that as much as rainfall is required to give a satisfactory production, on the other side, production might increase at a non-significant rate. For example, the Rainfall amount recorded in 1986/1987 was 1,139 mm, while the coffee production recorded in the same period was 392 tons. Therefore, farmers expected more production but needed help in this situation. The same experience appeared in 1990/1991, 1996/1997, and 2001/2002. Three-quarters of the respondents (75%) agreed that the yearly decrease in coffee production was mostly because of non-climatic factors, although rainfall plays a small part.

According to the data from the Kigoma District agriculture office and Kigoma weather station, annual rainfall and coffee production (1981-2010) show a decreasing trend. Some years have high rainfall but low production, while others have low production but high rainfall. Those indicate that coffee production in the area depends not only on rainfall; but other factors, such as shortage of agricultural inputs like fertilizers and pesticides, influencing coffee production in the study area.

Table 2. Correlation analysis between the amount of coffee in tons and the amount of rainfall in millimeters

		Amount of coffee	. Amount of rain
Amount of coffee (tons)	Pearson correlation	1	.206
	significant (2- tailed)		.275
	N	30	

Table 3. The relationship between coffee production and climate variability in Kigoma District, Tanzania-Regression analysis

	Unstandardized Coefficients		Standardized Coefficient		P value
Model	**B**	**SE**	**Beta**	**t**	**Significant**
Constant	192.276	231.153		.832	.413
Amount of rain	.263	.236	.206	1.113	.275

Note: Dependent variable: the amount of coffee

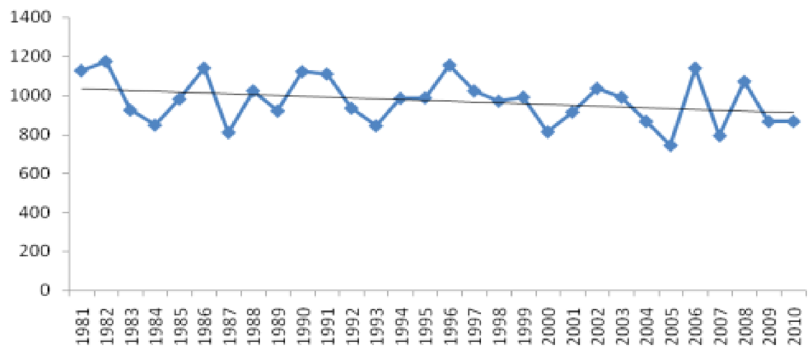

Figure 3. Annual rainfall trend in Kigoma District, Tanzania (1981-2010)

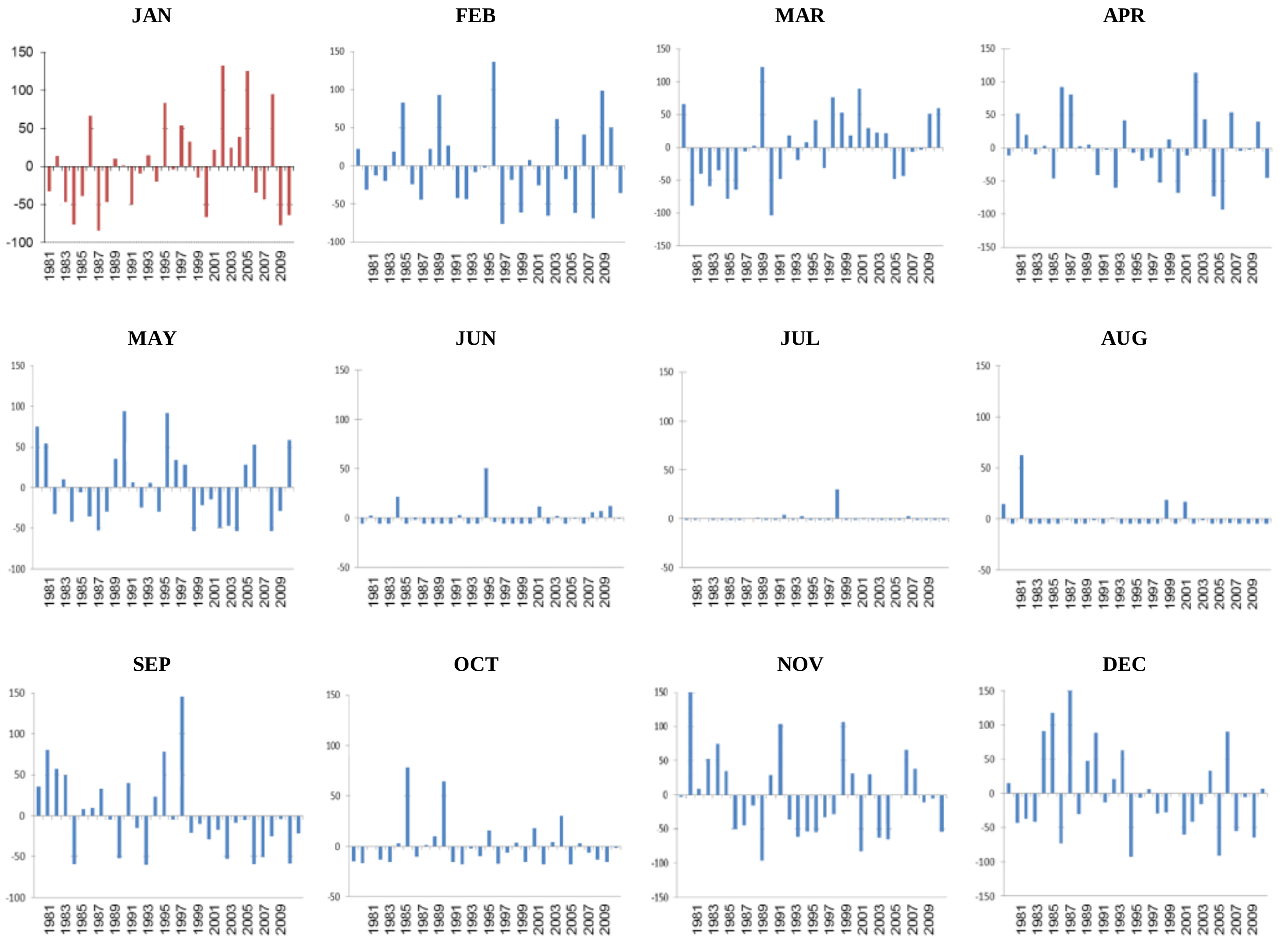

Figure 4. Anomalies for rain in Kigoma District, Tanzania (1981-2010)

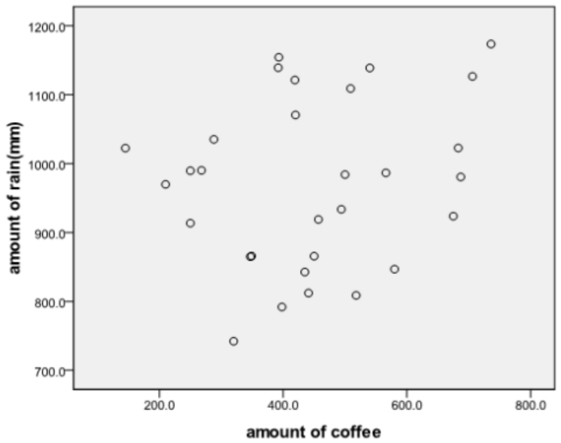

Figure 5. Scatter plot to demonstrate the amount of coffee in tons versus the amount of rainfall in millimeters

Farmer's perception of climate change and variability

Various stakeholders perceive climate change differently, even within the same level. For example, the household interviews revealed that farmers had a different understanding of climate variability. Over half (55%) explained climate variability due to a shifting rainfall as an extended dry season. Many respondents (33%) understood climate variability as decreases in rainfall, while the rest, 14 respondents (12%), defined climate variability as rainfall change and an increase in temperature; the temperature to be hotter today than in the past days perceived as climate variability.

Conversely, when asked about the causes of climate variability, most respondents (95%) mentioned the degradation of water sources and deforestation as the major factors of climate change. Other factors mentioned included bush fire and overgrazing (3%). Only a smaller number of respondents (2%) perceived climate change and variability due to breaking traditional rules laid down by their forefathers. They claimed that a rainmaker could solve drought during their time. Farmers" perceptions of changes in rainfall variability and temperature are closely similar to empirical results from the rainfall and temperature trends analysis using the data obtained from the Kigoma meteorological station.

Trend analysis of rainfall data (Figure 3) indicates that total annual rainfall has decreased over the years. A more pronounced decrease was from 1,173 mm in 1982 to 742 mm in 2005. Farmers" perceptions of rainfall trends in the area are also closely similar to the IPCC report (2007), which forecasted increasing warming in most of western Tanzania. A similar result from the International Institute for Environment and Development (IIED) forecasting that temperature will rise between 2 and 4ºC and decline in rainfall over western Tanzania (IIED 2009).

According to the respondents, the area was becoming warmer over the last 15 years, from September to December. The majority (95%) declared that the onset of rainfall had changed because rainfall used to be at the beginning of October. Still, nowadays, rains start in the middle of October or the beginning of November. Maddison's (2006) reports were similar, whereby many farmers in 11 African countries mentioned that precipitation had declined and temperatures had increased. Majule et al. (2008) also reported similar results. Other respondents' views were regarding the absence or drying of some water sources like natural springs, rivers, and natural water-hole in the area, implying rainfall amount changes. The respondents" views were also closely similar to the empirical analysis that showed drought occurrences in most of Tanzania between 1983 and 1992 (URT 1998).

Hatibu et al. (2000) analysis revealed that more than 33% of disasters in Tanzania over 100 years were related to drought. Interviews conducted in the study area included farmers" awareness assessment of years where drought has been observed. Most farmers mentioned 1974, 1979, 1982, 1983, 1992, 1996, and 1999 as the most severe drought periods and heavy rainfall of 1997 and 1998. However, some farmers needed help to recollect the dates of past droughts. In all drought periods, the farmers' main problem experienced was the absence of rainfall, which was related to a water shortage in the areas.

Coping and adaptation strategies

Farmers were asked about management practices in coffee production (coping and adaptive strategies) to reduce the risk and vulnerability under climate variability. Coping strategies are the actual responses that are considered short-term responses to the crisis in livelihood systems in the face of unwelcome situations (Boko and Niang 2007). Adaptive strategies are how a sector or a region responds to changes in their livelihood through either planned or autonomous adaptation (Smit and Skinner 2002). Most (95%) of the farmers interviewed knew the connection between climate variability and coffee production. However, only some have developed coping and adaptation measures that help them address climate change's short-term and long-term impacts and variability. A total of 53% of interviewed households adopted a range of practices in response to perceived climate change. The common practices included switching to non-farming activities (7%), engaging in casual labor (5%), rainwater harvesting (9%), mulching to reduce evaporation (4%), receiving the credit from the coffee cooperatives union (3%), planting hedge and shade tree to mitigate increased temperature because direct sun rays impact (5%), contouring/terracing to avoid soil erosion and to improve soil fertility (15%). Other responses included changing fertilizer application (2%) and planting trees (3%). On the contrary, 47% of the farmers responded to weather changes that they did not experience serious farming problems. Therefore, during extreme weather events, they did not take any coping or adaptation strategies. Table 4 shows the farmers in the Kigoma District's coping and adaptation strategies and practices.

Coping strategies

Coping strategies against low production experienced during extreme weather events, as depicted in Table 5, include switching to non-farming activities to extend household income, engaging in causal labor, and receiving the credit from the coffee cooperatives union. However, in most cases, the extreme weather events in the area did not impact coffee production because the main strategy during low production was switching to non-farm activities, according to some respondents.

Adaptation strategies

The farmers in the study area responded to the impacts associated with climate change and variability by implementing different adaptation measures to cope with the expected and unexpected rainfall variability. The strategies are mainly related to the adaptation of local people to the surrounding environment and local production systems. Therefore, the strategies to cope with changes and variations in rainfall differ depending on the farmers' knowledge and economic status. The adaptation strategies include rainwater harvesting, improving soil fertility, mulching to reduce evaporation, and terracing/contouring to avoid erosion. Other strategies include planting hedges and shading trees to mitigate increased solar brilliance, reducing temperature variations, and helping retain moisture. Respondents indicated that rainwater harvesting is effective and widely used as a coping mechanism to rainfall and water resource variability in the study area. The rainwater harvesting technique includes the construction of a water reservoir and the digging of shallow basins to collect run-off water.

Adaptation strategies have been advocated to potentially increase productivity in the face of climate change and variability. Majule et al. (2008) clearly indicated some adaptation measures that are more appropriate to address short-term impacts due to climate variability, with measures that are primarily used to address variability in the farming community. The IPCC and TAR (2001) also distinguish several types of adaptations that farmers in most African countries mostly use. Agricultural systems' adaptation to climate conditions is well documented (CAST 1992; Easterling et al. 1993; Kaiser et al. 1993). Moreover, good farming practices help to conserve soil and water and, in doing so, also make it easier to adapt to climate variability while at the same time lessening its impact. Studies on climate change (Boko and Niang 2007) suggest that coping and adaptation strategies to climate variability should be sustainable and environmentally friendly. A survey from these studies indicates that farmers in rural areas use temporary solutions that sometimes result in habitat changes and affect the surrounding environment.

Table 4. Farmers' perception of climate change and variability

	Frequencies	% of response
Farmers' perceptions on the definition of climate change and variability		
Climate variability as extended dry season due to shifting rainfall	70	58
Climate variability as decreases in rainfall	50	42
Farmers' perceptions on causes of Climate change and variability		
Deforestation and degradation of water resources is the primary factor of climate change and variability	114	95
Overgrazing and bush fire as the causes of climate change and variability	4	3
Climate change and variability as a result of breaking traditional rules laid down by forefathers	2	2

Table 5. Farmers' coping and adaptation strategies in the Kigoma District, Tanzania

Coping strategies	%	Adaptation strategies	%
Switching to non-farming activities	7	Rainwater harvesting	9
Engage in casual labor	5	Mulching to reduce evaporation	4
Cooperatives union credit erosion	3	Terracing/contouring to avoid	15
Reducing temperature variations	2	Tree planting	5

In conclusion, the global concern about climate change and its implication on agriculture, the most vulnerable sector to climate change, prompted the present study on assessing weather and coffee production trends in the Kigoma Highland District. The study has revealed that coffee production and rainfall in the area have decreased over 30 periods (1981-2010), and farmers are aware that agriculture production has decreased over time. At the same time, the climate has continuously been adversely changing over time. Data shows that rainfall has decreased over 30 years while temperatures have increased.

Consequently, farmers have developed and adopted coping strategies to combat drought and desertification in the area. Therefore, although rainfall and coffee production has been decreasing over the thirty years, this study concludes that; the decline in coffee production in the highland zone of the Kigoma District is not strongly attributed to the decline of rainfall and its variability. However, while the decline could be attributed to other factors, temperature, dry spells, and rainfall trends indicate that the study area is vulnerable to climate change and variability impacts.

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