Climate Variability Correlation with Tuberculosis Disease at Chiro District, West Hararghe Zone, Oromia Regional State, Ethiopia

M A. Thesis

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Climate Variability and its correlation with Tuberculosis disease at chiro District west Hararghe zone, Oromia regional state, Ethiopia

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In

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POSTGRADUATE PROGRAM DIRECTORATE

We here certify that we have read and evaluated this Thesis entitled "**Climate Variability correlation with Tuberculosis disease at chiro District west Hararghe zone, Oromia regional state, Ethiopia"** prepared under my guidance by Hadi Aliyi Ahmed. We recommend that it be submitted as fulfilling the thesis requirement.

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DEDICATION

I dedicated this thesis work to my late Sister Aisha Aliyi Ahmed, who was eager to see my success in work, but passed away too early. Peace and mercy from Almighty Allah be with her with his mercy.

STATEMENT OF AUTHOR

By my signature below, I declare and affirm that this thesis was my own work. I have followed all ethical and technical principles of scholarship in the preparation, data collection, data analysis and compilation of this Thesis. Any scholarly matter that was included in the Thesis has been given recognition through citation.

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BIOGRAPHICAL SKETCH

Hadi Aliyi Ahmed_was born at Ethiopia, Gelemso town, on September 1, 1988. He attended his elementary school education at chafe Primary School and completed his high school at Gelemso Secondary and Preparatory School in 2003. He attended University of Bahirdar from 2006 to 2009, graduated with B.Sc. In Natural Resource Management. He worked as forest expert in Habro District, West Hararghe zone, Ethiopia from 2010 up to 2018. Then worked as senior forest expert of REDD^{++}Investment Program Since July 2018 at chiro District, Ethiopia. The Author, entered graduate school at Haramaya University 2021 to pursue a master's degree in Climate change and Disaster risk Management.

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ACRONYMS AND ABBREVIATION

API	Annual Parasite Incidence
CHDHPO	Chiro District Health protection office
CHDAO	Chiro District Agriculture office
CHDANO	Chiro District Agriculture and Natural resource office
CSA	Central statics Agency
DHMIS	District health Management information system
DRMCC	Disaster Risk Management and Climate Change
DRMFSS	Disaster Risk Management and Food Security Sector
EFY	Ethiopia Fiscal Year
EPHI	Ethiopian Public Health Institute
FMOH	Federal Ministry of Health
GHG	Green House Gasses
GIS	Geographical Information Systems
HMIS	Health management Information System
IPCC	Intergovernmental Panel on Climate Change
KII	Key informant interview
NDRMCC	National Disaster Risk Management Coordination Commission
SPSS	Statistical Product and Service Solutions
TB	Tuberculosis
UNDP	United Nations Development Program
UNEP	United Nations and Environmental Protection
WHHO	West Haraerghe Health Offices
WHO	World Health Organization
WMO	World Metrological Organization
USAID	United States Agency for International Development

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ABSTRACT

The thesis was conducted on climate variability correlation with Tuberculosis disease Chiro District, West Hararghe zone, Oromia regional state, Ethiopia. The objective of the study were to assess the climate variability correlation with tuberculosis disease. It conducted using purposively selecting three sample of kebeles in Chiro District and 271 sample household heads and 87 TB patients in Chiro hospital. The data obtained from the household questionnaires, KII, FGD health station and metrological as primary. It used descriptive statistics, inferential and correlation to analyze. The analysis revealed that there were variability with Seasonal changes in tuberculosis. The results of the study were in forms of tables, graph and descriptive narrations. The factors that negatively or positively influence climate variability impact on Tuberculosis disease include: education, family size, access to health, access to information, total annual income, perception of households and basic services. Tuberculosis in Chiro were seasonal with peaks at the start and end of the rainy season, and were significantly influenced by weather conditions, particularly heavy rainfall and extreme temperatures. It, recommended that; better organizing institutions, processes and *actions around present and anticipated health challenges across sectors. Managers at the Chiro Hospital/Chiro town/Zonal health office level should strengthen supportive supervision to the health centers to support the TB prevention and control program by providing necessary materials and supplies for services. In this study as well as in previous studies little is clearly known about TB association with climate variability so further studies are suggested*

Key words: Adaptation, Climate Variability, Impacts, Trend, Tuberculosis (TB), patients

1. INTRODUCTION

1.1. Background of the study

It is predicted to have adverse consequences on the world's ecosystems, economies and societies (IPCC, 2007). But, the severity of adverse effects varies across countries, regions, and socio-demographic groups due to differences in exposures, sensitivities and adaptive capacities (Betelhem, 2014).

Tuberculosis (TB) is an infectious disease caused by Tubercle bacillus, known as Mycobacterium tuberculosis, whose host is human & is transmitted through the air or by ingesting infected milk or meat (Bovine TB) and it is both preventable and curable and People who have pulmonary tuberculosis (TB disease in the lungs) can infect others through droplet infection when they cough, sneeze or talk (Lemma,. 2017)

Overall, high rainfall was significantly associated with lower TB notifications; this association was greatest in the first weeks from onset of heavy rains, with an immediate maximum relative reduction of − 10%. Mid or high temperatures were not associated with significant changes in relative notifications compared to low temperature. There are uneven occurrences of changes in temperature and precipitation and hence its impacts will also be unevenly distributed around the globe. It is also recognized that even within regions impacts adaptive capacity and vulnerability will vary. (WHO 2022).

It was reported that the highest prevalence and estimated annual risk of TB infection are in sub-Saharan Africa and Southeast Asia. (Lemma N. 2017).

Africa has contributed the least to the amount of global emission of greenhouse gases, and has the least capacity to adapt and thus the most vulnerable to the adverse effects of Climate change and variability (Solomon, 2015).

According to the Federal Ministry of Health Guidelines for clinical and programmatic management of TB, TB/HIV and Leprosy in Ethiopia (2013), revealed that the prevalence of *Tuberculosis* disease among adults and all age group was found to be 108 and 63 per 100,000 populations, respectively.

1.2. Statement of the problem

Climate change is already taking place now, thus past and present changes help to indicate possible future changes. Over the last decades, the temperature in Ethiopia increased at about 0.2°c per decade. The increase in minimum temperatures is more pronounced with roughly 0.4°c per decade. Precipitation, on the other hand, remained fairly stable over the last 50 years when averaged over the country. However, the spatial and temporal variability of precipitation is high. Thus large-scale trends do not necessarily reflect local conditions (IPCC, 2007).

One of the earliest impacts of climate change on health may be altered distribution and incidence of vector-borne diseases, already a major cause of illness and death, particularly in tropical and subtropical countries (WHO, 2002). Some aspects of disease systems (e.g. seasonality of biting patterns of disease vectors) are likely to be affected by climate change (IPCC, 2007). For example, malnutrition and food insecurity are affected indirectly by climate change as high temperatures and erratic rainfall reduce crop yields which can lead to an other disease by running out the immunity (Costello et al., 2009).

About a quarter of the world's population is estimated to be infected with tuberculosis and hence millions of people are at risk of developing active disease each year. Global TB report, ware estimated 10 million people have developed TB disease in 2017, of which 5.8 million were men, 3.2 million among women and 1 million were children (WHO 2018).

Ethiopia is among the 30 high tuberculosis, human immune-deficiency virus and multidrug resistance tuberculosis burden countries that accounted for 87% of all estimated TB cases worldwide with annual estimated TB incidence of 164/100,000 population and death rate of 28/100,000 population for 2017(WHO 2018).

In a study from the Western Cape, South Africa that analyzed over 100-years of *Tuberculosis* disease case notification data, seasonal peaks were also found between September and

November (Andrews, J. R. *et al*. 2020) Similarly, in Zimbabwe, laboratory-confirmed TB case markedly increased between September and October (Mabaera, B. *et al.* 2009).

In different part of Ethiopia, many climates related studies have focused more on Pastoralism, droughts, climate mitigation and adaptation, but less has been done especially on linkage of Human health with climate variability trends. Thus in this study we try to fill this gap in the area for further specific and locally people livelihood in consideration.

1.3. Objectives of the study

1.3.1. General objective

The general objective of this Study was to investigate the correlation between climate variability and incidence of Tuberculosis at chiro district.

1.3.2. Specific Objectives

The specific objectives of this thesis were:

1. To assess temperature and rainfall variability of chiro district
2. To identify temporal pattern of Tuberculosis disease.
3. To correlate climate variability with Tuberculosis disease.
4. To assess adaptations strategies to impacts of temperature and rainfall variability on TB.
5. To examine the existing TB patient support and quality of treatment in chiro hospital.

1.4. Research Questions

The research questions that have to be answered in this thesis were:

1. was there temperature and rainfall variability in trends of 30 years in your village?
2. What were the relationship of climate variability and Tuberculosis disease?
3. What were temporal pattern of Tuberculosis disease?
4. What were adaptation strategies to temperature and rainfall variability impacts?
5. What are existing TB patient support and quality of treatment?

1.5. Significance of the Study

The study expected to benefit the Readers in the way that: aware the relationship of climate variability and Tuberculosis disease. It helps in understanding the climate variability and pushing to adaptation strategies to impacts on Tuberculosis disease. It was provided an opportunity to cope up with variability impacts on Tuberculosis disease. It may benefit for vulnerable people to show how to cope up with Tuberculosis disease. To show areas of intervention that addresses the impact of climate variability on Tuberculosis disease.

1.6. Scope of the study

The study was geographically limited to Chiro District, west Hararghe, Oromia, Ethiopia. It was conducted on climate variability impacts on Tuberculosis disease. Methodologically it is mixed research. It was based on primary data and some secondary data matching data from metrological station and health facilities to increase reliability. The concept is mostly limited to patterns of climate variability (temperature and rainfall) trends, impacts on Tuberculosis disease and adaptation strategies.

1.7. Limitation of the study

The study was geographically relied on three selected kebeles in chiro District because of time and financial limitations; some sample farmers were not willing to give correct information concerning their current income. Other did not remember about it before a years in relation to climate variability and tuber clause.

The other limitation is getting fully functional Tuberculosis data due to lack of HMIC/DHIS. It is by further gathering adequate information from annual reports of socio-economic aspects of the respondents in Chiro District Agricultural Office (CHDAO 2018). Well-designed studies on the direct and indirect effects of temperatures and Rainfall factors on TB Disease are needed.

1.8. Definition of Key Terms

Adaptation to climate variability refers to adjustment to actual or expected climatic effects, which moderates harm or exploits beneficial opportunities **(**A.J. McMichael, 2003).

Climate Variability: is climatic parameter of a region varying from its long-term mean. Every year in a specific period of the climate and different location. Some years have below average, average or above average rainfall/temperature (IPCC, 2007).

Impacts: Consequences of the variability on nature and health (A.J. McMichael, 2003).

Infectious Disease: disorders caused by organism such as: bacteria, fungi or parasites.

Patient: people who are suffering from *Tuberculosis disease* and registered in hospital (siddaram.*et.al*.2008)

Tuberculosis: an infectious disease mostly affecting bronchi and lungs caused by M. Tuberculosis (FMOH 2013).

Zone: refers to a formal administrative level in the government structure below a regional state and above District administration (WHZEDPO, 2019).

1.9. Organization of the Thesis

This thesis is structured and organized into five chapters. Chapter one deals with the background information, statement of the problem, objectives, research questions, significance, scope of the study, limitations of the study, and also definition of key terms. Chapter two presents the review of literature to climate variability, perception and adaptation strategies in response to climate variability. Description of the study area, sampling technique and sample size, data type and sources, methods of data collection and method of data analysis are presented in the third chapter. Chapter four deals with the results and discussions of the research outcomes and finally chapter five presents summary, conclusions and recommendations of the study**.**

2. LITERETURE REVIEW

2.1. Concepts of climate variability and Tuberculosis disease

2.1.1. Concepts of climate variability

It is important to note that the change in uncertainty is not linear. There are three General level of uncertainty in climate change relative to various timescales depending on time range and area coverage. These are weather (minutes to days), climate variability (3 weeks to years) and climate change (decades and centuries). (Source; Maggie. 2016).

Like other respiratory infections, seasonal patterns of TB have been observed in several countries in temperate regions (Naranbat.et al 2009). Nevertheless, high Tuberculosis disease burden, few studies have investigated seasonal trends in sub-Saharan Africa. TB diagnoses in two South African studies were at their zenith between September and November (Martineau, A. R. *et al.* 2011).

2.1.2. Concepts of Tuberculosis disease

Tuberculosis (TB) is a chronic infectious disease caused by Mycobacterium tuberculosis. It typically affects the lungs (pulmonary TB) but can affect other parts of the body as well (extra pulmonary TB). Tuberculosis, whose host is human and is transmitted through the air or by ingesting infected milk or meat (bovine TB) and it is both preventable and curable. TB disease is spread via droplet infection when people with pulmonary TB expel the bacilli while coughing, sneezing, talking, etc. Without treatment, mortality rates are high (WHO 2018)

Outbreaks of seasonal respiratory infections such as seasonal coronavirus infections and influenza may stimulate cough or other respiratory symptoms, “unmasking” Tuberculosis disease (Divala, T. H. *et al* 2016).

2.2. Association between Climate Variability and Tuberculosis disease

All populations was affected by climate variability, but the initial health risks vary greatly, depending on where and how people live. Health effects were expected to be more severe for elderly people and people with infirmities or pre-existing medical conditions (WHO, 2009).

A warmer climate is expected to bring benefits to some populations, including reduced mortality and morbidity in winter and increase local food production, particularly in northern high latitudes. Against this background, the negative effects of climate change on health are likely to be greater and are more strongly supported by evidence than are the possible benefits (Franklin A. et al 2017)

Understanding how seasonality and weather affect patterns of *Tuberculosis disease* could help generate hypotheses for underlying causal pathways, predict temporal trends in healthcare utilization, and develop strategies to improve access to *Tuberculosis disease* diagnosis and care. Using data collected over 10 years in Chiro, Ethiopia, we aimed to investigate the relationship between trends in *Tuberculosis disease* and weather conditions by different demographic groups. Seasonal changes in temperature and particulate matter exposure may lead to worsening of respiratory symptoms, prompting care seeking (Anyenda, E. O. *et al*. .2016).

2.3. Impacts of climate variability on Tuberculosis disease

2.3.1. Social impacts

Extreme weather can destroy shelter, contaminate water supplies, cripple crop and livestock production, tear apart existing health and other service infrastructures. This was ultimately increase the existing burden of disease and other non-health need of vulnerable human population.

2.3.2. Economic impacts

Economically, since most smallholders farmers depend on crop production as their source of livelihood, which climate variability lead to a reduction in food production, which can also cause hunger among people in the locality (Ayanlade, 2010).

Already, higher temperatures, declining rainfall and water scarcity and floods in Ethiopia were impacting negatively on food production resulting in food insecurity. Decreased agricultural productivity in the coming years could lead to food insecurity, hunger and famine affected by climate variability. Food insecurity would in turn increase illness and death of vulnerable groups including women and children (Shongwe, 2009).

2.3.3. Environmental impact

Climate variability was emerging as a major threat to health and adding pressure on public health systems. Climate variability was affect, in profoundly adverse ways, some of the most fundamental prerequisites for good health: clean air and water, sufficient food, adequate shelter and freedom from diseases (WHO, 2009).

In a study from the Western Cape, South Africa that analyzed over 100-years of TB case notification data, seasonal peaks were also found between September and November (Andrews, J. R. *et al.* 2020). Similarly, in Zimbabwe, laboratory-confirmed TB case markedly increased between September and October (Mabaera, B. *et al.* 2009). Lower temperatures and higher rainfall may increase indoor crowding and promote indoor droplet transmission (Ferraro, C. F. *et al.* 2014).

The prevalence of some of the tropical diseases and other threats to human health depend largely on local climate. Climate variability extreme temperatures can lead directly to loss of life, while climate-related disturbances in ecological systems can indirectly impact the incidence of infectious diseases. On the other hand, warm temperatures can increase air and water pollution, which in turn harm human health (IPCC, 2007).

2.4. Adaptation mechanism

An approach that uses both mitigation and adaptation was needed. Current commitment to mitigate climate variability by limiting the emission of greenhouse gases was not, even if implemented, stabilize the atmospheric concentrations of these gases. Adaptation efforts was requiring first steps towards mainstreaming climate issues into all national, regional, District and sectorial planning processes, such as poverty reduction strategies.

It was equally important that a ministry with a broad mandate, such as finance and economic affairs was being encouraged to be fully involved in mainstreaming adaptation. Developing adaptive capacity to minimize the damage to livelihoods from climate variability is a necessary strategy to complement climate variability mitigation efforts. Climate variability adaptation i.e. all those responses to climatic conditions that reduce vulnerability, should therefore be an integral and urgent part of overall poverty reduction strategies.

2.4.1 Traditional Adaptation

Traditional coping mechanisms at household and community levels were backward looking, based on historical experience and observation. In the face of changing patterns of climate variability and the significant deviations from historical experience, their effectiveness may be significantly reduced. Traditional/religious healing practices Patients and healthcare workers mentioned various informal healing practices including herbal medicines, spiritual healing practices and non-prescription medications.

The practices attempted before visiting healthcare facilities were the use of herbs, Chat chewing as a pain reliever, religious healing (Qur'an read by sheiks followed by something to drink), visiting traditional healers, and self-medication with antibiotics and syrups. Patients who thought their illness was caused by a curse opted for religious leaders, traditional healers, or herbal remedies.

The herbs used to treat pulmonary illnesses are locally named, Galool (Acacia bussei), Liike, and Ruman (Pomegranate). A 45 years pastoralist explained his experience as: "I didn't think that I had TB. I used 'Galool' leaves, boiled like tea and drunk it. I then tried 'Ruman' leaves. At last, I became very weak and bed-ridden." Medications by informal drug vendors More than half of the interviewed patients sought first care at rural drug vendors where they received medications. Rural drug shops (mostly unlicensed) are common in remote areas of the region. Patients chose these drug vendors as first point-of-care due to their convenience and permissive process to purchase drugs and obtain treatments.

2.4.2. Modern Adaptation

A change in timing of rainfall together with extreme rainfall events, including both drought and excessive rains, also emphasize the increasing need for multi-year planning. The providers and managers explained the limitations in basic infrastructure such as health facility designs, inadequate rooms, drug stores and water supply. Most health centers in the district did not have adequate rooms for TB laboratory services due to design defects.

It also observed that the rural health centers have very small rooms (roughly 2X3 square meters) but no isolated TB laboratory. District level manager said: “There is no standard TB clinic in health centers. The majority of them have very narrow rooms that are not ventilated and isolated. We always shout for renovation, but………” In addition to inadequacies in health centers, at the referral hospital there were shortage of rooms for admitted and TB patients. At rural drug shops, patients are told as having ailments like pneumonia and anemia without medical examinations and given injectable and capsule medications.

Patients only sought healthcare at a health center/hospital when the illness did not improve or got worse. A 27 years old patient said: “The first time i felt this illness, i went to the little pharmacy in our kebeles. The vendor said ‘you have pneumonia’. He gave me injections, but I didn’t recover. Lastly, i decided to come here.” Factors affecting effective service delivery.

2.4.3. Integrated Adaptation

There were two main types of adaptation measures to climate variability: reactive, which were measures taken in response to climate variability, and preventive measures taken in advance of climate variability to minimize or offset adverse impacts. For example, suggested adaptation strategies for diarrheal diseases concentrate on the reduction of vulnerability to current climatic events, as well as the inclusion of adaptation policies in planning for long-term sustainable development.

2.5. Conceptual framework

Datta (2013) identifies high temperature and rainfall variability as two most important parameters that influence climate variability. Rainfall itself is an important variable that affected by changing climate (Roudier, 2011).

In view of the enormity of the effects of these variables on TB disease therefore take steps to respond to the changing climate through actions of adaptation strategies to be able to cope with the situation this is as depicted in the diagram below.

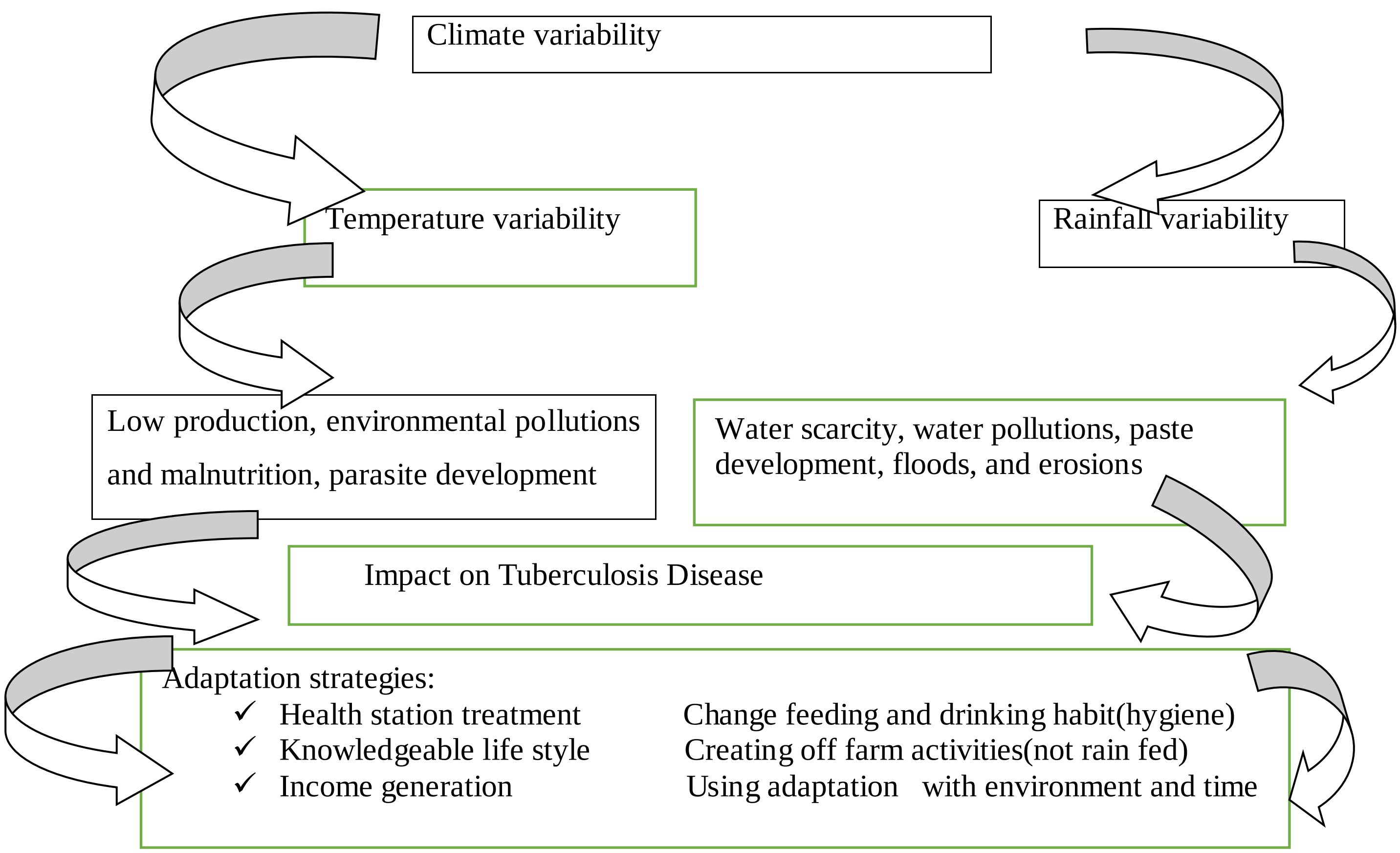

Figure 1. Conceptual Framework of the Study Source: (modified from FAO, 2010

3. RESEARCH METHODOLOGY

3.1. Description of the Study Area

3.1.1. Location and size

The study was conducted in Chiro District, West Hararghe Zone, Oromia Region, Ethiopia. It is about 325 km away from Addis Ababa. The District was Geographically, the area is found between 8° 50′ 0′′ to 9° 20′ 0′′ Northing(latitude) and 40° 40′ 0′′ to 41° 0′ 0′′ Easting(longitude).

The District was bounded to the north and north east by *Mi'eso* and *Dobba District*, respectively. The district is bordered in south by Gamechis and Messala *District,* in the west by *Guba Koricha* District. Tullo *District and Galetti* River in the east. Chiro town was the administrative center of the west Hararghe zone, Chiro District and Chiro town municipality administration. *The* town was found on the main road from Addis Ababa *to* Harar and Dire Dawa cities .The study again in Chiro Hospital in West Hararghe Zone(CHDANRO, 2018)..

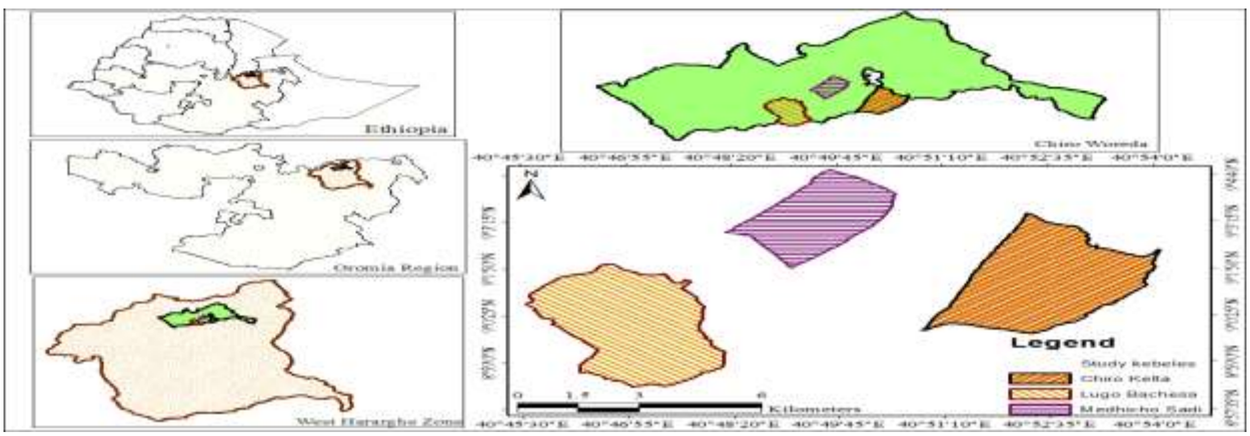

Figure 2. Map of study area (Chiro District, West Hararghe, Oromia regional state Ethiopia). Source :(Arc GIS, 2023).

3.1.2. Relief and soil

Having altitude ranges from (1500 m to 2800 m) a.s.l. Geographically the major known large mountains such as: - jallo muktar, nuguus, connected Bale Arsi massive, which create large watersheds and divided to Awash and wabe watersheds pass through the Districts. Soil types of the District were black soil 32%, red soil 25.5%, and loamy soil was 42.5%(CHDANRO 2018).

3.1.3. Climate and drainage

Through the District there were three Agro Ecology: - (highland) cold 17 %, (mid midland) moderate 38% and Desert (lowland) 45 %. Accordingly, *Belg* and *Kiremt*. *Belg* is the short rainy season and lasts between March and May. The *Kiremt* season, which is the longest rainy season, lasts between June and September. More than 75% of the total rainfalls during this season and the highest rainfall occur in July and August. Rain that occurs during the *Kiremt* season is very intensive and the warmest months of the area are between February and May. On the contrary, the coldest months of the study area range between June and August. October and November are windy months (CHDAO, 2018).

3.1.4. Vegetation and Wild life

The vegetation of the study area consists of different tree, shrub and herbaceous species. The common plant species include *Cordia Africana*, *Olea europea*, *Junipersprocera*, *Calpurnea aurea*,*Acacia* spp, *Ocimum* spp, *Ficus* spp, *Phoenix reclinata*, *Carissaedulis*, *Podocarpusfalcatus*,*Eucalyptus* spp, etc. Common crops in the study area include Barley (*Hordeumvulgare*), Wheat (*Triticum* spp.), Teff (*Eragrostis tef*), field pea (*Pisum sativum*), ground nut and Sorghum. Another is Chat (*Chata adulis*) is as cash crop (CHDAO, 2018).

3.1.5. Population

According to (CHDAO) report, total population of Chiro District was 207552, Out of 88873 for rural and 18679 for urban. Again 106,276 were male and 101,276 were female. The area is among highly populated areas of the country with a density of 231.1 people per square kilometers, which is bigger than the Zonal average of 101.8. Number of household was 38080 (CHDANO, 2018).

3.1.6. Socio-economic features

Chiro District is one of the District of west Hararghe zone, its livelihood depends on Agricultural production system. About 85% of the population depends on agriculture for their livelihood. There are two types of farming system found in the District; crop production and cash crop or chat. From the total land area coverage, 50% are suitable for crop production. During the main rain season, farmers plant sorghum, maize, chat and others like vegetable crops. The rainfall is erratic and crop failure is regular (CHDANRO, 2018). They use cultivated *chat* for their income. Thus, food insecurity is that the real and major problem and it must search lasting solutions in study area (CHDANRO, 2019).

Chiro Hospital is providing: inpatient, outpatient, emergency, preventive and primitive health services. The TB clinic in the hospital provides free anti tuberculosis drugs and free medical laboratory service. There are 39 health extension post, one per kebeles; seven health center and six lower limit Clinic in the District (CHDHPO, 2019).

3.2. Research Approach

Mixed methods of study was addressing the impact of climate variability on *Tuberculosis disease*. The mixing of quantitative and qualitative approaches are expected to enhance the overall strength of the study. To put it in a specific form, social survey and time series design were used as a research design. The reason for the selection of this method were to explain quantitative results with qualitative data. The data were analyzed separately and then compared and combined.

The purposive sampling method was used to select there sample kebeles out of the total 39 kebeles in the District. The Simple random sampling technique was employed to select 271 households from selected sample kebeles.

3.3. Sample Size and Sampling Technique

Multi-stage sampling technique was used. First, the district was purposefully selected due to the researcher's previous and current knowledge. The 39 *kebeles* of the district were stratified into three agro climatic zones such as highland, middle land and lowland. The Simple random sampling technique was employed to select 271 households from selected sample kebeles.

Three *kebeles* were selected According to agro-ecologies (one from each) i.e. *ciro-qela* from highland, lugo-bacesa from middle land and *madhicho-sadi* from lowland agro ecology by using simple random sampling.

3.3.1. Target population

The numbers of the households living in these three kebeles were 840. From those numbers of households chiroqalla contains 426, Lugo access 205 and madhicho sadii kebeles was about 209 households (CHDANO, 2018). So that, 271 households selected randomly from kebeles from lists of population names in series of numbers picked every interval of 19 person and 87 from chiro hospital TB patients. It was used simple random sampling to select sample households out of three kebeles because to give equal chance with climate zone.

3.3.2. Sample size Determination

This study was used a simplified formula provided by (Yamane, 1967), so as to determine the required sample size at 95% confidence level with a 5 % level of precision (e)

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

Where; n= sample size

N = the total household head n = 840/3.1; n = 271

Therefore, 271 sample respondents were selected by using (Yamane, 1967) formula. According to the total number of households in each sample kebeles sample respondents was determined proportionally, by using (Birch ally, 2004) formula: -

$$\mathrm{na} = \frac{Na}{N} \times n \quad \text{……………………….. Equation (2)}$$

Where: na = Sample of respondents from each sample kebeles

Na = Total households of each sample kebeles

N = Total households of sample kebeles n = Sample size

3.3.3. Sampling Technique

Chiro District was selected purposely from the 15 Districts of west Hararghe zone, because it was one of the most severely affected District by extreme climate variability and variability-related risks and was characterized by three distinct agro-ecological zones, highland, midland and lowland. District was divided in to 39 Kebeles, out of this three sample kebeles were purposely selected based on considering the variation in terms of agro climatic zones and accessibility and representation of the District features and near to meteorological Station.

The three sample kebeles have different agro climatic zone of which *chiro qalla* (highland), *Lugo bacceessa* (midland) and *madhicho sadii* (lowland). Three of them were selected purposely because of availability of data, magnitude of the problem of climate variability.

Table 1. Distribution of Sample Respondent by kebeles.

No	kebeles	Agro- ecology	No of Households in kebeles	Sample size in number
1	*Chiroqalla*	*Highland*	426	138
2	*Lugo bacceess*	*Midland*	205	66
3	*Madhichosadii*	*Lowland*	209	67
	Total		840	271

Source: (Own computation 2023).

In Addition, patients from Chiro general hospitals was interviewed for the case related reports and case test results per year. The metrology station of Chiro District in high school at chiro town was consulted to get data about climate related variables such as precipitation and temperature.

3.4. Types and Sources of Data

3.4.1. Types of Data

Qualitative data were collected through KII, Focus Group Discussion (FGD) and observation methods. FGD were discusses about climate variability in their residential kebeles and how do people perceive climate variability impact on tuberculosis. Observation methods were used in the field to see daily activity, habits and the largest group of people’s adaptation options practiced. Quantitative data were collected by administering a pre-tested interview schedule to the selected respondents. A questionnaire was used to collect information from the development agents, health extension workers and key informants.

3.4.2. Sources of Data

Both primary and secondary sources of data was used for this study. The primary data was collected from sample household, KII, FGD and meteorological data were used. Secondary data were collected from records of the District and zonal health office and related literatures prepped by governmental and non-governmental organization. The secondary data used to triangulate the primary data.

3.5. Instruments of Data collection

The data was collected by using Semi-structured questionnaire; KII, FGD and observation as instrument and some secondary data was from official report of health facility and metrological station. Data collection include climate variables (Rainfall and temperatures), tuberculosis disease case related in/outpatients (numbers of patients/year/woreda) and socio-economic variables (income, health personnel, Education, family numbers).

3.5.1. Questionnaires

Semi-structured questionnaire survey was employ to collect relevant data from the sample households for supplementing the data. Both close and open ended questions was prepared and distributed for selected sample of 271 households out of selected three *kebeles*. The questionnaire was administered by data collectors and it was translated to; *Oromic* before collecting data. Specific techniques were used for each specific objective.

3.5.2. Key informant interview

The key informant interview was conduct. The key informants were individuals who have a good knowledge of their locality, DAs, Health Extension worker, *kebeles* chair person. On other hand there was one KII woreda from concerned body.

Table 2. Key Informant Interviewed participants

No	Organization	Role	Number
1	CHANRO	Forest expert	1
2	Chiro district Environmental office	Office head	1
3	Chiro district Environmental office	Biodiversity expert	1
4	Chiro district Health office	Communicable disease control expert	1
5	From women representative	Representative	1
6	From youth representative	Representative	1
7	From merchants	Representative	7
	Total		

3.5.3. Focus group discussion

Three focus group was formed to discuss about perceptions of climate variability impacts and health with adaptive capacity which have nine members and one group for each kebeles group was selected according to their elite in the people, income, Education, Health personnel and by their experiences. It used discussion for develop questioner of HHs surveyed on impacts, causes and Effect, local adaptations to Climate variability and Tuberculosis disease

3.5.4. Observation

An important part of the research was also observation. It was done to know about the environmental situation and what the farmers did during visits to the villages for making interviews. Observation was not really data collection. But important parts of the field work because it gives the researcher a better understanding of the respondent’s situation. It was positive to try to see the situation through local people’s daily living.

3.6. Method of Data Analysis

The collected data was analyzed using both descriptive and inferential statistics. Qualitative data which was obtained from direct observation, FGDs and KII was analyzed by narrative descriptions. Whereas, the quantitative data generated by questionnaire was analyzed through inferential statistics (chi- square test, and correlation). Then annual maximum and minimum temperature and annual and seasonal rainfall values of Chiro district were analyzed in this study.

The existence of positive and negative trends among all the considered variables were analyzed using Statistical Product and Service Solutions (SPSS Version 20), meteorological (temperature and rainfall) and Tuberculosis disease data and adaptation method were analyzed using Microsoft Excel statistical software (mean, standard deviation, trends, coefficient of variation).

Analysis Concerns with climate trend, annual, *kiremt* and *belg* temperature and rainfall trend were analyzed. To determine rainfall and temperature trend, Mann-Kendall test was used. (Birsan *et al*., 2005).

3.6. 1. Independent variables

The independent variables in this study were climate variables, mainly focused on rainfall and temperature. A better value of CV is that the indicator of larger variability and vice versa which is computed as.

$$CV = \frac{\sigma}{\mu} x100$$ ………………………………………………… Equation 3

Where CV is coefficient of variation, σ is standard deviation and μ is that the mean precipitation. CV is employed to classify the degree of variability of rainfall events as, less when CV < 20, moderate when between 20 < CV < 30, and high when CV > 30 (Hare's, 2003), and higher CV value indicate that higher variability, moderate value indicates moderate and less values indicate low variability.

$$PCI = \frac{\Sigma Pi2}{(\Sigma Pi)\,2} x100$$ ………………………………………… Equation 4

Where Pi is that the rainfall amount of the i^{th} month; and Σ = summation over the 12 months.

Mann-Kendall (MK) test is widely used to detect trends of meteorological variables (Yilma and Zanke, 2004; Mekonnen and Woldeamlak, 2014; Tabari *et al*., 2015; Gebremedhin *et al*., 2016). On the other hand, the standard deviation is calculated as the square root of variance. Using the classification stated by Reddy (1990), the stability of rainfall is computed as:

$$SD = \sqrt{[\Sigma \qquad]}$$ …………………………………….……… Equation 5

When SD is standard deviation, SD <10 means very high stability, 10< SD<20 high stabilities, 20< SD<40 as moderate stability and SD >40 indicates less stability (Reddy, 1990).

Mathematically Mann-Kendall‟s test measured by;

$$S = \sum_{i-1}^{N-1} \sum_{j=i+1}^{N} sgn(x_j - x_i)$$ ………………….…………..…… Equation 7

Where S is the Mann-Kendal‟s test statistics; xi and xj are the sequential data values of the time series in the year's j and I (j > i) and N is the length of the time series.

Correlation and linear regression models were used to establish the relationship, cause, and effect of annual rainfall and temperature on Tuberculosis disease. The climate data was further correlated to Tuberculosis disease data. Correlation and linear regression models is used by the following formula:

$$Y = \beta 0 + b1\,x1 + b2\,x2 + \cdots + bnxn + e$$ ………………………. Equation 8

Where; Y= Tuberculosis disease, β0 = constant or intercept, b= parametric statistic, x_1= annual mean temperature, x_2 = annual total rainfall and e= error term.

Pearson correlation coefficient (r); analyses were used to analyze the correlation between health in general and (Tuberculosis disease in particular) with rainfall and temperature characteristics, value of r ranges between -1 to +1, a correlation coefficient closes to +1 indicates a strong positive correlation, a correlation coefficient closes to -1 indicates a strong negative correlation, while correlation coefficient of 0 indicates no correlation.

3.6.2. Dependent variable

For this study, the dependent variable in the empirical estimation is *Tuberculosis* patients in the districts. Pearson Correlation coefficient (r) analyses was used to analyze the correlation between Tuberculosis diseases (expressed in number of patients/years) with rainfall and temperature

Generally, descriptive statistics of climate variability analyzed by while other quantitative data analyzed by *SPSS* V20 and Microsoft Excel 2010, and information generated from key informant interview, focus group discussion and personal observation was analyzed qualitatively, and finally the results presented by frequency of occurrences, means, standard deviation, graph, table and figures. .

3.7. Reliability and Validity

3.7.1. Reliability test

Reliability is concerned with the extent to which a measure is consistent and stable in measuring what it is intended to measure; while validity is concerned with the accumulation of evidence about the extent to which an instrument or test actually measures what it is intended to measure (James, 2017). Thus, it was contacted experts from WHZANO, WHZHO and CHWANRO.

3.7.2. Validity test

Validity is concerned with the accumulation of evidence about the extent to which a study instrument actually measures what it is intended to measure (Kothari, 2004). Thus, question items were subjected to pre-testing on a small group of 19 (10 sample and 9 non sample) households in one sample kebeles. The purpose of the pilot test was to assess ease of comprehension, relevance, effectiveness in conveying useful information, and the questions are interpreted and understood by individuals. This procedure was conducted by familiar with tradition and local languages of community Thus, the validity test procedure helped ensure effectiveness of the items in proper information.

3.8. Ethical Considerations

Research ethics is the moral principle: which has an obligation to respect the rights, needs and desires of the informant(s) (Criswell, 2013). Barbie *et al.*, (2002) point out that conducting research requires good ethical considerations. The respondents were told that the information only be used for academic purposes. Ethical approval was granted by Haramaya University.

4. RESULT AND DISCUSSION

4.1. Background of Respondents

This chapter deals with presentation, analysis and interpretation of the time series data of Ten years (2008-2018). Data were collected from sample household heads, key informants interview and FGD and field observation. An attempt has been made to identify the observed temperature and rainfall changes and their impacts on Tuberculosis disease.

The socio-economic characteristics of sample households focus on social services, such as education; income, of a sample household head land ownership, land and livestock holding size and annual income. Livelihood was defined as adequate stock and flows of food and cash to meet basic needs (CHDED 2018). Finally, efforts were made to display the data by using graphs, tables and figures and percentage, which made the results clear and precise.

4.1.1. Household size and education

The number of persons in a family was related to the adaptation per person, according to (Canali M, et al. 2014). According to the interviews, the Chiro District household size ranged from 1 to 10 persons, 101 (27.3%) of respondents had less than 3 members, 99 (36.5%) of respondents had 3-7 members, and 99 (36.5%) of respondent’s members. There were 7 to 10 members in 71(26.2%) of the groups. This means that 36.5% of the households had an average size of three to seven persons, which was comparable to the country's average household size (CSA, 2007).

Education has traditionally been regarded as a tool of eradicating ignorance and enabling one to perform efficiently in any given work within a specific time frame (Kasanga, 2005). Figure 5 shows that the majority of the respondents, 134 (49.4%) were unable to read and write had no formal education, while 112(41.3%) had able to read and write whereas 25 (9.2%) had formal education level to high school. This indicates that the majority of respondents held unable to read and write. As a result, the majority of the respondents in the research area were expected to learn to play an active role in Climate variability impacts in their communities.

4.1.2. Household occupation, Income and landholding

Household respondents had a variety of jobs, according to the questionnaire research. Jobless, farmer, housekeepers, and other occupations fall within this category. As a result, the majority of respondents 234 (86.3%) were farmers followed by 14 (5.1%) house keeper, and 5(1.8%) jobless, out of a total of 271 households. The remaining 18(6.6%) of the respondents were engaged on other off farm activities.

Land was fundamental asset to the lives of subsistence farmers in rural Ethiopia. It was a source of food, shelter, income and social identity. The land ownership of sample households was assessed and the results revealed that of about 64(23.6%) of household was found landless. While 101 (66.8%) of household were owners. 26(9.6%) were shared from owner.

It was commonly understood that a household's annual income has an impact TB vulnerability and adaptation capacity. Table 3 shows that the majority of the respondents 106 (39.1 %) earned between 1500 and 3000 birr per month, 9 (3.3%) earned between 3001 and 5000 birr per month, and 11 (4.1%) earned between 5001 and 10,000 birr per month. While 4 (1.5 %) of them earned more than 10,000 birr, 121(44.6 %) earned between 601 and 1500 birr. the remaining 20(7.4%) earned less than 600.

For the current 2022 fiscal year, low-income economies were defined as those with a GNI per capita, calculated using the World Bank Atlas method, of $1,045 or less in 2020; lower middle-income economies were those with a GNI per capita between $1,046 and $4,095; upper middle-income economies were those with a GNI per.

According to World Bank 2022 Atlas:

Low-income level was that has monthly income less than 3000 Birr.

Middle income was those have monthly income between 3000 and 10000 Birr.

Higher income was that has monthly income greater than 10000 Birr.

Table 3. Income Category Total income per months’

Income range	Frequency	percent	valid percent
<601	20	7.3	7.4
601-1500	121	44.2	44.6
1501-3000	106	38.7	91.1
3001-5000	9	3.3	94.5
5001-10000	11	4.0	98.5
>10000	4	1.5	100.0
Total	271	98.9	100.0

Source: (SPSS, 2023)

4.1.3. Proximity to market center

The findings also revealed that the mean distance a sample household head needs to travel to reach the nearest local market or town center was found 19.7 kms that falls between length of 4 and 42 kms. Khatun and Roy (2012) suggested proximity to market has a significant influence on access to information sharing, frequency of contact to other households, advantages to diversify income options, inputs and outputs marketing.

Amare and Belianeh (2013); Barrett et al., (2001) also justified low pattern of livelihood diversification in remote areas during hazards was due to costly physical access to market center. Moreover, as most public institutions were located in urban centers the rural community adjacent to the urban area may look for additional job in urban centers in times of drought. The major market centers in the study area were Chiro: Ganda-hassan, Ganda-khulche as sample respondents, participants of FGDs and KII corroborated.

4.1.4. Proximity to health institution

Because vulnerability, mitigation and adaptations were varied greatly depending on the background characteristics of families, we attempted to create distinct sample households with various socioeconomic and demographic features in this study. According to KII from district health protection expert stated, there is average of health station 5km far away from 90% of rural community.

4.2. Temperature and Rainfall Variability

4.2.1. Temperature Variability

Study conducted by Tamiru (2015) stated that standardized maximum temperature anomaly also shows the general trend of maximum temperature at Mieso District over a period of 20 years, while warming trend of the minimum temperature at different spatial and temporal scales was reported by Jury and Funk (2012, Conway *et al.* (2004), NMA (2007), Tesso *et al.* (2012) and Zewdu (2012). Consistently, with Mengistu (2013) noted that, significant declining of minimum temperature in the western and northeastern parts of Ethiopia. In contradict, significant trend within the minimum temperature was absent in central, eastern and southern parts of Ethiopia (Mekasha *et al.*, 2013).

The temperature data for Chiro District for the year 2008 – 2018 was obtained and analyzed. Indicates some visible changes in temperature over the period of 10 years in Chiro District. It also showed that the maximum annual average temperature was 25.14 while the lowest annual average temperature was 22.56 occurred in the year 2014 and 2018, respectively.

4.2.2. Rainfal Variability

The quality of rainfall data is of great significance in reducing basis risk. Chiro District has four distinct seasons: a cold-dry season with low relative humidity (approximately May–August), a hot season with low relative humidity (approximately September–November), and a rainy season with high relative humidity (approximately December–April). Daily weather data (mean temperature [°C] and total rainfall [mm]) were obtained for (Chiro Weather Station 2019).

The rainfall trend analysis shows some significant changes in the rainfall patterns over the past 10 years in Chiro District. Rainfall in Chiro District indeed experienced a number of fluctuations over period. Analysis of annual average rainfall for the past 10 years showed that it ranged from 443.7 to 1265 mm with mean rainfall amount of 866.8mm, a SD of 252.6 mm and a CV of 29%. This indicates rainfall has moderate variability but it is very close to high variability. The area received lowest and highest annual rainfall amount at 2017 and 2012 year respectively.

The study is in agreement with NMA (2007) and Mc Sweeney *et al*. (2010) finding, who stated that both seasonal and annual rainfall exhibit high variability in Ethiopia, and study reported by Deressa *et al*. (2011) stated that moderately to high variability in rainfall was perceived in the country over the last 10 years.

The *kiremt* and *belg* rains over the last five decades show that the decreasing at a rate of 1.5 times faster than the monsoon summer rains, and *belg* rains are less voluminous, less reliable, and poorly predictable, and though agriculture in Ethiopia rely mainly on the *kiremt* rains (Fazzini *et al.*, 2015).

The mean of *belg* season total rainfall was 274.6 mm and the highest total rainfall amount was 538.40 mm in 2014 year, whereas the lowest being 78.50 mm in 2013 year, with less stability (SD of 136.1 mm), and highly variable condition (CV of 49.6%) then *kiremt* rainfall, which indicates that extreme rainfall variability observed in *belg* season.

In *kiremt* season, the mean rainfall amount is 357.3 mm and the highest total rainfall amount is 665.6 mm in 2017, whereas the lowest being 139 mm in 2013 with less stability (SD of 114.9 mm), and high variable condition (CV of 32.1%). *Kiremt* rainfall was relatively highly variable (CV=32.1%) and potential impact may have phased on crop growing as well as household food security.

Table 4. Descriptive statistics of annual, seasonal and monthly rainfall in Chiro District

Parameters	Min.	Max.	Mean	Std. Deviation	CV (%)
Jan	0.0	104.8	16.9	27.0	159.7
Feb	0.0	85.8	15.2	20.4	134.2
Mar	0.0	199.2	76.8	65.1	84.7
Apr	0.0	285.4	102.6	72.8	70.9
May	2.4	220.8	93.9	59.1	62.9
Jun	9.7	121.9	55.9	32.4	57.9
Jul	27.6	215.6	129.8	58.7	45.5
Aug	69.0	413.3	163.2	78.2	47.9
Sep	17.4	246.8	125.2	55.3	44.2
Oct	0.0	246.8	61.9	77.1	124.5
Nov	0.0	56.4	16.3	17.6	107.9
Dec	0.0	73.2	73.2	15.8	20.0
Belg	78.50	538.40	274.6	136.1	49.6
Kiremt	139.00	665.60	357.3	114.9	32.1
Annual	443.7	1265	866.8	252.6	29

Annual, *belg* and *kiremt* seasonal rainfall of the study area had a decreasing trend by a factor of -20.81, -0.36 and -4.49 mm per year, respectively for the past two decades. However, the trend was not statistically significant for *belg* and *kiremt* seasonal rainfall, but significant for annual rainfall trend. Sen's Slope of both seasonal rainfalls shows a decreasing trend by a factor of -0.36 mm per annual with -3.6 mm/decade for *belg*, -4.49 mm per annum with -44.9 mm/decade for *kiremt* (Table 4).

These results are consistent with Funk *et al*. (2012) report that stated *kiremt* rain in parts of Ethiopia has declined by 15-20 percent since the mid-1970s. USAID (2015) reported that, North and East parts of Oromia showed more rapid increases in maximum temperature in later part of *belg* (0.6°C per decade) and significant increases in the *kiremt* (0.4-0.6°C per decade) during 1981-2014.

4.2.3. Annual, seasonal and monthly maximum temperature variability and trend

In *belg* season, mean maximum temperature was 29.17 °C with a very high stability (SD of 1.95 °C), and less variability (CV of 6.68 %) temperature condition. In *kiremt* season, maximum temperature quantity extended from 26.93 to 30.30 °C with very high stability (SD of 0.81 °C) and a less variability (CV of 2.8%). Hence, less variability of maximum temperature observed during both seasons, these causes food security on study area.

The lowest maximum temperature amount December (16.8 °C) was recorded in 2013, August (24.2 °C) and September (24.5 °C) temperature were being in 2011, whereas highest maximum temperature recorded in 2018. The highest maximum temperature, March, April, May, and June were observed. On study area and neighboring, March, April, May, and June months were cultivation activity practiced. For this reason, drought occurred by maximum temperature had challenges for seed germination and plant growth.

Table 5. Descriptive statistics of monthly maximum temperature in District

Parameters	Min.	Max.	Mean	Std. Deviation	CV
Jan	25	30.2	26.8	1.4	5.22
Feb	26.0	35.1	28.2	2.0	7.09
Mar	26.4	37.7	29.3	2.2	7.51
Apr	27.5	37.4	29.0	2.0	6.90
May	27.4	36.8	29.3	2.0	6.83
Jun	27.7	37.1	29.5	2.0	6.78
Jul	26.5	30.2	28.1	0.9	3.20
Aug	24.2	29.5	27.0	1.1	4.07
Sep	24.5	29.3	27.2	1.1	4.04
Oct	25.2	29.6	27.2	1.2	4.41
Nov	25.7	29.3	27.1	0.9	3.32
Dec	16.8	28.5	25.1	2.5	9.96
Kiremt	26.93	30.30	28.23	0.81	2.87
Belg	27.43	37.28	29.17	1.95	6.68
Annual Tmax	26.90	30.80	27.83	0.88	3.16

Tmax; Maximum temperature, Min; minimum value, Max; maximum value; SD; standard deviation; CV; coefficient of variation.

The finding was linked with results in Conway *et al*. (2004), NMA (2007);Tesso *et al*. (2012); Mekash *et al.* (2013) that stated a warming trend of annual maximum temperature in Ethiopia. Additionally, decreasing trend observed in *belg* and increased trend detected in *kiremt* season and *kiremt* maximum temperature trend increased by a factor of 0.14 °C/year and 1.4 °C/decade, whereas *belg* maximum temperature trend decreased by -0.04 °C /year.

Annual minimum and average temperature of the Chiro District were extended from 13.48 to 16.05 °C and 20.3 to 22.62 ^{0}C with mean value of 14.77 and 21.29 °C respectively, where the quantity of minimum temperature value indicates less variable (CV of 5%) and a very high stability (SD of 0.74 °C), and average annual temperature indicates also less variable (CV of 0.02%) with a very high stability (SD of 0.59 °C).

According to Wasihun *et al*. (2019) report, annual minimum temperature over Habro District was less variable and stable, but more variable than average annual maximum temperature (CV=3.50%).

Minimum mean temperature of *belg* season was 14.77 ^{0}C, while lowest 13.87 and highest 17.20 °C *belg* season minimum temperature were recorded in 2011 and 2016 respectively, with very high stability (SD of 0.81 °C) and less temperature variability. In *kiremt* season, 14.77 °C was mean of minimum temperature, whereas lowest and highest minimum temperature were 13.70 and 17.03 °C respectively.

On the other hand, the smallest monthly minimum temperature was recorded in December (8.3 °C), then followed by November (9.2 °C) and January (9.5 °C), while highest monthly minimum temperature amount occurs in the month of February and June (18.1 °C), then followed by March (17.7 °C). Monthly SD of monthly minimum temperature amount varied from 0.58 to 2, and monthly CV between 3 to 17%, which is indicated that all monthly minimum temperature very high stability and less variability respectively.

January has highest variability than other months with a CV of 17%, while August has lowest minimum temperature variability with a CV of 3 %. Months of December, November and

January were coldest months, whereas, February, March and June months were warmest months. This result is consistent with IDP (2006) report, which stated that June is the warmest month of the year, while December and January are coldest months.

Table 6. Descriptive statistics of monthly minimum, maximum and annual mean temperature

Parameters	Min.	Max.	Mean	Std. Deviation	CV
Jan	9.5	16.6	12.78	2.12	16.59
Feb	10.8	18.1	14.11	2.28	16.16
Mar	12.4	17.7	15.09	1.52	10.07
Apr	14.2	17.4	15.83	0.89	5.62
May	14.3	17.6	16.32	0.86	5.27
Jun	13	18.1	16.35	1.14	6.97
Jul	12.1	17.1	15.58	1.17	7.51
Aug	14.1	16.2	15.70	0.48	3.06
Sep	14.8	16.9	15.64	0.58	3.71
Oct	13	17.1	14.96	1.25	8.36
Nov	9.2	15.7	13.08	1.95	14.91
Dec	8.3	15.8	11.79	2.36	20.02
Kiremt	13.70	17.03	15.88	0.83	5.23
Belg	13.87	17.20	15.75	0.81	5.14
Annual Tmin	13.48	16.05	14.77	0.74	5.01
Annual Tmean	20.30	22.62	21.29	0.59	2.77

Tmin; Minimum temperature, Tmean; Mean temperature, Min; minimum value, Max; maximum value; SD; standard deviation; CV; coefficient of variation.

Both annual minimum and mean temperature trends were statistically non-significant at α= 0.05, while both *kiremt* and *belg* minimum temperature showed a statistically significant increasing trend by a factor of by 0.13 °C and 0.2 °C/year respectively.

It has been demonstrated that farmers in both East and West Africa see opportunities to benefit from seasonal weather (Rao and Okwach 2005; Ron coli *et al.* 2009).

Ashenafi *et al*. (2019) reported that, the rate of increase in the mean annual maximum temperature was faster than the minimum.

Analysis of historical climate data across Ethiopia has presented increasing rates 0.13°C per decade and 0.37°C per decade for mean annual minimum and maximum temperature respectively. Statistically, minimum temperature trends of all months were non-significant except April and March, at $\alpha = 0.05$.

Mengistu (2013) reported significant declining trends for minimum temperature within the western and northeastern parts of Ethiopia, whereas Mekasha *et al*. (2013) reported no significant trend for minimum temperature in central, eastern, and southern parts of Ethiopia. Generally, most of the study results revealed that minimum temperature has been faster increased than maximum temperature.

4. 3. Temporal Analysis of Tuberculosis disease

Various researches have been conducted from different parts of world. which included in my write-up showed that there are more records of Tuberculosis disease outbreaks during the peak of the winter and new cases are been recorded during those peak periods; except for south Africa which showed a monthly occurrence of Tuberculosis disease irrespective of the change in climate. India also showed a seasonal pattern, with a peak during the months of March, April, May, October and December and new tuberculosis strains were discovered during these periods which falls during the spring season in Ethiopia.

Generally, findings indicate that weather conditions were associated with changes in Tuberculosis disease case. In Chiro, many people migrate from urban areas during onset of the rainy season to plant crops, with older adults more engaged in subsistence and commercial farming activities. This period of rainfall onset around November concedes with the end of hot temperatures and was consistent with our results of reduced overall Tuberculosis disease notifications. Care-seeking may not happen until after the planting period was completed. With adults moving to farmlands, children were also less likely to be identified with Tuberculosis like symptoms in the absence of caregivers.

Table 7. Socio demographic characteristics of the respondents in Chiro hospital.

Variables		Number	Percent
Sex(N=87)	Male	50	57.1
Female		37	42.9
Age category in years (N=87)	5-14yrs	5	6.1
	15-24yrs	16	18.4
	25-34yrs	30	34.7
	35-44 yrs	23	26.5
	45-54 yrs	9	10.2
	>=65 yrs	4	4.1
Level of Education(N=87)	Illiterate	40	45.9
	Elementary(1-8 grade)	34	38.8
	Secondary(9-12 grade)	9	10.2
	College	4	4.1
Marital status (N=87)	Married	61	70.1
	Single	20	22.4
	Divorced	4	4.1
	Widowed	2	2.0
Occupational status (N=87)	Farmer	15	17.2
	Merchant	25	28.7
	Employed	15	17.2
	Others(Daily laborer, student,	32	36.7
Monthly income(Birr) (N=87)	<500	30	34.7
	500 -1000	37	42.9
	1000 – 1500	11	12.2
	1500 – 2000	4	4.1
	> 2000	5	6.1
Residence (N=87)	Rural	9	10.3
	Urban	78	89.7
Distance from HFs(N=87)	0-3 KMs	78	89.7
	4-6 KMs	9	10.

In Cameroon, Tuberculosis disease cases increased during rainy seasons (Ane-Anyangwe, et al 2006).

According to Esmail et al.2012 postulated that bouts of cough due to infections other than Tuberculosis disease("unrelated cough") may promote Tuberculosis transmission and increase subjective awareness of previous subclinical Tuberculosis disease symptoms, increasing the likelihood sputum positivity, and of care-seeking and Tuberculosis disease diagnosis (Murray, E. L. *et al*. 2018).

Although some of our results are similar to what others have previously reported on the influence of seasonality and weather on TB notifications, some differences and limitations exist. For instance, in chiro, TB incidence was significantly associated with both lower rainfall and high temperature.

4.3.1. Trends of TB case notifications by sex and age

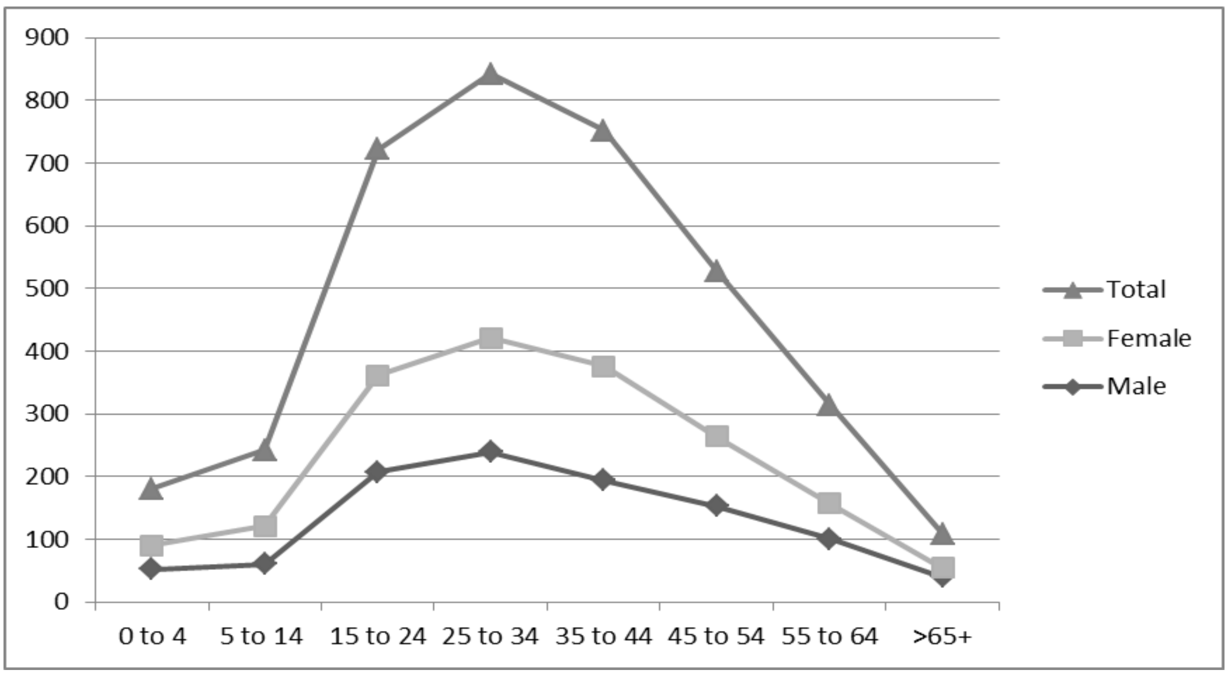

Figure 3**.** Trends of TB case distribution by sex and age Source: (WHHO 2022).

Table 8. TB cause, transmission, symptoms and prevention in Chiro hospital.

Variable	Frequency	%
Source of infection		
Bacteria	34	38.8
Cold air	37	42.9
Don't know	16	18.4
Total	87	100.0
Means of transmission		
Coughing /sneezing	64	73.5
Sharing dishes	2	2.0
Cold air	4	4.1
Drinking raw milk	14	16.3
Don't know	4	4.1
Total	87	100.0
Signs & symptoms		
Cough > 2 weeks	46	53.1
Coughing up blood	9	10.2
Night sweating	12	14.3
Shortness of breathing	7	8.2
Fever	7	8.2
Others(severe headache ,loss of appetite, chest pain)	5	6.1
Total	87	100.0
Prevention	32	36.7
Covering mouth& nose when coughing	20	22.4
Avoid drinking raw milk	16	18.4
Avoid sharing dishes	7	
Good nutrition	7	8.2
Closing window	5	8.2
Dot know		6.1

Source: (FMOH 2016)

4.3.2. Tuberculosis distribution by health center and type category

According to case Reports from WHHO 2022, Tuberculosis disease patient in chiro district as a general Frequency found to be 915, of which is about 292 is in hospital, 474 in chiro rural and 149 in chiro town.

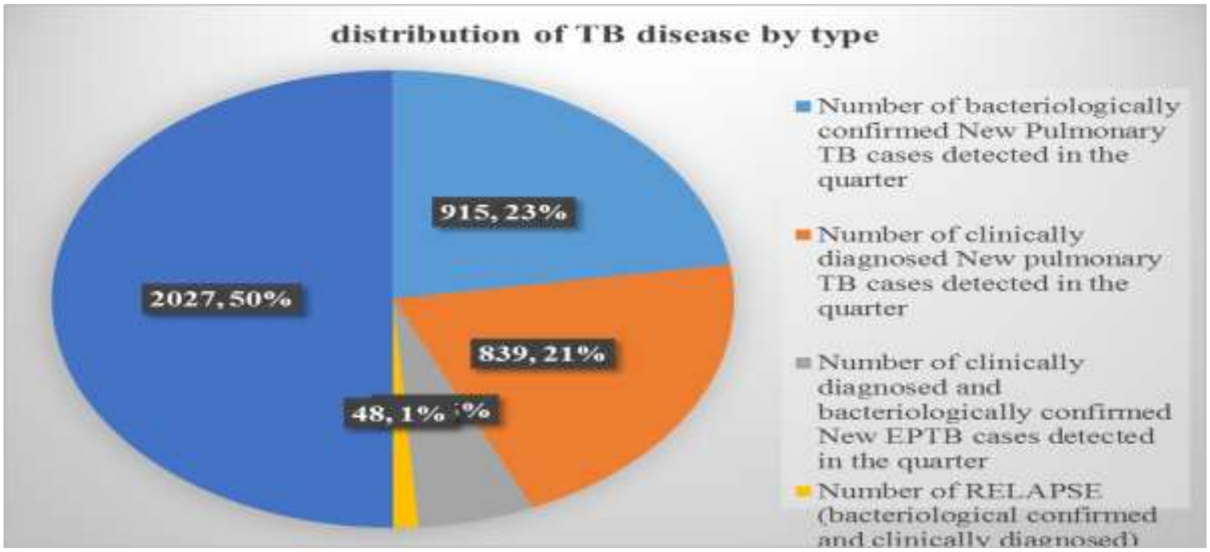

Figure 4. -Tuberculosis distribution by type category

1, Number of bacteriologically confirmed Tuberculosis case in health center

Number of bacteriologically confirmed new pulmonary Tuberculosis case detected in quarter were 2027 which cover about 50 percent.

2, Number of clinically diagnosed new pulmonary Tuberculosis disease case detected in quarter were 839 which is about 21 percent.

3. Number of clinically diagnosed and Number of bacteriologically confirmed new EPTB Tuberculosis disease case detected in quarter were 48.1% Which is about only 1 percent.

4. Number of RELAPSE clinically diagnosed and Number of bacteriologically confirmed new EPTB Tuberculosis disease case detected in quarter were about 915 and it is about 23 percent. (FMOH, 2016).

4.4. Correlations between climate variables and Tuberculosis disease

It may also mean that household crowding was reduced during this period resulting in even lower transmission events of Tuberculosis disease and related respiratory infections leading to reduced care seeking. With the usual onset of heavy rains, access to clinics (both for patients and health workers) may be challenging, with substandard roads, flooding and storms making roads treacherous and limiting transport options. Additionally, men have substantially longer delays in initiating care-seeking for Tuberculosis disease compared to women (Horton et al 2018).

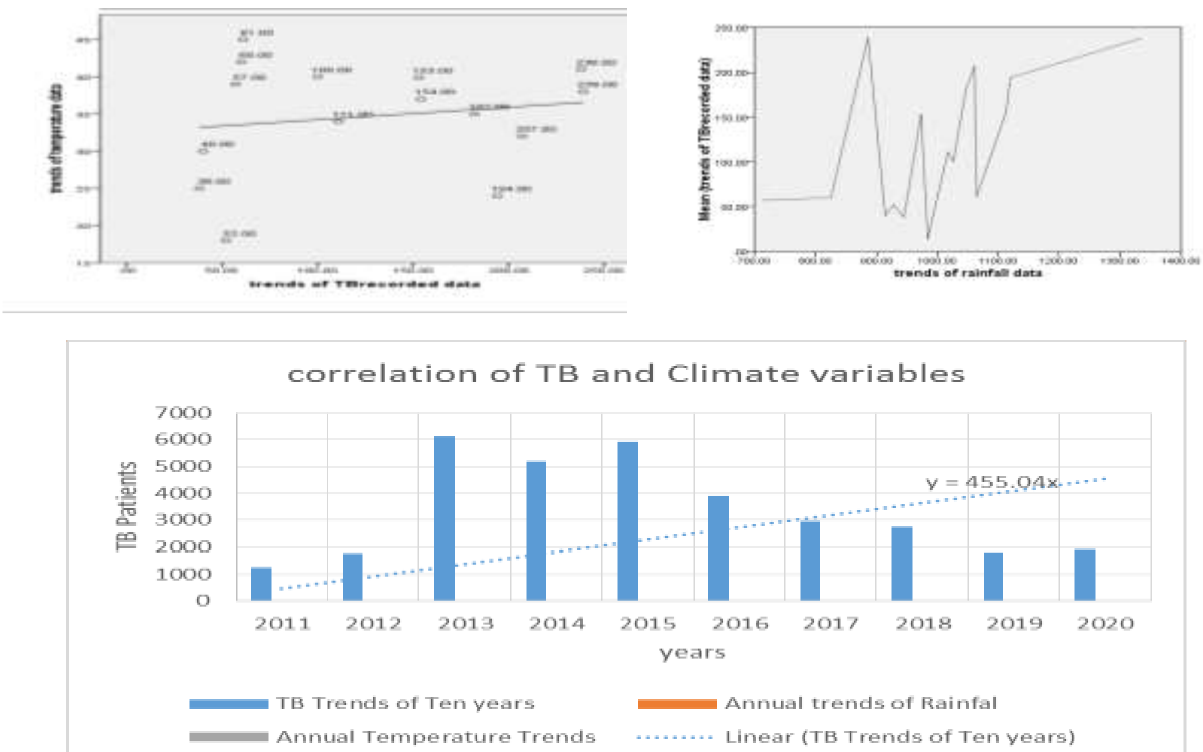

Figure 6. The correlation between rainfall and Tuberculosis disease

Chiro tuberculosis case notification rates, average weekly rainfall and temperature showed a pattern of peaks and troughs indicating seasonal variation in the TB. With most years having two peaks. Peaks tended to coincide with increasing temperature in September and October before the onset of rains, and later in the rainy season during January and March. The associations between rainfall and temperature and TB notifications, comparing conditions with no rainfall (0 mm) and low weekly average temperature (17 °C) to conditions with weekly average mid (18 mm) and high rainfall (30 mm), mid (20 °C) and high temperature (30 °C).

Farmers of our countries very dependent on *kiremt* rainfall amount for their crop production and a small fluctuation in the rainfall amount directly affect crop productivity (NMA, 2007).Furthermore, the monthly total rainfall amount was lowest for January, February, November and December, while highest rainfall observed in the month of April, August, September, and October. September to October months of crop maturation and harvesting. Therefore, high amount of rainfall may have negative impact.

According information from health experts and food security office of chiro district "Variations in Tuberculosis due to seasonality and weather could be mediated by increased transmission due to indoor overcrowding, limited healthcare access, patterns of seasonal respiratory infections precipitating cough and care-seeking, or migratory patterns related to planting and harvesting during rainy season".

Table 9. Tuberculosis distribution by trends of climate variables

Years	TB Trends of Ten years	Annual trends of Rainfall in (Dm)	Annual Temperature Trends in **(°C)**
2011	1234	5.58	20.55
2012	1786	8.24	24.44
2013	6154	10.17	21.38
2014	5200	8.85	20.44
2015	5939	6.94	24.21
2016	3889	8	23.01
2017	2967	7.07	25.66
2018	2760	8.15	23.66
2019	1806	9.32	21.89
2020	1899	8.28	25.81

Generally, findings indicate that weather conditions were associated with changes in Tuberculosis disease case. In Chiro, many people migrate from urban areas during onset of the rainy season to plant crops, with older adults more engaged in subsistence and commercial farming activities. This period of rainfall onset around November concedes with the end of hot temperatures and was consistent with our results of reduced overall Tuberculosis disease notifications. Care-seeking may not happen until after the planting period was completed. With adults moving to farmlands, children were also less likely to be identified with Tuberculosis like symptoms in the absence of caregivers.

4.5. Adaptations strategies to climate variability Impacts

According to FGD at kebeles level stated, adaptation efforts was requiring first steps towards mainstreaming climate issues into all national, regional, District and sectorial planning processes, such as poverty reduction strategies. It was equally important that a ministry with a broad mandate, such as finance and economic affairs was being encouraged to be fully involved in mainstreaming adaptation. Health education and good food hygiene were equally important. Also, strengthening surveillance and early warning greatly helps in detecting the first cases and put in place control measures. Reactive measures include treatment of the disease to reduce the negative impacts.

Many adaptation mechanisms need to be strengthened by making progress in areas such as good governance, human resources, institutional structures, public finance, and natural resource management. Such progress builds the resilience of the country, communities, and households to all types of shocks, including climate variability impacts. An approach that uses both mitigation and adaptation was needed. (District level KII 2022)

Current commitment to mitigate climate variability by limiting the emission of greenhouse gases was not, even if implemented, stabilize the atmospheric concentrations of these gases. Adaptation should not be approached as a separate activity, isolated from other environmental and socio-economic concerns that also impact on the development opportunities to the poor. A comprehensive approach was needed potential synergistic and antagonistic effects between local and global environmental changes and socioeconomic factors.

4.5.1 Traditional Adaptation

Traditional coping mechanisms at household and community levels were backward looking, based on historical experience and observation. In the face of changing patterns of climate variability and the significant deviations from historical experience, their effectiveness may be significantly reduced. This climatic shock caused some of the poorer farmers to give up maize farming and opt instead to sell their labor at farms in other more productive areas. The resulting dependence on physical working capacity as their sole endowment increased vulnerability, since malnutrition and disease can reduce their capacities for manual labor and force drastic changes to livelihood strategies.

Where economic diversification was low, income opportunities and hence option for developing alternative livelihoods in response to climatic variability may be limited. In some cases, migration, which was an important coping strategy for poor people, might be the only solution, but was potentially cause social disruption. Traditional/religious healing practices Patients and healthcare workers mentioned various informal healing practices including herbal medicines, spiritual healing practices and non-prescription medications.

The practices attempted before visiting healthcare facilities were the use of herbs, Chat chewing as a pain reliever, religious healing (Qur'an read by sheiks followed by something to drink), visiting traditional healers, and self-medication with antibiotics and syrups. Patients who thought their illness was caused by a curse opted for religious leaders, traditional healers, or herbal remedies.

The herbs used to treat pulmonary illnesses are locally named, Galool (Acacia bussei), Liike, and Ruman (Pomegranate). A 45 years pastoralist explained his experience as: "I didn't think that I had TB. I used 'Galool' leaves, boiled like tea and drunk it. I then tried 'Ruman' leaves. At last, I became very weak and bed-ridden." Medications by informal drug vendors More than half of the interviewed patients sought first care at rural drug vendors where they received medications.

4.5.2. Modern Adaptation

The adaptive measures that households use when faced with climate change could also differ in terms of their ease of implementation, equity effects, lag between implementation and effect, their cost of implications, compatibility with other programs, and agencies implementing measures Admassie, 2008).

To avoid future health risks associated with climate change, it will be necessary to organize and implement community-based health education programs in order to raise awareness and educate local population about the importance of personal hygiene and environmental health management. Such a community-based mechanism would benefit from training programs to build local capacity to take up adaptive measures such as use of bed nets and to encourage the use of climate and meteorological data in the planning of Vector control measures (CRACP 2011).

It observed that the rural health centers have very small rooms (roughly 2X3 square meters) but no isolated TB laboratory. District level manager said: "There is no standard TB clinic in health centers. The majority of them have very narrow rooms that are not ventilated and isolated. We always shout for renovation, but………" In addition to inadequacies in health centers, at the referral hospital there were shortage of rooms for admitted and TB patients.

Rural drug shops (mostly unlicensed) are common in remote areas of the region. Patients chose these drug vendors as first point-of-care due to their convenience and permissive process to purchase drugs and obtain treatments. At rural drug shops, patients are told as having ailments like pneumonia and anemia without medical examinations and given injectable and capsule medications. Patients only sought healthcare at a health center/hospital when the illness did not improve or got worse. A 27 years old patient said: "The first time I felt this illness, I went to the little pharmacy in our kebeles. The vendor said 'you have pneumonia'. He gave me injections, but I didn't recover. Lastly, I decided to come here." Factors affecting effective service delivery.

4.5.3. Integrated Adaptation

There were two main types of adaptation measures to climate variability: reactive, which were measures taken in response to climate variability, and preventive measures taken in advance of climate variability to minimize or offset adverse impacts. Measures for the prevention of TB mostly consist of providing clean milk, food, water, air and proper sanitation to populations who do not yet have access to basic services. According to FGD and KII, it is discussed that local community adaptation type varies depend on Income level, Education level, household size and some other socioeconomic values and factors. Access to health center and water availability have also contribution to help way to local adaptation. Some of the indigenous knowledge was used to adapt Tuberculosis disease impacts orally learned from elders: like eating garlic, eating better food type and clothing type from local extreme weather events.

5. SUMMARY AND CONCLUSION

5.1. Summary

In summary, there were number of potential impacts of climate variability on the national development goals. Climate variability was projected to reduce poor people's livelihood assets, health, and access to water, homes, and infrastructure. In conclusion, Tuberculosis in Chiro were seasonal with peaks at the start and end of the rainy season, and were significantly influenced by weather conditions, particularly heavy rainfall and extreme temperatures.

According information from health experts and food security office of chiro district "Variations in Tuberculosis due to seasonality and weather could be mediated by increased transmission due to indoor overcrowding, limited healthcare access, patterns of seasonal respiratory infections precipitating cough and care-seeking, or migratory patterns related to planting and harvesting during rainy season".

Studies of ecology of the disease agents and their reservoirs would be especially valuable. Such information could be used to predict more accurately which of the diseases to target as threats, and which was less likely to spread and/or become more severe. Attribution to current and future climate variability related disease burdens was a challenge because the determinants of diseases were complex.

The magnitude and factors affecting climate variability related diseases among communities in Ethiopia need to be better quantified. Research and information on the links between climate-change related diseases were therefore, necessary.

5.2. Conclusion

According to, participants from community representatives, health extension workers, DA and experts of Agriculture in different group, identified that; the area is affected by various factors such as, shortage of water, scarcity of feed, epidemic of livestock's disease such as foot and mouth diseases, and also raw milk of infected cow causing tuberculosis diseases to people are the most prevalent in the Districts that brought many to deaths. Again FGD and KII of the Districts describe as climate variability affects all ecosystem, both local people and labor resource and Again livestock's and their products which results in reduced livestock productions and their products. (CHDAO, 2018).

According to KII and FGD at District level generating and acquiring new knowledge or synthesizing existing knowledge on anticipated future climate variability risks and their possible consequences, responses to these stresses have to be faster, more efficient and effective.

5.3. Recommendation

The government should bring together stakeholders with a role in the climate variability agenda to discuss and agree on a common strategy to address climate variability and its impact on socio-economic development.

It was envisaged that the local population was increased knowledge of potential health impacts of climate variability; was able to identify key groups including professionals, politicians, policy makers and community groups who have roles to play in reducing likelihood of adverse health outcomes from climate variability and ultimately, be more aware of what action was needed to reduce likelihood of adverse health outcomes.

FGD suggest that the results from this study can be used to plan service needs in Chiro by anticipating higher service use between November and March. Furthermore, the government can play a significant role by promoting policies aimed to enhance adaptation at household level through basic public services and the support of extension services.

Ethiopia should aim to devise better direct intervention measures for these diseases. Moreover, health professionals especially TB focal persons in the health centers should give emphasis for completeness and updating of information on TB prevention and control program registers. Managers at the Chiro Hospital/Chiro town/Zonal health office level should strengthen supportive supervision to the health centers to support the TB prevention and control program by providing necessary materials and supplies for IEC/BCC services. In this study as well as in previous studies little is known about TB related knowledge, adherence and their association, so further studies are suggested.

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7. APPENDIXES

Appendix 1. Questionnaire to be filled by Sample Household Heads

My name is Hadi Aliyi Ahmed. I am MA student in Haramaya University studying Geography and Environmental studies (Climate Change and Disaster Risk Managements). I am doing my thesis on: Impact of Climate Variability on Human Health: The Case of Tuberculosis disease in Chiro District, Oromia Regional State, Ethiopia. The objective of this Questionnaire is to collect data for the purpose of education and all information provided will be simply used for education purpose and remain confidential. You are kindly requested to answer all questions. I would like to express my appreciation in advance for your cooperation in giving me your time and being committed for the success of this work. Thank you in advance.

1.1. General Characteristics of Respondents

1. Name of kebeles------------------------------------- Dates of Interview-------------------
2. Enumerator‘s name------------------------------------Signatures ---------------------------
3. Checked by--- Signatures--------------------------

Part I. Demographic and Socio-Economic Characteristics and Institutiona
Land tenure Owned

S/No.	Variables	Data type to be filled	Make "x" symbol on choice
1.	Sex of households	Male	
		Female	
2.	Altitude	<500amsl	
		500-1500amsl	
		1500-2000amsl	
		>2000	
3.	Marital status	Unmarried	
		Married	
		Divorced / Widowed	
4.	Age of respondent	<5	
		5-65	
		>65	
5.	Education	Un able to Read and write	
		Read and write	
		High school	

6.	main Occupation	No occupation Farming Non farming
7.	land ownership	Own shared Rent
8.	Family size	Female male Total
9.	Farm size(**hectare**)	<0.25 0.25-0.75 0.75-2 >2
10.	Income per year in Ethiopian birr from (Livestock, On farm , OFF fam, and others)	<5000 5000-10000 10000-50000 50000-100000

Part II: Climate Variability

12. Do you think the climate variability in past decade? 1. Yes ☐ 2. No☐

13. If Q. No ‘12’ is ‘yes’ what is relation of climate variability and Tuberculosis disease?

1. No affect ☐ 2. Increase ☐ 3. Decrease☐.

14. If Q. No ‘12’ is’ yes’ is there Tuberculosis disease caused by climate variability??

15. Do you think The Rainfall Change happened in last Ten years? 1. Yes ☐ 2.No ☐

Part III: Association between Climate Variability and TB

16. If Q. No. ’15’ is’ yes’, what is relation of climate variability and Tuberculosis disease? 1. No affect ☐ 2. Increase ☐ 3. Decrease☐.

17. If Q. No ’16’. Is’ yes’ is there TB caused by climate variability? 1. Yes.☐ 2. No, ☐

Part IV: Impacts of Climate Variability on TB

18. Is there factors affect use of health services? 1. Yes ☐ 2. No ☐

19. If Q. No. '18' is 'yes' what is that? 1. Far distance ☐ 2. Poor services ☐
3. No medicine ☐ 4. High cost ☐ 5. Other ☐specify__________________

Part V: Adaptation Strategies to climate variability

20. Which adaptation measure you use to Climate Variability Impact on Tuberculosis disease? 1. Traditional ☐ 2. Modern☐ 3. Others☐ (specify) ___4. No Adapt ☐

21. If you practice Modern Adaptation, which type you practice? __________________

22. If you practice Traditional Adaptation which type? _____________

23. Which Adaptation practice you use for climate variability? shocks on TB?
1. Traditional☐ 2. Modern☐ 3. Others ☐(specify) ___________4. No Adapt☐

Part VI: Determinants of Adaptation Strategies to TB

24. If you use Modern Adaptation strategies which type you practice? ________________

25. If you practice Traditional Adaptation to TB which type? _________________

26. What is your suggestion for the government, NGO and Local Communities to do with Climate Variability Impact on Tuberculosis disease? ___________

Checklist for Key Informant Interviews

1. Personal information

Name______________________Position/profession_______________________

2. Climate and human health related questions

Is there Temperature variability relate with human health (TB)? 1. Yes ☐ 2. No ☐

If the answer to Q no.'1'is 'yes', explain the relation of Temperature variability health in your area? 1. No affect ☐ 2. Increase☐ 3. Decrease☐,

3. Is there Tuberculosis Caused by Temperature Fluctuation? 1. Yes ☐2. No☐
4. How Rainfall change relate to human health? 1. No affect☐ 2.increase ☐3.Decrease☐
5. Is there Tuberculosis disease Caused by Rainfall Fluctuation? 1. Yes ☐ 2. No☐

3. Health Institution Service

6. Is there factors affect use of health services? 1. Yes ☐ 2. No ☐
7. If you say 'yes' what are there? _______________________
8. What method or knowledge you use to forecast and pro-act change in climate with human health? 1. Government ☐ 2. NGO ☐ 3. Local elders ☐

4. Adaptation

9. What local/ traditional Adaptations used to reduce climate related (TB) disease? ______
10. What modern adaptation used you know to reduce climate related (TB) disease? _____
11. What is the challenge to adapt impact of climate change on health? Describe: _______
12. What is the solution to these challenges? Describe: _______________________

GUIDE FOR FOCUS GROUP DISCUSSION

1. District Experts

1. What are the climate variability in the past decade?

1. No affect 2. ☐ 3. Increase ☐ 4. Decrease ☐

2. Is there Tuberculosis disease related to climate variability? 1. Yes ☐ 2. No ☐

3. What are the local adaptation mechanisms used to reduce the effects? _________

4. What are the modern adaptation mechanisms used to reduce the effects? ____________

5. What is your suggestion for the government, NGO and local communities to do with climate shocks on Tuberculosis disease? _______________________

2: Farmer Trainers, DA's and Extension Workers

5. What are TB relations to climate variability in past decade?

1. No affect 2. ☐ 3. Increase ☐ 4. Decrease ☐

6. Is Tuberculosis disease known to be related to climate variability? 1. Yes ☐ 2. No ☐

7. What are the local adaptation mechanisms used to reduce the effects? ____________

8. What are the modern adaptation mechanisms used to reduce the effects? __________

9. What is your suggestion for the government, NGO and local communities to do on Tuberculosis disease? _________________________

3: Smallholder Farmers (3 FGDs for Three *Kebeles*)

10. What are the TB relations to climate change in the past decade?

1. No affect 2. ☐ 3. Increase ☐ 4. Decrease ☐

11. Is Tuberculosis known to be related with climate variability? 1. Yes ☐ 2. No ☐

12. What are the local adaptation mechanisms used to reduce the effects? ____________

13. What are the modern adaptation mechanisms used to reduce the effects? _________

14. What is your suggestion for government, NGO and local communities to do on TB? ____

Appendix .2. Some primary and secondary Data tables in document

Appendixes Table 1. Key Informant Interviewed participants

No	Organization	Role	Number
1	CHANRO	Forest expert	1
2	Chiro district Environmental office	Office head	1
3	Chiro district Environmental office	Biodiversity expert	1
4	Chiro district Health office	Communicable disease control expert	1
5	From women representative	Representative	1
6	From youth representative	Representative	1
7	From merchants	Representative	7

Appendixes Table 2. Trends of average temperature, rainfall, Change in TB disease of the study area

YEAR	AVERAGE ANNUAL RAINFALL (MM.)	AVERAGE ANNUAL TEMP. (°C)	TB RECORDED DATA OF PATIENTS
2011	5.58	20.55	1234
2012	8.24	24.44	1786
2013	10.17	21.38	6154
2014	8.85	20.44	5200
2015	6.94	24.21	5939
2016	8	23.01	3889
2017	7.07	25.66	2967
2018	8.15	23.66	2760
2019	9.32	21.89	1806
2020	8.28	25.81	1899

Source: NMA, 2020

Appendixes Table 3. Chiro annual rainfall trends of one decades

Row Labels	1	2	3	4	5	6	7	8	9	10	11	12	Grand Total
2011	1	121	131	71	60	65	140	193	66	4	39	9	900
2012	5	3	26	238	97	83	168	265	120	0	58	2	1065
2013	1	0	21	159	37	37	154	209	98	11	0	1	728
2014	10	0	103	99	432	228	196	201	69	190	88	0	1616
2015	1	178	53	146	89	23	197	185	163	151	6	1	1193
2016	0	0	27	10	164	143	142	213	121	13	12	2	847
2017	26	13	32	244	228	76	179	235	109	13	13	0	1168
2018	0	35	77	105	171	65	164	239	235	82	3	0	1176
2019	0	148	165	145	99	65	74	224	45	53	28	1	1047
2020	0	15	34	46	66	114	143	199	98	57	41	3	816
Grand Total	525	1179	2010	3624	3209	2591	5679	6602	3801	1989	847	157	32213

SOURCE: (WHANRO)

Appendixes Table 4. Monthly mean rainfall of chiro metrological station

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2011	32	10.1	42.2	71.1	92	51.8	93.7	95.6	58.2	59.9	54.5	63.3
2012	2.5	85.8	199.	87.2	65.1	49	133	103	211.	0	3	0
2013	0	0	43.2	36	110.	46	98.5	147.	57.5	0	0	4
2014	0	0	0	95.5	44	33.7	88.5	192	108.	13	1.6	7
2015	26.7	2	7	51.5	20	12	58	69	98.4	5	41	5
2016	0	3.1	172.	174.	190.	31.5	181.	205	108.	147.3	8.9	3.1
2017	0	0	9	42.6	131	101.	49.8	236.	105.	2.6	0	18.8
2018	5.3	36.6	39.6	254.	220.	87.7	205.	119.	116.	28.2	4.4	10.9
2019	2.6	39.1	24.5	35.5	77.6	20.9	86.2	162.	166.	11	0	0
2020	3.9	25.9	32	144.	149.	54.3	67.2	141	98.7	69.2	25.9	9.4

Appendixes Table 5. Sum of annually temperature tends of chiro woreda

Row Labels	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Grand Total**
2011	24.1	25	25.1	28.1	29.1	29.1	26	25.4	25.4	27.6	26	25.3	316.2
2012	24.4	26.3	26.4	28.9	27.9	29	27.3	25.6	25.3	26.8	25.8	24.6	318.3
2013	23.7	29.4	26.6	26.4	28.8	29	26	25.3	26.5	26.7	26.8	25.5	320.7
2014	24.9	26.9	27.9	28.9	29.9	28.8	26.4	25.7	26.3	26.5	25.7	24.4	322.3
2015	25.1	25.7	27.4	28	28.5	29.5	27	26.1	25.5	25.7	26.1	25.7	320.3
2016	24.1	27.4	28.7	28.5	29.1	29.5	29	27.3	27.2	28.2	26.6	23.1	328.7
2017	23.6	26.1	29.8	27.6	27.7	28.8	27.1	26.1	26.2	27.2	25.9	25.1	321.2
2018	25.1	25.3	27.1	27.3	28.3	29.1	27.7	26.3	26	26.4	26.7	24.9	320.2
2019	23.6	27.3	27	26.9	28.8	28.2	28.2	26.1	27.9	26.5	25.2	25.3	321
2020	25.1	28	28.9	29.5	29.4	29	27.6	26.4	25.9	26.4	26.7	25.2	328.1
Grand Total	764.4	832	852.2	874.5	917.1	914.7	852.7	824.7	818.1	839.5	825.2	781.1	10096.2

Source; (WHANRO 2021).

Appendixes Table 6. Monthly maximum temperature of chiro meteorological station

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2011	25.8	27.5	29.9	28.6	28.1	31	28.8	24.2	24.5	25.2	25.7	26.1
2012	25.4	26.8	26.4	27.6	28.3	28.3	27.7	26.6	27.5	27.1	26.2	24.9
2013	25.9	27.4	28.2	28.8	29.2	28.4	28.7	28.6	28	26.8	27.5	26.3
2014	25.1	26.7	28.4	27.7	28.4	28.9	28.3	28	28.2	27.2	27.8	27.7
2015	28.3	27.1	27.9	28.4	28.4	28.7	28.6	27.9	27.6	26.9	28.4	16.8
2016	26.6	27.7	28	27.5	27.5	30.1	28.3	27.1	27.3	26.9	27.6	25.4
2017	25.4	29.3	29.9	29.9	28.2	28.9	28.8	27.5	27.8	28.2	26.9	25.4
2018	26.1	26.4	31.2	27.8	27.4	28	26.8	26.3	27.2	27.3	26.3	25.3
2019	28.5	26.6	29.8	29.5	28.6	30.5	28.7	27.2	26.2	26.4	26	24.2
2020	30.1	35.1	37.6	37.4	36.8	37.1	27	26.8	27	27.4	26.3	20.9

Appendixes Table 7. Monthly minimum temperature of chiro meteorological station

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2011	11.6	11.4	13.2	16.4	16.6	16.3	15.8	15.9	15.8	15	12.8	12.8
2010	12.1	13.1	14.5	17.4	16.9	18.1	16.6	16.2	16.9	14.5	14.6	15.6
2012	14.1	15.5	16.1	16.5	17.2	17.3	16.9	16	16.6	16.7	15.2	14.2
2013	15.4	16.8	17	15.2	14.9	15.9	15.7	15.6	15.7	15.4	15.6	14.4
2014	11.1	12.9	13.3	14.2	15.2	15.3	15.1	15.3	15.6	14.5	15	14.5
2015	15.3	14.4	15.3	15.7	16	16.6	15.8	16	15.8	14.3	14.6	12.1
2016	10.9	14	15.9	16.8	16.3	16.7	16.1	15.5	15.6	13.3	12.2	9.7
2017	9.8	13.1	16.1	15.9	16.7	16.6	16.6	15.7	15.9	14.4	13.6	12.8
2018	13.3	12.9	17.7	17.1	16.8	17.3	16	15.9	15.7	17.1	12.5	10.5
2019	11.5	13.4	15.1	16.7	16.9	17.1	16.4	16.1	15.1	13.7	11.4	8.3
2020	10.8	13.5	16.4	16.9	16.4	17.2	15.5	16	14.8	13.9	12.5	9.4