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Original Research

Assessment of the impact of climate variability on *Sesamum indicum* L production in Gimbi district west Wollega Ethiopia

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Abstract

This research aimed to understand the impact of climatic variability on sesame yield, plant growth, and rainfall and temperature changes in Gimbi District over the past 30 years. Data was collected through surveys and analyzed using tables and percentages. The study found that temperature is increasing annually, with an average maximum temperature of 260 degrees Celsius and a range of 270 degrees Celsius. The 176 farmers in the study region were selected using a random sample procedure. The study reveals a positive correlation between maximum temperature and sesame output, with a 100% positive correlation. However, a negative correlation exists between sesame and minimum temperature, indicating a drop in production as temperatures drop. A complete positive correlation (.127) exists between average temperature and sesame, indicating a strong relationship between the two variables. The shattering problem is the largest loss of produce when the wet season is prolonged at harvesting time. Late sowing and sufficient human work are the best ways to avoid this issue. Sesame production was significantly related to extreme weather events, average temperature, precipitation, and minimum and maximum temperatures. Maximizing sesame output in the research region requires examining additional variables such as humidity, snowfall, fertiliser, and other soil components.

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INTRODUCTION

Probably the oldest oil crop that has adapted to tropical and semi-tropical climates worldwide is sesame. After coffee, it is the second-most significant agricultural commodity in terms of foreign exchange. In Ethiopia, the crop is grown in a variety of agro-ecological zones. Most of the time, traditional production methods are used to grow soybeans, which lowers crop yield and output (Abadi, 2018).

Drought: Ethiopia's erratic rainfall patterns have an impact on sesame yield and quality, as well as production. Sesame is a very drought-tolerant crop; however, protracted dry spells during the early stages of growth stunt the plant's development. Pollination and seed set are inhibited when rainfall stops during the middle growth phases (flower commencement and grain filling). Sesame output in Ethiopia is impacted by El Nino in 2020 (Berhane, 2020), resulting in total crop loss in the Humora region.

A rise in the mean temperature might result in several consequences. First, in areas with relatively cool spring and fall temperatures, an increase in temperature can prolong the growing season. In areas where summer heat already restricts crop productivity, it might also have a negative impact on crops. There's a risk that rates of soil evaporation will grow, increasing the likelihood of severe droughts (Rind et al., 1997). More insects may be able to overwinter in high-altitude regions due to warmer temperatures. Because many bacterial and fungal diseases have a greater potential to become severe when temperatures rise or precipitation increases, crop damage from plant diseases is predicted to increase in temperate countries.

Rainfall variations can have an impact on soil moisture levels and soil erosion rates, both of which are critical for yields and growth. Ethiopia will experience severe land degradation as a result of the anticipated increase in precipitation and extreme weather events, such as floods, which will be exacerbated by the country's difficult terrain and careless land use. Certain crops, like wheat, rice, and sesame, can grow more readily when atmospheric CO_2 levels rise due to human activity-induced emissions. One of the limiting elements that, when raised, can improve crop growth is CO_2. The availability of nutrients and water are further limiting considerations. While some crops are predicted to benefit from CO_2 fertilization, variations in temperature and precipitation may negate any favorable CO2 effects.

One major obstacle to food security is thought to be climate change and variability (Misra, 2014). The main effects of climate change on crop production have been predicted and partially experienced. These effects have included variations in minimum and maximum temperatures, changes in the amount and temporal distribution of rainfall, higher rates of evapotranspiration, increased repeatability of floods and droughts, and the intrusion of salty water due to sea level rise affecting coastal areas. New cultivation methods with more adapted genotypes are adopted in response to these consequences (Ceccarelli, 1996). Global farming techniques and agricultural output are thus impacted by climate change, which could potentially have a significant impact on crop health.

One of the earliest oilseed crops farmed in nations where manual labor is reasonably priced in the tropics and subtropics is sesame (Sesamum indicum L.). The seeds of this plant contain 50% high-quality edible oil that is exceptionally resistant to oxidation because of the presence of sesame lignans in them, which have been shown to have antioxidative properties. Sesamin and sesamolin, two oil-soluble lignans, have also been shown to have exceptional antioxidative activity in vivo (Li et al., 2024). The functional properties of sesame seeds have led to a rise in demand for the crop worldwide and good crop liquidity.

As a result, after a steady rise, sesame production recently reached 4.3 million tonnes from 7.9 million hectares (FAO, 2007). However, the main issues limiting its production are its unpredictable growth habit, sensitivity to infections, and seed shattering at maturity, which necessitates hand harvesting and makes huge amounts of land difficult to manage (Cagirgan, 2013). In Gimbi district, there is also a high rainfall, which destroys plants by flood and 'ice-rain' in Tole and Jogir kebeles of the sesame growers in the area. On the other hand, there is an increasing temperature, which aggravates heavy rain. In addition to these, there is no research done aboutthe impact of climate variability on sesame production.

MATERIALS AND METHODS

The assessment was conducted in Gimbi district for a duration of six months in 2014 E.C., at the site located in Oromia regional state west of Wollega Gimbi district. The population of the area 1-19 age group was male 19,514 female 20,310 total 39,823 and 20-34 age group male 8,912 female 9,272 total 18,186 also 35-49 age group male 16,366 female 17034 total was 39,400. Again, in the 50-64 age group, there are also male 6,228 female 6,475 total 12,700, and above 65 male 1,275 female 1,327 total population male 52,290 female 54421, and the general population male and female is 106,711 (Gimbi Agriculture Office, 2013).

Within the West Wollega Zone is Gimbi. Gimbi district shares borders with the following areas: Homa district to the southwest; East Wollega zone to the east; Benishangul-Gumth region to the north; Haru district to the south; and an exclave of the Benishangul-Gumth region to the east (Figure 1).

Gimbi town serves as the district's administrative hub. This district's main cash crop is coffee. This crop is cultivated on more than 28,530 hectares. Although they have not yet been commercially developed, the phosphate and iren deposits are known to lie in the vicinity of Bikilal, a community approximately 18 to 20 kilometres north of Gimbi (Gimbi Agriculture Office, 2013).

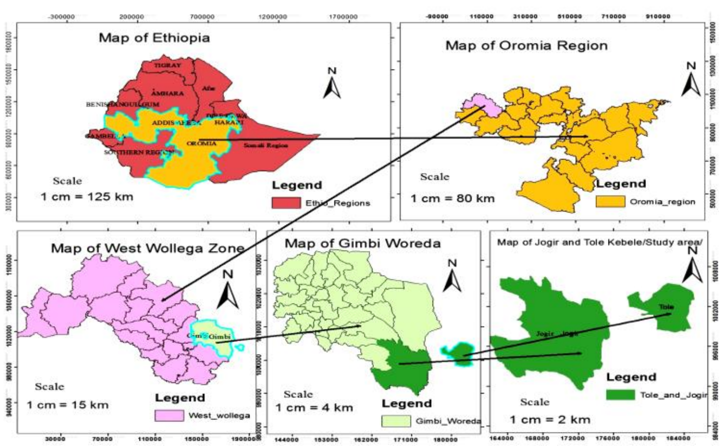

Figure 1. *Map of the study area (Regional data, 2021)*

Location

The study was conducted at Jogir and Tole kebele which was located in Gimbi district. West Wollega Oromia region , which were 441 km far from Addis Ababa and 30 km far from Gimbi town. This area was bordered by four directions that means north of

Marachemika'elkebele, south of Bunobedele zone east of BenishangulGumuz region and west of Aba sena Kebele.(Figure 1)

Climate

This district is characterized by hot climate condition. In the Jogir and Tole, the average annual range of temperature lies between from 13^0c -26^0c average temperature 19.5^0cand this Kebele receives average annual rainfall from 1500-1800mm (Gimbi agricultural Administration office, 2012). The altitude is (weynadega), 70% 0f high altitude (dega), 10% (desert area) 20% of medium (hot) (Gimbi Agriculture office, 2013) (Figure 2).

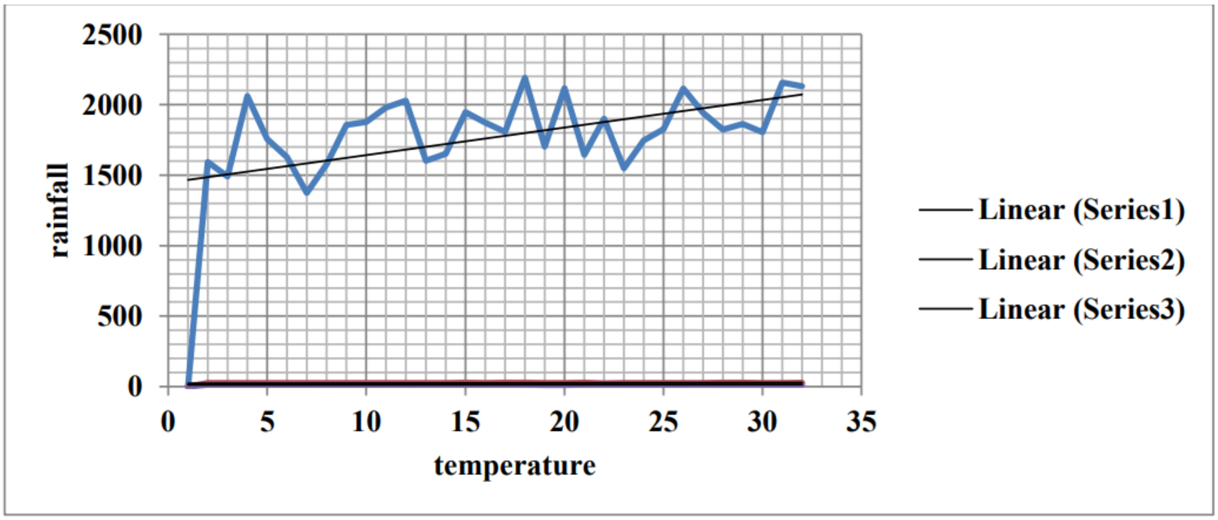

Figure 2. *Climate diagram of Gimbi District*

Topography

The area was geographically steeply sloping, which covers about 80% of the total area; undulating, which covers 5% of the total area; and hilly, which covers 15% of the total area. The elevation ranges from 1204.2 m to 2127.2 m above sea level. (Gimbi Agriculture Office, 2013).

Soil type

The study area was dominated by different soil types. Thus, the dominant soil types were classified as red soil 20%, light red soil 20%, and brown red soil 60%, respectively. The fertility status of the soil ranges from fairly to good but has a limitation due to its steeply sloping susceptibility to water erosion (Gimbi Agriculture Office, 2013).

Vegetation cover

The vegetation cover in the area was highly dense, especially as far as natural forest cover is concerned. The main tree species that were found in that forest were: *Vernonia spp., Croton macrostachyus, Acacia abysinnica, Albizia gummifera, Ekebergia capensis, Combretum molle, Terminalia brownie, Anogesis sp., Cordi aafricana, Arundinaria spp., and Ficus spp.* (Gimbi Agriculture Office, 2013).

Sample size sampling technique

Among the 31 kebeles from Gimbi district, the Tole and Jogir were purposefully selected because the sesame production is high in these kebeles. These two Kebeles have Jogi male households (594 women householders), 48 total households (642), and in Tole male households (1423 women householders), 149 total households (1572), and a total population of 2214 households. The total population of these two kebeles is 5,338 males and 5,562 females, and the total of them is 10,900. Out of 1572 households, 315 are sesame producers.

Table 1

Research sample size

S.No	Selected Kebelee	Target population	Sample size
1	Tole	186	105
2	Jogir	129	71
Total		315	176

Data collection methods

A household survey was implemented to collect a range of quantitative and qualitative data through a structured questionnaire on the main problems related to the to the impact of climate variability in the area concerning sesame production. For this household survey, I have taken 176 householders (Table 1).

I have interviewed individuals who were knowledgeable householders about climate change in the age group of 25–60. This was a person who knew about rainfall, temperature, and the variability of weather patterns.

Data collection includes both primary and secondary data sources. The primary data sources were obtained from household surveys, interviews, etc.—methods that were related to the impact of climate change on sesame production. The secondary data were obtained from different publications related to research and documents of the agricultural office. Other climate data were also obtained from the National Metrological Agency and the Yield of Sesame from the Central Statistical Agency of Ethiopia.

The sampling strategies or techniques were conducted to select the respondents. Those techniques focused on sesame producers household was identified by using purposive technique. After having the list of farmers according to the sesame producers of male and female categories, the purposeful technique was employed to select representatives of household proportionality.

The sample size was determined basing on Yamane (1967)

$n = \frac{N}{[1+N(e)^2]}$ = 176, Where n=sample size, N=Number of P=households e=precision/error level e=(0.05)

Method of Data Analysis

All the data or information that was collected from the respondents through a questionnaire, interview, and field observation was used to prepare the final output. The method of data analysis comprises both descriptive and quantitative statistics. The descriptive statistics were prepared in terms of tables, graphs, and percentages. I have studied the relationship between sesame production and rain falls and the regression between sesame production and temperature because correlations were used. To analyse other data, I have used SPSS and Microsoft Office Excel.

RESULTS AND DISCUSSION

Demographic characteristics of the respondents

Age of the sampled households: As it can be seen from Table 2, the majority of the respondents are aged between 25 and 50; this accounted for 70%. The age class above 50 accounted for 30%. However, most of these age groups are adults who have participated in the cultivation of sesame. These age groups mostly spend their time on farm activities for their livelihoods (Table 2).

Table 2

Ages of the sampled households

Questionnaire	Response	No of respondent	Percentage (%)
Age of the sample households	25-50	123	70%
	50 and above	53	30%
	Total	176	100%

Crop yields per hectare during three years:

As can be seen from Table 3, 93.2% of the respondents said there was an there was an increase, and 6.8% of the respondents said there was no change. But when heavy rain occurs at harvesting time, the total crop is shattered from the pod of sesame, and 100% loss happens during such years (Figure 3-6). The farmer is economically damaged according to their idea, and when heavy rain occurs at planting time, the flood erodes the sawn seed. In this condition, the plant becomes thinner and thinner, and as a result, the yield decreases (Table 3). This is in line with the work of Niguse and Aleme (2015), who modeled how climate change might affect sesame output in Tigray's western zone.

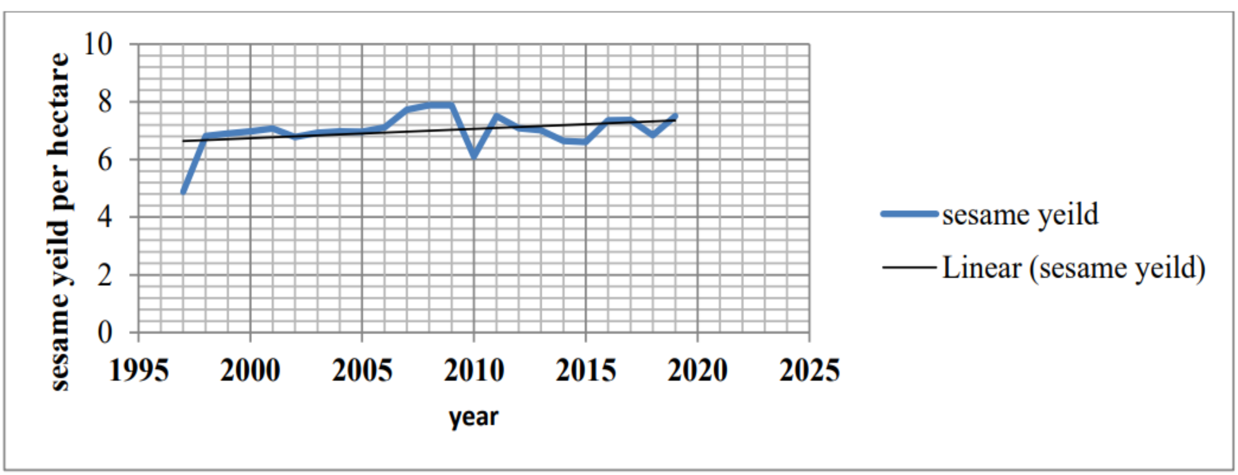

Figure 3.*Graph of sesame yield per hectare of Gimbi area*

Table 3

Crop yield per hector from the respondents

Questionnaire	Response	No of respondent	Percentage (%)
Crop yields per hectare during three years	Increase	164	93.2%
	No change	12	6.8%
	Total	176	100%

Distribution of respondents by family size:

As indicated in Table 4, 17.5% of the respondents have 1-3 family sizes. This includes children who are engaged in different jobs like education and agriculture. In addition, 35% of the respondents have a family size ranging from 3–5, indicating that they have better manpower or labor. On the other hand, 37.5% of the respondents were those who had 5-7, and the remaining 10% were those who had a maximum potential to cultivate sesame on a large farm compared to others who had a small family size.

Table 4

Distribution of sampled respondent by family size

Questionnaire	Response	No of respondent	Percentage (%)
	1-3	31	17.5 %
Family size	3-5	62	35 %
	5-7	66	37.5%
	More than 7	17	10 %
	Total	176	100 %

The education level of the respondents

The respondents were categorized into two groups based on their status and education level. As shown in Table 5, about 2.5% of the respondents were illiterate, and the remaining 77.5% were educated or literate (i.e., 28.75% are educated 1-4, 58.75% are educated 5-8, and 10% are educated 9-12, 0% are dipiloma). So, education is important in any activity, and it enhances the knowledge, awareness, and experience of the respondents. The ability to think, understand, and adopt the ideas of others is based on education. Therefore, education influences the farmer's decision to adapt to the impact of climate variability (Table 5).

Table 5

Education level of the respondents

Questionnaire	Response	No of respondent	Percentage (%)
	Illiterate	4	2.5 %
Education level	1-4	51	28.75%
	5-8	103	58.75 %
	9-12	18	10%
	Diploma	0	0%
	Total	176	%

The grazing land of the sample of households to their livestock

As shown in Table 6, the grazing land of the livestock of the sample of respondents indicated that 85% of the respondents have enough grazing land for their livestock's, like crop residue and hay fodder, but the remaining 15% of the householders were under scarcity in the amount of grazing land for their livestock (Table 6).

Table 6

Grazing land of the respondents

Questionnaire	Response	No of respondent	Percentage (%)
	Yes	150	85 %
Do you have enough	No	26	15%
grazing land	Total	176	100 %

Details on farmers knowledge of climate variability

Landownership of samples of householders: As indicated below, 100%% of the respondents have their own land of 1–1.75 hectares, 35% have 2–3 hectares of farm size, and the remaining 25% have greater than 3 hectares of farm size. Thus, the householders have their own land for their own survival (Table 7).

Table 7

Land ownership of the respondents

Questionnaire	Response	No of respondent	Percentage (%)
Do you have your	Yes	176	100 %
own land	No	0	0%
	Total	176	100 %

Distribution of respondents by farm size

As shown above, the farm size of the sample respondents indicated that 40% of the sample size of households has 1–1.75 hectares, 35% have 2-3 hectares of farm size, and the remaining 25% have greater than 3 hectares of farm size. This indicated that the shortage of farmland forced them to cultivate less sesame compared to other crops (Table 8).

Table 8

Distribution of the respondents by farm size

Questionnaire	Response	No of respondents	Percentage (%)
How many ha of land do you have	1-1.75 ha	70	40 %
	2-3 ha	62	35 %
	>3 ha	44	25 %
	Total	176	100 %

Types of rainfall occur in the kebele.
As shown in Table 9, the majority (41.4%) of the respondents answered heavy rain, and 38.75% said medium rain. 20% of the respondents said ice or rain (Table 9).

Table 9

Types of rainfall occurred in the kebele

Questionnaire	Response	No of respondents	Percentage (%)
type of rain fall occur in the kebeles	Heavy	73	41.4%
	Ice-rain	35	20%
	Medium	68	38.75%
	Total	176	100%

The respondent answered the question provided for them about the types of rain rained around them: heavy, ice rain, and medium rain. There is no scarcity of rain, which is not enough for crop cultivation. They get rain from early March to the end of November (Table 10).

Table 10

Farmers Knowledge on climate variability

Questionnaire	Response	No of respondent	Percentage (%)
Do you have any awareness about impact of climate variability?	Yes	35	20%
	No	141	80%
	Total	176	

Temperature trends of over the past three decades

It appears that the temperature is rising annually based on the trend. According to an Oxfam Research Report from July 2011, the rising temperature is in line with the pattern seen in Ethiopia's sesame industry. The average maximum temperature began at 26 degrees Celsius and ended at 27 degrees Celsius (NMA, 2019).

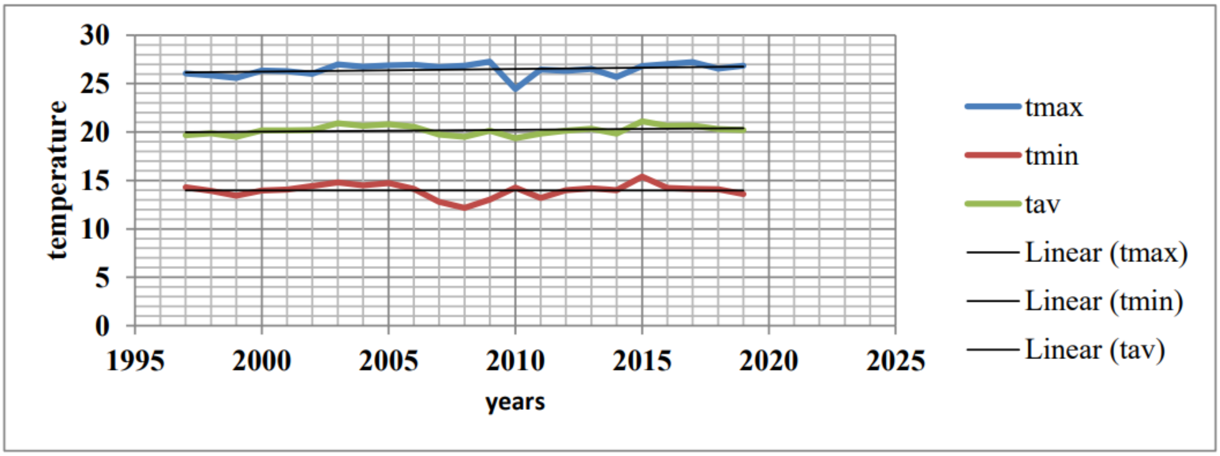

Figure 4. *23 years of maximum temperature of Gimbi area*

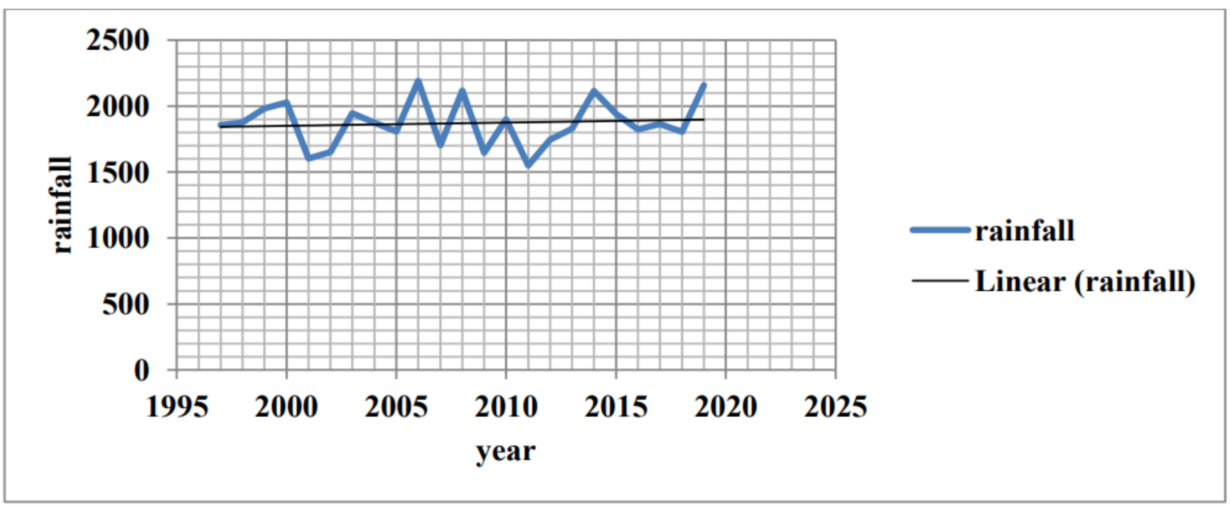

Figure 5. *23 years of annual rainfall Gimbi Area: (NMA,2019)*

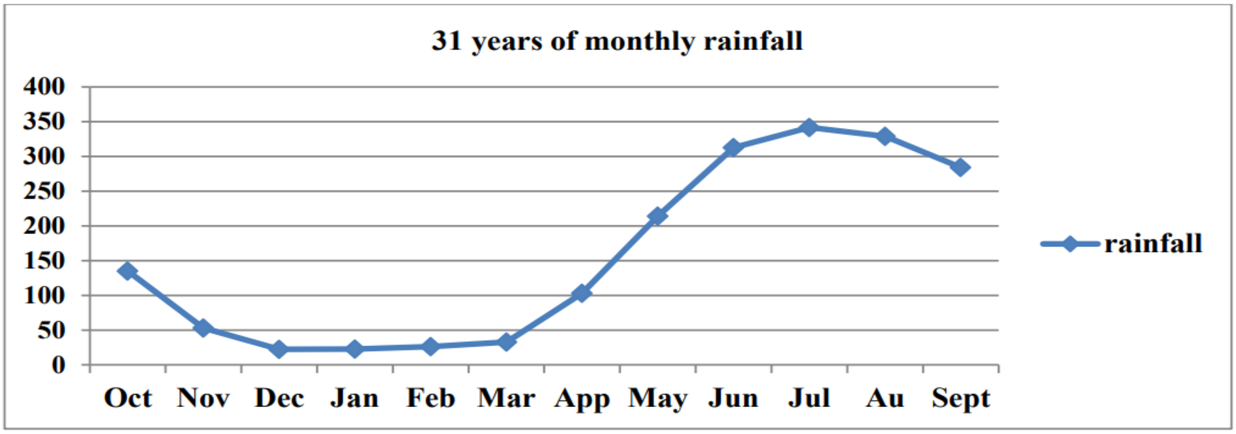

Figure 6. *23years monthly rainfall of Gimbi area*

According to the trend formed in October about 100mm of rain is observed in November about 50mm is observed. In December, January and February nearly 0mm is observed but in the month of summer season means June, July August high mm of rain is observed (Figure 7-9).

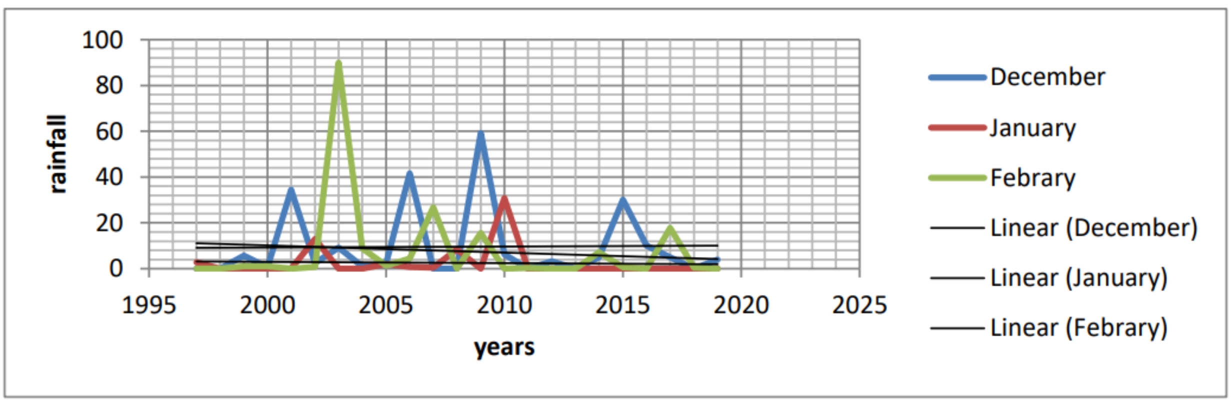

Figure 7.*23 years monthly winter rainfall of Gimbi area*

In winter season the observed rain become zero but in the month of February 2003 about 89mm of rain is observed and it showed these phenomena. From the spring season high amount of rain observed in the month of May.(NMA,2019)

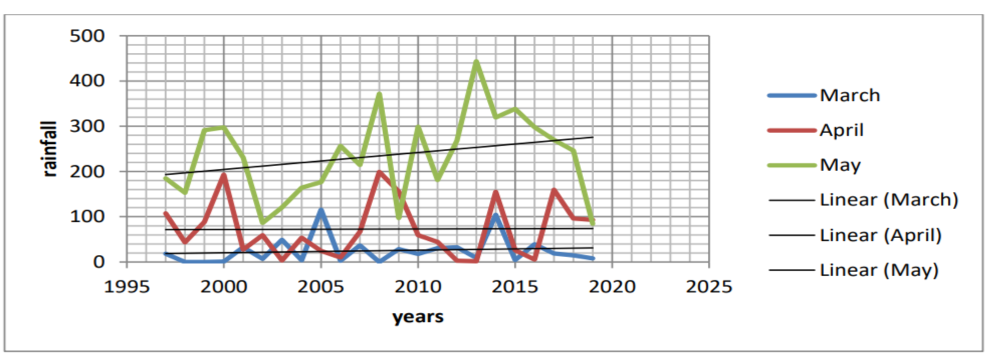

Figure 8. *23 years of monthly spring rainfall of Gimbi area*

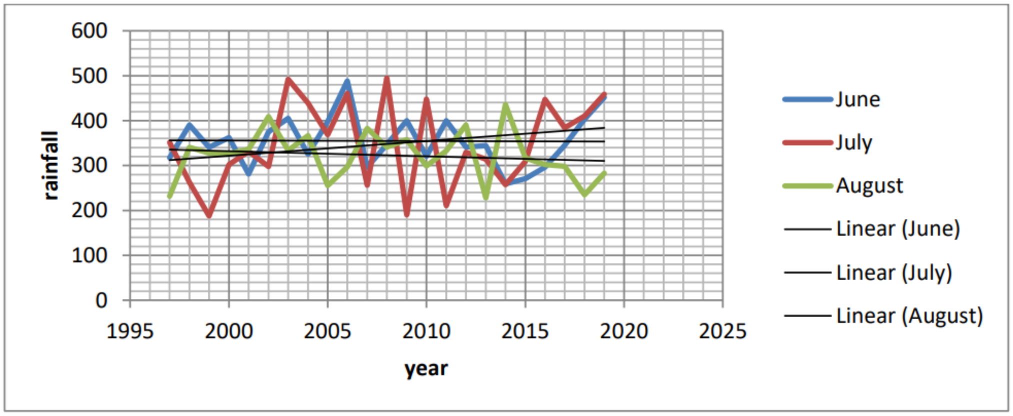

Figure 9. *23years summer rainfall of Gimbi area*

Generally, a sesame plant is a kind of plant that does not have a strong stem or is an herbaceous plant and is easily damaged by flooding, heavy rain, and ice rain. Flooding can destroy all the sown sesame, especially during the germination period and on the day of sowing, according to the sampled respondent. On the other hand, if the rain is prolonged at maturity, the shattering problem is the main problem of yield loss.

As can be seen from Table 3, 93.2% of the respondents said there was an increase, and 6.8% of the respondents said there was no change. But when heavy rain occurs at harvesting time, the total crop is shattered from the pod of sesame, and 100% loss happens during such years. The farmer is economically damaged according to their idea, and when heavy rain occurs at planting time, the flood erodes the sawn seed. In this condition, the plant becomes thinner and thinner, and as a result, the yield decreases (Table 3). This is similar to Niguse and Aleme (2015) modelling the impact of climate change on the production of sesame in the western zone of Tigray.

The SPI was calculated by the formula of observation (mean/standard deviation), and the result is that in 1996, 2001, 2002, 2005, 2007, 2009, 2011, 2016, and 2018, a negative number was observed that shows the dryness of the year. For the rest of the years 1997, 1998, 1999, 2000, 2003, 2004, 2006, 2008, 2010, 2013, 2014, 2015, 2017, and 2019, positive numbers were observed. These show that there is enough rainfall in the district. This is similar to Guttman, 1999.

According to the trend formed, the temperature is increasing from year to year. The increment in temperature is similar to the trend formed by Ethiopia's sesame sector, Oxfam Research Report, July 2011. It started from 26^{0}c average maximum temperature ends in average maximum temperature with 27^{0}c (NMA,2019). Most of the temperatures from year to year show an increasing graph in maximum temperature, average temperature, and minimum temperature when we observe the trend.

In the autumn season, high rainfall is observed in the month of September. But the linear graph is in declining order. The next month that high rain is observed is October. In October, at the beginning of the month, high rainfall was observed compared to the rest of the month. In November, at the beginning of the month, low rainfall is observed, and at the end, high rainfall is observed. In the winter season, all three months are nearly equal, but in the year 2003, 89mm of rain was observed in February.

The spring rainfall starts in the month of March. But it is not much considered as rainfall and sowing of crops have not started in this month. The next month is April, which is somewhat greater than the rain that rained in March. In general, high rainfall was observed in the month of May, and most farmers started their agricultural practices in this month. In the summer season of twenty-three years, all three months are nearly equal, but in July, there is a little more than other months.

The mean of all variables, meaning sesame yield, maximum temperature, minimum temperature, average temperature, and rainfall, are calculated using SPSS software, and the results were observed as 6.9961, 26.4549, 13.9690, 20.1908, and 1869.9739, respectively. The standard deviation of all five variables was calculated by the SPSS software, and the result was a sesame yield of 0.62473, a maximum temperature of 0.64263, a minimum temperature of 0.70007, an average temperature of 0.47303, and a rainfall of 176.21126. The sesame data obtained from the Central Statistical Agency showed an increase in relation to the temperature of the district. In the situation of increasing temperatures in the future, all kebeles in the district have the probability of cultivating sesame.

Table 11

The correlation between dependent and independent variables

Correlations

		YEILD OF SESAME	Maximum temperature	Minimum temperature	Average Temperature	Rain Fall
Pearson Correlation	YEILD OF SESAME	1.000	.565	-.561	.127	-.084
	Maximum temperature	.565	1.000	-.062	.662	-.023
	Minimum temperature	-.561	-.062	1.000	.676	.019
	Average Temperature	.127	.662	.676	1.000	.002
	Rain Fall	-.084	-.023	.019	.002	1.000
Sig. (1-tailed)	YEILD OF SESAME	.	.002	.003	.282	.351
	Maximum temperature	.002	.	.388	.000	.459
	Minimum temperature	.003	.388	.	.000	.465
	Average Temperature	.282	.000	.000	.	.496
	Rain Fall	.351	.459	.465	.496	.
N	YEILD OF SESAME	23	23	23	23	23
	Maximum temperature	23	23	23	23	23
	Minimum temperature	23	23	23	23	23
	Average Temperature	23	23	23	23	23
	Rain Fall	23	23	23	23	23

Yearly sesame production in Ethiopia was observed from 1997–2019 and is increasing in quintals per hectare. In 1997, the yield was 4.88, but in 2019, the yield was increasing dramatically, and now 7.5 quintals per hectare are harvested. In the future, when temperatures increase, the crop will also increase, and all kebeles in Gimbi district have the probability of producing this crop. The graph is from 2010; it shows that the sesame production decreased in this year, yielding 6.1 quintals, and the temperature of this year also decreased to 24.4. (CSA,2019)

Sesame plants are, by nature, more sensitive to changes in rainfall than to changes in temperature. About 25% of the respondents were affected by their level of education about climate variability. This shows that education influences farmers decisions to sow the sesame on time and harvest on time. Based on the above facts, in the study area, the level of education highly influenced the knowledge of the farmer (Table 6). Family size has a high influence on the potential to manage climate variability in the study area. Family size was negatively associated with the impact of climate variability because large families were the whole consumers of food, and the required oxygen was held and carbon dioxide was emitted by individuals (Table 5).

About 40% of the respondents were affected by farm size and decided to cultivate more sesame to overcome the negative impact of climate variability at harvesting time. Farmers with small landholdings were not interested in cultivating more sesame. (Table, 10). As shown in Table 2, about 16% of respondents were affected by age in terms of climate variability. In other words, farmers usually have less interest in long-term solutions to overcome the impact of climate variability in the study area due to a lack of labour and a short planning horizon (Table 2). The knowledge of the respondents was defined in the research as a proper understanding of climate variability. The knowledge of climate variability among the respondents was measured by asking them in their local language to answer the questions presented to them. As indicated in Table 12, the minority (80%) of the respondents were less knowledgeable about climate variability, and the remaining 20% of the respondents had good knowledge of climate variability, which could influence them to prefer the time of sowing and harvesting (Table 11).

The relationship between dependent and independent variables:

As shown in the table above, rainfall and sesame are perfectly negatively correlated because the result shows a negative (-.084). This means that when rainfall increases, sesame production decreases in the normal condition. This is when there is no flood, ice rain, or heavy rain, which results in the destruction of the stems of sesame and makes them shatter at harvesting time. (Table,12). As shown in the table above, maximum temperature and sesame are perfectly positively correlated because the result shows a positive correlation. This means that when temperature increases, sesame production increases in the normal condition (Table 12).

Table 12

The coefficient of the variables

Coefficients [a]								
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	1.910	.798		2.393	.028	.233	3.587
	Maximum temperature	-1.506	.090	-1.550	-16.826	.000	-1.694	-1.318
	Minimum temperature	-2.359	.083	-2.643	-28.250	.000	-2.534	-2.183
	Average Temperature	3.882	.165	2.940	23.578	.000	3.536	4.228
	Rain Fall	.000	.000	-.075	-2.859	.010	.000	.000

As shown in the table above, minimum temperature and sesame are perfectly negatively correlated because the result shows a negative (-.561). These mean that when the temperature decreases, sesame production decreases in this condition. As shown in the table above, average temperature and sesame are perfectly positively correlated because the result shows a positive (.127). This means that when the temperature increases, sesame production increases in this condition. They are highly significant but have a very low relationship with minimum temperature, a medium relationship with average temperature and rainfall, and a very high relationship with maximum temperature**.**

CONCLUSIONS

Generally, according to the trend formed, the temperature is increasing from year to year. It started from 26^0c average maximum temperature ends in average maximum temperature 27^0c. Extremely wet conditions were observed in the years 1991 and 2020, and more of them were nearly neutral or moderately wet, according to the SPI formed. There is no dryness in the study area because no negative numbers are observed, which fulfils the criteria of dryness. During the early vegetative stage, respondents or sampled farmers replanted the entire damaged plot of sesame; 10% undertook partial replanting; 25% faced growth retardation; and 65% did not face any crop damage. The average replanting cost at which the sesame seeds were sown again when rain completely damaged the crop accounted for nearly equal to the previous planning cost. Rainfall and sesame are perfectly positively correlated because the result shows a positive (.118). This means that when rainfall increases, sesame production increases in the normal condition. when there is no flood, ice rain, or heavy rain, which results in shattering the seed and damaging the plant parts.

Maximum temperature and sesame are perfectly positively correlated because the result shows a positive correlation. These mean that when temperature increases, sesame production increases in the normal condition. Also, minimum temperature and sesame are perfectly negatively correlated because the result shows a negative (-.561). This means that when the temperature decreases, sesame production decreases in this condition. Average temperature and sesame are perfectly positively correlated because the result shows a positive (.127). This means that when the temperature increases, sesame production increases in this condition. They have a highly significant but very low relationship with minimum temperature, a medium relationship with average temperature and rainfall, and a very high relationship with maximum temperature.

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DECLARATION

The authors declare that they have no conflict of interest.

DATA AVAILABILITY STATEMENT

All data are available from the corresponding author upon request.

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