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Temperature Change Trends and Perceptions in Kolla Temben District, Tigray Regional State, Northern Ethiopia

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Abstract: **The main objective of research was to examine temperature trends and household's perceptions on temperature characteristic changes. Maximum and minimum temperature data records for 31 years were used in the study. The sources of the data were gridded meteorological satellite data of 250 grid cell points and 400 households from Kolla Temben district. Meteorological data was accessed from the TAMSAT satellite. The data were analyzed in monthly and annual bases to investigate the variability and trends of temperature for the past 31 years. The study revealed that temperature has increased rapidly with more extreme events. Minimum and maximum temperature was increased at 0.0348 and .0848 degree Celsius per year respectively for three decades. The temperature increase pace of the district for past 31 years was much greater than the average global surface temperature speed in the past hundred years (1905-2005, 0.74 degree Celsius). Most of households were found perceiving that temperature has increased more rapidly in the past three decades. The 31-year temperature trend analysis confirms that some areas may face unpredictable and very odd climate feedbacks in the near future. Reversing temperature increases could take hundreds of years as some of the GHG[1] atmospheric life time is very long and; the atmosphere has already absorbed enough GHG to sustain the existing trends for decades. Vulnerable societies should be addressed by evidence based adaptation policy direction as climate is unstoppable. Mitigation through adaptation is the most appropriate way to achieve two goals at a time; adapting the existing changes and fighting for the possible future temperature changes. More area specific researches should scrutinize the possible temperature changes and potential impacts as climate change peril the planet unevenly.**

Keywords: **Temperature rises, trends, migration, mean temperature, Conflict, Adaptations, perceptions.**

I. INTRODUCTION

Surface temperature has projected to rise in the 21st century under all assessed emission scenarios [3].The global average temperature increase from 1910s to 1940s was 0.35 degree Celsius but; in the past 100 hundred years (1906-2005), surface temperature has been increased by 0.74 degree Celsius [1]. Linear trend study results show that the combined land and ocean average global warming in the period of 1880 to 2012 was 0.85 degree Celsius [3]. The single longest dataset results revealed that the average temperature increase in the periods 1850–1900 and2003–2012 were 0.72 to 0.85 degree Celsius [3]. Globally scaled result on ocean surface temperature shows that oceans are getting more warmer near to the surface [3].The upper 75 m ocean surface gets warmed by 0.11 degree Celsius per decade over the period of 1971 to 2010[3]. Global mean sea level rises will amplify existing risks and create new risks for the natural and human systems. Temperature increase has been responsible for extending the geographical range of some insects [17].[3]. Heat waves are

[1]Greenhouse Gas

expected to occur more often and last longer [3]. The ocean surfaces (70 meter above) has warmed in the period 1971 to 2010 and it is highly likely that it warmed between 700 to 2000 meter from 1957 to 2009[2] . Climate change risks are unevenly distributed and its impacts are greater for those disadvantaged people [3].Many aspects of climate change and associated impacts will continue for centuries, even if anthropogenic emissions of greenhouse gases are stopped [3]. There is an increased frequency of warming days and nights and decreased frequency of cold days and nights [2]. The impact of temperature variability study has been given less attention [10]. Annual maximum temperature trend in India was found significant only in the second half of 20th century [8]. Temperature has increased at .092 degree Celsius per year in the past 31 years (1983-2013) in Nigeria, Gombe State [13]. Rainfall changes for the past two decades are well perceived by 75 percent of households [9]. Most of local people perceptions on climate variability are consistent with research evidences [19]. Significant proportions of population in rural Nepal were not able to perceive temperature and rainfall change and variability [20]. A survey study conducted in Ethiopia reported that only 64 percent of farmers perceived that temperature has increased in 20 years [16]. Climate change perception vary with household's education level, age, willingness to accept risks, farm ownership and off farm employment status [5]. Risk perceptions of climate change are complex and multidimensional [6]. Women farmers understand their local climate but their ability to cope with extreme climate event is low [12]. Combining scientific facts and figures with local people's opinions provides more reliant and relevant investigations of climate change and; allows for better planned adaptations [15]. Understanding farmers' perception on climate variability is very curial as perception is the most significant barrier to adaptation [18]. Public perceptions on local risks from global warming are ever more important as communities face decisions on how best adapt to coming changes [11]. Household perceptions on extreme climate events are similar for temperature extremes trend across eco-environments and seasons, whereas the perceptions on rainfall extremes vary with eco-environments and seasons [14].

Integrated risk communications should get more attention to address the multiple aspects of human judgment and behaviour on climate change [6]. Further study is needed to see if household's observed stances on climate change and variability are evolving over time [5]. Continuous research work, regular monitoring systems, knowledge management and development are important to manage climate change and its impacts [7].This study was therefore initiated to examine temperature trends of Kolla Temben district for the past 31 years and to assess household's perceptions on such changes.

II. MATERIALS AND METHODS

Climate models are mathematical representations of the climate system, expressed as computer codes and run on powerful computers [22]. Global climate models incorporate the latest scientific understanding of the physical processes in the atmosphere, oceans, and Earth's surface and detect how all of these are interconnected [22]. This model is the complex climate modelling types which climate scientists use for global climate modelling purposes. Most of the time the resolution used for this model is 300 x 300 km [22]. Trend modelling is designed to facilitate statistical testing for trend and change in time series data [21]. This is called Simple modelling technique which focuses only on one climate variable. This modelling was used in this study to examine the past climate trends and to forecast future temperature changes in the district. The researchers used the TAMSAT satellite gridded climate data records for 31 years (1983-2013). The gridded climate data was taken from 250 grid cell points with 4.5 km^2 resolution in the Kolla Temben district. The monthly mean temperature time series plot was calculated as explanatory data analysis (EDA) techniques to see outliers and extreme temperature events of each month for the past three decades (1983-2013). The researchers were used the miniTab version 16 statistical computer software to exame the linear trends and time series plot of T_{max} and T_{min} for the past three decades. The meteorological gridded data (T_{max}[3] and T_{min}[4]) was used to scrutinize the temperatures change trends of Kolla Temben district for the past three decades (1983-2013). The monthly mean temperature was calculated by taking the average daily temperature and divided by 30 days. Annual mean temperature was calculated by taking monthly average records and divided by 12 months. Structured interview schedules with open ended questions were used to assess household's perception on temperature changes in the time duration and intensity of temperature. Multistage sampling

[2]Kilo Meter
[3]Maximum temperature
[4]Minimum temperature

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techniques were applied to select 400 households for interview. In the first sampling stage 4 Kebelle[5] were selected randomly from the given 27 kebelles and; then 400 households were selected randomly for interview. The possible responses on perceived changes of temperature characteristics were coded into three scales (1=Increase, 2=decrease, 3=No change). These scales were used to simplify the analysis and interpretation of the data.

III. RESULTS

1. Maximum temperatures Trend for three decades (1983-2013):

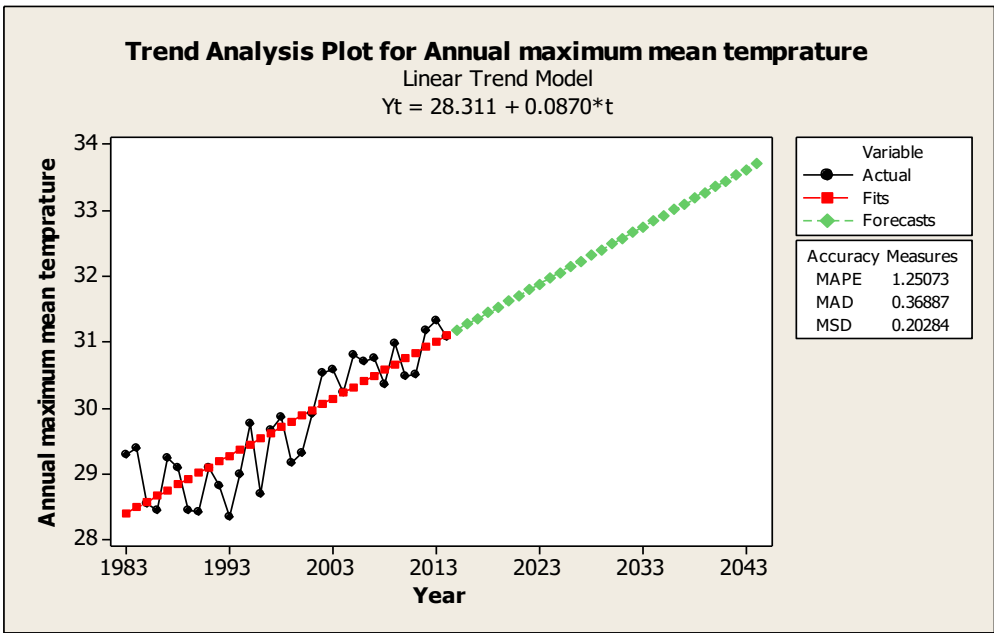

Figure 1.Graph for Trend Analysis for Maximum temperature variability of the Temben District

Sources; field study results, 2017

2. Monthly maximum temperature time series plot for the past three decades (1983-2013)

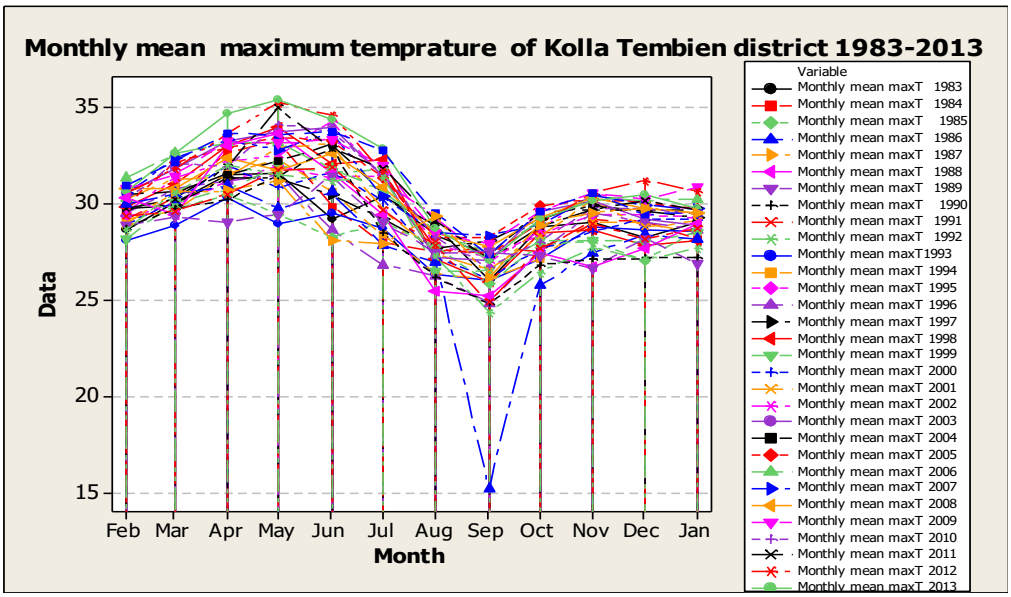

Figure 2. Graph for Trend Analysis for Maximum temperature variability of the Temben District

Sources; field study results, 2017

[5] The smallest administration unit of the government of the Federal Democratic Republic of Ethiopia

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3. ***Minimum temperatures trend for three decades (1983-203)***:

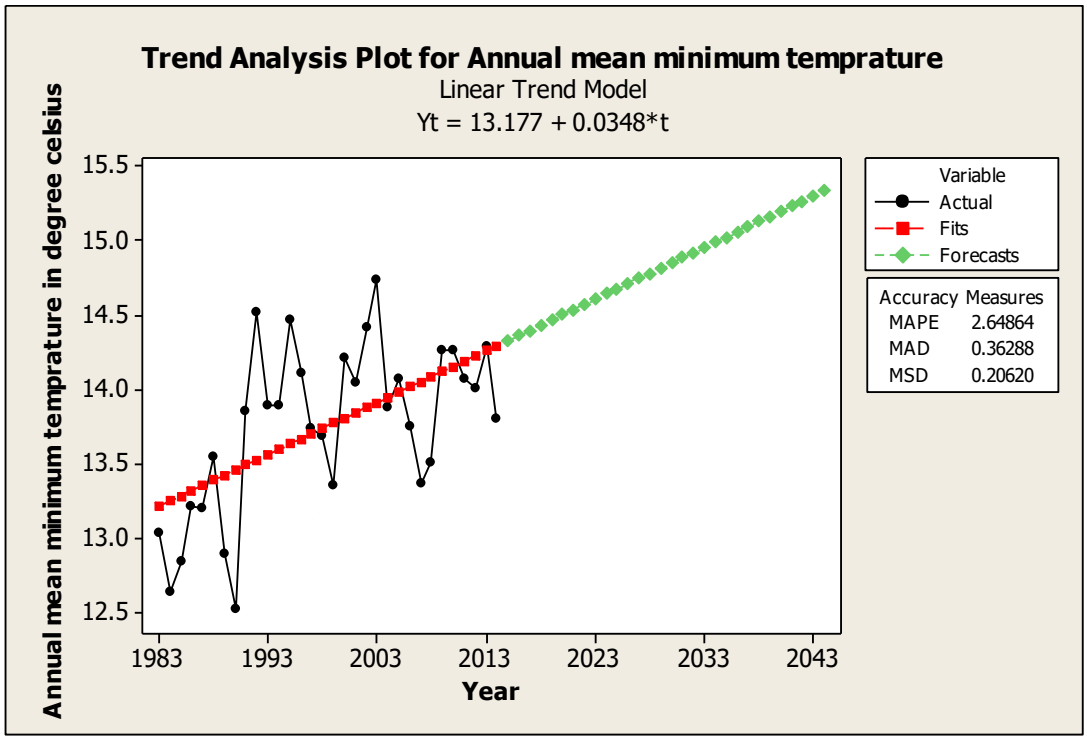

Figure 3. Graph for Trend Analysis for Maximum temperature variability of the Temben District

Sources; field study results, 2017

4. **Monthly minimum temperature time series plot for the past three decades (1983-2013):**

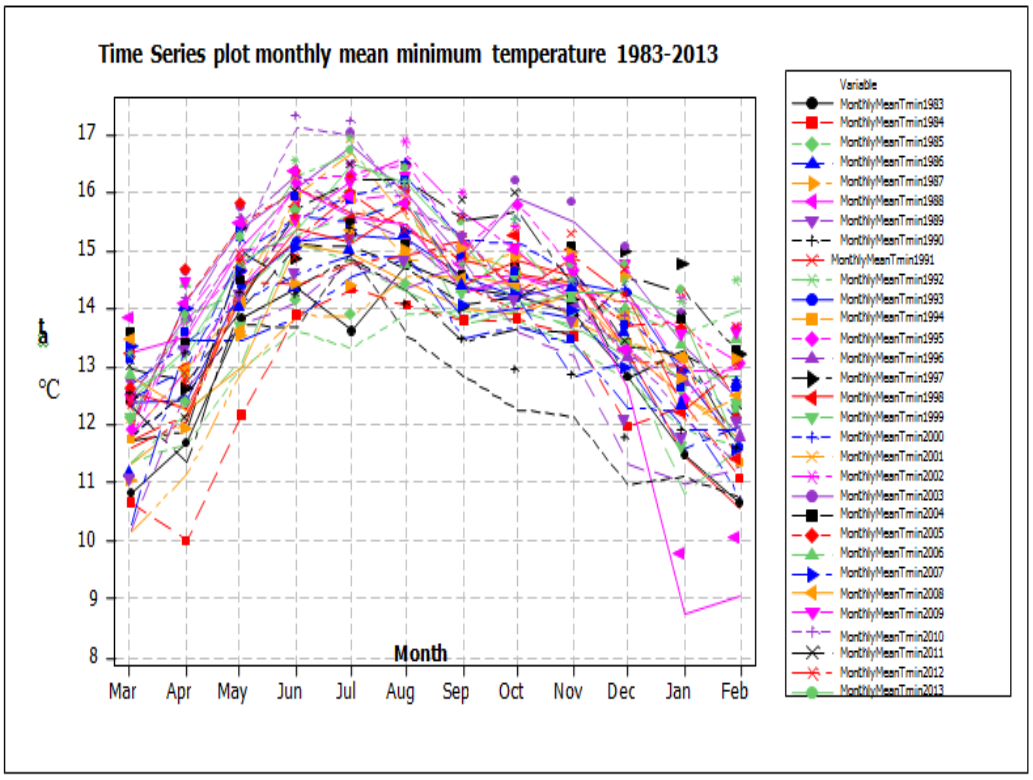

Figure 4. Graph for Trend Analysis for Maximum temperature variability of the Temben District

Sources; field study results, 2017

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5. Perceptions on temperature characteristics

Table 1. Perceptions on temperature characteristics

Temperature characteristics	Households perceptions and responses on perceived temperature changes for the past 31 years and above in Temben district						Total households responded to each characteristics		Total households not responded to each cxs	
	Increase		Decrease		No change		Total		Missing Values	
	No	%	No	%	No	%	No	%	No	%
Duration of high temperature	326	81.5	36	9.0	34	8.5	396	99	4	1
Intensity of high temperature	326	81.5	46	11.5	24	6.0	396	99	4	1
Duration of sunny time	299	74.8	62	15.5	34	8.5	395	8.8	5	1.3
Intensity of sunny time	305	76.3	62	15.5	25	6.3	392	98.0	8	2.0
Frequency of occurrences of excessive heat	158	39.5	205	51.3	33	8.3	396	99.0	4	1

Sources; field study results, 2017

IV. DISCUSSIONS

The annual T_{max} record in 1983 was 28. 31 °C but in 2013 it reaches 31.33°C which is a 3.02°C increment over a 31-year period. The linear regression trend line (figure 1) shows that the T_{max} for 2043 is projected to be 33.62°C which is a 5.31°C increment from 1983. The linear trend line plot also revealed that there was an increase of average annual maximum temperature in the range of 0.09°C per year.

September 1986 was the month with extreme low monthly mean maximum temperature over the 31-year period, while the warmest month was May 2013. The months April, May and June were found to be the hottest months in 31-year record. August, September and October had the lowest maximum monthly mean temperature records. September 1986 was found with records of extremely low maximum temperature in 31 years records (figure 2).

The annual mean T_{min} has increased in Kolla Temben district at a rate of 0.03°C per year, and more than 1°C in 31 years. The annual mean minimum temperature increase was compounded with more frequent occurrences of extreme climate events. This finding was found with 2.65°C mean absolute percent errors (MAPE), 0.36°C of mean absolute deviation error (MAD) and 0.21°C mean square deviations (MSD). The study revealed that the yearly minimum average temperature was increased by more than 1 °C in the past 31 years (1983-2013) and projected to increase into the future (figure, 3).

January 2009 was found as the coldest month in the record (less than 9 °C). June 2010 and July 2010 were found as the hottest months in 31 years with monthly mean minimum temperature records of 17 °C (Figure 4). The year 2010 was the warmest year in the Temben district over the period of study.

Table 1 result revealed that 81.5 percent of households perceived that the duration and incidents of high temperature in the area had increased compared with the situation 30 years ago. Only 9 percent of households perceived that the duration and incidents of high temperature had decreased. Intensity of high temperature, duration of sunny periods and the frequency of occurrences of excessive heat waves were perceived by the majority of households as increasing over the decades (Table, 1). The results in Table 1 also revealed that less than nine percent of households were found having a difficulty to understand temperature changes trends of the past 31 years.

V. CONCLUSION

Temperature in northern Ethiopia is increasing very rapidly; more than global climate models project for the area. The temperature rising rate is more than double compare with the past hundred year increments and this trend is exposing the area to unknown climate feedback. Global climate modelling results are not enough to make decisions at local level. Most of households' perceptions on temperature trend are consistent with most of research findings but do not understand its long term consequences on their livelihood bases and health. More area specific research is very important to predict

possible irreversible damages. Globally coordinated action is needed to tackle the temperature increases. Further research on temperature changes trends at different ecological zones should be done to get more clear pictures of the impacts of climate change at local level. Temperature trend changes and its immediate feedback at local level are not clear. Trans disciplinary research can help to figure out the overall implications of such temperatures change trends on socio-economic activities, migration trends, diseases outbreak, conflict incidents and water resource availabilities.

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