Indigenous and Scientific Evidence on Climate Change Effects on Cereal Crops Production in Semi-arid Areas of Central Tanzania

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Abstract

Changes in temperature and rainfall have been reported at both local and global level with negative influence on crop yields. This article attempts to investigate the effects of climate change on cereal crops in semi-arid areas of Dodoma region, Tanzania. To achieve the research objectives, mixed method research approach under cross-sectional design was used. A total of 366 heads of households and 36 key informants were involved in this study. The study further used archival data on rainfall, temperature and crop yields of maize, sorghum and bulrush millet for the past 27 years (1984 to 2011). Simple linear trend analysis and Mann-Kendall test were used to establish and test for rainfall, temperature and crop yield trends. Linear regression analysis was applied in establishing the relationship between climate variables and crop yields. Findings from this study reveal increased temperature and reduced rainfall and crop yields as perceived by smallholder farmers and verified by archival data. Results for both minimum and maximum temperature indicate significant increased trends (p=0.000, p=0.000) respectively. Conversely, non-significant decreasing trends for rainfall were noted for Bahi, Mpwapwa and Dodoma stations (p=0.505, p=0.911, p=0.474) respectively. The findings on correlation analysis indicate both positive and negative influence of temperature and rainfall on cereal crop yields. The study concludes that, climate change has impacted cereal crop yields in the study area calling for implementation of more viable adaptation strategies in order to reduce the adverse effects of the changing climate. The study recommends on the use of more drought tolerant crop varieties of cereal seeds that can suit the changing climate.

Keywords: Climate change, climate variables, climate change effects, crop yields, Tanzania

Introduction

Changes in temperature and rainfall have been reported at both local and global level with negative effects in developing countries (Myeya, 2021, Berhane *et al.,* 2020; Byakatonda *et al.,* 2018; He *et al.,* 2018; Intergovernmental Panel for Climate Change (IPCC), 2014; Hernandez, 2012). Africa is not isolated from the global climatic changes noted through increased temperature and declined rainfall at varying levels. Temperature increase both maximum and minimum has been noted in various parts of the continent as reported by Abaje and Oladipo (2019), Adu-Boahen *et al.* (2019) and Sarr, (2012) in West Africa regions, Swai *et al.* (2012), Mafuru and Guirong (2020) and Park *et al.* (2020) in East Africa region as well as Myeya (2021) and Matata *et al.* (2019) in Tanzania. The continent has experienced rapid changes in temperature where between

1979 and 2010 temperature increased to about 0.5°C per century (Collins, 2011). However, the year 2020 is reported to be the second warmest year ever seen (McGrath, 2020).

Apart from temperature changes, the African continent has also experienced rainfall change since 1960s (Myeya, 2021; Berhane *et al.,* 2020; Umar & Bako, 2019; Owusu, 2009; Sivakumar *et al.,* 2005) where both declining and increased rainfall have been noted at varying levels. Declining annual rainfall was reported in Ghana since the early 1970s (Owusu, 2009), while Abaje *et al.* (2018) reported the increased rainfall trends in parts of Nigeria. Similarly, increased rainfall trend was reported in Ethiopia and East Africa highlands (Collier *et al.,* 2008) as opposed to the declined rainfall trends reported in dry lands of Northern and Southern Africa (Collier *et al.,* 2008). Tanzania, like other East African countries has experienced both increased and declined rainfall trends reported in different parts of the country (Myeya, 2021, Lyamurenye *et al.,* 2019; Mkonda *et al.,* 2018; Mongi *et al.,* 2010; Kangalawe and Lyimo, 2010), semi-arid areas being more vulnerable to rainfall change.

Changes in climate variables are the major threats to crop productivity at different levels (Ahmed *et al.,* 2018). Cereal grain yields particularly of maize (Zea Mays) have been reported to decrease in many arid and semiarid lands of the world (Ray *et al.,* 2013; Thomas, 2008; ICRISAT, 2008). Conversely, pearl millet (Pennisetum glaucum) and sorghum (Sorghum bicolor) yields are projected to increase in some dry land areas due to high ability to tolerate increased temperature (Kimenye, 2014; Andreas, 2015).

Studying the influence of climate change and change is important in order to generate climate change resilience strategies (Byakatonda *et al.,* 2018). The effects of climate change and change on agricultural sector in Tanzania has been carried out by several studies namely: Paavola (2003), URT (2007), Meena *et al.* (2008), Rowhan *et al.* (2010) and related studies have been conducted in semi-arid areas of Tanzania (e.g., Mkonda *et al.,* 2020; Lyimo and Kangalawe, 2013; Shemdoe 2011; Mongi *et al.,* 2010; Kangalawe and Lyimo, 2010 and Mary and Majule, 2009). However, these studies have not adequately captured the indigenous and scientific evidences on the influence of climate change on cereal crops in semiarid areas. This study therefore aims at establishing trends of temperature and rainfall based on small holder farmers' perceptions and archival data and their associated effects on cereal crops in semi-arid areas of Dodoma region, central Tanzania. The finding from the present research is a contribution to the existing body of knowledge on temperature and rainfall analysis in the study area which would be helpful in future climate projections. The results further adds knowledge on the cereal crop yield trends and the influence of temperature and rainfall on cereal crop yields thus being useful for policy formulation on appropriate ways to be taken for proper adaptation to the changing climate.

Materials and methods

The study area

Dodoma region (Figure 1) lies in the central Tanzania mainland between latitudes 4° to 7° South and longitude 35° to 37° East (URT, 2011). The region occupies about 41,310 km² of which 85% is a potential agricultural land. Dodoma region is largely a plateau rising gradually from some 830 metres above the sea level (m.a.s.l) in Bahi swamps to 2000 metres above the sea level (m.a.s.l) in the highlands, north of Kondoa (URT, 2011). The region has seven (7) districts namely: Bahi, Chamwino, Chemba, Dodoma Municipality, Kondoa, Kongwa and Mpwapwa.

The study design and sampling techniques

This study employed cross-sectional design. Cross-sectional design was used on the grounds that it allows the collection of data from different groups at once. Both purposive and simple random sampling techniques were employed in the selection of the study area and respondents. A total of 366 households were technically selected from two districts (Bahi and Kongwa) where four villages (Ibugule, Nkhome, Mtanana A and Mtanana B) were selected. The sample size of 366 household heads was determined by using a formula proposed and used by Israel (2009). The formula which is based on 95% confidence level and p=0.05 reads as:

$$n = \frac{N}{1 + N(e)^2} \quad \text{.............................}(1)$$

Where n is the sample size to be calculated, N is total population of the study (households) and e is the level of precision measured by probability scale of 5%. Plugging data into the formula, the following was in order;

$$n = \frac{4312}{1 + 4312(0.05)^2} = 366$$

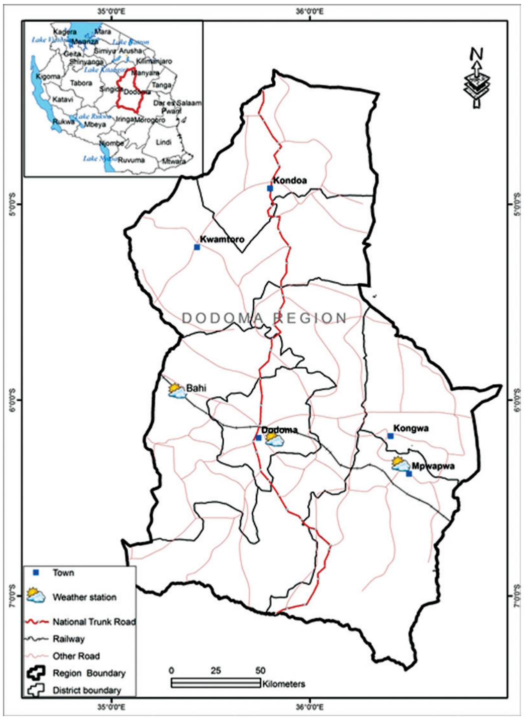

Figure 1: A Map of Dodoma region showing the study area

The calculated sample size was applied to compute the proportion of households in all villages that was determined by the number of households in each village. The formula used reads as:

$$n_h = \frac{N_h}{N} n \quad \text{...}(2)$$

Where by nh is proportional sample of each village (1, 2, 3 and 4), Nh is the number of households of each village, N is the total number of households in all villages and n is the total sample size of the study population. Plugging data in the formula above resulted to a proportional of 41, 107, 101 and 117 households for Ibugule, Nkhome, Mtanana A and Mtanana B villages respectively.

Data sources, collection and analysis techniques

Data sources and collection techniques

This particular study used both primary and secondary data collected through questionnaires, in-depth interviews, focus group discussions (FGD) and archival documents. A total of 366 household heads were involved in questionnaire survey and 36 participants were involved in focus group discussions and in-depth interview. A total of 4 FGD (Two from each ward) with 7 members in each group were involved. Members in FGD included village chairpersons, representatives from the village agricultural committees and adults (males and females) who were thought to be more knowledgeable on temperature and rainfall trends and how these variables related to cereal crop production for a long period of time. All focus groups used a standardized set of questions to elicit information. In-depth interviews were held with government officers, particularly, district agricultural officers, ward extension officers and village executive officers. A total of 8 participants were involved for in-depth interview in this study.

Moreover, climatic data was collected from Tanzania Meteorological Agency (TMA) offices in Dodoma and Dar es Salaam. Data on crop yields for maize, sorghum and bulrush millet was gathered from the Ministry of Agriculture, Food Security and Cooperative (MAFC) offices and the National Bureau of Statistics (NBS) in Dar es Salaam.

Data analysis techniques

Both quantitative and qualitative analysis techniques were employed in analyzing the research findings. Data obtained through questionnaire survey were coded and analyzed by using Statistical Package for Social Sciences (SPSS) and Microsoft Excel software to generate descriptive statistics. Qualitative data collected through interviews and FGDs were coded and arranged according to research themes through content analysis.

Data for temperature, rainfall and crop yield were time series thus, prompted to test for unit root problem and linearity before establishing trends and regression analysis. Augmented Dickey-Fuller (ADF) test was undertaken to test for Unit root problem (Blanc, 2012; Aminkuzuno and Donkoh, 2012). The ADF test showed that there was no unit root problem associated with the data. Thereafter, all data were subjected to scatter plot/ graph method to test for the linearity before regression analysis was performed. The climatic and cereal crops data were found not to be linear and therefore were transformed into natural logarithm (Blanc, 2012). Data transformation helped to improve the distribution of variables (Blanc, 2012).

Simple linear trend analysis and Mann-Kendall test were applied to establish and test for temperature, rainfall and crop yield trends. The test was intended to show how strong the trend of the variables was either increasing or decreasing (Karmeshu, 2012). By using Kendall's test, p-values of less than or equals to the significance level (0.05), indicate the existence of significant trend while the p-value larger than the significance level (0.05) indicate insignificant trend. Moreover, multiple regression analysis was used to determine the nature and strength of relationship between temperature, rainfall and crop yields. The equation showing such relationship reads as follows:

$$Y = \beta_0 + \beta_1 T_1 + \beta_2 R_2 + \varepsilon \quad ....(2)$$

Whereby:
Y = crop yields (Mt/ha),
β0 = intercept,
T1= seasonal mean temperature (^{o}C),
R2 = seasonal total rainfall (mm),
β1, β2, = parameters for estimation,
ε = is the error term

Results and discussion

Demographic characteristics of the surveyed head of households

It was important to study the age and sex of the population under study because it helps to determine smallholder farmers' responses to climate change effects. Climate change effects and adaptation measures vary based on age, sex, education and income levels. Results in (Table 1) show that, majority of the respondents (53.9%) falls under two age groups (30 – 39 and 40 - 49 years). The above findings in Table 1 imply that, based on age, the population had enough experience and knowledge as far as the subject matter was concerned.

Moreover, the sex composition of the population comprised 65% males and 35% females. According to the IPCC (2014), gender roles and gender relations are very crucial in climate change adaptation as they shape vulnerability and people's capacity to adapt to the changing climate. Women are greatly vulnerable than men due to limited access to resources, poverty, as well as social and cultural norms which contributes to their vulnerability.

Table 1: Demographic characteristics of household heads

Age	Percentage (n=366)
20-29	10.3
30-39	27.1
40-49	26.8
50-59	14.5
60-69	15.1
> 70	6.2
Gender	
Male	65
Female	35
Education	
No formal education	15
Primary education	74
Secondary education	10
Post-secondary education	01
Marital status	
Married	76
Single	10
Widowed	08
Divorced	06

Furthermore, the findings on education levels indicate that, majorities (74%) of the smallholder farmers in the study area had primary school level education, 15% had no formal education, 10% had secondary education and the remaining 1% had attained post-secondary school education level. Education levels influences perceptions on climate change and the adaptation strategies to the emerging effects.

It was also vital to be aware on marital status of smallholder farmers in the study area as married and unmarried are differently affected by climate change depending on variations on resource access and ownership. The findings from the smallholder farmers indicate that, the majorities (76%) of the population were married, (10%) were single, (8%) were widowed and the remaining (6%) were divorced. The percentage of married group is higher as compared to other groups because of cultural trait of which being married is a symbol of respect.

Smallholder farmers' perceptions on climate variables and crop yield trends

Perceptions on climate variable trends

The results of this study shown in Figure 2 indicate that on average, 79% of the study population felt that temperature was increasing, 10% reported that temperature was fluctuating, 7% reported on decreasing trends and the remaining 4% reported to have noted no change. Village-wise, more than 70% of the smallholder farmers in each village reported to have noted increased temperature rates. Among all the four villages, Mtanana B (Kongwa district) had the highest (83%) of the respondents who reported on increased temperature trends. Perceptions on temperature variations over time were further noted during in-depth interviews and Focus Group Discussion (FGD) as presented through quotation1. During the discussions, smallholder farmers emphasized on the increased temperature as compared to the past 10 to 20 years that was linked with frequent crop failure as reported hereunder;

"…….Really, there is an increase in temperature in Dodoma Region. When I compare temperature of the 1970's and the current one, I note some differences. In those days, the rain season was marked with higher temperature accompanied by heavy rainfall which resulted into high production……Nowadays, temperature can be high for some time but with little or no rainfall at all. Duration of dry spells have increased causing crop failure almost each year" (Male, 78 years in Nkhome village, Bahi district).

Not only temperature was perceived to change, smallholder farmers in the study area have also noted on the decline of rainfall for the past 10 to 20 years. The study results in Figure 3 show that on average, 81% of the respondents had noted a decline in seasonal rainfall, 13% reported on fluctuating rainfall trends, 4% of the respondents knew nothing and the remaining 2% reported on increasing trends. Decreased rainfall was explained based on rainfall duration, intensity and interval.

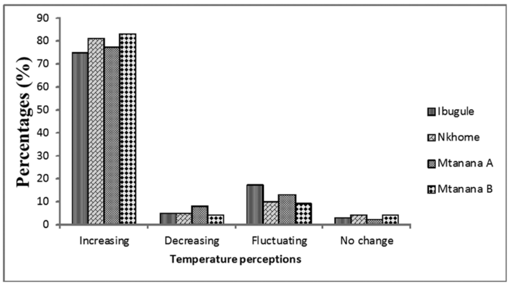

Figure 2: Smallholder farmers' perceptions on temperature in Bahi and Kongwa districts, (***Source:*** Field Data, 2013).

Smallholder farmers during the FGD further reported that, the rainfall onset and cessation dates were unpredictable. They noted that in the past, rainfall started in late November and used to end in late April or sometimes, in early May. This is contrary to the situation today where it starts late December through January and ends in late March or earlier April thus, causing frequent crop failures as seen in the quotation hereunder;

"……. The starting dates for rainfall are unpredictable nowadays. In the past years, it was known late November or earlier December as months for rainfall onset, but nowadays even October or earlier November rains may start and the raining duration is also unpredictable…" (Female, 57 years at Ibugule village, Bahi district).

Generally, based on the perceptions from the smallholder farmers during the household survey and FGD, one can reasonably argue that temperature and rainfall trends in Bahi and Kongwa districts have varied over time.

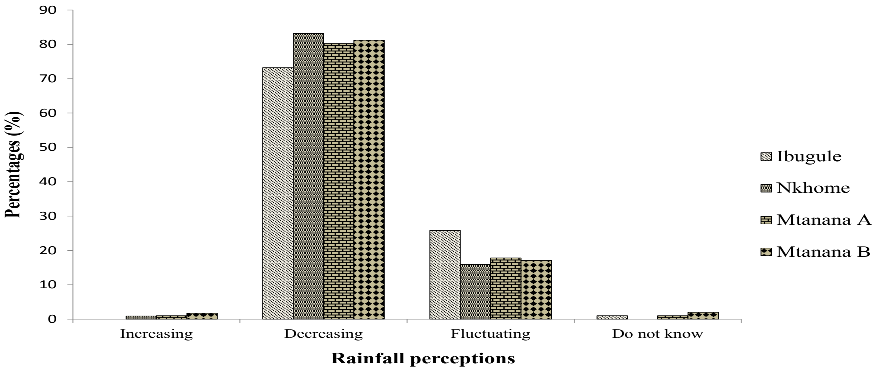

Figure 3: Smallholder farmers' perceptions on rainfall in Bahi and Kongwa districts, (*Source:* Field Data, 2013)

Changes in temperature and rainfall can be associated conveniently with the increase of dry spells, pests and disease, desiccation of local water bodies, late rainfall onset, earlier rainfall cessation, few rainfall days and reduced rainfall frequency all of which can be linked to frequent crop failure. These results concur with the previous studies done in Tanzania by Mary and Majule (2009), Mongi *et al.* (2010), Lyimo and Kangalawe (2010) and Shemdoe (2011). The aforementioned authors reported similar observation from smallholder farmers in the semiarid areas of Mpwapwa, Tabora, Shinyanga and Singida Regions in Tanzania.

Perceptions on cereal crop yield trends

Apart from smallholder farmers' perceptions on temperature and rainfall trends, further analysis was carried out on how they perceive crop yields trends for the past 10 to 20 years (Table 2). Findings from the surveyed population in Table 2 revealed that, 93.8% of the respondents noted a decrease on crop yields, 5.1% reported on fluctuating trends and 1.1% reported slightly increasing yield trends.

Table 2: Perceptions on cereal yield trends in Bahi and Kongwa districts

Perceptions	Bahi (%)	Kongwa (%)	Total (%) (n=366)
Decreasing	96.2	91.5	93.8
Fluctuating	2.5	7.6	5.1
Increasing	1.3	0.9	1.1
Total	**100**	**100**	**100**

Smallholder farmers in Bahi district reported high percentage (96.2%) of decreased cereal yields as compared to their counterparts (91.5%) in Kongwa district. This implies that growing cereal crops in Bahi district is nowadays more difficult than it used to be in the past 10 to 20 years. The smallholder farmers reported to have harvested 10 or more maize bags (1 bag is equivalent to 100 kilograms) in the past years but currently, they harvest between 3 - 6 bags or less per acre depending on the type of cereal crop grown and the rainfall season for that particular year.

The findings on the reduction of cereal yields in the study area were linked to unpredictable and unreliable rainfall. These findings concur with those of previous studies done in other semiarid areas of the world, particularly IPCC (2014), Latha (2012) in India, Shemdoe (2011), Kangalawe and Lyimo (2010), Mongi and Lyimo (2010), Mary and Majule (2009) all done in Tanzania, Thomas (2008) in Asia and North Africa who reports on reduction in crop yields for maize, sorghum, millet and other cereals as a result of increased temperature and reduced rainfall.

Temperature and rainfall trends based on archival data, 1984 - 2011

Temperature patterns and trends

Understanding temperature patterns and

trends for this study based on archival data was imperative in order to understand the climate change scenario in semiarid area of Dodoma region. It was further vital for assessing if the trends were statistically significant or insignificant. The study results in Figure 4 on temperature analyses for the study area from 1984 to 2011 show increased values for both the mean annual minimum and maximum temperature.

Latha, (2012) and Sivakumah *et al.* (2005) in India who also observed increased temperature of both minimum and maximum temperature but minimum temperature have been reported to increase more than the maximum.

Similar observations have been noted by other studies, including Ahmad *et al.* (2020) in semiarid environments, Malik *et al.* (2012) in Pakistan, Aondoakaa (2012) in Abuja Nigeria, Sarr (2012) in dry land areas of West Africa,

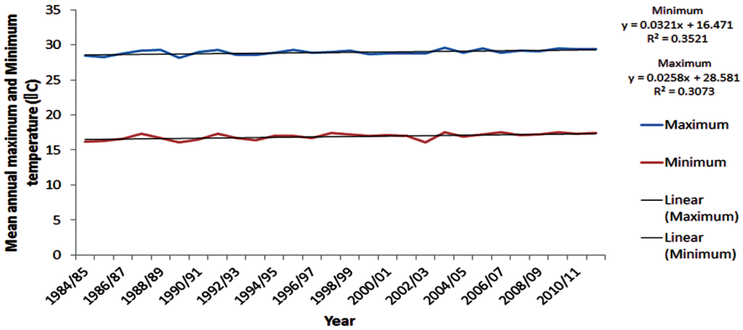

Figure 4: Annual mean minimum and maximum temperature in Dodoma, 1984 to 2011, (*Source:* TMA (2013)

The fitted linear trends in the minimum temperature (Tmini) and maximum temperature (Tmax) are statistically significant at 5% level of significance (p=0.000, p=0.000). The minimum temperature increased faster (slope 0.032˚C y^{-1}) than the maximum (0.025˚C y^{-1}). This is explained by a higher percentage (35.2%) of the observed variance in the minimum (R^2=0.352) than that observed (30.7%) in the maximum (R^2=0.307) throughout the study period (1984 to 2011). These results concur with previous studies done in semiarid areas worldwide by Bryan *et al.* (2009) in Ethiopia and South Africa, Owusu-Sekyere *et al.* (2011) and Owusu (2009) in Ghana, Kangalawe and Lyimo (2013), Lyimo and Kangalawe (2010), Mary and Majule (2009) in Tanzania who also observed increased in both minimum and maximum temperature but in all cases the minimum temperature has been reported to increase more than the maximum.

Rainfall patterns and trends

Apart from temperature trends, rainfall analysis was also carried out. The results on

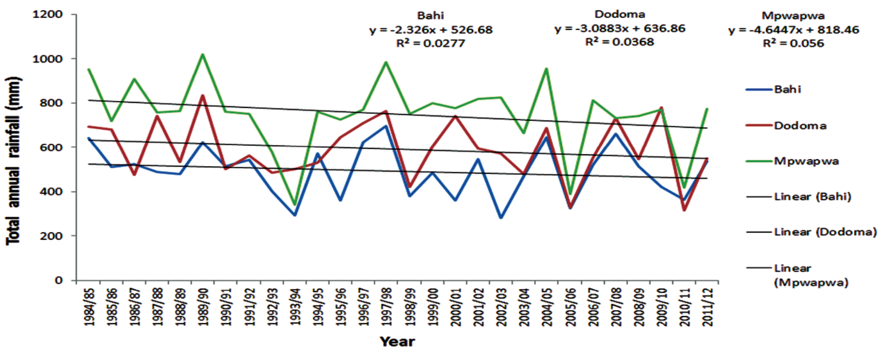

Figure 5: Annual mean rainfall for three stations in Dodoma, 1984 to 2011,
Source: TMA (2013)

the rainfall analysis presented in Figure 5 for the three weather stations from 1984 to 2011 indicate a decrease in the total annual rainfall for Bahi, Dodoma and Mpwapwa stations. The fitted linear trends are statistically insignificant at the 5% level of significance (p=0.505, p=0.911, p=0.474). The rainfall decline was higher at Mpwapwa station (slope 4.6447 mm y^{-1}) as compared to that of Dodoma station (slope 3.0883 mm y^{-1}) and Bahi station (slope 2.326 mm y^{-1}) throughout the study period, 1984 to 2011. Decline in rainfall have an influence on crop yields either negatively or positively depending on the rate of change as well as on the type of the crop grown.

Cereal crop yield patterns and trends

It was important to establish patterns and trends of crop yields in the study area so as to be familiar with crop performance. The results on crop yield analysis for maize, sorghum and bulrush millet presented in Figure 6 covering 27 years (1984 to 2011) indicate a decreasing trend in all three crops. The fitted linear trends are statistically insignificant at the 5% level of significance (p=0.202, p=0.172, p=0.100). These findings concur with what is reported by URT (2012), Rowhan (2010) and Meena *et al.* (2008) who observed cereal crop yields declining trends in Tanzania. Decline in crop yields is associated with both climatic and non-climatic factors. However, this particular study examines the influence of temperature and rainfall on crop yields while keeping other factors constant.

Influence of temperature and rainfall on cereal crop yields in Dodoma region (1984 – 2011)

Influence of temperature and rainfall on maize yields

Results on the correlation between temperature, rainfall and maize yields (Table 3) show that both temperature and rainfall had positive influence on crop yields implying the increase of both temperature and rainfall also influenced the increase of maize yields in the study area if other variables are held constant.

The fitted regression equation is;

Maize yields=-14.015+0.175**temperature*+0.0

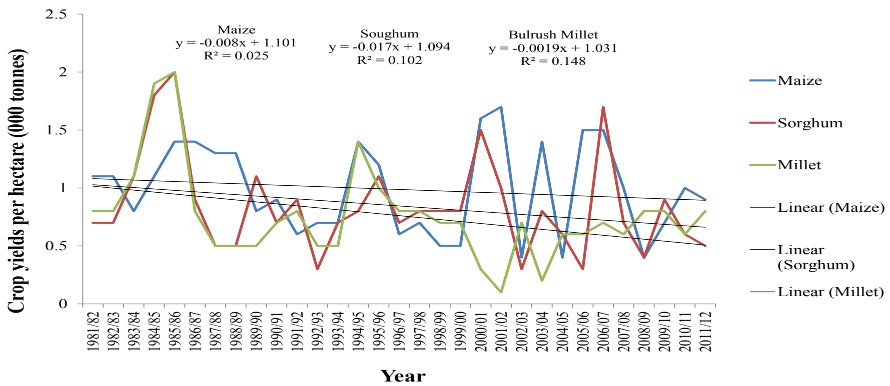

Figure 6: Cereal crop yields in Dodoma region, 1984 to 2011,
Source: NBS, MAFC (2013)

Table 3: Effect of temperature and rainfall on maize crop yields

Variable	Coefficients Beta	T	Probability (P)
Temperature (°C)	0.175	0.817	0.421
Rainfall (mm)	0.064	0.301	0.765
Constant or intercept	-14.015	-0.768	0.450
R-Square = 0.044			
F = 0.605			
P = 0.553			

Source: Computation based on TMA and NBS Data

Table 4: Effect of temperature and rainfall on sorghum yields

Variable	Coefficients Beta	T	Probability (P)
Temperature (^{o}C)	-0.018	-0.091	0.925
Rainfall (mm)	0.413	2.085	0.047*
Constant or intercept	-0.911	-0.099	0.922
R-Square = 0.177			
F = 2.805			
P = 0.079			

* = Significant at 0.05 level of significance

Source: Computation based on TMA and NBS Data

64**rainfall* ....(3)

The research results on positive effect of temperature and rainfall concur with the findings by Amikuzuno and Donkol (2012) in drought areas of Ghana, Meena *et al.* (2008) in semiarid areas of Tanzania who also observed positive effect of temperature and rainfall on maize yields. Although the current research has shown positive effects of temperature and rainfall on maize yields, their effect are insignificant. Similar results on insignificant effects of both temperature and rainfall have been reported by Meena *et al.* (2008) in Tanzania, Chipanshi *et al.* (2003) in Botswana and Aminkuzuno and Donkoh (2012) in Ghana.

Influence of temperature and rainfall on sorghum yields

While temperature and rainfall has shown positive insignificant relationship with maize yields, the current results on sorghum yields in Table 4 has shown both positive and negative relationship between rainfall and temperature on sorghum yields respectively. This imply that increase in rainfall resulted to the increase in sorghum yields while increase in temperature resulted to the decrease of yields if other variables are held constant.

The fitted regression equation is;

Sorghum yields = -1.911–0.018**temperature*+0.413**rainfall* ....(4)

Results in Table 4 shows that temperature had insignificant influence on sorghum yield (p=0.928) while rainfall had significant influence (p=0.047) on sorghum yields at 5% level of significance. These results concur to that of Rowhan (2010) done in Tanzania who noted significant influence of rainfall on sorghum yields but contrast to that of Meena *et al.* (2008) in Tanzania who reported insignificant influence of rainfall on sorghum yields.

Influence of temperature and rainfall on bulrush millet yields

Moreover, the study findings on the influence of temperature and rainfall (Table 5) on bulrush millet yields have shown both negative and positive influence respectively. This implies that rainfall increase in the study area also influenced the increase in millet yields while temperature increase reduced crop yields.

Results on positive effect of rainfall are

Table 5: Effect of temperature and rainfall on bulrush millet yields

Variable	Coefficients Beta	T	Probability (P)
Temperature (^{o}C)	-0.230	-1.086	0.287
Rainfall (mm)	0.043	0.203	0.841
Constant	19.252	1.010	0.322
R-Square = 0.063			
F = 0.878			
P = 0.428			

Source: Computation based on TMA and NBS Data contrary to what is reported by Amikuzino and Donkoh (2012) in drought areas of Ghana and Andreas (2013) in semiarid areas of Namibia who reported negative effect of rainfall on millet yields. This is unusual in semiarid area where water is a limiting factor for production due to high evaporation, therefore water is highly needed.

The fitted regression equation is

Bulrush millet = 19.252 – 0.230**temperature* + 0.043**rainfall* ....(5)

Though temperature and rainfall had both negative and positive influence on crop yields, their effect were statistically insignificant (p=0.841, rainfall) and (p=0.287, temperature) at 5% significance level. Similar insignificant influences of temperature and rainfall on bulrush millet yields have been reported by Amikuzuno and Donkol (2012) in northern Ghana, Makudze *et al.* (2000) in Zimbabwe and Andreas (2013) in Namibia.

Conclusion and recommendations

The current research has noted increased temperature and reduced rainfall as perceived by smallholder farmers and verified by statistical data. Changes in climate variables have impacted crop yields both positively and negatively. This calls for more viable adaptation strategies in the study area and other places of the same characteristics in order to reduce the adverse effects of the changing climate as more climate variability is expected in the near future. The study recommends on the use of improved droughts tolerant crop varieties that can suit the changing climate.

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