Federal Democratic Republic of Ethiopia

Ministry of Health

Vulnerability and Adaptation Assessment of Health to Climate Change in Ethiopia

Final Report

September 2015
Addis Ababa, Ethiopia

Acknowledgments

The Federal Ministry of Health (FMoH) would like to extend its gratitude to the World Health Organization (WHO) Ethiopia Country Office for the technical and financial support through building adaptation to climate change in health in least developed countries through resilient water, sanitation and hygiene (WASH) of the WHO/DFID project to undertake Vulnerability and Adaptation (VA) Assessment of Health to Climate Change in Ethiopia.

Special thanks go to Dr. MPELE-KILEBOU Pierre, WHO Country Representative to Ethiopia, for initiating the VA assessment and for his continuous follow-up and guidance throughout the process. Furthermore, the FMoH greatly acknowledges Mr. Waltaji Terfa and Dr. Admas Tefera WHO Ethiopia Country Office professional officers and Ms. Elena Villalobos Prats, WHO Geneva Technical Officer, Mr. Goitom G/Medhin WHO Consultant, Mr. Misganaw Teachew FMoH expert and Mr. Balew Yibel for taking the lead in developing concept note, consultant terms of reference and providing technical support and coordination throughout the development of VA process which resulted in country Health Vulnerability Index (HVI) development by regional states.

Moreover, the assessment team did an amazing job technically starting from writing inception report up to the production of the final vulnerability assessment report. Thus, we highly appreciate and thank the following assessment team members for their highly commendable work that is the first of its kind in the country with regard to health and climate change linkage.

SN	Full Name	Organization	VA Assessment of Health to Climate Change in Ethiopia
1	Wakgari Deressa (PhD)	School of Public Health Addis Ababa University, Associate Professor of Epidemiology and Public Health	Team leader, climate sensitive diseases and human resources for health
2	Belay Simane (PhD)	College of Development Studies, Addis Ababa University, Associate Prof of Environment and Agricultural Development	VA assessment
3	Abera Kumie (PhD)	School of Public Health, Addis Ababa University Associate, Professor in Environmental and Public Health	Climate change and diarrhea linked with WASH
4	Adugna Woyessa (PhD)	Ethiopian Public Health Institute, (EPHI), Director of Bacterial, Parasitic and Zoonotic Diseases Research Directorate	Climate sensitive diseases
5	Mirgissa Kaba (PhD)	School of Public Health, Addis Ababa University Assistant, Professor of Epidemiology and Social Studies	Social determinants
6	GirmaTaye (PhD)	School of Public Health Addis Ababa, University Associate Professor of Biostatistics	Assessment design, data analysis
7	Getachew Berhane (PhD)	Department of Earth Sciences, College of Natural and Computational Sciences, Addis Ababa University, Assistant Professor of GIS	GIS

Furthermore, the FMoH acknowledges the contribution of the National Climate Change and Health Technical Working group members from 16 different sectors (government, universities and development partners). The members were very helpful during the preparation phase of the assessment especially during the development of the concept note and term of reference. The FMoH extends its gratitude to Ethiopia National Assessments on Climate Change stakeholder's workshop participants for their valuable comments and inputs to the assessment report. The workshop was organized by Bahir Dar University in collaboration with Ahmara Regional State

Government, Ethiopia Academy of Sciences, Addis Ababa University and WHO Ethiopia Country Office, and was attended by over 45 experts from academia, government sectors, private sectors and NGOs. Special thanks go to Professor Jonathan Patz, MD, MPH, John P Holton Chair in Health and the Environment, Director, Global Health Institute, University of Wisconsin US for taking lead in organizing this workshop and inputs to the concept note on time series analysis. Dr Baylie Damtie, the President of Bahir Dar University, is greatly acknowledged for inviting the study team members to a workshop on climate change and health held on 07/05/2015 in Bahir Dar.

Finally, the FMoH is delighted to thank all government sectors, agencies and individuals who have provided relevant data and support which makes the preparation of this assessment report possible. These include National Meteorology Agency, Ministry of Environment and Forest, Disaster Risk Management and Food Security Sector, Addis Ababa University and Ethiopia Public Health Institute, FMoH Planning Directorate and others.

Foreword

Health sector is one of the sectors affected by weather variability and climate change. That includes morbidity and mortality due to climate sensitive disease, health infrastructure damage and shift of resources to respond to the health crisis as the result of weather variability and climate change. The common direct health sector weather variability and climate change effects of human health in Ethiopia are also morbidity and mortality due to vector-borne infectious diseases like malaria, trypanosomiasis, onchocerciasis, schistosomiasis and leishmaniasis including the 2013/2014 phenomenon of yellow fever and dengue fever outbreak for the first time. Though there is significant progress diarrhea mainly linked to poor water and sanitation, including outbreak of acute watery diarrhea (AWD) in the past and malnutrition are also among the major public health problems in Ethiopia. Furthermore, this risk is exacerbated by drought and flood which occurs in different pocket of the country. However, evidence on weather variability and climate change, and its impact on health sector are very scanty.

It has been also highlighted in the 5th IPCC report that there is a need for reducing vulnerability in the near term by implementing programs that improve basic public health measures and WHO Regional Committee for Africa 2011, Framework for Public Health Adaptation to Climate Change requesting countries to identify country-specific health risks associated with climate change in all African countries through VA assessment of health sector.

Therefore, FMoH undertook this assessment in recognition of the need for information on health vulnerability to climate change and their inter-linkage. The vulnerability assessment, executed by the technical and financial support of WHO Ethiopia Country Office through building adaptation to climate change in health in least developed countries through resilient WASH of WHO/DFID project, is useful in providing tool for health sector at all levels to make evidence-based decisions. This assessment came up with Health Vulnerability Index (HVI) for each regional state by taking in to account hazard, exposure and adaptive capacity of health sector which includes social and environmental determinants of health. Furthermore, the assessment identified priority areas for Health National Adaptation Plan(H-NAP) which is currently under preparation to adequately inform the health specific National Adaptation Plans (2016-2020). The findings of this assessment and H-NAP will be used to guide the development of national strategic action plan. The plan will be used to manage climate change impact on health and regional state specific action plan and also develop annual work plan of health with due consideration of climate change impact.

The present vulnerability and adaptation assessment report has been developed by an interdisciplinary national senior experts in the area of health, climate change, socioeconomic and environmental determinates of health with robust background in research, teaching and publication both at national and international levels. This document is the first of its kind in Ethiopia which can be used as a tool by policy makers, program managers, researchers, private sectors, civil societies and international organizations working on health, climate change and socioeconomic and environmental determinates of health. It also facilitates intersect oral collaboration between public-private sectors and between non-governmental organizations on policy and integration of programs and plans at the implementation levels. Furthermore, it will serve the government and partner organizations to mobilize resources at local, national and international levels.

Finally, I hope that this report, among other development tools, serves as a baseline for all stakeholders concerned with health and climate change impact on health including the Health Sector Transformation Plan (2016-2020) and Sustainable Development Goals target of health. Thus, the FMoH would like to urge all stakeholders and regional health bureaus to take the impact of climate change on health seriously and effectively use the evidence contained in this assessment report during planning, implementation, review, monitoring and evaluation of health programs and activities.

Dr. Kebede Worku

State Minister

Ministry of Health

Executive Summary

Background

The fact that climate is changing has become increasingly clear over the past decade. Recent evidence suggests that the associated changes in temperature and precipitation are already adversely affecting population health. The future burden of disease attributable to climate change will depend in part on the timeliness and effectiveness of the interventions implemented. Extreme weather events such as floods, droughts and severe storms, which are attributed to climate change claims millions of lives each year. Furthermore, global evidences suggest that climate change facilitates and exacerbate the transmission of several infectious diseases, especially water-borne, food-borne and vector-borne ones in connection to its effect on drinking water, production of unsafe food, deteriorating sanitation and hygiene. In recognition of the challenges posed to the health sector, many countries consider adaptation strategy as important prepositioning step.

Though Ethiopia`s contribution to the global warming is negligible over the last decades, the temperature is increased at about 0.2°C per decade. The increase in minimum temperatures is more pronounced with roughly 0.4°C per decade. The mean annual temperature in the country will increase in the range of 1.7-2.1°C by 2050 and in the range of 2.7-3.4°C by 2080. However, precipitation over much of the country remained stable; it showed a 15-20% decreasing trend in the eastern and south eastern semi-arid and arid regions with increased frequency of drought. On the other hand, other areas of the country had experienced increased precipitation, causing an increase in the frequency of floods.

In Ethiopia, despite wide recognition of the impact of climate change on health, there is scanty information on the implication of climate variability on health making it difficult to develop evidence based adaptation strategy. The aim of this 'health vulnerability and adaptation to climate change assessment' is to assess climate variability and its impact on health in Ethiopia and develop national adaptation strategy aimed at reducing vulnerability in the near term by implementing programs that improve basic public health measures.

Methods

Assessing the potential health impact of climate variability and change requires understanding both the vulnerability of a population and its capacity to respond to new conditions. Vulnerability is understood as the degree to which individuals and systems are susceptible to or unable to cope with the adverse effects of climate change, including climate variability and extremes. It depends on levels of exposure (local climate change patterns), sensitivity (impacts of change on climate sensitive diseases) and adaptive capacity (wealth, access to markets, risk aversion, food security) that, together, determine the distribution of vulnerability across the regions. The Health Vulnerability Index (HVI) assessment used the Livelihood Vulnerability Index (LVI) approach after critical modifications. The HVI reorganizes the health determinants into new categories, which includes an explicit climate component, and is framed in a manner amenable to the use of secondary data from published documents. The methodology places multiple indicators under the broad umbrella of the three factors which define vulnerability: exposure, sensitivity and adaptive capacity, using a balanced weighted average approach where each sub-component contributes equally to the overall index

The assessment used secondary data on exposure, sensitivity and adaptive capacity obtained from National Meteorology Agency (NMA), Central Statistical Agency (CSA), Ministry of Health (MOH), Ethiopian Public Health Institute (EPHI) and on line documents including published reports. While data on changes in annual rainfall and temperature for 20 years (1996-2014) were collected from NMA, health related data were collected from MOH, EPHI and CSA. Electronic documents and reports were either collected from the internet using Google scholar or getting hard copies of reports from concerned sectors. The data were organized by region and analyzed using SPSS and ArcGIS. Descriptive, time series and regression/association analysis were employed to determine vulnerability in terms of exposure, sensitivity and adaptive capacity of the health system.

Key findings

Trends in weather/climate data

Ethiopia has become warmer over the past century and human-induced climate change will bring further warming over the next century at unprecedented rates. Both average maximum and minimum temperatures are characterized by high inter-annual variability for all regions with different trends for the regions. Analysis of the total annual rainfall over 1996-2014 was characterized by high inter-annual variability among regions. It tends to steadily decrease in all regions except in Harari. There was no connection with average maximum and minimum temperature, characterized by high inter-annual variability among regions, and rainfall. Flash floods and seasonal river floods were found to occur regularly throughout the country inflicting significant losses in terms of human life as well as productive capital.

Climate Sensitive Disease

Acute Watery Diarrhea (AWD) has been striking Ethiopia since 2006. The outbreak was in 146 weredas of 8 regions of the country while in 2007 it has expanded to all regions of the country. To date, an estimated total of 100,712people were affected of which 1,333 people were dead. . Of the regions, Gambella, Harari, and Benishangul-Gumuz Regions encountered relatively more incidence. The occurrence of was associated with flooding in Gambella and Dire Dawa while it is associated with increased rainfall in Amhara, Oromia, Somali, Addis Ababa, and SNNPR regions. Although lack of basic sanitation, limited access to safe drinking water supply, and poor hygienic practice explains the occurrence of the outbreaks of AWD, one cannot exclude the effect of climate change that impacts water quality and quantity and compromised personal hygiene practice. Furthermore, behavioral factors related to drinking water, sanitation, and hygiene (WaSH) play equally important role.

Minimum temperature and malaria case were found to have statistically strong association in Tigray, Gambella, Dire Dawa and Afar regions, while maximum temperature and malaria case was found to have statistically strong association in SNNP, Oromia, Benishangul-Gumuz, Amhara, and Afar regions. Emerging and remerging vector-borne diseases were found to be reported in recent years. Recent evidence reveals re-emergence of Yellow fever in southwestern and Dengue fever in eastern parts of Ethiopia. Dengue fever is among climate sensitive diseases that are believed to intensify with the rise of temperature.

Health infrastructure and human resources

The last decade has seen a significant increase in the number of health facilities in all regions in the country including health posts, health centers and hospitals, resulting in increased accessibility and coverage of the population. However, the bigger regions such as Amhara, SNNPR and Oromia have lower hospital: population ratio which was below the national average. Similarly, the human resources for health have increased over the decade in all regions. The least physician: population ratio was reported for Somali (1:67961) and Afar (1:62846) regions, followed by Oromia (1:56645) and SNNPR (1:57059) regional states. The highest physician: population ratio was reported for Addis Ababa (1:6062), which is well above the WHO standard of 1:10000. Moreover, even the larger regions such as Oromia, Amhara and the SNNPR are less than the national ratio (1:32132) with regard to physician: population ratio.

Health vulnerability analysis

Exposure levels ranged from 0.12 (AA) to 0.69 (Gambella). While Amara, Tigrai, Harari and SNNP regions are moderately exposed, the lowland emerging regions (Afar, Gambella, Benshangul and Somali regions) are highly exposed to changes to climate change. All the regions are highly sensitive to CC induced diseases with the exception of Addis Ababa.

Adaptive capacity of regions is dependent on several socio-economic factors. It ranges from 0.21 (Somali) to 0.65 (AA). The finance, infrastructure, human and social profiles are found to be strong determinants of adaptive capacity. Addis Ababa and Dire Dawa regions have the highest adaptive capacity. While Somali and Afar regions have the lowest adaptive capacity, the rest do have intermediate capacities.

The calculated HVI values ranged from -0.247 (Dire Dawa, less vulnerable) to 0.279 (Gambella, highly vulnerable). The two urban regions (Dire Dawa and Harari) having less than -0.2 values are categorized as least vulnerable. Oromia, Addis Ababa, Tigrai, and Amhara regions with a value of -0.2 to 0.0 medium vulnerable. SNNPR with a value of 0.033 is categorized as highly vulnerable and those with greater than 0.1 (Afar, Somali, Gambella and BenshangulGumuz) are very highly vulnerable. All the emerging regions are very highly vulnerable to the impacts of climate change sensitive health issues indicating that an adaptive capacity is in deficit and high exposure relative to other regions.

In terms of land mass, HVI analysis identified four categories: 0.6 % of the total land mass is relatively least vulnerable to climate change sensitive diseases, 49.95 % relatively moderately vulnerable, 10.35% as highly vulnerable, and the rest 39.5 % of the total land mass very high relative vulnerability. Considering the population 0.74 % (0.07 million) are relatively least vulnerable, 69.48 % are moderately vulnerable, 20.3% is highly vulnerable and 9.48% are categorized as very highly vulnerable to climate change sensitive diseases. .

Health adaptation strategies

Based on the results of the vulnerability assessment the following adaptation actions related to protecting health from climate change are recommended:

- Improve public health surveillance systems;
- Establish health and climate data management system;
- Strengthening early warning systems;
- Improved public health services;
- Improved water, sanitation, and hygiene system;
- Human resource development;
- Enhanced public awareness and attitudes;
- Targeted intervention to regional contexts by enhanced financial resources; and
- Partnership, coordination and collaboration

Conclusions and recommendations

Based on the preceding evidences, successful adaptation strategy for the health system needs to explore available opportunities and priority focuses of interventions in the face of looming challenges from climate change. In view this, decision makers are expected to identify contexts where impacts in another sector such as water, agriculture and other sectors could adversely affect population health. Many of the possible health sector adaptation measures to climate change lie primarily outside the direct control of the health sector embedded such areas as sanitation and water supply, education, agriculture, trade, tourism, transport, development, urban planning, housing and so on. This calls for inter-sectoral and cross-sectoral adaptation strategies to reduce the potential health impacts of climate change and to optimize adaptive responses. Climate change does not create new health problems but may worsen known clinical problems and alter geographic patterns of disease occurrence. Based on these, the following recommendations are proposed:

- Mainstreaming climate change adaptation into the national health planning process;
- Establish multi-sectoral processes to oversee climate change and health policy development;
- Strengthening disaster preparedness, response and recovery actions; and
- Stakeholder driven research, focusing on cost effectiveness, equity and sustainability.

Table of Contents

List of Figures

List of Tables

List of Annexes

Acronyms and abbreviations

AWD	Acute Watery Diarrhea
CLTSH	Community Led Total Sanitation and Hygiene
CO_2	Carbon dioxide
CRGE	Climate Resilient Green Economy
DFID	Department for International Development
DEM	Digital Elevation Model
EDHS	Ethiopia Demography Health Survey
EFY	Ethiopian Fiscal Year
EIA	Environmental Impact Assessment
FMoH	Federal Ministry of Health
GHG	Greenhouse Gases
GIS	Geographical Information System
HEP	Health Extension Program
HSDP	Health Sector Development Strategy
IPCC	Intergovernmental Panel on Climate Change
LVI	Livelihood Vulnerability Index
masl	Meters above sea level
MDG	Millennium Development Goal
NAP	National Adaptation Plan
NGOs	Non-Governmental Organizations
OPD	Out Patient Department
RH	Relative humidity
RVF	Rift Valley Fever
SNNPR	Southern, National, Nationalities, People's Region
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
V&A	Vulnerability and Adaptation
VRAM	Vulnerability and Risk Assessment and Mapping
WaSH	Water, Sanitation and Hygiene
WHO	World Health Organization

1. Introduction

At present climate change becomes a reality and in progress in which its effects are well pronounced in developing countries including Ethiopia. Overall, the global evidences generated so far were instrumental and adequately informed policy-makers. The Intergovernmental Panel on Climate Change (IPCC) has shown that the climate will change, and provides different scenarios on what may happen and when (IPCC, 2014).

The IPCC forecasts that some parts of Africa will become warmer and wetter, whereas others will become drier, and there will be higher frequencies of storms and floods. Thus, climate change is high on the agenda of public health worldwide since 2008. World Health Assembly reinforced the need for countries to develop health measures and integrate them into plans for adaptation to climate change, to strengthen the capacity of health systems for monitoring and minimizing the public health impacts of climate change through adequate preventive measures, preparedness, timely response and effective management of natural disasters; and for the health sector to effectively engage with all of the relevant sectors, agencies and key partners at national and global levels to reduce current and projected health risks from climate change (World Health Organization, 2008).

From the health sector's perspective, climate information needs to be geographically specific and readily available on the time-scales relevant to public health decision-makers. However, at country level there is limited information on trends of health impacts due to climate change and variability in varying geographic locations. This information is very important for countries like Ethiopia experiencing heterogeneous climate climatic conditions, and subsequently endemic to various climate-sensitive diseases. More interestingly, currently, Ethiopia is developing its five-year (July 2015-June 2020) Health Sector Transformation Plan (HSTP). In addition, most importantly the health sector needs to adjust its plan with the goals of the national long term vision and Growth and Transformation Plan (GTP). In the last decades, the country has shown vigorous improvements in delivering cost-effective basic services using Health Extension Program (HEP) and improvement in reduction of morbidity and mortality mainly in child as well as good progress in maternal mortality is worth mentioning (World Health Organization, 2014). Thus, it appears reasonable for the country to move towards achieving the major elements of primary health care. Thus, over the last couple of years, the Ministry of Health (FMoH) has been engaged in dealing with the long-term development of the Ethiopian primary health care system to ensure quality health services and be equitable, sustainable, adaptive and efficient to meet the health needs of a changing population between now and 2035. Ethiopia envisioned becoming a lower-middle income country by 2025 and a middle-middle income country by 2035. Consequently, the sustainable development would progressively lead towards achieving universal health coverage (UHC). However, climate change is identified one of the major threats in achieving HSTP. Therefore, this calls for generating information in key health components affected by climate variability and change.

Accordingly, the present assessment is designed with the aim of assessing health vulnerability and adaptation to climate change in Ethiopia. Thus, the FMoH initiated to bring altogether research team of multidisciplinary background to synthesize the existing research evidence that could support and protect public health from climate change effect in collaboration with WHO Ethiopia Country Office through Building adaptation to climate change in health in least developed countries through resilient WASH of WHO/DFID project financial support. As the country transitions and trying to implement climate resilient green economy (CRGE), the health sector intends to continue to invest in primary care in order to advance the overall health and wellbeing of the population, and serve the priority health needs of Ethiopians.

2. Background of the assessment

2.1. The current health sector status in Ethiopia

The current health sector development in Ethiopia stems from the implementation of a sector wide approach since 1997/98 through the Health Sector Development Program (HSDP). There have been already in place four HSDPs, the HSDP IV (2010-2015) being in its terminal phase. The primary purpose of HSDP includes the provision of primary health care services through the improvement of health service coverage and utilization of health services. The health facilities serving the grass root population have grown tremendously. The growth of health posts from some 76 to 16048, and health centers from 243 to 3215 (Federal Democratic Republic of Ethiopia Ministry of Health, 2010, Federal Ministry of Health Ethiopia, 2012) is a tremendous achievement. Health posts together with health centers compose a primary health care (PHC) unit that serves about 25,000 populations. Every village now has at least one health post staffed with two health extension workers (HEWs).

The Health Extension Program (HEP) has evolved as a result of testing the implementation during HSDP II with the view of enhancing universal health service coverage through PHC services. The increased health service coverage at household level has greatly impacted maternal and child health and significantly reduced the burden of communicable diseases. The HSDP IV has greater emphasis on the improvement of the quality of health services by diversifying the training of health cadres and increasing their number. Every phase of HSDP (I, II, III, IV) has been synchronized and aligned with the previous years of national development plan linked to Sustainable Development Poverty Reduction Plan, Plan for Accelerated Sustainable Development to end up Poverty (PASDEP), and now Growth and Transformation Plan (GTP I) (Federal Ministry of Finance and Economic Development (MoFED), 2010).

The approach of HSDP is in a smooth transition to HSTP that will be aligned with the national GTP II. HSTP will continue to improve the performance of HSDPs by considering newly emerging health risks because urbanization, industrialization and globalization. The emerging new environment is expected to challenging in terms of owing a three burden of health including communicable diseases, non-communicable diseases and injury. The health facilities and trained human resources will be organized to address emerging health issues including the effect of health transitions.

The success of national effort in health development has faced lots of challenges to reach to its present level. Uncertainties in the internal environment such as efficiency in human resources utilization, adequateness of equipment for health facilities and maintaining the required financial flows were absorbed thorough rigorous human resource development, standardizing health facilities, community mobilization, and improving leadership in health management. In addition, Ethiopia has adopted environmental policies (Federal Semocratic Republic of Ethiopia, 1997) and board based strategy of Climate Resilient Green Economy (CRGE) (Federal Democratic Republic of Ethiopia, 2011), disaster preparedness and prevention Strategy/Policy, Ethiopia's Programme of Adaptation to Climate Change (EPACC) (Federal Semocratic Republic of Ethiopia, 1997), health policy (Transtional Government of Ethiopia, 1993).

2.2. Climate change in Ethiopia

Global climate change has emerged as a challenge to the global and national socio-economic developments. There is a growing concern that climate change could negatively affect the global efforts such as Millennium Development Goals (MDGs). Climate change is understood to occur in a long term changes of weather related variables such as rain fall, temperature, heat waves. A relatively short term events, flooding and drought are extreme events with the capacity to destruct infrastructure and displacing population. The consequences of climate change are huge in a way to affect health and development in many ways.

Ethiopia is among many nations vulnerable to health impacts of climate change(UNDP, 2011, César, 2013). The country is part of the East African highlands supporting a large population size in which agricultural activities are solely sources of income and livelihood Thus, the East African highlands including Ethiopia experienced ecological changes as a result of intensive environmental changes such as agricultural activities and deforestation in the last three decades (Himeidan and Kweka, 2012). Because of its geographical characteristics, the size of its territory, its climatic profile, its large population and its structural social problems, Ethiopia is considered an area vulnerable to the impacts of a changing climate on human health.

Over the last decades, temperature in Ethiopia has increased at about 0.2°C per decade (Tadege, 2007b). The increase in minimum temperatures is more pronounced with about 0.4°C per decade with an alarming increasing trend since the 1990's (Figure 1). The mean annual temperature in the country will increase in the range of 1.7-2.1°C by 2050and in the range of 2.7-3.4°C by 2080 (Tadege, 2007b).

Precipitation, on the other hand, remained fairly stable over the last 50 years when averaged over the country despite high spatial and temporal variability of precipitation and uncertain changes in precipitation (Figure 2). However, forecasts indicate that the amount of annual rainfall and number of rainy days will decrease in some parts of the country by the 2080 (Ayalew et al., 2012).

Variability of precipitation in combination with the warming will likely lead to increase in the occurrence of droughts on the one hand and projected likely occurrence of heavy rains and floods in the country (Tadege, 2007a). The detrimental and beneficial impacts of the evident climate change are widespread in the social, economic and physical environmental spheres mirrored in agriculture and food security, availability of clean drinking water, increased incidence of water, food and vector borne diseases; potential occurrence of forest fires that threatens life of plant and animal species (Tafesse et al., 2013).

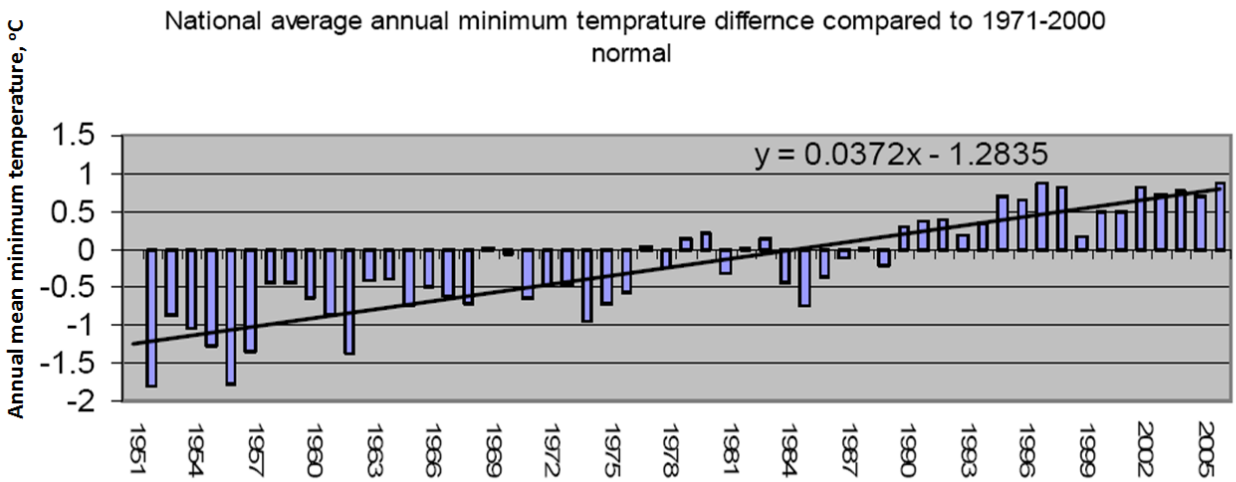


Figure 1: Year to Year Variability of Annual minimum Temperature over Ethiopia expressed in temperature

(**Source**: *Climate Change National Adaptation Programme of Action (NAPA) of Ethiopia. The Federal Democratic Republic of Ethiopia Ministry of Water Resources and National Meteorology Agency. 2007)*

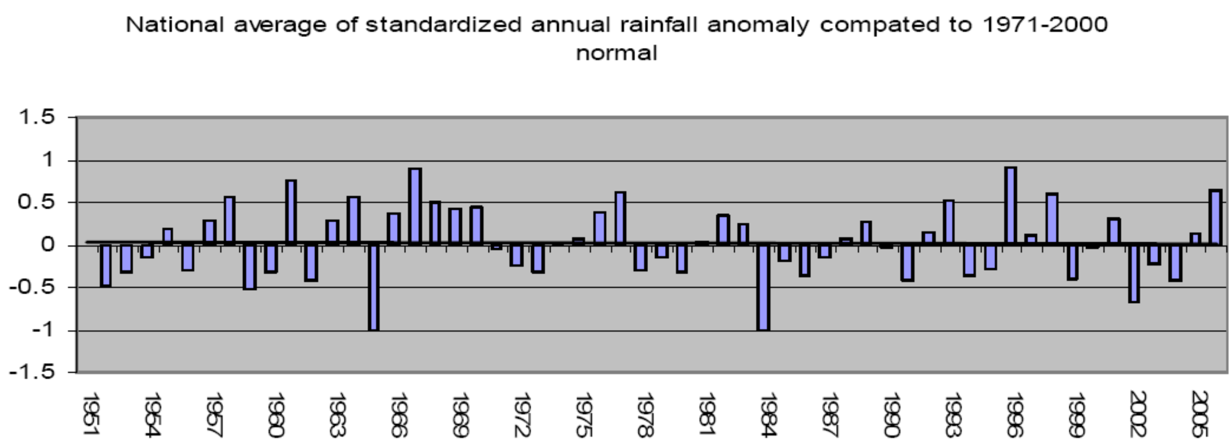


Figure 2: Year to Year Variability of Annual Rainfall and trend over Ethiopia expressed in Normalized Deviation

(***Source:*** Climate Change National Adaptation Programme of Action (NAPA) of Ethiopia. The Federal Democratic Republic of Ethiopia Ministry of Water Resources and National Meteorology Agency. 2007).

The National Adaptation Programme of Action (NAPA) estimates on precipitation and temperature variability is consistent with other data sources (Figure 3). Overall there is variability in indicators, precipitation and temperature in the long run (Keller, 2009).The available data indicate that climate change is obvious in Ethiopia, which is more pronounced in temperature variability and steadily changing in rainfall.

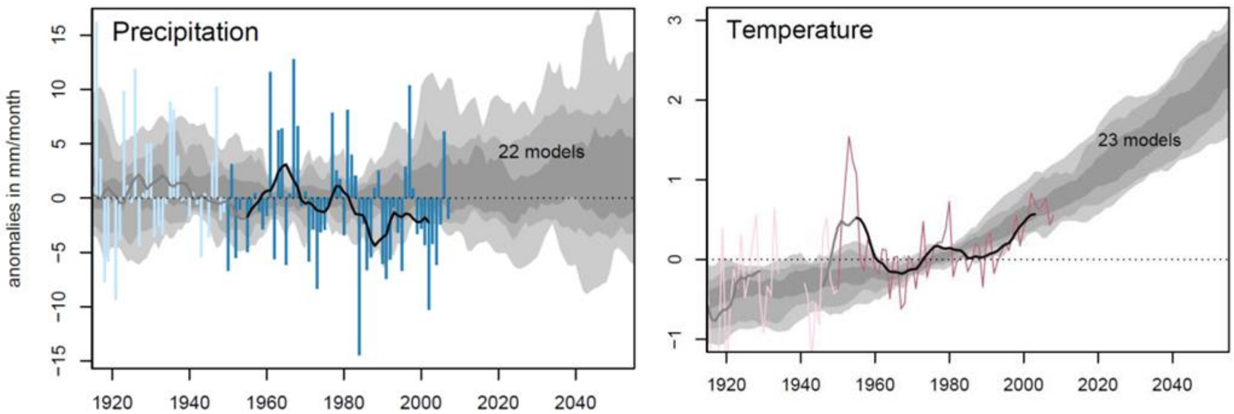


Figure 3: Observed precipitation and temperature changes in Ethiopia (annual averages).

(**Source**: Marius Keller (2009). Climate Risks and Development Projects Assessment Report for a Community-Level Project in Guduru, Oromia, Ethiopia).

2.3. The impact of climate change on health

2.3.1. The context

Climate change is currently adversely impacting the health and lives of people around the world, particularly in low-income countries (Patz JA et al., 2005, Portier et al., 2010, McMichael AJ, 2013). There are several mechanisms in which climate change impacts on health (World Health Organization (WHO), 2003). However, two main climatic impacts on health are evident from literatures: direct effect because of heat stress and weather related extreme events that results in increased morbidity and mortality, and an indirect effect that is climate-mediated change in the incidence of infectious diseases and deaths (Figure 4). Furthermore, some impacts occur relatively immediately, while others depend on a succession of changes that may occur incrementally.

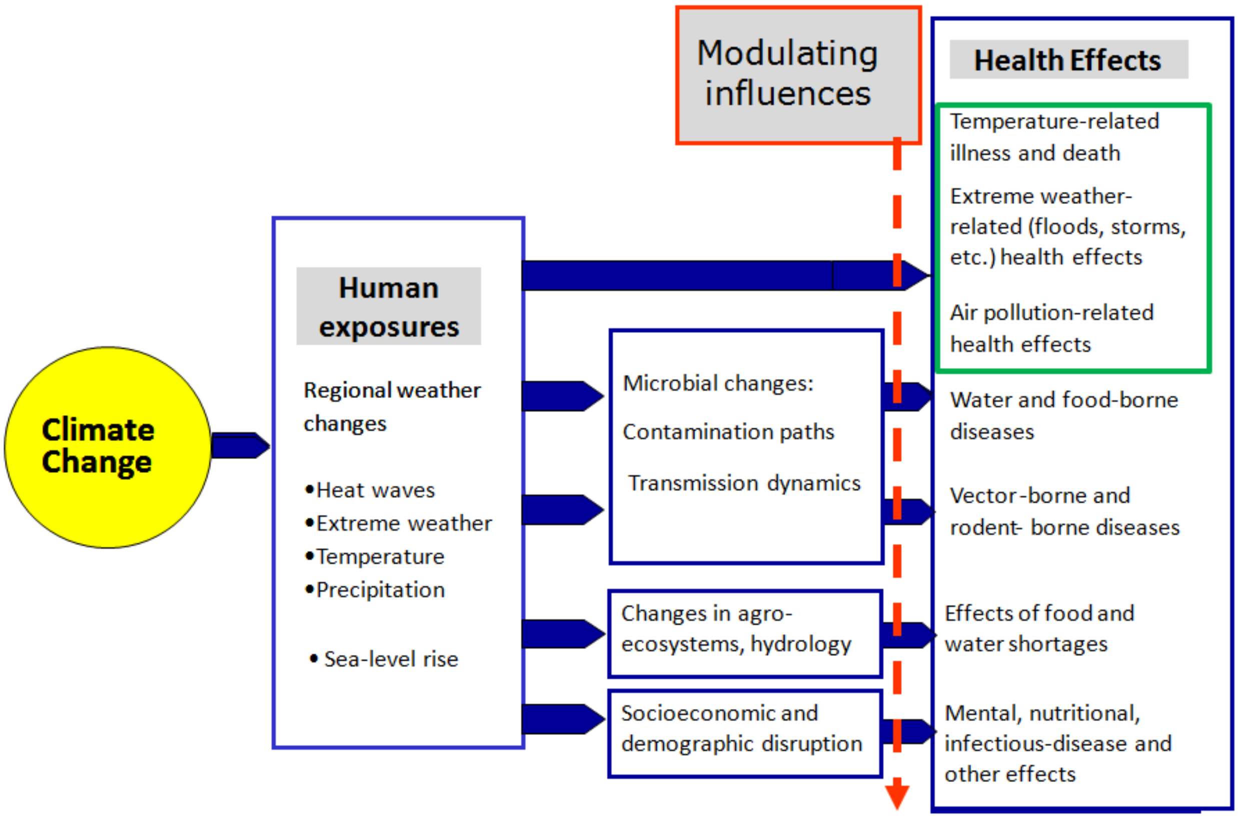


Figure 4: Climate change, mechanism of exposure and related impacts. (***Source:*** *World Health Organization (who) 2003. Health impacts of climate extremes: in Climate change and human health: Risks and Responses.).*

2.3.2 Extreme of climate events

Extreme climate events include heavy precipitation that results flooding, low precipitation combined with changes in temperature resulting drought, heat waves due to unusual increased in daily temperature, and flooding due to excessive rainfall. Flooding is strongly associated with malaria and other vector-borne diseases transmission. Flooding could destroy the existing inbuilt health infrastructure with the possible effect on health service coverage. Flooding destroys latrines and small scale water facilities with likely of contaminating both surface and underground water drinking sources given the common practice of open defecation (WHO and Unicef Joint Monitoring program, 2006, Wolld Health Organization and UNICEF, 2014). Extreme weather events have been implicated to increase diarrheal diseases, while climate resilient drinking water sources and latrines were found to be protective in Cambodia, where the country is sensitive to extreme weather events (Davies et al., 2015). The outbreak of in Oromia in 2007 (Alemseged et al., 2013), Gambella in 2007 and 2009 (Wakuma et al., 2009), in Dire

Dawa in 2006 (DireDawa Adminsitartion, 2011)was associated with flooding event. Climate change mediated by poor hygiene and sanitation was associated with the outbreaks of AWD in 2006-2010 in Ethiopia (Federal Democratic Republic of Ethiopia, September 2014).

2.3.3. Climate sensitive diseases

The common direct effect of climate change on human health in Ethiopia is not well documented (Ghebreyesus et al., 2008). However, anecdotal evidence reveal high burden of morbidity and mortality linked to climate change and consequent water-, food- and vector-borne diseases are common. Evidences of widespread vector-borne infectious diseases like malaria, schistosomiasis and leishmaniasis are available. The recent (2013) phenomenon of yellow fever and dengue fever outbreak are good examples of climate change induced public health challenges in the country. Water-borne disease mainly diarrhea, including outbreak of acute watery diarrhea (AWD) during the past few years and malnutrition are also among the major public health problems linked to weather variability and climate change (Tamiru et al., 2013). Malaria has substantial link with climate change. An increase in temperature and rainfall variability is believed to host the breeding of mosquitoes and early maturation of the parasite, hence increasing probability to sustain the transmission of malaria.

Ethiopia is in the African meningitis belt, and is regularly affected by both the endemic and epidemic forms of meningococcal disease. During 2001, a serious outbreak threatened 8 million people. In 2002, Ethiopia reported a total of 1 332 cases of meningococcal disease including 185 deaths mainly in Southern Nations, Nationalities and Peoples Region (SNNPR) since the onset of the outbreak in September 2001 (WHO, 2015).

Outbreaks of meningococcal meningitis are reported in the African meningitis belt each year during the hot, dry season, between December and June. The UN Office for the Coordination of Humanitarian Affairs (OCHA) has reported an increase of meningococcal meningitis cases during the first week of August 2014 (OCHA, 2014). Thus, increasing numbers of meningitis cases are being reported from Amhara, Gambella, Oromia, SNNP and Tigray regions. 26 cases were reported from Amhara and SNNP regions in the first week of August alone (OCHA, 2014).

Climate change directly affects food and nutrition security, undermining current efforts to address under-nutrition. As agriculture is mostly rain-fed in Ethiopia, low annual rainfall and frequent drought makes farming difficult. Malnutrition and climate-related infectious diseases will seriously affect the most vulnerable segment of the population including small children, the elderly and the infirm. Moreover, women living in poverty also faced particular risk when natural disasters and other global warming-related dangers strike (Hunter, 2003). In Ethiopia, malnutrition particularly under nutrition is one of the public health problems. The major problems are protein-energy malnutrition and micronutrient deficiencies such as vitamin A, iron, and Iodine. These are responsible for morbidity and mortality among the general community although children and women are affected most. National Nutrition strategy has been developed to address the policy issues in relation to health and nutrition (Federal Democratic Republic of Ethiopia, 2008).

In order to overcome the nutrition related issues the FMoH of Ethiopia initiated National Nutrition Program. A recent FMoH report has shown that trends in percentages of underweight children below two years of age in community-based nutrition surveillance between 2008 and 2010 (Federal Ministry of Healt, 2014) It is observed that percentage of children underweight is in strong down ward trend and the seasonal and year to year variability.

2.4. Significance of the assessment

The effect of climate change on health is multiple. The national socio-economic could be negatively affected because of modifying disease transmission and disabling the working population. Ethiopia's economic development on the track of two digits is possible if the risk of climate change is properly mitigated and adapted. The current existing health management information system is not in a position of handling adequately the progress of climate sensitive diseases with the trend of climate variability. The presence of heterogeneous agro-ecology and diverse culturally sensitive vulnerable population calls upon the need of placing strategic direction for a long term climate adaptation of the health sector. The need of developing a health sectors climate adaptation strategy is, therefore, the necessity for the prevention and control of climate related health risks and disaster. The assessment used the following conceptual framework to link climate related exposure, sensitivity, and adaptive capacity to define vulnerability, on the basis of which health adaptation capacity will be developed and implemented .The vulnerability of human health to climate change is a function of exposure, sensitivity and adaptive capacity (IPCC, 2007b) (Figure 5).

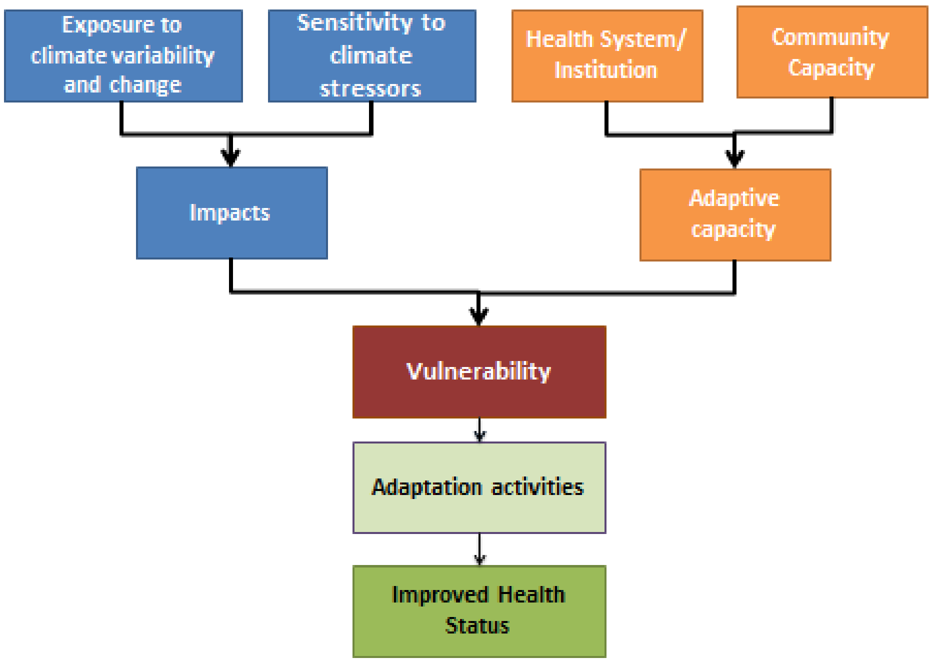


Figure 5: Conceptual model for vulnerability and adaptation assessment to health impacts of climate change

We adopted the following definitions in the process of assessing vulnerability:

- **Exposure:** the weather or climate-related hazard, including the character, magnitude and rate of climate variation. It also addresses Climate-related risks (hazards) by assessing the probability of occurrence of the impacts of climate change, such as epidemics, drought and flooding. The numerical value of hazard risk can also be computed by establishing quantitative value of the elements of risk namely probability (P), exposure (E) and impact (I) and multiplying them using the formula Hazard = P*E*I.

- **Sensitivity:** includes the extent to which health, or the natural or social systems on which health outcomes depend, are sensitive to changes in weather and climate (the exposure–response relationship) and the characteristics of the population, such as the level of development and its demographic structure to protect endemic infectious diseases sensitive to climate variability, such as malaria, meningitis, leishmaniasis, and different forms of diarrheal diseases; and

- **Adaptive capacity:** the whole of capabilities, resources and institutions of a region to implement effective adaptation measures. This will be captured by measuring the selected socio-economic indicators, health facility, health status, and social determinants of health (World Health Organization 2013, VRAM guideline). Adaptive capacity describes the general ability of institutions, systems and individuals to adjust to potential damages, to take advantage of opportunities and to cope with the consequences. The primary goal of building adaptive capacity is to reduce future vulnerability to climate variability and change. Coping capacity describes what could be implemented immediately after a hazard to minimize negative effects of climate variability and change

Assessing the potential health impact of climate variability and change requires understanding both the vulnerability of a population and its capacity to respond to new conditions. In the context of climate change, the Intergovernmental Panel on Climate Change (IPCC) adopts a variant of this definition, stated as “the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes” (IPCC, 2007a). In this definition, vulnerability is typically presented as a condition of three inter-related factors: exposure to impacts, sensitivity to impacts, and capacity to adapt to impacts (Snover et al., 2007).

3. Objectives

3.1. General objective

The general objective of this study was to assess vulnerability of population and the health system in Ethiopia to the impacts of climate related risks and weather variability, and in response, develop appropriate national health adaptation strategies. The goal of this assessment isto contribute to the Ethiopia's Climate Resilient Green Economy (CRGE) strategy through developing the country's health sector NAP based on the long term data on health impacts and vulnerability to climate variables.

3.2. Specific objectives

This study aimed to determine health vulnerability and adaptability to climate related risks with the following specific objectives:

- Define level and distribution of vulnerability
- Generate evidences of risks associated with climate change and develop recommendations for key national adaptation strategies and sectoral programming
- Assess implications for health based on the impacts of climate change on water availability and quality, in order to inform investment in climate resilient water safety plans and other WASH programs
- Establish baseline health conditions and risk factors which can be monitored overtime to observe additional impacts of climate variability and change on health
- Describe policy landscape and opportunities available to bridge coverage and synergize efforts under climate strategy for health
- Determine the association between climate change and priority health issues (nutrition, vector-borne diseases, disasters, occupational health and water related diseases)
- Identify information gaps and research needs

4. Methodology

The assessment was carried out from January – May 2015 using secondary data obtained from relevant sources. A team of multidisciplinary experts was established by the WHO Ethiopia Office to identify and analyze readily available information and data on health impacts of climate variability and change. Both health and climate data were obtained from relevant sources mainly based on quantitative epidemiological approaches. A comprehensive literature review was carried out to assess and analyze the health impacts of weather variability and climate change, with the ultimate aim of developing vulnerability index to health problems in order to develop appropriate and relevant adaptation strategies.

Data abstraction format was developed to address key research questions of the study. Author names, year of the publication/ report, type of the publication and the web site address were abstracted as well. Search key words/ terms were developed for each specific objective for the selection of the titles of the published articles and various reports. Raw data on morbidity/mortality and weather/climate related data were obtained from selected institutions through formal request as most of these data are sensitive and easily unavailable. Available data on specific social and economic (allocation and expenditure of resources) determinants were also collated from the various documents in line with the objectives of this assessment. The findings were organized in themes that served writing the report on this study. The review was concluded with the identification of gaps in adaptation, research needs and policy gaps.

4.1. Health data and information

In order to get health data and information comprehensive literature search or a systematic approach to literature retrieval from relevant sources was carried out using electronic, print or both sources. Data on some climate sensitive diseases with significant public health importance such as malaria, diarrheal diseases, meningitis, and schistosomiasis and leishmaniasis were also collected. Data on yellow fever, dengue fever, rift valley fever, trachoma, and anthrax were also important climate-sensitive diseases that occurred as outbreak in recent years. Thus, retrospective monthly/yearly morbidity and mortality data were obtained for the above climate sensitive diseases from national health records mainly from health and health related indicators of the MOH. Data on human resources for health, health facilities and other infrastructures were also obtained from the health and health related indicators and ESPA+(Ethiopia SPA Plus).

4.2. Climate data and information

Monthly mean weather data (maximum and minimum temperature and rainfall) for 19 years (1996-2014) were obtained from the National Meteorological Agency of Ethiopia (NMAE) to demonstrate the association of some of the epidemic diseases and climate in the country. Thus, associations of average minimum and maximum monthly temperature, rainfall and relative humidity with selected health outcomes were used to illustrate the situation. We aimed to describe the geographical/spatial distribution, seasonality effect, inter-annual variability and future trends of the climate-sensitive disease of epidemic form using conventional global models. The association of extreme climate situations and historical epidemic events mainly for vector-borne diseases such as malaria and diarrhea were assessed using time series analysis despite limitations due to incompleteness of data.

4.3. Data analysis

The WHO Ethiopia Office assisted in obtaining electronic copies of the health and climate data as requested by the research team. The data sources were ENMA for climate/weather information and MOH, EPHI, CSA and others for health-related data. Data were stored using appropriate software. Both raw data and electronic information obtained using internet search were kept at central and shared among the team members. It must be ensured that all required (and accessible) data were collected and compiled before proceeding to analysis.

A biostatistician and geographical information system (GIS) specialist performed data cleaning to ensure quality control, and analysis was performed using quality ensured data. Data quality plays crucial role in any study as small mistake done at raw data handling stage would affect the overall pattern of the outcome since the problem propagates through the various analysis stages done. Findings encountered during quality control were carefully documented and corrected, and included in the report. Next, based on the data analysis plan the research team undertook data analysis and interpretation.

Analysis of the data was carried out using descriptive, time series and regression/association analysis methods for selected health outcomes and weather data. At national and regional levels, existing global climate projections models were used to forecast future occurrences of morbidity from diseases included in the study to predict the potential impacts. Data were transported to excel to calculate percentages and show trends as well as differences between regions using bar and line graphs. In this health vulnerability analysis and report, historical trend of the two climatic parameters: rainfall and temperature were assessed. Later on the change or historical deviations of the two parameters were associated with their subsequent effect on health outcomes (morbidity and mortality).

4.3.1. GIS data analysis

The GIS data analysis presented here includes the data analysis techniques based on the spatial distribution of malaria in Ethiopia. A total of four major steps were followed to get the final malaria distribution map using ArcGIS 10.10.

i. The Digital Elevation Model (DEM) layer was reclassified into five classes
ii. Reclassified DEM was converted from raster to vector-polygon
iii. The five malaria classes were generated in the attribute table of the vector layer
iv. Reclassified vector DEM map was joined with regional administrative map

DEM Data Reclassification

The reclassification tool of ArcGIS 10.0 was applied. This tool reclassifies or change cell (pixel) values to a total of five elevation classes. These classes were:

1. Malaria-free highlands (>2500m)
2. Highlands affected by occasional epidemics (>=2000m and <=2500m)
3. Highland fringes with low transmission; epidemic-prone (>=1750m and <2000m)
4. Highland fringes with high transmission; epidemic-prone (>=1500m and <1750m)
5. Malarious lowlands with seasonal transmission (<1500 m)

For each of the reclassified pixel values (elevation values) in the five classes, the numbers 1 to 5 were given.

DEM Image to Vector-polygon Conversions

The raster imagery DEM dataset was converted into vector polygon dataset for creating the textual attributes of the five elevation classes: malaria-free highlands (>2500m), highlands affected by occasional epidemics (>=2000m and <=2500m), highland fringes with low transmission; epidemic-prone (>=1750m and <2000m), highland fringes with high transmission;

epidemic-prone (>=1500m and <1750m), and malarious lowlands with seasonal transmission (<1500 m). The conversion was decided because the tectual values cannot be entered into raster attribute pixel values.

Attribute Creation for Elevation Map of Ethiopia

For creating the five altitudinal classes in the new polygon vector map, a new attribute was created. To fill the polygons respective elevation classes, Field-Calculator-Tool option of ArcGIS 10.0 was used. Accordingly, each polygon was assigned their respective altitudinal classes and the altitudinal class map was generated.

SPI Data Derivation

The three-month SPI was obtained from Rainfall Estimate (RFE) data, which were blended with rain gauge rainfall measurements in Ethiopia. Using this RFE image data, a total of 2812 point data were extracted for Ethiopia (almost one point data for every 20km). Using these point data, the SPI was calculated. The SPI was calculated by fitting historical precipitation data to a Gamma probability distribution function for a specific time period and location, and transforming the Gamma distribution to a normal distribution with a mean of zero and standard deviation of one (Ji and Peters, 2003). Since the SPI is equal to the Z-value of the normal distribution, McKee et al. proposed a seven-category classification for the SPI: extremely wet (z > 2.0), very wet (1.5 to 1.99), moderately wet (1.0 to 1.49), near normal (-0.99 to 0.99), moderately dry (-1.49 to -1.0), severely dry (-1.99 to -1.5), and extremely dry (<-2.0) (McKee, 1997).

Computation of the SPI involves fitting the Gamma probability density function to a given frequency distribution of precipitation totals for a station. The probability density function of the gamma distribution can be expressed in terms of the gamma function parameterized in terms of a shape parameter. The alpha and beta parameters of the Gamma probability density function were estimated for each point location, for each time scale of interest (1, 3, 6, 9, 12 months), and for each month of the year. The Gamma distribution was defined by its frequency or probability density function using equation 1 (Chow et al., 1988, Ntale and Gan, 2003):

$$g(x)=\frac{1}{\beta^{\alpha}\Gamma(\alpha)}x^{\alpha-1}e^{\frac{-x}{\beta}} \qquad \textit{Equation 1}$$

where, $g(x)$ is probability function, x is the precipitation amount, $\Gamma(\alpha)$ is the gamma function, α and β are shape and scale parameters, respectively. Maximum likelihood solutions were used to optimally estimate α and β using equation 2 (Edwards and McKee, 1997).

$$\hat{\alpha}=\frac{1}{4A}\left(1+\sqrt{\frac{4A}{3}}\right),\ \hat{\beta}=\frac{\hat{x}}{\hat{\alpha}}\ \textbf{\textit{and}}\ A=\ln\left(\hat{x}\right)-\frac{\sum\ln(x)}{n} \qquad \textit{Equation 2}$$

where n is the number of precipitation observations.

The resulting parameters were then used to find the cumulative probability of an observed precipitation event for the given month and time scale for the station in question. Since g(x) is undefined for x=0 and a precipitation distribution may contain zeros, the cumulative probability is obtained using equation 3 (Edwards and McKee, 1997):

$$H(x)=q+(1-q)G(x) \qquad \textit{Equation 3}$$

where q is the probability of a zero and $G(x)$ is the cumulative probability of the incomplete gamma function. If m is the number of zeros in a precipitation time series, then q can be estimated by m/n. By applying Equation 3, errors are eventually introduced to parameters a and b of the Gamma distribution. These errors depend on the number of months with null precipitation (x=0), and they are evident only for the 1-month precipitation. For larger time scales (e.g., 3-month, 6-month, etc.), the probability of null precipitation is usually zero (Ntale and Gan, 2003).

After its computation, the cumulative probability, H(x), is transformed to the standard normal random variable Z with mean equal to zero and variance of one, which is the value of the SPI. SPI value is more easily obtained computationally using an approximation that converts cumulative probability to the standard normal random variable Z using equation 4 and 5 (UNL, 2000).

$$Z=SPI=-\left(t-\frac{C_0+C_1t+C_2t^2}{1+d_1t+d_2t^2+_{d_3}\ t^3}\right)\ \textbf{\textit{for}}\ 0<H(x)<=0.5 \qquad \textit{Equation 4}$$

$$Z = SPI = \left(t - \frac{C_0 + C_1 t + C_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3} \right) \textbf{\textit{for}}\ 0.5 < H(x) <= 1 \qquad \textit{Equation 5}$$

where $t = \sqrt{\ln \frac{1}{(H(x))^2}}$ for $0 < H(x) <= 0.5$ and $t = \sqrt{\ln \frac{1}{(1.0 - H(x))^2}}$ for $0.5 < H(x) <= 1$.

Estimations are done for the variables C_0 =2.515517, C_1 = 0.802853 1, C_2 = 0.010328, d_1 = 1.432788, d_2 = 0.189269 and d_3 = 0.001308.

6.11.1. Data analysis and interpretation

After data obtained from all institutions a statistician did the data cleaning and checking. Descriptive statistics such as frequency, tables, box plot and time series plot was used to see the nature of the data. Malaria data from 2004 to 2014 was obtained from PHEM dataset. To see time series trends of malaria and future forecast, both unstandardized and standardized malaria case used. The standardized malaria case was calculated in such a way that total malaria cases divided by total population for particular region and year. Time Series Model fitting was done by automatic model selection using SPSS version 20.

6.11.2. Fitting time series models and forecasting

Using the time series models and forecasting the upcoming five years, 2015-2020, was computed. The Generalized Linear Model (GLM) was fitted to disease related data as response variable and weather data as predictor variable in which the former depend significantly on the later. Therefore, it would be logical to use rainfall, relative humidity and maximum temperature variables of each region as predictor variables in order to forecast disease outcome through 2020.

Malaria cases were standardized against the corresponding population of each region. In here bot unstandardized and standardized malaria cases were presented for forecasting in the upcoming five years. Various models such as ARIMA with different parameters (i.e., different AR, Differencing and MA values) and a number of smoothing methods were fitted and the best fitting models selected based on results of model diagnostics. Predictions may not be reliable unless the existing series (2004-2014) is sufficiently smoothed. For this reason the observed time series was smoothed using best chosen model so that forecasts can easily be made in to the future. However, since the length of the observed data is short (only about 11), the forecast depends only on a single decade series.

In the following, we will present graphs showing plot of observed data (in red color), fitted curve with 95% C.I in the first panel and forecast line with its C.I. in the second panel for each disease data by region. A table is also presented to provide numerical forecasts with corresponding C.I for use in reports as necessary. The confidence Intervals are often very wide due to high variability in the disease cases from year to year which is associated with high standard error of the mean. It is safer to refer to confidence limit than considering a single value as forecast because we are 95% sure that disease cases will lie between those intervals in the years ahead.

4.3.2. Vulnerability assessment

Assessment of vulnerability to climate change mainly involves the exposure, sensitivity and adaptive capacity levels of a system in the presence of a specific impact e.g., rising frequency of climate sensitive diseases like malaria. The basic approach for the macro level study has been to compare the vulnerability index values of all the regions and identify the most vulnerable regions. After a review of existing methods, the Livelihood Vulnerability Index (LVI) adapted to the IPCC framework was adopted and applied after modifications of the components (Belay et al., 2014, Hahn et al., 2009) (LVI-IPCC). The methodology places multiple indicators under the broad umbrella of the three factors which define vulnerability: exposure, sensitivity and adaptive capacity. Table 1 presents the indicators and the broad structure chosen for this work.

Assessing vulnerability to climate change has several approaches and various methodologies have been used in different countries globally. Reviews of these methodologies indicate that the scale of assessment is an important factor of the kind of data collection required. As this study is a macro level analysis with broader scale like at regional level, we used secondary data to explain the indicators.

The Health Vulnerability Index (HVI) assessment was adopted from the LVI adapted to the IPCC framework (Hahn et al., 2009, Belay et al., 2014) (LVI-IPCC). The HVI-IPCC is an implementation of the Sustainable Livelihoods Approach to development analysis (Chambers and Conway, 1992), according to which regions are described in terms of their natural capital, social capital, financial capital, physical capital, and human capital. The HVI reorganizes determinants of health into new categories, which includes an explicit climate component, and is framed in a manner amenable to the use of secondary data from published documents.

The HVI-IPCC maps the HVI components onto the three IPCC contributing factors to vulnerability — exposure, adaptive capacity, and sensitivity (Table 1). It used a balanced weighted average approach where each sub-component contributes equally to the overall index even though each major component of different livelihood assets includes a different number of sub-components. This weighting scheme could be adjusted by future users as needed.

Table 1: Vulnerability factors, health determinants, profiles, and indicators used for HVI analysis using the IPCC framework.

Vulnerability Factors	Health determinants	Profiles/	Indicators	Units of Measurements
Exposure	***Climate***	1.Climate	• Change in temperature • Change in precipitation	• Changes over time, ^{o}C • Changes over time, mm
		2. Hazard	• Occurrence of extreme events (Drought +Floods)	• No of population supported with PSPN • No of events and affected population over the last 20 years
Sensitivity	***Natural Capital***	3. Ecosystem/Geographic	• Suitability of the area for the CC sensitive diseases	• % of the area prevalent to CC sensitive health issues
		4.Demography	• Proportion of population who are vulnerable (young children, women & elderly)	• % of young children, women and elderly, exposed work force • % HHs in the exposed area
Adaptive Capacity	***Financial Capital***	5. Wealth (Health care financing)	• Health care financing	• Wealth profile • Per capita government expenditure on health • Percentage budget of national budget allocated to health • Per capita government expenditure on health
	Physical capital	6. Technology and Medicine	Critical systems, infrastructure and equipment safety	• Status of health facility systems such as electrical, telecommunication, water supply, waste management, fuel storage, medical gases, ventilation, equipment and supply , access
		7. Infrastructure	Health care	• Physical infrastructures status • No and type of health facilities • Health coverage • Safe water coverage and trend • Latrine coverage and trend
			Water and sanitation	• Physical infrastructures status • No and type of health facilities • Health coverage • Health care waste management
	Human capital	8. Community	Human resources for health	• Health professional (doctors, nurses, midwives) proportion per population by geographic area • Number of Health Extension workers per 5 000 by admin unit • # of HDA (Health Development Army) per 5 HHs
	Social Capital	9. Social	Social determinants of health and nutrition	• Male No education (%) • Female No education (%) • Safe water coverage (%) • Latrine coverage (%)

Calculating the HVI

Because each of the sub-components is measured on a different scale, it was first necessary to standardize each as an index to a common scale. The equation used for this conversion was adapted from that used in the Human Development Index to calculate the life expectancy index, which is the ratio of the difference of the actual life expectancy and a pre-selected minimum, and the range of predetermined maximum and minimum life expectancy (UNDP, 2008). Some sub-components such as the 'number of health professionals' are assumed to decrease vulnerability. In other words, we assumed that a region with more health professionals is less vulnerable than a region with less number. By taking the inverse of the crude indicator, we created a number that assigns higher values to regions with a lower number of health professionals. The maximum and minimum values were also transformed following this logic and Eq. (1) used to standardize these sub-components.

$$I_v = \frac{I_a - I_{min}}{I_{max} - I_{min}} \qquad (1)$$

where I_v is the standardized value for the indicator, I_a is the value for the indicator I for a particular Region a, I_{min} is the minimum value for the indicator across all the Regions, and I_{max} is the maximum value for the indicator across all the Regions.

After each was standardized, the sub-components were averaged using Eq. 2 to calculate the value of each major component:

$$\boldsymbol{P_a} = \frac{\sum \boldsymbol{I_v}}{\boldsymbol{N}} \qquad (2)$$

where P_a is the value for the profile in Region a and N is the number of variables in the profile.

Values for each of the nine components were then combined to obtain the Region level HVI using Eq. 3:

$$\boldsymbol{HVI_a} = \frac{\sum_{p=1}^{8} \boldsymbol{N_p P_{a,p}}}{\sum_{p=1}^{8} \boldsymbol{N_p}} \qquad (3)$$

where HVI_a is the Health Vulnerability Index for Region a and N_p is the number of indicators in each profile.

The nine profiles are then combined according to the IPCC categorization scheme using Eq. 4:

$$CF_a = \frac{\sum_{p=1}^{f} N_p P_{a,p}}{\sum_{p=1}^{f} N_p} \qquad (4)$$

where CF_a is an IPCC contributing factor (exposure (E), sensitivity (S), or adaptive capacity (A), f is the number of profiles associated with the contributing factor, and p is indexed to the profiles associated with the CF.

Finally, the HVI for Region *a* is calculated using Eq. 5:

$$HVI\text{-}IPCC_a = (E_a - A_a) * S_a \quad (5).$$

The HVI-IPCC is scaled from -1 (least vulnerable) to 1 (most vulnerable) and is best understood as an estimate of the relative vulnerability of compared populations.

5. Ethical considerations

The purpose of this study was to assess the association of climate and health outcomes. As we used secondary health and climate data from different institutions, ethical approval was not required.

6. Results and discussion

6.1. Climate outcome

6.1.1. Trends in weather/climate data

Ethiopia is a large complex country, with complex patterns of rainfall and livelihoods. In Ethiopia, higher elevations receive more rainfall than low arid areas and support agricultural livelihoods and higher population densities whereas the lowlands like receive minimal rainfall, and people generally support themselves by raising livestock (Figure 6). The seasonality of rainfall varies in different areas of Ethiopia. In the eastern Somali region, rains come twice a year–during the March–June Belg season, and during the October–December Dryer season. In the south-central part of the country, most areas receive both Belg and summer (June–September) Kiremt rains. Many farmers plant slowly maturing but high yielding 'long cycle' crops that grow during both the Belg and Kiremt seasons.

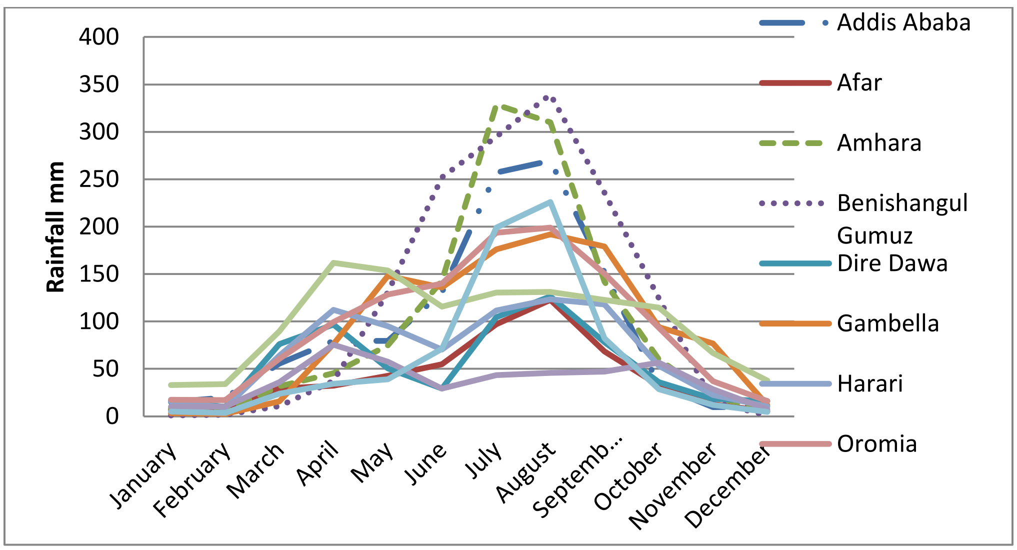


Figure 6: Long-term monthly average rainfall distribution by region (1996-2014)

Ethiopia receives most of its rain between March and September. Rains begin in the south and central parts of the country during the Belg season, then progress northward, with central and northern Ethiopia receiving most of their precipitation during the Kiremt season. Rainfall totals of more than 500 mm during these rainy seasons typically provide enough water for viable farming and pastoral pursuits.

Changes in annual rainfall and temperature have been analyzed based on region-averaged rainfall and temperature data obtained from NMA for the period 1996-2014. Total annual rainfall is characterized by high inter-annual variability for all regions (Figure 7). Annual rainfall trend analysis for the years 1996 to 2014for all regions decreased by 4 (SNNP)–20mm (Gambella) per season across country except Harari. As regions in Ethiopia are very big and diverse in various bio-physical parameters, region-averaged rainfall and temperature time series constructed from varying station density in time and over diverse topography may mask the true variability.

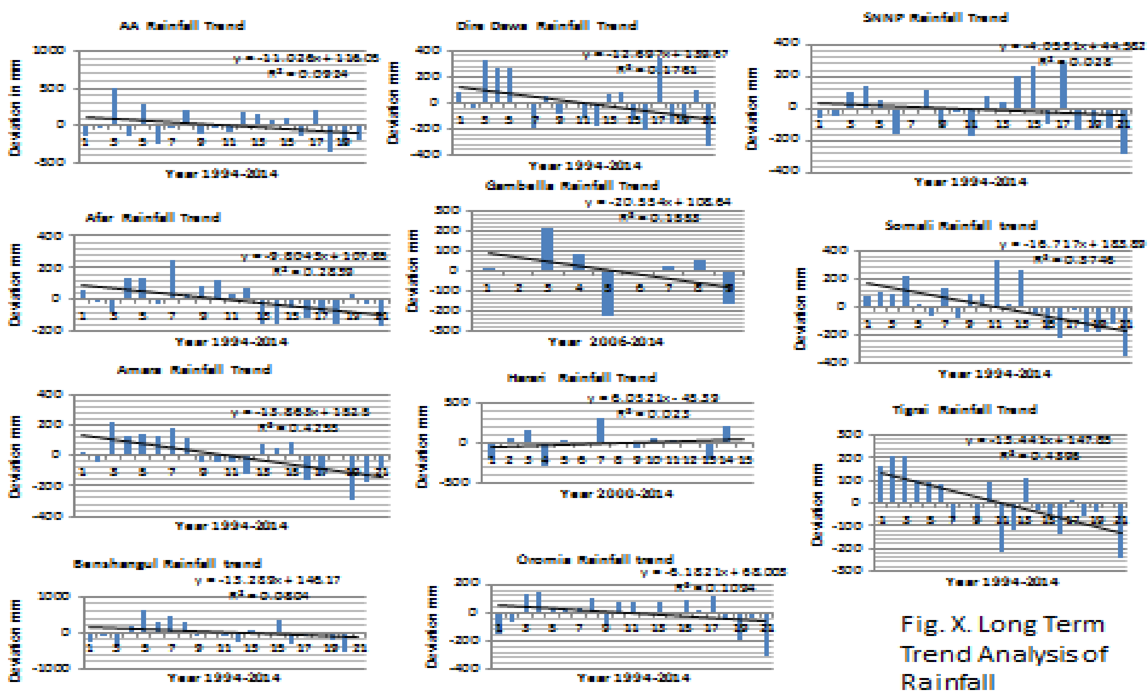


Figure 7: Standardized time series plot of annual rainfall totals of regions for the years 1996 to 2014

Ethiopia has become warmer over the past century and human-induced climate change will bring further warming over the next century at unprecedented rates. Spatial patterns and changes in maximum and minimum temperature have been analyzed based on region-averaged maximum and minimum temperature data obtained from NMA for the period 1996-2014 (Figure 8 and 9). Both average maximum and minimum temperatures are characterized by high inter-annual variability for all regions. There is no similar trend for both parameters for the regions.

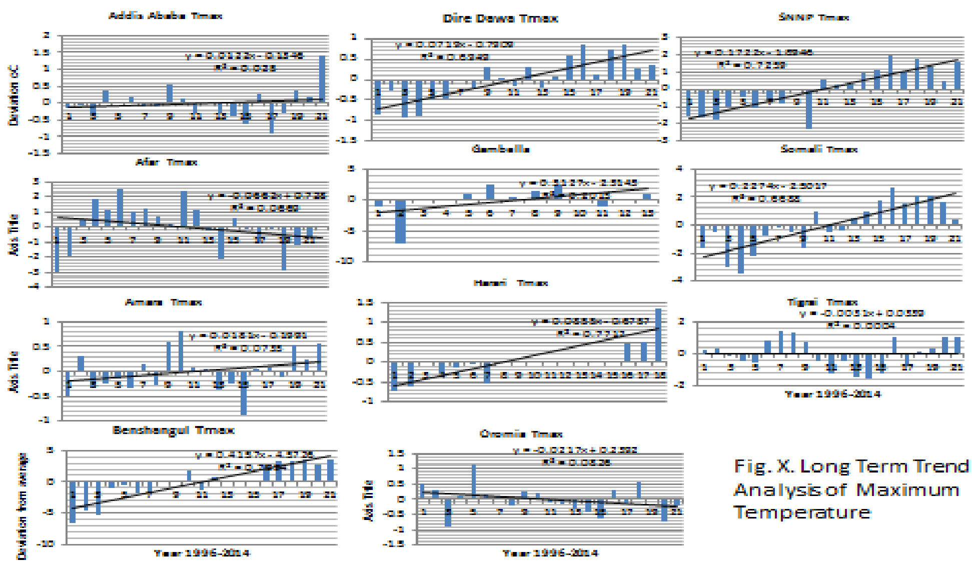


Figure 8: Annual maximum temperature trend and variability of Regions for the years 1996 to 2014

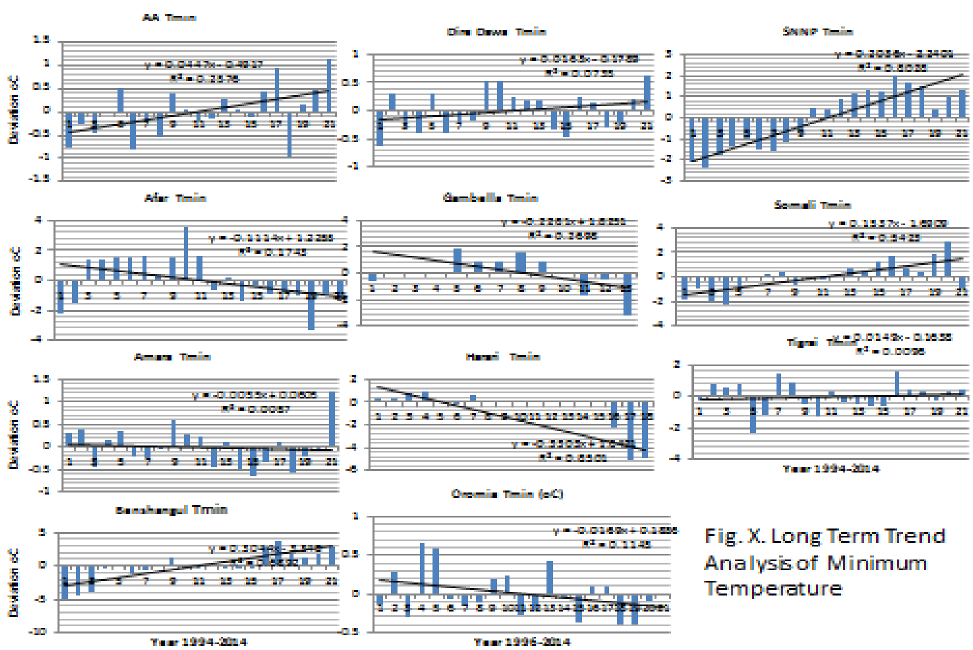


Figure 9: Annual minimum temperature trend and variability of Regions for the years 1996 to 2014

Warming has occurred across much of Ethiopia, particularly since the 1970's at a variable rate but broadly consistent with wider African and global trends (Conway et al., 2010). Mean annual temperature has increased by 1.3°C between 1960 and 2006, an average rate of 0.28°C per decade. According to the country's First National Communications to the UNFCCC, temperature change evidence is most clearly visible in temperature with increasing trend of 0.37°C /decade (NAPA, 2007). Daily temperature observations show significantly increasing trends in the frequency of hot days, and even higher increasing trends in the frequency of hot nights. Climate models suggest that Ethiopia will see further warming in all seasons of between 0.7°C and 2.3°C by the 2020's and of between 1.4°C and 2.9°C by the 2050s(Federal Democratic Republic of Ethiopia, 2011).

6.1.2 Describing weather data using Box Plot

Box plot is used to depict central tendency, variation, and presence of outliers; and in general distribution of the data in just one graph. Boxplot is presented for each of the weather and disease cases by region. The plots show 1) characteristics of data within a region and 2) comparison across regions since they are plotted on same scale. Figure 28, for example, present box plot for mean monthly rainfall (1994-2014) by region.

The plot shows that Gambella have high variability in rainfall with large interquartile range, whereas Afar has very similar amount of rain from year to year, although small in amount. Benishangul-Gumz has the highest monthly average over a period of one decade. There is also an indication that rainfall was not normally distributed over the ten years period for some regions like Addis, Benishangul-Gumz, Dire and Gambella. Harari region is characterized by extreme rainfall situations (high or low) in some years. In fact it is the only region to have shown unique rainfall situation. Inspection of the three plots (Fig 10-12) show that Gambella tends to have high variability in all the three weather variables.

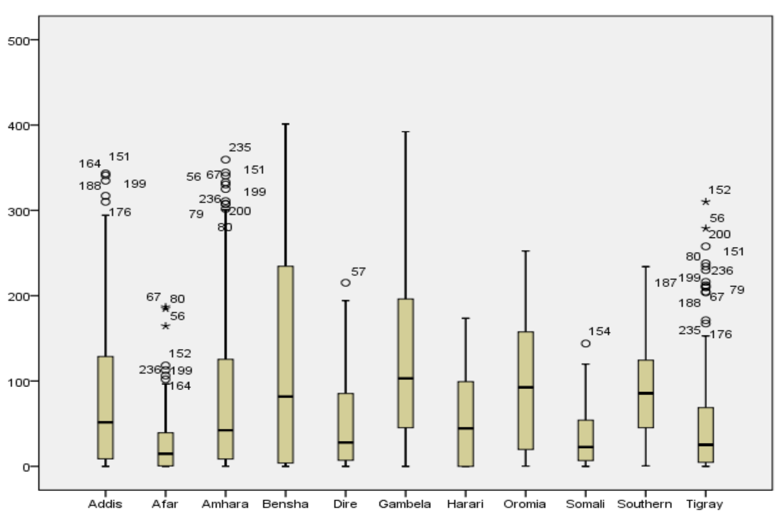


Figure 10: Box Plot for mean monthly rainfall (1994 – 2014) by region

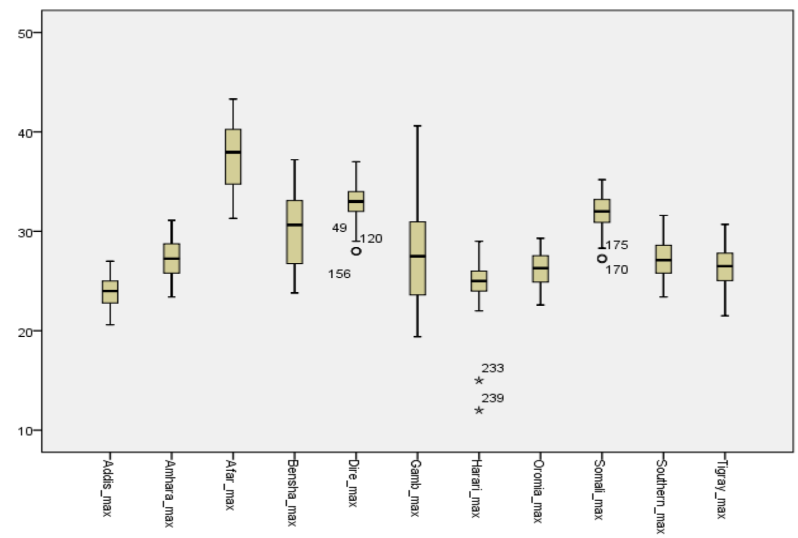


Figure 11: Box Plot for mean monthly Max temp (1994 – 2014) by region

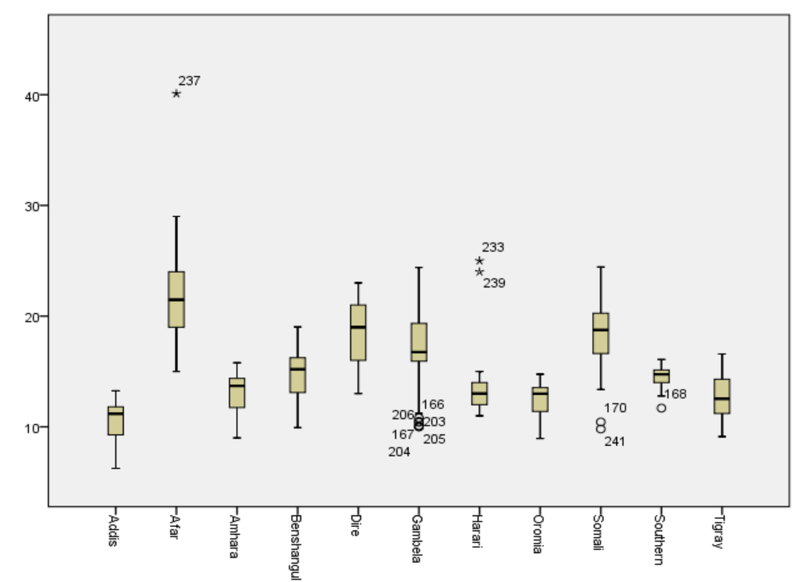


Figure 12: Box plot for Monthly Mean Minimum Temperature (1994 – 2014) by Region

6.2. Occurrence of hazards (extreme events)

The occurrences of extreme events, both droughts and floods are becoming critical issues to the health and livelihoods of millions of Ethiopians. Ethiopia has a long history of coping with extreme weather events. Rainfall is highly erratic and typically falls in the form of intensive convective storms spawned by the country's varied topography. Over the past three decades, Ethiopia has experienced countless localized drought events and seven major droughts, five of which resulted in famines. Droughts are the greatest and most recurring climate hazard in

Ethiopia, particularly for pastoral and agro-pastoral communities that inhabit drought-prone areas. The country encompasses primarily dry sub-humid, semi-arid, and arid regions, all of which are highly prone to desertification and drought. While droughts have always plagued Ethiopia, their magnitude, frequency, and intensity have significantly increased since the 1970s. Droughts threaten areas where livestock rearing is a primary activity, and threaten fodder and range productivity, all of which are likely to worsen under projected changes in climate.

Flash floods and seasonal river floods pose a significant challenge to the country's vulnerable institutions. Flash floods occur regularly throughout the country, particularly after a long dry spell. More recently, in the years 1988, 1993, 1994, 1995, 1996, and 2006, major floods inflicted significant losses in terms of human life as well as productive capital. Floods are occurring with greater frequency and intensity across the country due to vulnerabilities imposed by high rates of deforestation, land degradation, increasing climate variability, and settlement patterns. Large scale floods occur mostly in the lowland areas, while flash floods resulting from intense rainfall events destroy settlements in the Highlands (including in the Awash River Basin and in the Rift Valley) (USAID, 2012). The drought historical events are indicated in Table 2.

Table 2: Historical events of drought, Ethiopia

El Niño Years	Drought/ Famine	Regions Affected	Impact on human life and property
1965	1964-1966	Tigray and Wollo	About 1.5 million people affected
1972-1973	1973-1974	Tigray and Wollo	0.2 million people and 30% of livestock dead
	1978-79	Southern Ethiopia	1.4 million
	1982	Northern Ethiopia	2 million People affected
1982-1983	1983-1984	Ethiopia	8 million affected
1986-87	1987-1988	Ethiopia	7 million people affected
1991-92	1990-1992	North, Eastern, Southeastern Ethiopia	About 0.5 million people affected
1993	1993-94	Tigray and Wollo	7.6 People affected
2000		Ethiopia	About 10.5 million people affected
2002/2003	2002/2003		13 million people in need of food assistance
	2005-2006	Somali region	1.75 million people need food assistance
2006-2007	2007-2008	Arsi, West Arsi, and West Shoa	3.4 million people need emergency food relief
2009-2010	2009-2010	Eastern and Southern Tigray, Eastern Amhara, Eastern Oromia, Somali, SNNP, Gambella	5.2 million people require emergency food assistance

Source: Adapted from MDGs Country Draft Report, 2010.

As there is no region-based figures and facts for drought and flood prevalence and intensity, the population percentage for receiving PSNP supports and average emergency beneficiaries are used as proxy indicators of extreme events (Figure 13). The frequency and intensity of its occurrence is increasing in recent years. Flooding is the second most important natural disaster increasing in its occurrence adding more stress on social institutions, and increased the vulnerability of the households.

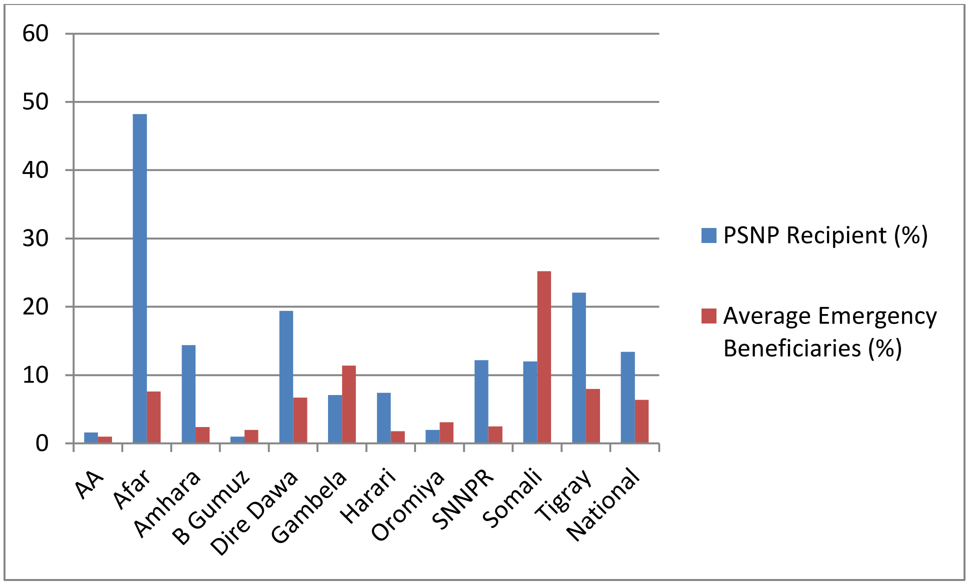


Figure 13: Population percentage average PSNP supports and emergency beneficiaries for the period 1997- 2006 EC by region

6.3. Nutrition

Stunting is taken as a proxy to determine chronic food insecurity, given the fact that with compromised nutrition children will have compromised height for age. Data from recent EDHS (2014) shows that prevalence of stunting increases as the age of a child increases, with the highest prevalence of chronic malnutrition found in children age 24-35 months (Central Statistical Agency Addis Ababa Ethiopia, 2014) (Figure 14). Fifty eight percent of children under age five years are stunted. Besides, regional variation in the prevalence of stunting in children was evident. The same report shows that level of stunting is above the national average in Afar, Tigray and SNNP regions while stunting is found to be low relatively in Addis Ababa, Gambella, Dire Dawa and Harari as shown in the bar graph below.

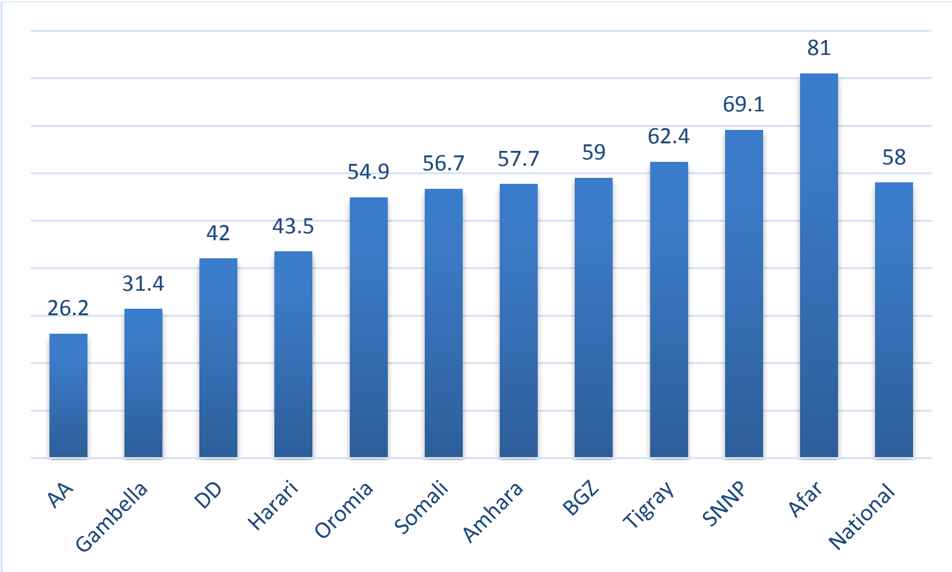


Figure 14: Level of stunting for children under the age of five by region, CSA 2014

6.4. Climate sensitive diseases

Climate change and variability are the main drivers of several infectious and non-infectious diseases that are of great public health importance in Ethiopia. Malaria, yellow fever and dengue fever, meningitis, leishmaniosis, and different forms of diarrheal diseases are the most common climate sensitive diseases. Malaria is one of the most studied climate-sensitive diseases. In Ethiopia, 75% of the total landmass (or <2000 m) is malarious or potentially malarious (Adhanom et al., 2006). However, the occurrence of endemic malaria is documented during non-epidemic years beyond the threshold elevation for transmission (Tesfaye et al., 2011, Graves et al., 2009).

Yellow fever and dengue fever are also climate sensitive vector-borne diseases. For instance, WHO report showed the re-emergence of yellow fever in southwestern during 2013 and newly emerging of dengue fever in eastern part of Ethiopia. Climate Changes have the potential to increase the risk of transmission by increasing the distribution and abundance of vectors, and duration of mosquito and seasons (Russell, 1998). Another important issue is that it is likely that some areas will have increases in activity and human infection with predicted climate change, but risk of increased transmission will vary with locality, vector, host and human factors (Russell, 1998).

The general population at times of extreme weather events and generally under-five children because of poorly developed defensive mechanism are most vulnerable to diarrhea. Recent EDHS data (2011) indicated the two weeks prevalence of diarrhea among under five was 13.4%, while diarrhea with blood was 3.3% (Central Statistical Agency Addis Ababa Ethiopia, 2012). The same data source showed children aged 6-23 were the most affected, which can be linked to the exposure to contaminated water and food, and poor hygienic practice. The prevalence of diarrhea among under five children varied in the three EDHS consecutive surveys, indicating a declining trend (Figure 15) from 23.6% in 2000, 18.0% in 2005 to 13.4% in 2011 (Central Statistical Agency Addis Ababa Ethiopia, 2001, Central Statistical Agency Addis Ababa Ethiopia and ICF International Calverton M, 2006, Central Statistical Agency Addis Ababa Ethiopia, 2012).

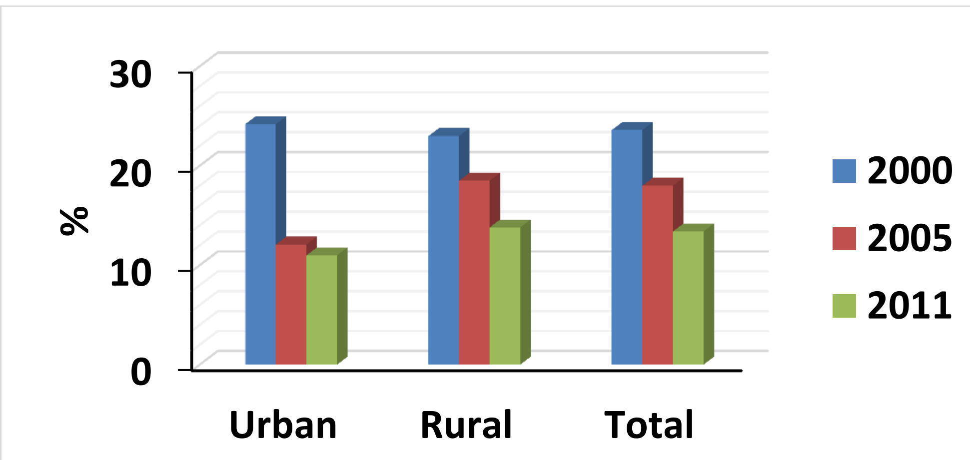


Figure 15: Trend of diarrhea among under-five children, Ethiopia, EDHS 2005, 2011, Ethiopia

The three EDHS data (2000, 2005, 2011) were used to extract data on diarrhea among under-five children. The overall long term trend is declining over years. There existed regional variability in diarrheal diseases. Harari, Oromia, Gambella, Benishangul-Gumuz and SNNPR had prevalence greater than the overall mean of the three EDHS data (18.3%). Addis Ababa, DireDawa, Afar and Tigray had prevalence below the mean value. The pattern of diarrhea aggregated data is generally consistent with that in EDHS 201. Diarrhea in emerging Regions including Somali, Gambella, Benishangul-Gumuz and SNNPR among big regions had increased prevalence of diarrhea compared to the national data, 13.4% in 2011 (Figure 16).The increasing trend perhaps might be due to the contamination of drinking water sources by flooding or prevailing drought in the regions mediated by limited access to WASH services

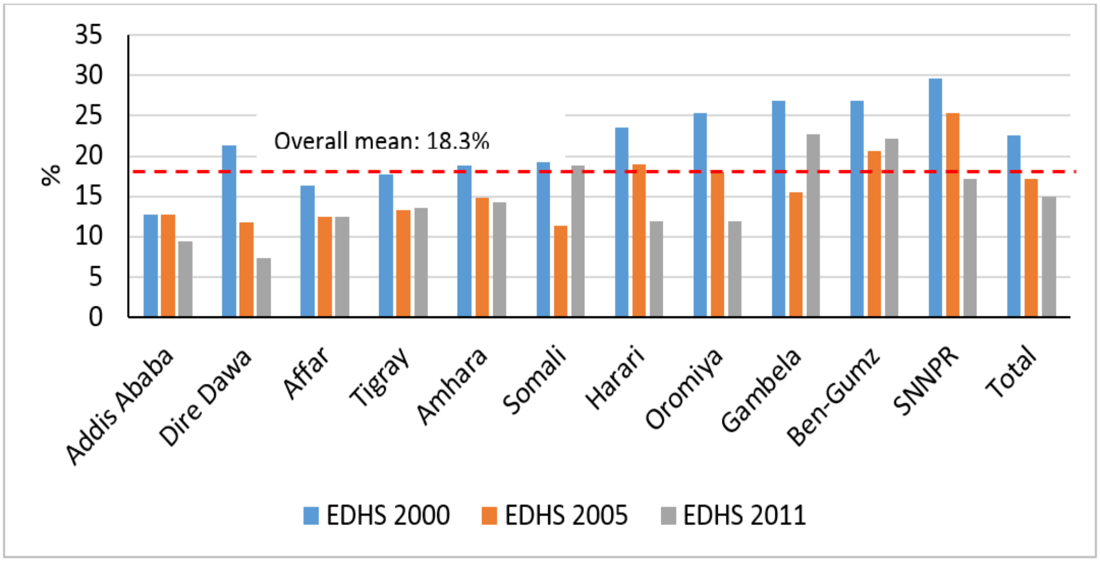


Figure 16: Prevalence of diarrhea among under-five children by Region, Ethiopia, (EDHS 2000, 2005, 2011)

6.5. Water and sanitation infrastructure

Water and sanitation infrastructure in Ethiopia seem fragile to extreme events of climate change, such as flooding. The majority of the Ethiopian population is served by traditional pit latrines that are characterized not having concrete floor. WHO/ UNICEF Joint Monitoring Program of Water and Sanitation accounts traditional pit latrine without slab as un-improved type of sanitation, also categorized as un-sustainable technology (WHO and Unicef Joint Monitoring program, 2006, WHO and UNICEF, 2013, Wolld Health Organization and UNICEF, 2014). The shelf life of traditional pit latrines usually does not last long because of the poorly used local materials that can easily be destroyed by flooding. The mouth of the latrine (pit foundation) is not usually raised from the ground surface, which makes it vulnerable to damages by flooding (Figure 17). Overall traditional pit latrines in Ethiopia represent non-climate resilient structures in many ways. Protected springs and traditional pit latrines are easily destroyed by meteorological extreme events such as flooding. The emergency of AWD during the Ethiopian rainy seasons could be partly explained by the damages the integrity of springs and wells. In addition, surface and unprotected underground drinking water sources can be contaminated by a flood that carries faecal matter and other organic wastes as a run off. Though, there is a significant improvement open defecation is still practiced by 1/4th of the total population

Ethiopia (WHO and UNICEF, 2013). The flooding event in Gambella and Dire Dawa was accompanied with the diarrhea and destruction of homes including latrines and water sources (Alemseged et al., 2013, International Federation of Red cross and Red Crsecent Societies, 30 August 2007).

Figure 17: Traditional pit latrines in rural areas of Ethiopia (Source: photo, Abera Kumie)

6.6 Improved drinking water supply coverage

The four EDHS data were used to extract data on improved water supply by region. EDHS define improved drinking water sources as water from a source that is more likely to provide "safe" water. These are household connection (piped into a dwelling, compound, outside compound), public standpipe, borehole, tube well, protected dug well, protected spring, rainwater collection or bottled water). Overall, there is a growing trend of access to improved water. Harari, Dire Dawa, and Addis Ababa had significantly higher improved water supply coverage compared to the national average of the 2011 EDHS of 51%. Afar, Somali, Oromia, Amhara, and SNNPR had the lowest performance (Figure 18).

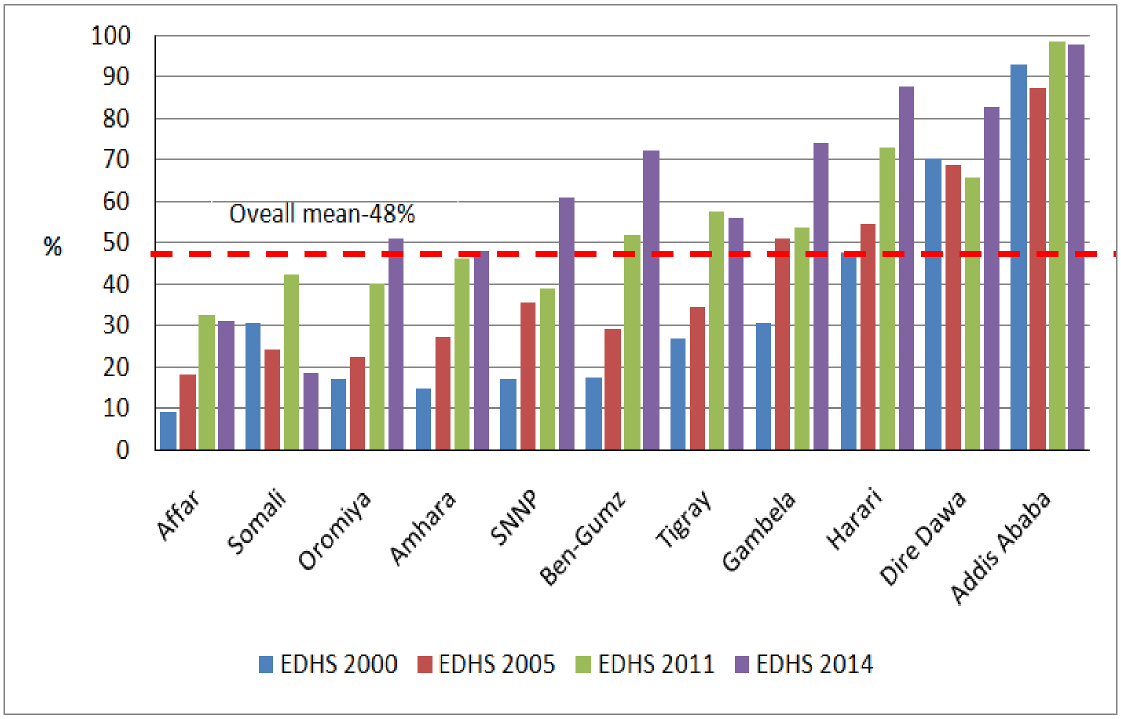


Figure 18: Percent distribution of access to improved drinking water by Region, EDHS 200-2014

6.7. Sanitation coverage in Ethiopia

The four EDHS data were used to extract data on improved sanitation by region. Improved sanitation, traditional pit latrines with and without slab and shared latrines were labeled access to sanitation (latrine) and considered for the analysis. The increase rate was relatively strong in 2011 and 2014 for all regions, except in Dire Dawa and Gambella that exhibited no change or even declining. Harari, Ben-Gumuz, Dire Dawa, SNNPR, and Addis Ababa showed performance above the overall mean of the national average, 41%. Afar, Tigray, Somali and Amhara had the poorest performance for the three EDHS surveys (Figure 19).

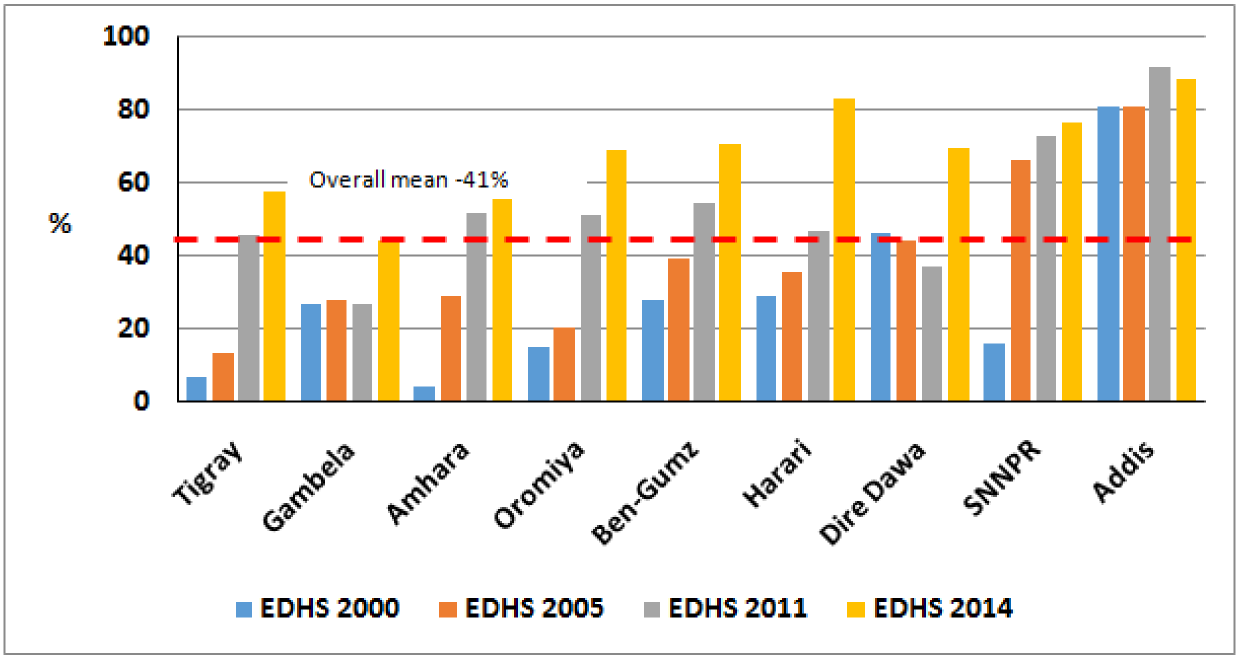


Figure 19: Percent distribution of access to sanitation by Region, EDHS 200-2014

6.8. Physical infrastructure

6.8.1. Access to water

the Ethiopia SPA census 2014 reported that, on average, two-third of all facilities have an improved water source in the facilities (i.e., water is piped into the facility or onto facility grounds, or else water is from a public tap or standpipe, a tube well or borehole, a protected dug well, or protected spring, or rain water, or bottle water). Somali and afar scored less than 50% while all others regions are more than 72% and are disadvantaged compared to other regions.

6.8.2 Access to electric power

Based on Ethiopia's SPA Plus-Census 2014 report, 62 percent of all facilities had regular, uninterrupted electricity (i.e., the facility is connected to a central power grid, or has solar power or both, and power is routinely available during regular service hours), or has a functioning generator with fuel; whereas 70% of the facilities were reported to have been connected to central power grid. The proportion of facilities with electricity increased from 48% in 2005 to 62% in 2014, compared to 2005 HFS. In terms of regional distribution, the proportion of facilities with regular power supply for major regions ranges from 45% for Amhara to 64% in Tigray. Emerging regions seems to be well covered but the number of facilities is few. For example, 78% of facilities have regular power supply but there are only 8 facilities in the region. (Table 1).

6.8.3 Access to communication equipment

The 20014 SPA+ reported that 48% facilities, excluding health posts, as having communication facilities. There is however considerable variations among regions and facilities. Among facilities, higher clinics have more number of facilities (93%) with communication equipment compared to hospitals (which ranges from 77 to 88%). Among regions, Dire Dawa and Harari (with 88 and 86 % respectively) lead while Somali stand the least (15%).

6.8.4 Available latrine

SPA Census 2014 reported that 83 percent of facilities have a functioning client latrine (i.e., the facility had a functioning flush or pour-flush toilet, a ventilated improved latrine, pit latrine with slab), or else the facility has composting toilet. This figure, however, shows variations over the regions; as number of facility increases proportions with functioning latrine decreases. For example, Oromia with largest number of facilities have lowest proportion, while Dire Dawa with few facilities has highest proportion.

6.8.5 Computer and internet

The NHFS 2005 reported that access to internet within the health facility was estimated as 19.3% of the surveyed health facilities. Some regions such as Afar and Benishangul-Gumz had no internet access in any of the health facilities. However, most of these connections were not functional at that time, either computer not functioning or internet not working.. But SPA Census 2014 reported that Only 7% of all facilities have computer with internet (i.e., the facility had a functioning computer with access to the internet that is not interrupted for more than two hours at a time during normal working hours), or else facility has access to internet via a cellular phone inside the facility which is supported by the facility. There is a considerable variation among facility types and less variations among regions (Table 3).

Table 3: Availability of basic amenities for client services, ESPA+ 2014

Region	**Regular Electricity**	**Connected to power grid**	**Improved water source**	**Client Latrine**	**Communication Equipment**	**Internet access**		**Emergency transport**	**Average travel time to ambulance**	**Number of facilities**
Tigray	64	83	86	86	45	8		87	18	22
Afar	70	59	45	88	53	8		67	37	5
Amhara	45	65	79	71	48	5		69	61	87
Oromia	49	60	74	67	45	3		64	35	116
Somali	78	46	48	81	15	12		66	161	8
Bensha	47	70	76	82	34	6		60	48	4
SNNPR	50	66	72	71	44	8		65	33	80
Gambela	68	29	77	77	45	0		45	21	6
Harari	63	94	94	94	86	11		51	15	2
Addis	60	98	97	97	78	17		59	20	31
Dire	82	94	96	98	88	28		66	14	3

Source: Ethiopia SPA Plus-Census 2014

6.8.6 Availability of basic medical equipment

The 2014 ESPA+, the only reference found as national census, assessed the availability of basic equipment in the facilities (Table 4). The result shows that 70, 48, and 32 percent of all facilities at general outpatient service area have adult, child, and infant scale respectively. Majority of facilities have thermometer, blood pressure apparatus and stethoscope and almost all facilities (except health posts) have stethoscope. Addis Ababa (14%), Somali (18%), Oromia (23%), Gambella (26%) and Harari (36%) have lowest infant scale.

Table 4: Availability of basic equipment

Region	Scale (adult, child, infant)	Stadiometer(height Rod)	Measuring tape	Memometer	Stethoscope	BP Apparatus	Light Source	Number of facilities
Tigray	160	37	25	97	95	88	39	54
Afar	155	38	18	76	90	79	29	14
Amhara	154	34	16	77	80	64	45	269
Oromia	140	33	27	62	64	61	36	432
Somali	104	29	12	52	76	75	18	39
Bensha	156	35	12	84	82	73	21	21
SNNP	172	34	30	88	83	72	41	285
Gambela	101	30	16	71	77	70	27	10
Harari	149	48	43	66	95	91	43	3
Addis	130	56	26	94	97	97	84	31
Dire	152	56	33	74	94	93	49	5

Source: Ethiopia SPA Plus-Census 2014

6.8.7 Health infrastructure

The health facility assessment was conducted for the first time in the country. There are two previous efforts, before DHSP 2008 census, to assess profile of health facilities. In 2000, the

WHO made an assessment of the facilities and found that there existed a total of 103 hospitals (all denominations), 338 health centers (HC), 2,029 health stations (HS), 833 health posts (HP) and 1,119 private clinics in Ethiopia. The NHFS conducted in 2005 also provided some assessment option on the health facilities. The NHFS (2005) sampled a total of 362 health facilities (187 health centers, 54 higher clinics and 121 hospitals) all over the country. Although some recommendations for policy direction were abstracted from this study, there were obvious shortcomings. For instance, infrastructure and equipment is difficult to determine for woredas and facilities based on samples and these efforts may not help for equity in the use and distribution of resources.

A total of 10542 facilities, including government, private, NGO and faith based organizations, were available in the country by end of 2008 (DHSP, 2008). The proportion of private facilities out of total facilities in the region varied from 1% in Somali to 80% in Addis Ababa. One facility serves on average 3400 people in Gambella (DHSP 2008), while a single facility serves 29000 in Addis Ababa and 10700 in Oromia. This shows that facility to population ratio is highly influenced by population density. In urbanized areas private and other facilities provide extensive support to the population reducing the burden on government facilities. When total number of facilities is considered, for example, one facility served about 5000 people, while in Amhara a single facility served about 6400 during this period by then. Thus, there is large decrease in the proportion for Addis Ababa due the fact that private facilities are many and play great role.

There were more than thirteen types of health facilities in Ethiopian health system around the period 2007-8 (DHSP, 2008). By this period, health post constituted about 61% of all health facilities, followed by clinics (20%). While majority of health centers and all health posts were owned/managed by government, almost all clinics were privately owned. Proportion of health post to total number of population was largest in SNNPR (73%), Afar (72%) and Amhara (72%), followed by Tigray (68%) and Gambella (63%). The lowest proportion is observed in Addis Ababa (3%), Harari (30%), and Dire Dawa (47%). The current status of these proportions could not be established as information could not be obtained from ESPA 2014.

Table 5: : Distribution of facilities, by region, Ethiopia SPA Plus-Census 2014

Facility type	Region											Total
	Tigray	**Afar**	**Amhara**	**Oromia**	**Somali**	**Ben. Gumuz**	**SNNP**	**Gambella**	**Harari**	**AA**	**DD**	
Referral Hospital	1	1	5	7	1	0	5	1	1	13	1	36
General Hospital	14	3	4	31	8	2	10	0	1	0	0	73
Primary Hospital	16	2	64	63	1	4	13	2	0	0	1	166
Health Center	213	78	849	1,317	165	40	731	32	8	97	15	3,545
Total	244	84	922	1,418	175	46	759	35	10	110	17	3,820

Source: Ethiopia SPA Plus-Census 2014

It seems that the increase in the HCs is not only due to construction of new HCs but also due to conversion of health stations (HS) to HCs, which is probably why the number of HSs decreased over the years.

By end of 2008, an overall population to HC ratio were 57,200 (excluding Somali for which complete information was not obtained). However, as the HC increased to 3545 by 2014 (ESPA, 2014), the envisaged ratio of one HC for 25,000 has been achieved (Table 5). The last seven years saw the number of HCs in the country being nearly tripled. The ratio, however, varies from region to region.

According to the Health Sector Development Program (HSDP), a primary health care unit comprises of 5 health posts and a health center serving as a referral point. This seems to have been achieved nationally some seven years back as the ration of health post to health center was about 5.0. The ratio showed very little variability from region to region. Primary and general hospitals (which were called District and Zonal respectively) each were also envisaged to serve 250,000 and 1,000,000 people respectively based on the HSDP. Since distinction between district and zonal hospital was difficult during the DHSP 2008, their combined effort shows that one district/zonal hospitals was for an average of 995,500 people. However, although there is an increase in the number of Primary hospital to 166, serving half a million people on average, the number is half way to the HSDP target. On the other hand, the general hospitals (n=73) on average serve about a million people currently which is hitting the target of HSDP. In general, today one hospital serves approximately about 300,000 persons, which is great improvement over 479,000 people obtained from DHSP 2008.

Trends of health posts

Health posts are staffed by two female health extension workers whose services mainly focus on the promotion and preventions services, including hygiene and sanitation, maternal and child health, and prevention of communicable diseases. The HSDP has targets to establish fully HP in rural villages and urban communities, which were made possible since 2003 EFY for the rural population. The number of health posts is indicated in Table 4.

The progress of HP coverage steadily has grown since 1995 EFY and reached about 95% in 2005, which implies that all villages have established HP (Table 6 and 7). The coverage by HP was calculated with an assumption of 5000 catchment population for 1 health post divided by the respective population (Annex 1-Table 1).

Table 6: The number of health posts by region, Ethiopia, 1992-2005EFY (1999-2013)

Year	Addis Ababa	Afar	Amhara	Ben_Gumuz	DireDawa	Gambella	Harari	Oromia	SNNPR	Somali	Tigray	National
1992	21	25	308	40	10	0	7	102	208	11	101	833
1993	47	36	361	24	10	0	7	145	290	0	103	1023
1994	47	49	385	44	17	18	7	244	306	82	112	1311
1995	46	56	410	44	20	42	7	326	306	54	121	1432
1996	78	59	1128	60	23	42	7	440	801	97	164	2899
1997	43	59	1421	65	34	22	7	912	1316	121	211	4211
1998	37	83	2075	74	37	32	12	1097	1828	95	586	5955
1999	37	154	2590	88	38	64	22	1985	4258	149	529	9914
2000	0	614	2664	166	39	51	23	3758	3729	290	614	11440
2001	0	238	2856	235	33	99	19	4685	3238	547	538	12488
2002	0	251	2941	291	34	132	20	5930	3340	701	552	14192
2003	0	272	3093	339	34	175	23	6053	3603	951	552	15095
2004	0	272	3267	372	34	132	23	6320	3707	952	589	15668
2005	0	314	3302	361	31	105	26	6368	3829	1062	650	16048
Source: Annual reports of health and health related indicators, Ministry of Health, Ethiopia, 1992-2005												

*Table 7: Health coverage by health posts, Ethiopia, 1992-2005 (1999-2013) (PHC coverage or Health post coverage is calculated: Number of HP*5000/total population)*

Year, EFY	Addis Ababa	Afar	Amhara	Ben_Gumuz	Dire Dawa	Gambella	Harari	Oromia	SNNPR	Somali	Tigray	National
1992	4.2	10.3	9.5	37.3	15.7	0.0	21.8	2.3	8.3	1.5	13.7	6.6
1993	9.1	14.5	10.8	21.8	15.2	0.0	21.1	3.1	11.2	0.0	13.6	7.8
1994	8.9	19.3	11.2	38.9	24.9	40.5	20.3	5.1	11.5	10.5	14.4	9.8
1995	8.4	21.5	11.6	37.9	28.0	92.1	19.7	6.7	11.2	6.7	15.1	10.4
1996	13.9	22.2	31.1	50.5	31.1	89.7	18.9	8.8	28.4	11.8	19.9	20.4
1997	7.4	21.7	38.1	53.3	44.3	45.8	18.5	17.7	45.4	14.3	25.0	28.8
1998	6.2	29.9	53.9	59.2	46.5	64.8	30.6	20.7	61.3	11.0	67.7	39.7
1999	NA	54.3	66.0	68.8	46.1	126.5	54.2	36.3	139.0	16.8	59.5	64.3
2000	NA	38.6	66.2	126.5	45.6	98.5	55.0	66.9	118.4	31.8	67.3	72.2
2001	NA	80.0	95.0	165.0	46.0	149.0	49.0	81.0	102.0	59.0	59.0	80.0
2002	NA	83.4	79.8	191.0	45.9	190.2	50.5	100.2	101.8	72.9	59.4	88.8
2003	NA	88.0	84.0	225.0	45.0	243.0	57.0	99.0	107.0	97.0	58.0	92.1
2004	NA	84.8	86.6	189.4	43.9	171.0	54.8	101.0	106.8	92.4	59.7	92.9
2005	79	96.0	84.0	191.0	37.0	137.0	59.0	100.0	110.0	103.0	67.0	94.0

NA: Data not available

Trends of health centers

Health centers are part of the PHU that provide basic health services for a catchment population of 25, 000. Health stations (clinics) that were organized to provide health services at the grass root level were upgraded in to a health center, contributed to the overall rapid growth health centers. In addition, the construction of new health centers has improved greatly access to health services (Table 7). The coverage provided by health centers had rapid growth since 2000 and reached about 95% in 2005 (Table 8 and 9). The coverage by the health center was calculated with an assumption of 25000 population catchment for one health center divided by their respective population (Annex 1-Table 1).

Table 8: The number of health centers by region, Ethiopia, 1992-2005EFY (1999-2013)

Year	Addis Ababa	Afar	Amhara	Ben_Gumuz	DireDawa	Gambella	Harari	Oromia	SNNPR	Somali	Tigray	National
1992	21	5	67	7	2	5	2	93	107	18	29	356
1993	24	5	77	7	2	5	2	114	107	10	29	382
1994	24	8	82	7	3	8	6	115	114	17	28	412
1995	28	8	81	7	3	8	2	141	118	20	35	451
1996	27	9	115	10	5	8	2	167	127	17	32	519
1997	29	9	126	11	5	8	2	185	161	16	48	600
1998	29	14	155	14	6	8	2	192	161	14	40	635
1999	28	14	169	14	7	9	3	202	163	19	42	670
2000	28	14	171	17	6	9	3	171	181	21	40	732
2001	24	23	378	23	14	11	7	548	244	20	70	1362
2002	26	28	520	29	15	23	8	825	463	35	170	2142
2003	37	50	724	30	15	24	8	991	513	85	183	2660
2004	50	61	796	31	16	28	8	1085	599	113	212	2999
2005	62	62	805	32	16	28	8	1215	663	140	214	3215
Source: Annual reports of health and health related indicators, Ministry of Health, Ethiopia, 1992-2005. The data does not include private HCs												

Table 9: Health coverage by health centers, Ethiopia, 1992-2005

Year	Addis Ababa	Afar	Amhara	Ben_Gumuz	Diredawa	Gambella	Harari	Oromia	SNNPR	Somali	Tigray	National
1992	21.0	10.3	10.3	32.6	15.7	59.2	31.2	10.4	21.4	12.2	19.6	14.0
1993	23.3	10.1	11.5	31.8	15.2	57.9	30.1	12.4	20.7	6.6	19.1	14.6
1994	22.7	15.7	11.9	31.0	21.9	90.1	87.2	12.1	21.4	10.9	17.9	15.3
1995	25.7	15.4	11.5	30.2	21.0	87.7	28.1	14.4	21.6	12.5	21.8	16.3
1996	24.1	16.9	15.8	42.1	33.8	85.5	27.0	16.6	22.5	10.3	19.5	18.3
1997	25.1	16.6	16.9	45.1	32.6	83.2	26.4	17.9	27.8	9.5	28.4	20.5
1998	24.4	25.0	20.4	56.0	37.7	81.0	25.5	18.0	26.8	8.1	23.1	21.2
1999	22.9	24.7	21.5	54.7	42.5	88.9	36.9	18.5	26.6	10.7	23.6	21.7
2000	22.2	24.2	21.2	64.8	35.0	86.9	35.9	21.6	28.7	11.5	21.9	23.1
2001	21.0	39.0	53.1	80.8	97.2	82.7	90.7	47.6	38.3	10.7	38.6	43.8
2002	22.0	46.4	70.7	98.9	101.6	165.7	101.0	69.6	70.1	18.1	91.4	67.0
2003	31.1	81.2	98.3	99.3	99.1	166.5	98.4	81.4	76.0	43.2	96.1	81.2
2004	41.1	95.1	105.5	78.9	103.4	181.3	95.2	86.7	86.3	54.9	107.5	88.9
2005	49.6	94.9	102.5	84.5	96.4	182.8	90.9	95.1	95.2	67.8	109.9	93.8

Trends of hospitals by Region, 1992-2005

The number of public hospitals has shown growth by 62% in 2005 EFY relative to the number in 1992EFY. Steady growth was observed since 2001. Amhara, SNNPR and Oromia have hospital:population ratios below the national average. The hospital distribution by region is indicated in Table 10.

Table 10: The number of hospitals by region, Ethiopia, 1992-2005

Year	Addis Ababa	Afar	Amhara	Ben_Gumuz	DireDawa	Gambella	Harari	Oromia	SNNPR	Somali	Tigray	National
1992	9	2	14	2	1	1	3	18	10	6	12	78
1993	9	2	14	2	1	1	3	20	10	6	12	80
1994	9	2	15	2	1	1	3	20	11	6	12	82
1995	9	2	15	2	1	1	3	21	11	6	12	83
1996	9	2	15	2	1	1	3	20	11	6	12	82
1997	9	2	16	2	1	1	3	21	12	6	12	85
1998	9	2	17	2	1	1	3	21	12	6	12	86
1999	9	2	16	2	1	1	2	22	14	6	13	88
2000	9	2	16	2	1	1	2	23	14	6	12	88
2001	10	3	17	2	1	1	2	23	22	6	13	100
2002	10	4	17	2	1	1	2	42	16	7	14	116
2003	10	4	19	2	1	1	2	41	20	8	14	122
2004	11	5	19	2	1	1	2	41	21	8	14	125
2005	11	5	19	2	1	1	2	41	21	9	15	127
Population 2005	3122000	1634000	19626000	947000	415000	383000	220000	31948000	17403000	5165000	4866000	85729000
Pop ratio to a hospital	283818.2	326800	1032947.368	473500	415000	383000	110000	779219.5	828714.3	573888.9	324400	675031.5
Source: Annual reports of health and health related indicators, Ministry of Health, Ethiopia, 1992-2005. The data does not include private hospitals												

6.9. Human resources for health care

Human resources for health represent the central component of the health care system and are considered to be the core to managing and delivering health services. It has been recognized that insufficient number of health professionals have been identified as one of the major constraints limiting proper delivery of health services. Table 11 shows the distribution of health professionals in the country in service in 2005 EC by Region. From the total categories of health professionals in the country, this assessment considered seven categories for description in this report [physician, health officer, nurses (all categories), midwives, pharmacists, laboratory (BSc+diploma) and health extension workers (HEWs)]. A total of 107947 health workers in the above categories of health professionals were in service in 2005 EC, including HEWs. During the year a total of 2668 physician, health officer (5621), nurses (45509), midwives (5774), pharmacists (6858) and laboratory (6667) were reported from the public sector. To meet the needs for the community level health services, a total of 34,850 HEWs were reported in 2005 EC (2012/13).

Table 11: Distribution of health professionals by Region (2005 EC) (012.13)

Region	Population	Physician	Health Officers	Nurses	Midwives	Pharmacists	Lab (Dip+BSc)	HEW
Addis Ababa	3,122,000	515	606	3980	416	591	578	1261*
Afar	1,634,000	26	69	684	108	128	128	772
Amhara	19,626,000	437	963	7447	587	1364	1296	7599
Ben-Gum	947,000	23	97	841	105	113	107	1001
Dire Dawa	415,000	48	64	488	71	109	75	78
Gambella	383,000	14	49	499	55	19	67	218
Harari	220,000	69	58	557	72	117	92	39
Oromia	31,948,000	564	1647	13873	1894	1932	1939	14121
SNNPR	17,403,000	305	1343	9755	1284	1084	1291	8473
Somali	5,165,000	76	157	1691	369	242	237	908
Tigray	4,866,000	190	439	4562	762	770	615	1641
National**	85,729,000	2668	5621	45509	5774	6858	6667	34850

*2004 EC data; **Includes Health Professionals in the central gov;

Source: Health and health related indicator

Population ratio of the different categories of health professionals by Region for the 2005 EC is presented in Table 12. The least physician:population ratio was reported for Somali (1:67961) and Afar (1:62846) Regions, followed by Oromia (1:56645) and SNNPR (1:57059) Regional States. The highest physician:population ratio was reported for Addis Ababa (1:6062), which is well above the WHO standard of 1:10000. Moreover, even the larger regions such as Oromia, Amhara and the SNNPR are less than the national ratio (1:32132) with regard to physician: population ratio. Similar ratios were also observed for health officers, nurses, midwives, pharmacists and laboratory personnel. Similarly, the highest HEW-to-population ratio was reported for Somali (1:5688), Harari (1:5641) and Dire Dawa (1:5321) Regions. Overall, there is a wide variation in the distribution of health personnel and health personnel:population ratio across the different regions of the country. Therefore, it is important to consider the disparity of health professionals between regions and to improve the overall health system in the country. In addition, the Somali and Afar regions which have the lowest ratio of health professionals to population ratio need special attention to improve their human resources for health.

Table 12: Distribution of population ratio by different categories of health professionals by Region (2005 EC)

Region	Population	Physician	Health Officers	Nurses	Midwives	Pharmacists	Lab (Dip+BSc)	HEW
Addis Ababa	3,122,000	6,062	5,152	784	7,505	5,283	5,401	2,476
Afar	1,634,000	62,846	23,681	2,389	15,130	12,766	12,766	2,117
Amhara	19,626,000	44,911	20,380	2,635	33,434	14,389	15,144	2,583
Ben-Gum	947,000	41,174	9,763	1,126	9,019	8,381	8,850	946
Dire Dawa	415,000	8,646	6,484	850	5,845	3,807	5,533	5,321
Gambella	383,000	27,357	7,816	768	6,964	20,158	5,716	1,757
Harari	220,000	3,188	3,793	395	3,056	1,880	2,391	5,641
Oromia	31,948,000	56,645	19,398	2,303	16,868	16,536	16,477	2,262
SNNPR	17,403,000	57,059	12,958	1,784	13,554	16,054	13,480	2,054
Somali	5,165,000	67,961	32,898	3,054	13,997	21,343	21,793	5,688
Tigray	4,866,000	25,611	11,084	1,067	6,386	6,319	7,912	2,965
National	85,729,000	32,132	15,252	1,884	14,847	12,501	12,859	2,460

6.10. Socio-economic determinants of health

6.10.1. Social determinants of vulnerability to climate change

It has long been recognized that climate change is an outcome of human actions with reverse negative consequences on livelihood, social life and wellbeing of communities (Intergovernmental Panel on Climate Change, 2014). Often vulnerability is facilitated by widespread poverty, fast depleting natural resources, low level of development and weak coping capacity (IPCC, 2007b).

Health inequities as reflections of social inequality and exclusion, ethnic disparities in access to livelihood, engagement in precarious work, poor housing and homelessness, and inadequate access to health and social services play important role in explaining vulnerability of specific groups in society. What is going on social sphere may also help meet the challenges posed by climate change.

a) Population

In Ethiopia population growth is documented to have declined from 3.1% in 1984 to 2.6% in 2007(Central Statistical Agency Addis Ababa Ethiopia and ICF International Calverton Maryland USA, 2012 March). However, population growth rate is found to vary between regions. Amhara is found to be the least in its annual population growth rate, while Gambella, Benishangul Gumuz, Oromia and SNNPR has higher population growth rate above the national average of 2.6% as shown in the below bar graph (Figure 20).

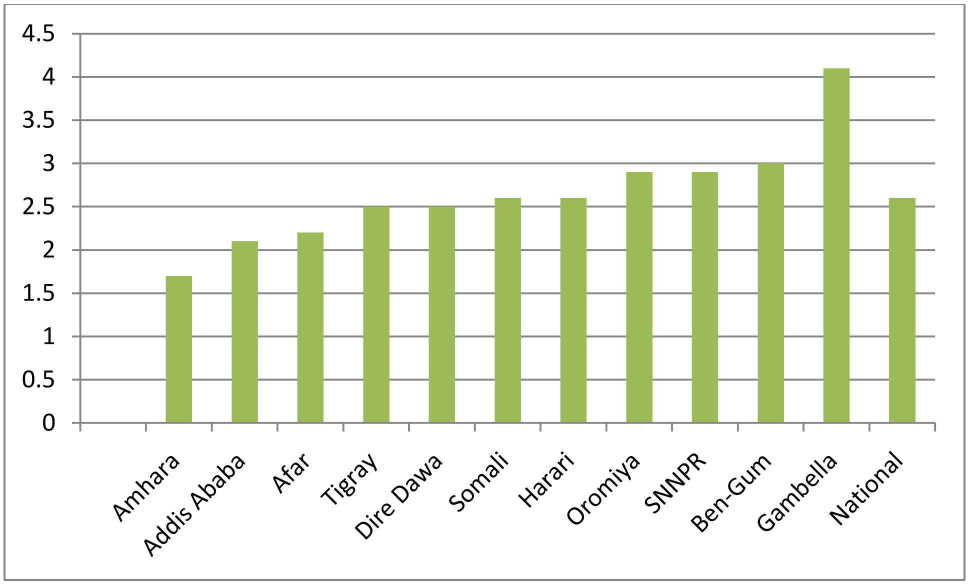


Figure 20: Population growth rate by regions, Ethiopian Demographic and Health Survey Report, CSA 2012

In Ethiopia population growth is believed to have declined although density is continuously increasing as shown below (Figure 21). The increasing population implies increased consumption of fossil fuels, fresh water, crops, fish, and forests that may exceeds what the mother earth would manage to hold (Editorials, 2008).

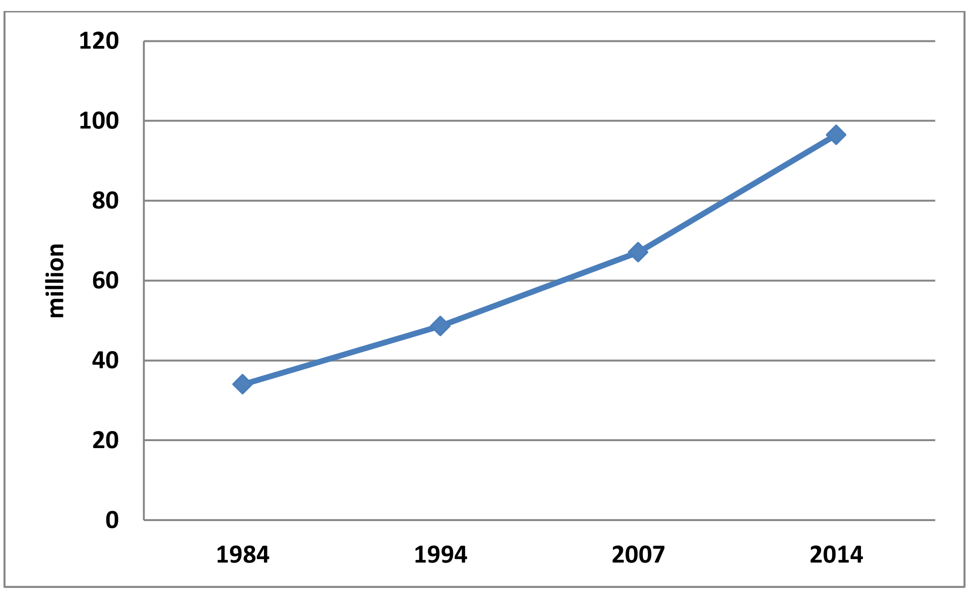


Figure 21: Population density per sq/km over the years, CSA 2012

Despite slowly declining population growth rate, density has increased from 34 people per sq/km to 67.1 people per sq/km between 1984 and 2007 (Central Statistical Agency Addis Ababa Ethiopia and ICF International Calverton Maryland USA, 2012 March). This shows a linear progress in population density which would mean an increasing pressure on natural resources on the one hand and putting pressure on existing facilities on the other hand. The implication of this on vulnerability to climate sensitive health problems is apparent given widespread resource limitation and consequent competition.

b) Education

The role of education as regards to vulnerability is well established. Equally important, state of citizen's education plays pivotal role in adaptation to climate change. Attendance of primary education over the years has increased from 22% in 2000 to 47% in 2011, which is 113% increase (2012, Central Statistical Agency Addis Ababa Ethiopia and ICF International Calverton Maryland USA, 2012 March) (Figure 22). Yet, there are still significant proportions of school age children who are not attending primary school. Afar, Amhara, Benishangul-Gumuz and Somali regions were found host proportionally more uneducated population(Central Statistical Agency Addis Ababa Ethiopia, 2014). Consistently, in all regions, more women were found be uneducated. In as much as this may have to do with several factors implication of this on vulnerability to climate sensitive health problems is clear (Figure 23).

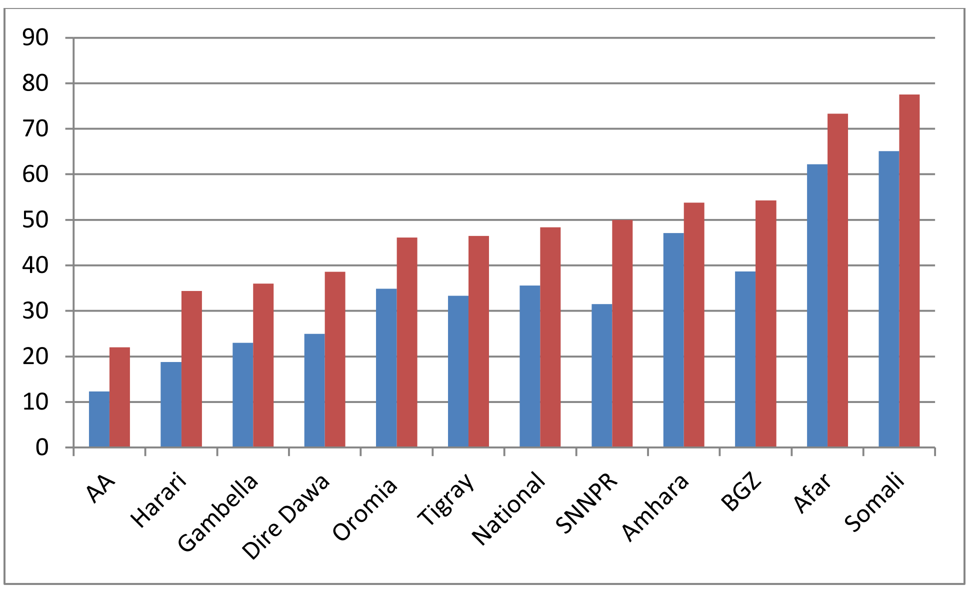


Figure 22: Percent distribution of populations with no educational attainment by sex and region, Mini-EDHS, 2014

Recent data shows that in as much as there are variations between men and women in terms of educational accomplishment, there is evident regional variation. Relatively more men and those in urbanized regions and Gambella were found to have relatively better accomplishments in educational achievements (Central Statistical Agency Addis Ababa Ethiopia, 2014) (Figure 23, 24).

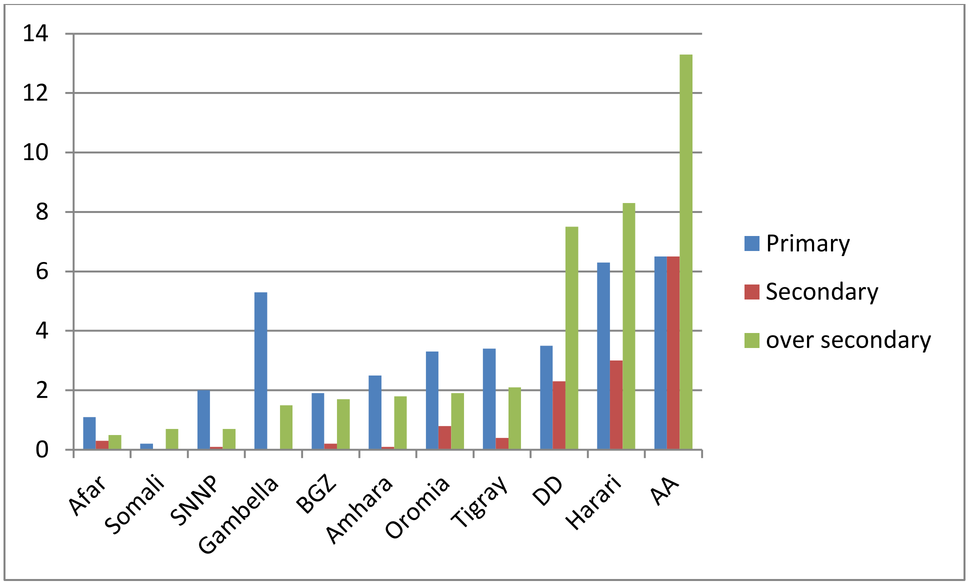


Figure 23: Percent distribution of populations with highest level of schooling attended among female by region, Mini-EDHS, 2014

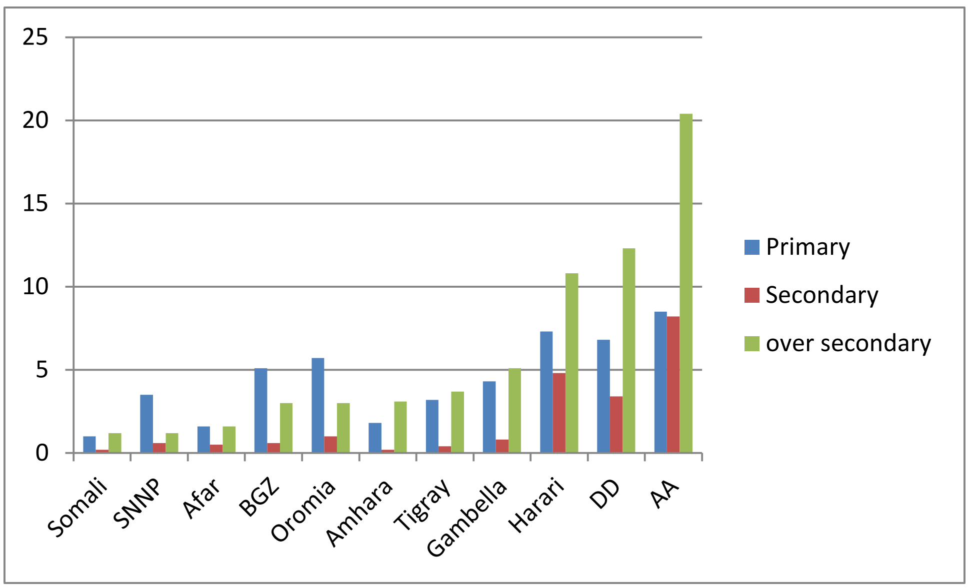


Figure 24: Percent distribution of populations with highest level of schooling attended among male by region, Mini-EDHS, 2014

From the above bar graphs it is clear that male are relatively better educated where 63% are completed at least primary level education contrary to women 51% of whom have completed at least primary education. So, adaptive strategies may need to firstly target regions with limited educational accomplishments and those with relatively better accomplishment may serve as resources.

c) Dependency ratio

Age dependency ratio is the ratio of dependents--people younger than 15 and older than 64 to the working-age population (15-64 years). Data shows the proportion of dependents per 100 working-age population (Figure 25).

In Ethiopia, the number of dependents per 100 persons was calculated at 93 where 100 people in productive age group are supporting 93 children below the age of 14 and the elderly over the age of 64 years of age. However, evidence shows that there is a huge regional variation. As depicted in the bar graph below, dependency ration is huge for Oromia and SNNP where 100 working people are supporting more than 100 dependents. On the other hand, dependency is very low in Addis Ababa. Although it will be challenging for the country at large, the bigger regions are in an awkward position to confront additional challenges posed by climate change. Besides, it is evident that those regions with heavy burden of dependency need special attention in an endeavor to build capacities of regions to mitigate challenges posed by climate change.

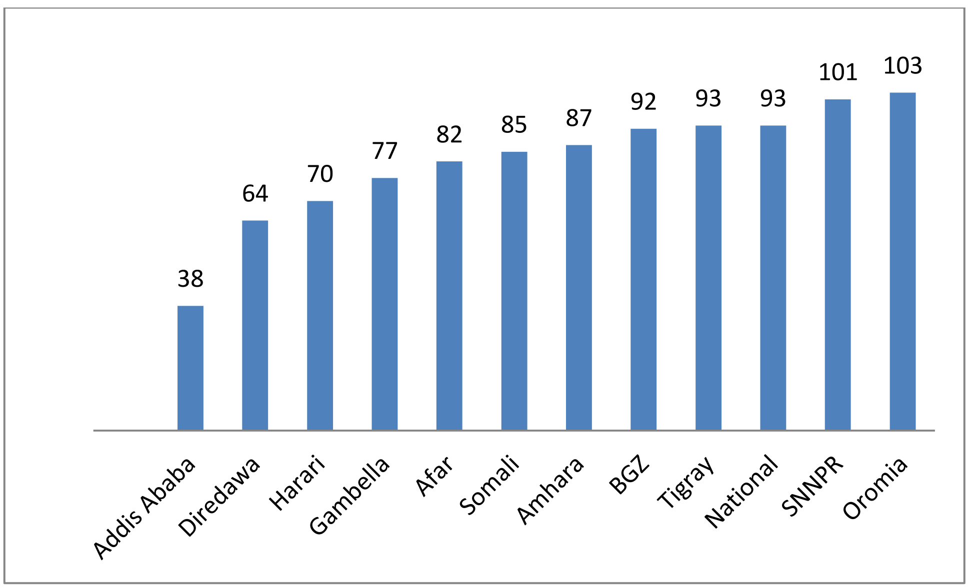


Figure 25: Dependency ratio by region, CSA, 2007

d) State of poverty

Poverty status as measured by wealth quintile reveals that 43.7% of the population lives in poor state (lowest and second lowest wealth quintile) of life(2014, Central Statistical Agency Addis Ababa Ethiopia, 2014). As shown in the bar graph below, Afar, Somali, Gambella, Benishangul-Gumuz, Amhara and Tigray regions host the largest proportion of the poor in the country (Figure

26). On the other hand, regions that are predominantly urban appear to have relatively better wealth.

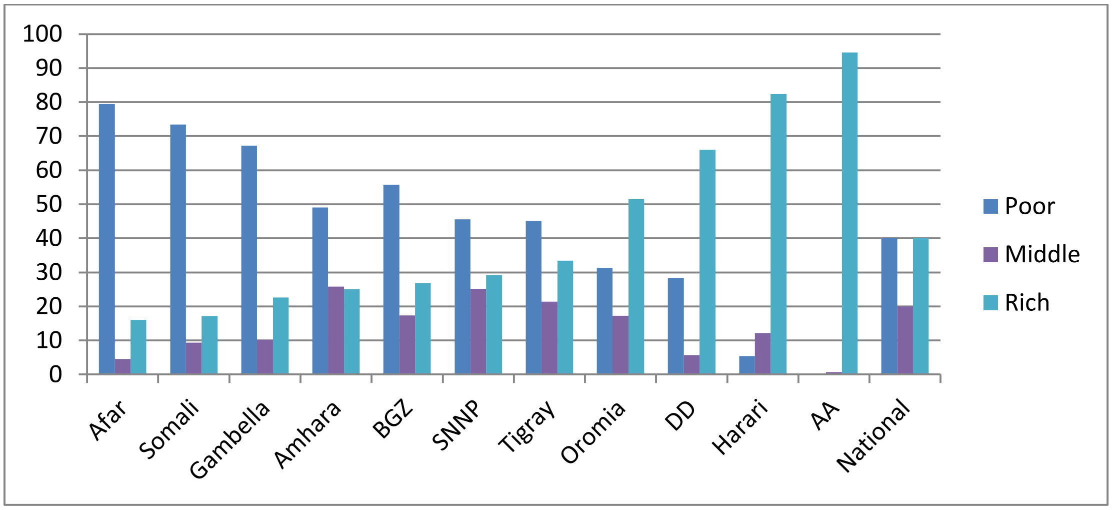


Figure 26: Wealth status by region, CSA 2014

f) Financing health services

Globally climate change poses major challenges among others to health care financing (Hutton, 2011). Sustained financing of health sector is believed to compromise the hard won gains in improving public health by limiting the amount of financial resources allocated to the health sector. To date, health service in Ethiopia is primarily financed by federal and regional governments, grants and loans from bilateral and multilateral donors and non-governmental and private contributions.

Health budget allocation as share of total budget: Available evidence reveals that government budget allocation (both capital and recurrent) for the health sector has generally declined from 10.4% in 2010 to 9.1% in 2012 (Figure 27). Similarly regional allocation has declining during the reference time. Table below clearly depicts level of allocation for health sector as proportion to overall allocation. Proportion of health budget allocation has steadily been declining for Tigray, Afar, Somali, SNNPR, Oromia, FMoH and the nation at large. However, Gambella and Dire Dawa enjoyed an increase in health budget allocation as shown by bar graph below.

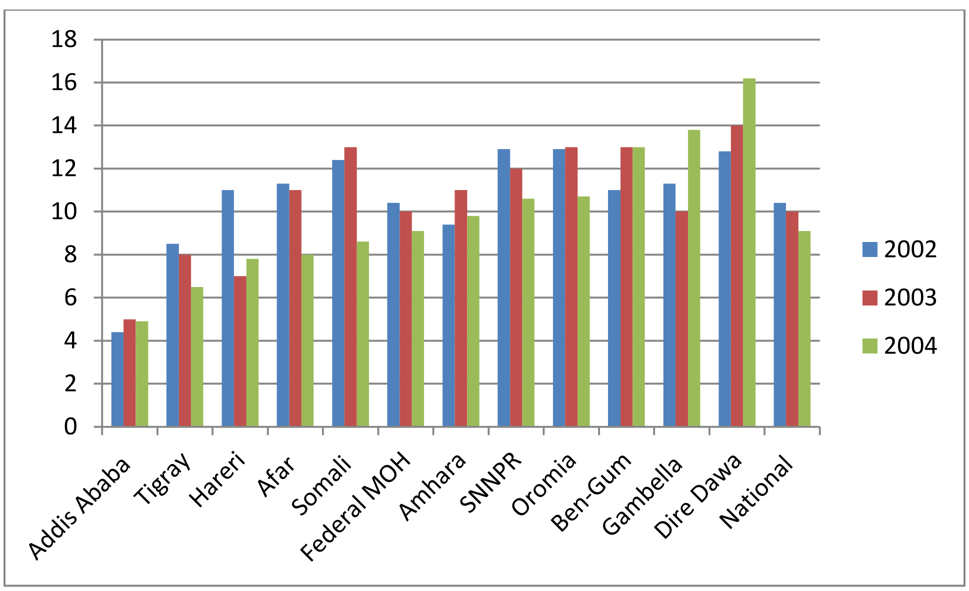


Figure 27: Share of Health Budget as proportion of Total Budget by Region for 2002-2004 EFY (2009-2012)

Despite the Abuja Declaration (OAU, 24-27 April 2001) where memeber states pledged to set a target to allocate at least 15% of their annual budget to the health sector, Ethiopia appears to have failed to meet its commitments on the one hand and in fact allocation has steadily declined over the years. This shows the fact the health sector is short of resources to meet emerging challenges in connecion to climate change.

Expenditure of health buget allocation: Further review of health budget expenditure from health allocation reveals that Tigray, Dire Dawa, Gambella and Harari manged to spend over 75% of financial resources allocated for their region (Figure 28). However, most of the bigger regions, Addis Ababa and emerging regions were found to spend 60% or less of the financial allocation for health (Federal Democratic Republic of Ethiopia Ministry of Health, 2011). This again shows capacity differences between regions.

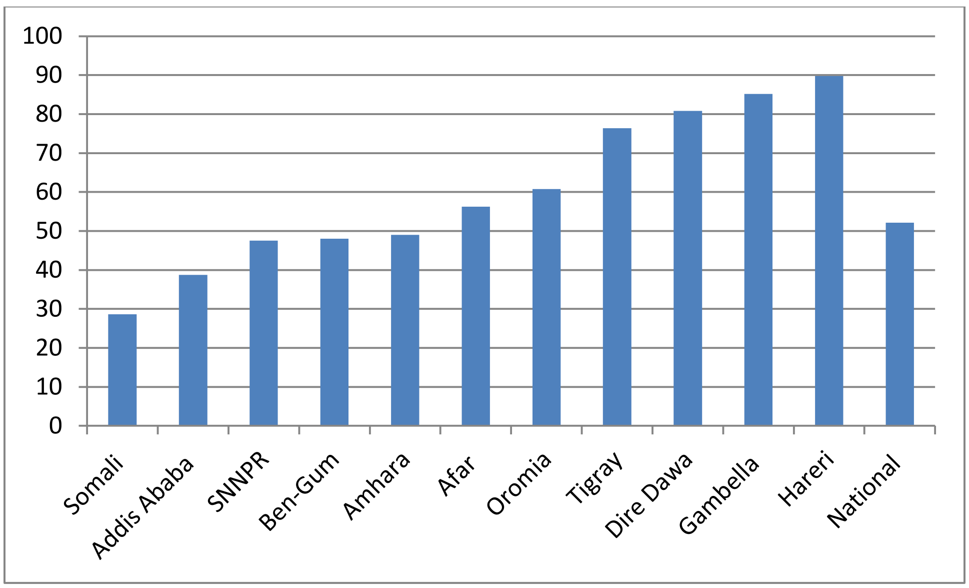


Figure 28: Percent of health expenditure from health budget allocation by region, HMIS 2003 EFY

Per-capita health expenditure: Further review of per capita health expenditure for 2011 shows disparity among regions in per capita expenditure (Figure 29). Such disparity in capacity to spend is assumed to imply varied level of vulnerability irrespective of availability of resources. Harari, Gambella and Dire Dawa has spent 80% and above of health allocation while Somali, SNNPR, Amhara , Oromia and Afar were found to have spent much less. This may have to do with the limited capacity of the regions in spending.

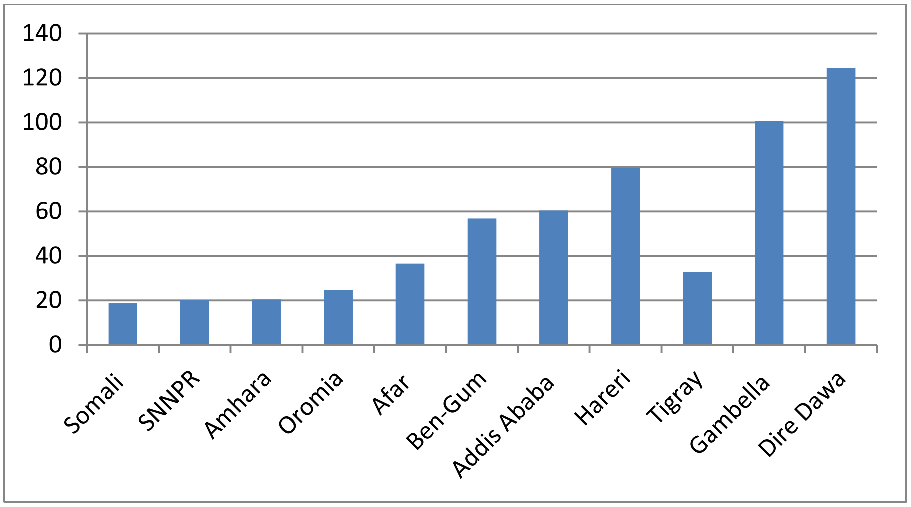


Figure 29: Per capita health expenditure, HMIS 2003 EFY (20010/11)

h) Urbanization

In Ethiopia urbanization is steadily growing during the last three decades. As shown in the chart below, urbanization jumped from 11% in 1984 to over 18% in 2013 (Figure 30).

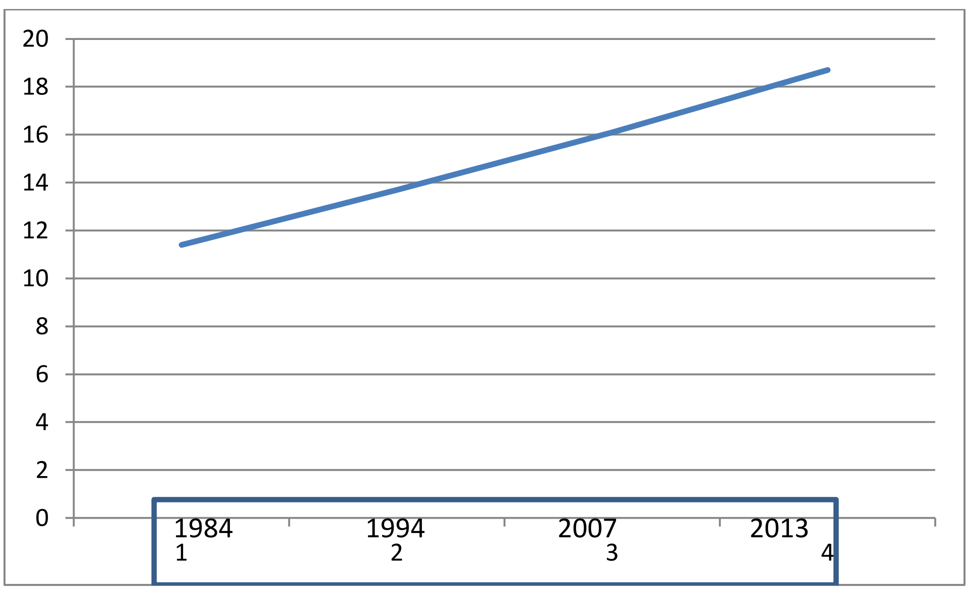


Figure 30: Change in percentage of urban residents over the years, Inter Census report, 2013

Based on the most recent census data (Central Statistical Agency, 2013), there is regional variation of the level of urbanization. As can be seen from the chart below, Harari, Dire Dawa and Addis Ababa are predominantly urban while Afar, Amhara, Oromia and SNNPR are relatively least urbanized and well below the national average (Figure 31).

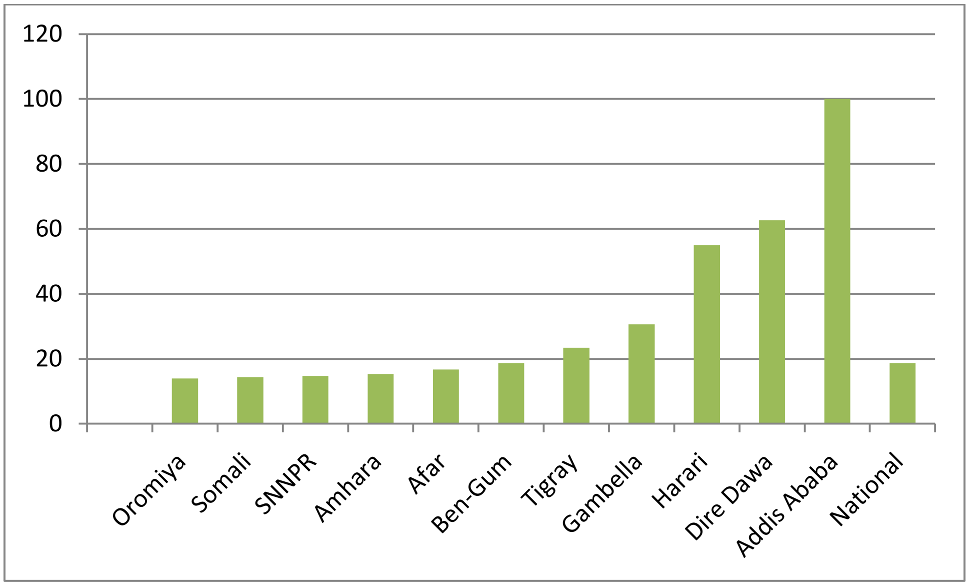


Figure 31: Percent of urban population, Inter Census report, 2013

Growing urbanization entails its own feature regarding vulnerability to climate sensitive health problems. In fact adaptation strategies would also seek to establish measures specific to urban settings.

6.11. Evidence of association of climate change and diarrhea in the context of Ethiopia

There are studies that indicated climate change affects diarrheal diseases through various mechanisms as indicated above. There exist no studies in Ethiopia on this matter. Discussing from the context meteorological vulnerability using proximate factors will be relevant to elaborate the concern.

Ethiopia is known for its ecological diversity that is mainly categorized in three ecologies. The low land known as hot climate lies below 1500 meters above sea level (masl), midland , temperate climate lies between 1500-2500 masl and highland, representing cool climate is >2500masl (Helmut and Zerihun, 2005). Diarrhea is common in the lowlands due to the fact flies are involved in the transmission on the top of limited WASH. The proportion of diarrhea among under five children was 1.5 times more than that in the Dega ecology (1.48,95%CI: (1.14, 1.93), although this was not significant for the ecology in Dega (World Health Organization Ethiopia, 2014). Fifty percent of the Ethiopian population is known to live in the lowland (Cezar and Anders, 2013). Extreme weather events such as flush flooding commonly occur in the lowlands (DireDawa Adminsitartion, 2011, Alemseged et al., 2013). The impact of climate change in this ecology is high given the weak WASH coverage. The major source of drinking water in the lowland rural areas is well water that is discharged using hand pumps or using traditional methods. Underground well is vulnerable to climate effect at times of flooding.

Other climate variable is the relatively increased temperature in the lowlands compared to the highland areas, which can be a factor to increased diarrhea because of decreased rainfall or drought that poses water shortage for hygienic practice. About 75% of the land mass in Ethiopia has been affected by desertification in one or another way (Federal Democratic Republic of Ethiopia, 2012). Temperature was found to significantly associated with diarrhea in Vietnam (Phung et al., 2014).

Residential environment from climate change perspective can be discussed as well. About 85% of the Ethiopian population lives in the rural areas. Its population is heavily dependent on rain fed agriculture. The socio-economic related services are poorly developed in rural areas compared to urban. The WASH coverage generally is also poorly developed in this population. The effect of climate change mediated by WASH shortcomings will be intensifying the transmission of diarrhea in the rural areas Vs urban. The association between climate factors and diarrhea was stronger in rural than urban areas (Phung et al., 2014, Kim et al., 2014). Climate variability, measured by temperature, flooding and drought, is projected to increase diarrhea by 13% in India (Moors et al., 2013).

Another possible proxy factor is the seasonality of diarrhea. Season in Ethiopia is heavily dependent on parameters of rainfall and temperature. Ethiopia has mainly two seasons: dry season extending from October to May, and wet season from June to September. Diarrhea has two peaks following the pattern of these two seasons. Local studies have indicated this pattern (Gedlu and Aseffa, 1996, Bezatu et al., 2013, Abebe et al., 2014). The incidence of diarrheal cases showed two peaks, one towards of the end of the wet season and the second peak just following the dry season (Alexander et al., 2013). Perhaps, we can speculate the pattern of rainfall could have changed the water use and sanitation behavior of the population that could favor the transmission of diarrhea. Water contamination is highly possible just at the beginning of rainfall and poor sanitation behavior is also possible during the dry season.

There are studies in Africa that indicated the impact of climate change on diarrhea. The increasing trend of maximum temperature and decreasing trend of rain fall and minimum temperature over 11 years of analysis (1999-2010) explained 38% of the variation in the incidence of climate sensitive diseases (diarrhea, respiratory infection, malaria, asthma, meningitis, measles) among children < 13 years old after adjusting other in Limpopo Province which is characterized by vulnerability to climate change (Thompson et al., 2012). The number of reported diarrhea over 30 years (1974-2003) in Botswana was positively associated with the increasing trend of minimum temperature, rain fall and vapor pressure (Alexander et al., 2013). The situation is consistent in Asian countries as well. A study involving records of diarrhea over 12 years (1996-2007) in Taiwan indicated maximum temperature and extreme rainfall were strongly associated with diarrhea morbidity (Chou et al., 2010). Records of diarrhea in Nepal over 10 years, however, suggested indicative association with a climate variables (increasing min and max temperature, decreasing rainfall) because of the shorter span of the records (Bhandari et al., 2012).

6.12. Synthesis of the review

Limited access and utilization of WASH facilities, the diversity of topography, knowledge and attitude of community to WASH, and the prevailing poor socio-economic status play in one or another way to impact diarrheal diseases in Ethiopia. Ethiopia will face climate induced diarrhea caused by three key mechanisms. Drought is likely to dry up small scale water points (wells and spring), which will influence to limit the quantity of household water, hence poses poor hygiene practices in all aspects. Flooding will destroy and contaminate small scale water points, in addition to destroying traditional pit latrines, hence sustaining diarrhea and inflicting outbreaks of water borne diseases. Increased temperature (max and min) is likely to affect water quality vector breeding and hygiene that can be linked to diarrhea. Hence, building adaptive capacity to climate change is the necessity.

6.12.1. Trends of diarrhea in Ethiopia

Data on diarrhea was taken from the health and health related indicators of 1992-2005 EFY (1999-2013), constituting 14 years. Categories of diarrhea were identified as the number of reported cases of cholera, dysentery, AWD, ADD that were reported as epidemics and weekly and monthly reportable diseases. Under-five diarrhea that was observed in OPDs and admissions of health facilities were also included. The incidence rate was calculated by dividing the total number of diarrhea with the regional population for each respective region, and expressed as rates per 10000 population. The population for each region was taken from the annual health and health related reports for the period of 1992-2005 EFY (1999-2013). The occurrence of diarrhea is expected in both dry and wet seasons. Shortage of drinking water is associated with poor hygiene practice, while the water quality matters during the rainy season on the background of limited access to latrine.

Increased pattern of incidence of diarrhea above the average was observed for three regions: Gambella, Harari, and Benishangul-Gumuz. Outbreaks seemed to occur in Gambella in 1994 and 1998, Harari in 1999 and BenishangulGumuz1997. Other Regions showed of no concern compared to the average occurrence over the 14 years (Figure 32). The event of flooding in Ethiopia was documented on 1994, 1995, and 1996, which might be linked to the initiation of diarrhea (Federal Democratic Republic of Ethiopia Ministry of Water Resources and National Meteorology Agency, 2007). The occurrence of diarrhea after flooding was documented in Gambella, Dire Dawa, and SNNPR (Federal Democratic Republic of Ethiopia, September 2014, International Federation of Red cross and Red Crsecent Societies, 30 August 2007, Alemseged et al., 2013). The interpretation of these data, however, needs to be, in light of the nature of secondary data because of not having other variables, such as climate data, that could explain the events. There is also a concern in the data validity for the number of cases in reference to the reporting regions. Harari for example might have reported trans-regional cases of individuals who had permanent residency from neighboring regions. Gambella and Benishangul-Gumuz might have other explanations.

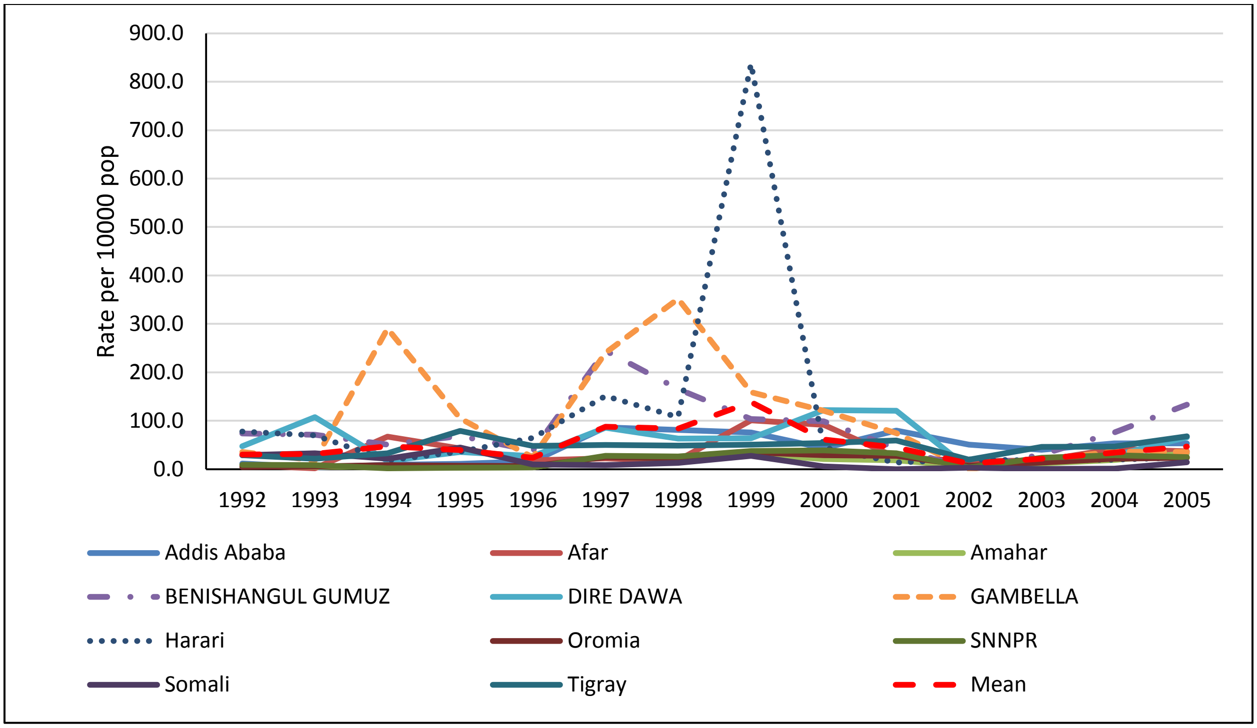


Figure 32: Trend of diarrhea in Ethiopia, 1992-2005 (1999-2013)

6.12.2. Association of climate change and diarrhea

The number of annual cases of diarrhea was subjected in a Poisson regression with annual average climate data, rainfall, humidity, and max and min temperature. Model fit test was checked to select stable model. Any model with of uncertainties due to incomplete iteration is dropped. Models were compared using Akaike's information criteria and that model with the smallest criteria was considered. Among 11 regions, only 5 had fitted model with the four climate predictors (Afar, DD, Harari, Somali, Addis A), 5 had fitted with three predictors, and one with 2 predictors (Benishangul-Gumuz) (Table 13).

Numbers of diarrheal cases are found to significantly depend on climate variables. The estimated parameter for Minimum and Max temperature is always higher than parameters for rain and relative humidity whether positive or negative. Overall, the increase in rainfall is positively associated with diarrhea. However, regional variability in the association was observed. Diarrhea is positively associated with rainfall in Amhara, Oromia, Somali, Addis Ababa, and SNNPR regions. The degree of increase rate in diarrhea for every 1mm of rain is highest in SNNPR and Addis Ababa, 5.0% and 4.2%, respectively. Increased rainfall is likely to be accompanied with flooding, and therefore, posing the risk of faecal contamination of drinking local water sources. This true in Ethiopia where one third of households use open defecation, (Central Statistical Agency Addis Ababa Ethiopia, 2014) and using local water sources such as surface water, springs and well water, about 70%% (World Health Organization and UNICEF, 2014). The national study on drinking water quality in Ethiopia is indicative of the majority of local drinking sources were heavily contaminated with faecal micro-organisms (WHO and UNICEF, 2010). The biological quality of drinking water and the casual use of unprotected sources of drinking water are factors to sustain the movement of pathogenic micro-organisms from faecal sources to drinking water sources. The transmission of diarrhea is temporal and is expected at times of rainy season, which this study was unable to describe. There are studies that supports the positive relationship between increased rainfall and diarrhea: increasing trend during wet season in Botswana (Alexander et al., 2013); flooding in Cambodia (Davies et al., 2015); Flooding was accompanied with diarrhea in Bangladesh (Qadri et al., 2005), and in Mozambique (Kondo et al., 2002), where the extent of open deification was high.

The association between rainfall and diarrhea was negative in Afar and Dire Dawa. There was about 7.6% and 6.3% decline of diarrhea for every 1 mm of rainfall in Afar and Dire Dawa, respectively. Declining rainfall in either absolute amount or in frequency is very much related to shortage of water that can be used for proper hygiene and sanitation at household level. Although diarrhea is a classic example of water borne diseases, shortage of water for hand washing, for example, makes diarrhea to be water washed (Cezar and Anders, 2013). Perhaps, the amount of water at household level in Afar and Dire Dawa might have been a factor for the increasing trend of diarrhea.

Recurrent drought and flooding in Ethiopia is a common event in Ethiopia since the 15^{th} century. Major floods took place in 1988, 1993, 1994, 1996, and 2006 in which deaths, loss of livestock and displacement occurred. The Awash and Wabi-Shebele water basins, Gambella along Baro-Akobo River, SNNPR along Omo River, and Fogera area in Gondar region are highly susceptible to flooding. However, data on the link between flooding and diarrhea is not well documented (Federal Democratic Republic of Ethiopia Ministry of Water Resources and National Meteorology Agency, 2007).

Overall, relative humidity is negatively associated with diarrhea. This is consistent in all regions, except Afar and Dire Dawa, where the increase in RH is accompanied with an increase in diarrhea. The impact of RH is highest in Oromia, Somali and Addis Ababa and Dire Dawa. For every 1% of change in the RH, diarrhea changes by 17.5% in Oromia, 15.5% in Addis Ababa and Somali. Dire Dawa had 26.7% changes in diarrhea forever unit change in RH. Vapor pressure or relative humidity is likely to affect the survival of micro-organisms in faecal matter and soil, hence the potential of infectivity. The study in Botswana indicated a directional pattern: increasing humidity (vapor pressure) increased diarrhea during wet seasons, and decreased diarrhea in dry seasons (Davies et al., 2015).

The majority of regions showed negative association between diarrhea and max temperature. The degree of the change in the max temperature is relatively increased for all regions, except Gambella and Somali. The increase in the min temperature was generally accompanied with an increase in diarrheal diseases in all regions, except in Dire Dawa and Harari. The increased unit change in the parameters in max temperature for Addis Ababa and SNNPR, and minimum temperature in Addis Ababa could be explained in poor data quality of the secondary data. This is visible in the inconsistency and huge range of the estimates of diarrheal cases for the study period. For example, the number of cases in 2001 was 1013 compared to 24934 in 2005 which is an indicative of incomplete data set. The crude estimate for degree of changes is indicated in Table 14. There are studies that indicate changes in temperature affect the trend of diarrhea (Alexander et al., 2013, Thompson et al., 2012, Chou et al., 2010).

Table 13: Association of diarrhea with climate data, 1992-2005 EFY (1999-2013)

Region	Rainfall	Relative humidity	Max temperature	Min temperature
	Rate Ratios (95%CI)	**Rate Ratios (95%CI)**	**Rate Ratios (95%CI)**	**Rate Ratios (95%CI)**
Addis Ababa	1.042 (1.041, 1.042)*	0.845 (0.843, 0.847)*	2.855 (2.781, 2.931)*	6.291 (6.158,6.426)*
Amhara	1.020 (1.020, 1.021)*	-	0.543 (0.539, 0.548)*	1.414 (1.401,1.438)*
Afar	0.924 (0.921,0.927)*	1.023 (1.019,1.027)*	1.202 (1.16,1.246)*	1.287 (1.278,1.295)*
Benishangul_G	-	0.927 (0.925,0.929)*	0.817 (0.800,0.835)	-
DireDawa	0.937 (0.934,0.939)*	1.267 (1.254,1.281)*	0.687 (0.659,0.717)*	0.267 (0.257, 0.277)*
Gambella	1.004 (1.004,1.0041)	-	1.068 (1.066, 1.070)	0.92 (0.968,0.975)*
Harari	0.992 (0.991,0.993)*	0.889 (0.885,0.894)*	0.705 (0.687,0.723)*	0.634 (0.620,0.648)*
Oromia	1.032 (1.031.1.032)*	0.825 (0.824, 0.826)*	-	1.129 (1.120,1.139)*
SNNPR	1.059 (1.059, 1.060)	0.966 (0.965, 0.966)	3.547 (3.515, 3.579)*	-
Somali	1.032 (1.031,1.033)*	0.845 (0.842, 0.847)*	0.979 (0.963, 0.995)**	1.204 (1.188, 1.220)*
Tigray	-	0.992 (0.991,0.994)*	0.825 (0.812,0.838)*	1.497 (1.472,1.523)*

*p<0.0001; **p<0.001

Table 14: Degree of changes in diarrhea (%) for very unit of the respective parameter

Region	Rainfall, %	RH, %	Max, %	Min, %
Afar	-7.6	2.3	20.2	28.7
Dire Dawa	-6.3	26.7	-31.3	-73.3
Harari	-0.8	-11.1	-29.5	-36.6
Gambella	0.4	(-)	6.8	-8
Amhara	2	(-)	-45.7	41.4
Oromia	3.2	-17.5	(-)	12.9
Somali	3.2	-15.5	-2.1	20.4
Addis Ababa	4.2	-15.5	185.5	529.1
SNNPR	5	-3.4	254.7	(-)
Tigray	(-)	-0.8	-17.5	49.7
Benishangul_Gumuz	(-)	-7.3	-18.3	(-)

(-): Not Model fitted; negative sign indicates inverse association; + sign indicates positive association. Unit changes for max temperature for Addis Ababa and SNNPR; and min temperature for Addis Ababa might be due the inconsistency of secondary data.

6.12.3. Evidence of association of climate change and malaria

Since malaria is one of the most studied climate-sensitive diseases; evidences are taken into account to describe the relationship between climate variables and malaria transmission. For instance, temperature is known to affect sporogonic development of *P.falciparum* by altering the kinetics of ookinete maturation(Noden et al., 1995). So, as temperaturesdecreasefrom27 to 21°C ookinete development and blood meal digestion takes longer duration. However, high temperatures of 30 and 32°C appeared to significantly affect parasite densities and infection rates by interfering with developmental processes occurring between parasite fertilization and ookinete formation, especially during zygote and early ookinete maturation (Olson et al., 2009).

Another study indicated the influenceofclimateonmalariatransmissiondependsondailytemperature variations, with temperature fluctuations around low mean temperatures facilitating to speedup rate processes, whereas fluctuations around high mean temperatures act to slow down the processes (Paaijmans et al., 2010). On the basis of basic biology of malaria vectors, studies showed absence of the vectors in geographic zones with very cool ones to survive (Martin and Lefebvre, 1995, Martens et al., 1999). But forecasts depicted increase in the geographic range of malaria following the escalating of temperature (Martens et al., 1995, Lysenko and Semashko, 1968).

In Ethiopia, 75% of the total landmass (or <2000 m) is malarious or potentially malarious (Adhanom et al., 2006). However, the occurrence of endemic malaria is documented during non-epidemic years beyond the threshold elevation for transmission (Graves et al., 2009, Tesfaye et al., 2011) malaria transmission in highland areas is critically influenced by night time temperature. The role of temperature in determining malaria endemicity and intensity is more pronounced at areas boundary to upper limits of malaria endemicity (Molineaux, 1988) Consequently, the abrupt rise in night time temperature mainly due to warming is expected to push the elevation known to be the upper limit boundary, which is 2000 m in Ethiopia.

So far, in the Ethiopian situation, there is a supporting evidence for the rise of minimum temperature in the last decades. A rise of in daily minimum temperature of $0.4^{o}C$ per decade has been recorded in the highlands of Ethiopia (Conway et al., 2004). Probably, as described earlier, persistent increase in minimum temperature in the highlands above the threshold for completion of the parasite life cycle in mosquitoes within the life span of the vector (sporogony) (Molineaux, 1988).

According to projections in the past the highland areas of Ethiopia and Zimbabwe are among those with expected rise of malaria incidence in higher altitudes. A climate forecast related to future distribution of malaria in relationship with climate change or temperature rise demonstrated both Ethiopia and Zimbabwe will be the most affected (Tanser et al., 2003). The Highlands of Zimbabwe become more suitable for transmission (Craig et al., 199).

Moreover, a study considered composite of vector-borne diseases demonstrated the increase in geographical areas of the diseases beyond their endemicity limit. Martens *et al*. (1997) assessed the potential impacts of anthropogenically-induced climate change on vector-borne diseases globally and suggested an increase in extent of the geographical areas susceptible to transmission of malarial Plasmodium parasites, dengue Flavivirus and Schistosoma worms (Martens et al., 1997). Those diseases are highly sensitive to climate changes on the periphery of the currently endemic areas and at higher altitudes within such areas. The study indicated that compared to the present endemic areas the increase in the epidemic potential of malaria and dengue transmission may be estimated at 12-27% and 31-47%, respectively, while in contrast, schistosomiasis transmission potential may be expected to exhibit a 11-17% decrease (Martens et al., 1997).

More surprisingly, emerging and remerging vector-borne diseases also reported in recent years. For instance, WHO report showed the reemergence of Yellow Fever in southwestern during 2013 and Dengue Fever in eastern part of Ethiopia. Changes have the potential to increase the risk of transmission by increasing the distribution and abundance of vectors, and duration of mosquito and seasons (Russell, 1998). Another important issue is that it is likely that some areas will have increases in activity and human infection with predicted climate change, but risk of increased transmission will vary with locality, vector, host and human factors (Russell, 1998). A literature has shown that dengue was relatively uncommon in East Africa before 1952. However, outbreaks were documented in several countries between 1924 and 1950; Mozambique, Madagascar, Ethiopia, Somalia, and the Comoros.

A recent study indicated that dengue was present in Ethiopia (Dire Dawa and Harrar), Somalia (Mogadishu), Madagascar (Diego Suarez) and in the Comoros Islands (Mayotte) and in other parts of Somalia (Kismayu, Berbera and Hargeisa) and Mauritius (McCarthy and Bagster, 1948). It has been described that the disease is well adapted to the urban environment but also occurs in rural areas. The vector breeds in containers where water is allowed to accumulate. *Aedes* mosquitoes thrive in warmer environments, but not in dry environments. Higher ambient temperatures favor rapid development of the vector, increase the frequency of blood meals, and reduce the extrinsic incubation period (EIP). Dengue fever is among climate sensitive diseases believed to aggravate with rise of temperature and environmental changes. A study has shown, if the ambient temperature is too low, mosquitoes are unlikely to survive long enough to become infectious and pass on dengue (Patz et al., 2000). The Comoros, Ethiopia, Kenya, the Seychelles, Somalia, Tanzania, Réunion, Mauritius, and Mozambique were considered to be endemic from 1975 to1996 (Van Kleef et al., 2010). Dengue occurs sporadically in Kenya and Somalia in which four major outbreaks between 1982 and 1993 in various regions of Somalia. This review didn’t uncover any notable outbreak for Ethiopia (WHO, 2009). But it was confirmed that there was an outbreak in Eritrea in 2005. In order to support the planning and designing of adaptation strategies to protect health from climate change in Ethiopia this project is prepared to generate data from various sources. This is therefore to conduct online review of available evidence and see the relationship of climate- sensitive diseases and climatic elements. This study is aimed at the most vulnerable regional states to inform policy-/decision-makers.

6.12.4. Results from time series analysis

The association of climate and malaria cases for seven regional states and two city administrations using GLM regression model is presented (Table 15). A minimum temperature and malaria case showed statistically significant association in Tigray, Gambella, Dire Dawa and Afar. The association was more remarkable in the case of Tigray. Similarly, maximum temperature showed association with malaria case in SNNP, Oromia, Benishangul-Gumuz, Amhara, Afar and Addis Ababa. From this finding the association of malaria cases and rainfall and both temperature variables showed high variability among regional states.

Table 15: Regression using GLM for malaria cases, May 2015.

Regional States	Variables	RR	95%CI
Addis Ababa	Rainfall	0.991	0.990-0.992
	Tmax	1.291	1.248-1.336
	Tmin	0.836	0.809-0.863
Afar	Rainfall	0.862	0.860-0.863
	Tmax	1.121	1.110-1.132
	Tmin	1.506	1.501-1.511
Amhara	Rainfall	1.038	1.038-1.038
	Tmax	1.746	1.741-1.750
	Tmin.	0.293	0.292-0.294
Benishangul-G.	Rainfall	1.006	1.006-1.006
	Tmax	1.399	1.392-1.407
	Tmin	0.731	0.729-0.733
Dire Dawa	Rainfall	0.951	0.949-0.953
	Tmax	0.266	0.254-0.279
	Tmin	2.165	2.052-2.285
Gambella	Rainfall	0.996	0.996- 0.996
	Tmax	0.878	0.876-0.881
	Tmin	1.239	1.236-1.243
Oromia	Rainfall	0.971	0.970-0.971
	Tmax	1.851	1.844-1.859
	Tmin	0. 653	0.651-0.655
SNNP	Rainfall	1.042	1.042-1.042
	Tmax	2.099	2.093-2.102
	Tmin	0.722	0.720-0.724
Tigray	Rainfall	1.032	1.032-1.032
	Tmax	0.858	0.848-0.869
	Tmin	3.036	2.999-3.074

Somali with three year missing and not included in the analysis.

6.12.5. Future Vulnerability

6.12.5.1. Predicting diarrheal using time series model

Data were converted to incidence (diarrhoea cases divided by population) before subjecting it to analysis. From fitting Generalized Linear Model (GLM) to the disease related data as response and weather data predictors, the former was found to depend significantly on the later. Therefore it would be logical to use Rainfall, RH, minimum and maximum temperature variables of each region as predictor variables in order to forecast disease out come through 2020. Various models such as ARIMA with different parameters (i.e., different Autocorrelation, Differencing and Moving Average values) and a number of smoothing methods were fitted and the best fitting models selected based on results of model diagnostics. Predictions may not be reliable unless the existing series (2004 – 2014) is sufficiently smoothed. For this reason the observed time series was smoothed using best chosen model so that forecasts can easily be made in to the future. However, since the length of the observed data is short (only about 11), the forecast depends only on a single decade series.

In the following, we will present graphs showing plot of observed data (in red color), fitted curve with 95% C.I in the first panel and forecast line with its C.I. in the second panel for each disease data by region in the Annex (Annex 10). A table is also presented to provide numerical forecasts with corresponding C.I for use in reports as necessary. The confidence Intervals are often very wide due to high variability in the disease cases from year to year which is associated with high standard error of the mean. It is safer to refer to confidence limit than considering a single value as forecast because we are 95% sure that disease cases will lie between those intervals in the years ahead, given that the current mode of services continue in the same manner.

Looking through the plot of the observed diarrhoea data, two pick points may be observed, lowest and highest diarrhea cases in 2010 and 2005 respectively in considerable number of regions. These years may be attributed to interventions (2010) and occurrence of high cases for some reason (2005). In Somalia region, the fitted (smoothed) curve shows a rapid overall decreasing trend in diarrhoea incidence from year to year, with forecast values followed similar pattern. In most regions the forecast values are constant, due to small range in the incidence values, indicating that the current trend in diarrhea prevalence will continue in the similar manner if no further intervention is designed. Generally the predicted estimates of diarrheal diseases for the next five years (2015-20120) based on 2000-2013 diarrheal data is constant for all regions, except Somali region. No appropriate model was available for forecasting diarrhoea incidence in Benishangul-Gumuz and SNNPR regions. The case of Amhara region is presented in Figure 33. A trend in Diarrhea between 2000 and 2013 is undulating for Amhara region. It showed increase between 2005 and 2009, but decreased rapidly afterwards, then increased after 2011 reaching about 35 cases per 10000 people by 2013. From the forecast panel, although the predicted diarrhea case seems to be constant at 35000, the confidence interval for the forecast goes up to 80 cases per 10000 people by the end of 2020. Therefore, it must be assumed that diarrhea cases in Amhara region will lie between 35 and 80 cases per 10000 people in the years ahead if no intervention is in place. Figures for the remaining regions are presented in Annex 17.

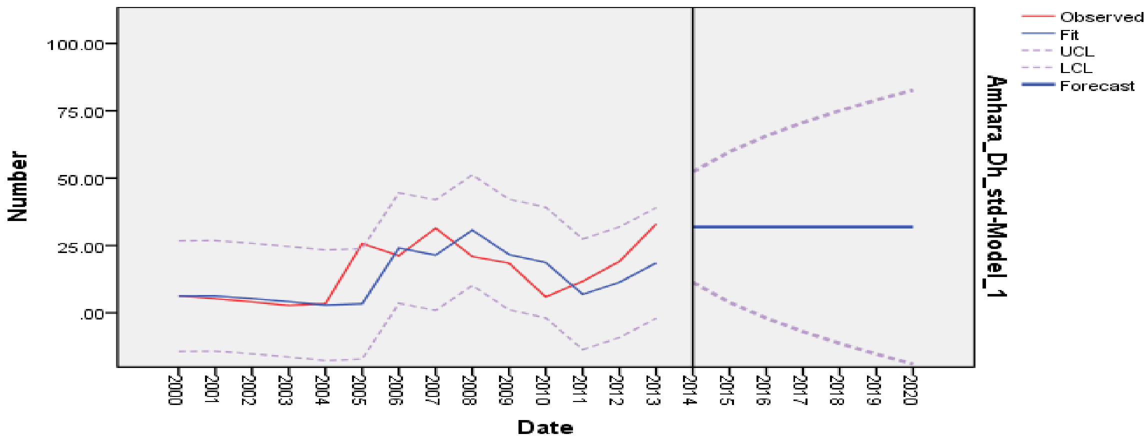


Figure 33: Current trend of Diarrhea in the left panel (with its observed in red, estimated in blue and 95% Confidence interval) and predicted values in the right panel (again with estimated value in blue and 95% C.I) for Amhara region

6.12.5.2. Forecasting malaria cases by Region

Looking through the plot of the observed malaria data, two pick points may be observed, lowest and highest malaria cases in 2009 and 2013 respectively in considerable number of regions. These years may be attributed to interventions (2009) and normalization of cases for some reason (2013). In Amhara region, the fitted (smoothed) curve shows a rapid overall increasing trend in malaria cases from year to year (Figure 34). The forecast values followed similar pattern. For example, malaria cases are projected to be about 833,586 by 2015 (or from 48 persons to 75 persons per 1000 people following the C.I.) and expected to reach over one million by 2020 (or approximately 55 to 120 persons per 1000 people using the C.I) if things continue the way they are today. Therefore, there is some limited evidence that climate change exacerbate malaria cases if no action is taken.

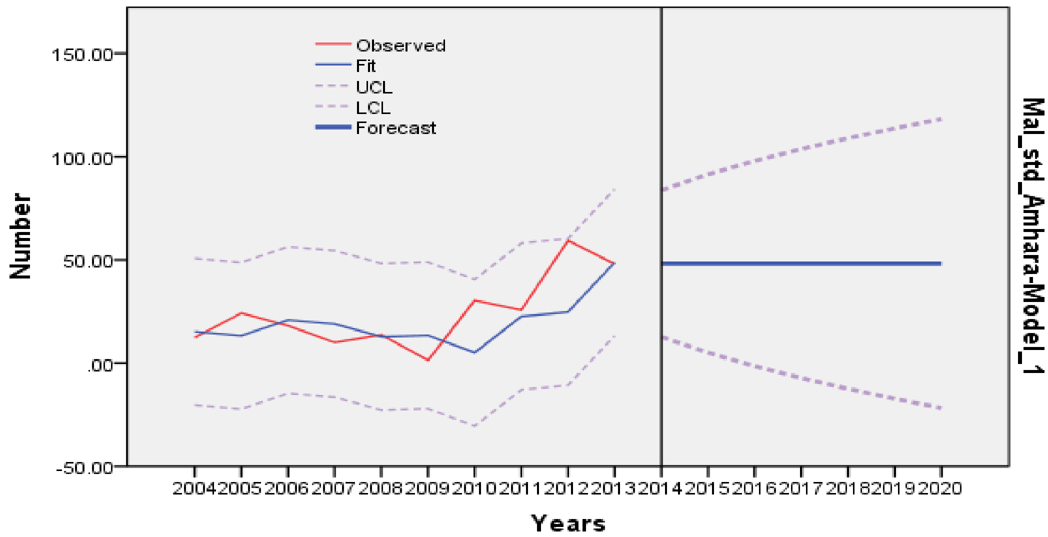


Figure 34: Current trend of Malaria (persons per 1000 people)in the left panel (with its observed in red, estimated in blue and 95% Confidence interval) and predicted values in the right panel (again with estimated value in blue and 95% C.I) for Amhara region.

In Oromia region, malaria cases showed a small but gradual decrease from 2004 up to 2009, and then sharp increase during the following year reaching the maximum by 2013 and started to decline again. Due to short fluctuations in the annual data, the estimated line could not be smoothed as that for Amhara region. Although there is a general increasing trend through the decade, the fitted curve is a bit undulating. Because of lack of smoothens in the fitted line contributed to a constant forecast of 359,941 (approximately 17 cases per 1000 people which may reach 45 cases per 1000 people by 2020) throughout. The 95% Confidence Interval on the other hand is very wide, even getting wider becoming a parabola, which is an indication of difficulty of projecting in the future based on present observation. Oromia and Southern region showed a similar pattern in the malaria cases.

No appropriate model was available for forecasting Meningitis cases in Addis, Amhara, Oromia and Tigray regions where modeling was attempted, but better model among those available (mean model) is selected by the diagnostic tool to give an idea of the trend. You may observe that the lower confidence bound is negative owing to inappropriateness of the model for Addis case. The forecast is a constant value which may not be realistic. To demonstrate the problem, various models were fitted and lines plotted on same graph for Amhara to show the lack of fit of these models to the observed data. Therefore, since no appropriate forecasting model is available it may not be possible to predict what the Meningitis cases will look like in the next five years.

The findings discussed so far are summarized for each regional state and malaria case as well as forecast for the upcoming five years (2015-2020) and shown in the Annex 10. In general, forecasting using standardized malaria cases showed steady state but with wide C.I which fits to the expected rise of malaria in the coming five years.

6.13. Vulnerability assessment

Assessing the various components that contribute to climate change vulnerability is an important part of adaptation planning, and one of the first steps. Vulnerability assessments can assist in (1) determining the extent that climate change is likely to damage or harm a system and (2) adapting to the impacts of climate change. They provide hence a basis for identifying the most appropriate adaptation options. Vulnerability assessments are also important as they can provide evidence of the linkages between climate and development, improve understanding of specific risks and vulnerabilities in different localities, provide the opportunity for capacity building, and serve as a baseline analysis to monitor how risks may be influenced by a changing climate over time.

This national assessments of the potential effects of climate change on human health to better understand current vulnerability and to evaluate the country's capacity to adapt to climate change by modifying the health adaptive capacity or by adopting specific measures of public health. In addition, more national information and assessments are needed to feed into the international policy processes, such as that of the national communications to the UNFCCC and those from other climate change assessments.

The HVI analysis considers the three IPCC contributing factors to vulnerability — exposure, adaptive capacity, and sensitivity as major factors, the 9 profiles that determine the three major components in detail for the analysis as explained in the previous sections. The standardized values were used to calculate and explain the major factors' values only.

6.13.1 Exposure

The exposure component encompasses two profiles: climate and Hazard under this component. The climate profile includes the annual average rainfall and temperature (both maximum and minimum). The hazard profile takes into account Average Emergency Beneficiaries (1997- 2006 EC) and distribution of population in the climate sensitive disease exposed area by Region.

The combined standardized climate profile values ranges from 0.09- to 0.96 while the combined standardized Hazard profile values ranges from 0.04- to 0.58 (Table 16). The final values for the exposure levels ranged from 0.12 (AA) to 0.69 (Gambella). The analysis show that Amhara, Tigrai, Harari and SNNP regions are moderately exposed. A combination of moderate variation in climate and medium values in hazard profile are the probable reasons. The lowland emerging regions Afar, Gambella, Benishangul and Somali regions are highly exposed to changes to climate change.

Table 16: The combined standardized values for climate and hazard components and exposure by region

Region	Sub-Component		Exposure
	Climate	Hazard	
AA	0.23	0.036	0.12
Afar	0.41	0.480	0.45
Amhara	0.09	0.398	0.26
B.Gumuz	0.96	0.401	0.64
Dire D	0.15	0.206	0.18
Gambella	0.88	0.540	0.69
Harari	0.61	0.166	0.36
Oromia	0.09	0.151	0.13
SNNPR	0.37	0.483	0.43
Somali	0.43	0.575	0.51
Tigray	0.21	0.344	0.29
Avg	0.40	0.343	0.37
Max	0.96	0.575	0.69
Min	0.09	0.036	0.12

6.13.2 Sensitivity

Sensitivity reflects the degree of response to a given shift in climate. As a result the area that are favorable to malaria, vulnerable population (Dependency Ratio) and the proportion of households living in a climate sensitive disease prone areas (malaria) are grouped under the sensitivity component (Table 17). As evident from the average sensitivity value, all the regions are highly sensitive to climate induced diseases with the exception of Addis Ababa.

Table 17: Standardized index values of major determinants of sensitivity by Region

Region	Climate Sensitive Area (%)	% HHs in the exposed area	Dependency Ration	Population at Risk for Malaria %	Sensitivity
Addis Ababa	0.15	0.26	0.50	0.00	0.23
Afar	1.00	1.00	0.74	0.98	0.93
Amhara	0.57	0.67	0.87	0.75	0.72
Ben-Gumuz	0.98	0.91	0.51	0.79	0.80
Dire Dawa	1.00	0.88	0.43	0.42	0.68
Gambella	1.00	0.92	0.55	1.00	0.87
Hareri	0.77	0.88	0.53	0.79	0.74
Oromia	0.79	0.55	0.98	0.65	0.74
SNNPR	1.00	0.59	1.00	0.63	0.80
Somali	0.80	0.83	0.80	0.89	0.83
Tigray	0.75	0.76	0.96	0.71	0.80
National	0.80	0.75	0.72	0.69	0.74
Max	1.00	1.00	1.00	1.00	0.93
Min	0.15	0.26	0.43	0.00	0.23

6.13.3 Adaptive capacity

Adaptive capacity is the theoretical ability of a region or community to respond to the threats and opportunities presented by climate change. It is affected by a number of factors. It encompasses coping capacity and the strategies, policies and measures that have the potential to expand future coping capacity. Adaptive capacity denotes the capacity to cope up with the changes and adapt to changing conditions. It is dependent on several socio-economic factors such as finance, infrastructure, available health professionals and social determinants of health (Table 18).

Table 18: Standardized index values of the major determinants of adaptive capacity

Region	Finance Resources (3)	Physical Facilities (7)	Human Resources (4)	Social Determinants (6)	Adaptive Capacity
Addis Ababa	0.34	0.73	0.47	0.83	0.650
Afar	0.20	0.35	0.11	0.22	0.240
Amhara	0.36	0.57	0.09	0.35	0.377
Ben-Gum	0.42	0.32	0.39	0.37	0.365
Dire Dawa	0.63	0.63	0.32	0.55	0.543
Gambella	0.34	0.36	0.34	0.41	0.369
Harari	0.58	0.70	0.75	0.56	0.650
Oromia	0.53	0.32	0.11	0.38	0.328
SNNPR	0.44	0.45	0.17	0.44	0.389
Somali	0.26	0.38	0.00	0.12	0.208
Tigray	0.31	0.53	0.20	0.46	0.410
Average	0.40	0.49	0.27	0.43	0.412
Max	0.63	0.73	0.75	0.83	0.650
Min	0.20	0.32	0.00	0.12	0.208

The financial component values show that most regions have very low capacity as the values range from 0.63 (Dire Dawa) to 0.20 9 (Afar). Higher adaptive capacities are seen only in the main urban regions (Harari and Dire Dawa).Adequate funds are needed to maintain core health system functions, including in the case of a crisis. In addition to providing funds for core health and public health services (water/sanitation/environmental hygiene/disaster and health emergency preparedness), it is necessary to plan for insurance or replacement costs for health facilities and equipment lost or damaged due to extreme weather events.

Provision of infrastructure, facilities and services are highly interrelated and require increase at the same rate or higher to the level of population growth in order to provide the minimum health service package to the community. Health service delivery should combine inputs to provide effective, safe, good-quality health interventions in an efficient and equitable manner. In terms of physical facilities all the urban regions (AA, DD and Harari) have the highest indexes (more than 0.5). Addis Ababa has the highest physical capital (0.73). The three major regions have moderate values (Amhara (0.57), SNNPR (0.45) and Tigray (0.53). Oromia and the other emerging regions relatively low physical resource indexes. A range of medical products and technologies are needed to protect populations from climate-sensitive health conditions. These include medical equipment and supplies for emergency response, permanent and emergency health facility services, and technologies in health-supporting sectors such as water and sanitation and environmental hygiene.

A well-performing health workforce is needed to achieve the best health outcomes possible in view of climate change. This includes sufficient numbers and a mix of qualified, competent and productive staff to address all the climate sensitive health problems. In terms of human resources all regions have very low indexes with the exception of Harari. This is because of the low population number it has.

Social determinants included are demography, education and food security status of the respective regions. The standardized values ranged from 0.12 (Somali) – 0.82 (AA). While the three urban regions have relatively better values, the four big regions have medium values. Afar and Somali have the least values. The average adaptive capacity values range from 0.21 (Somali) to 0.65 (AA). The finance, infrastructure, human and social profiles are found to be strong determinants of adaptive capacity. Addis Ababa and Dire Dawa regions have the highest adaptive capacity. While Somali and Afar regions have the lowest adaptive capacity, the rest do have intermediate capacities.

6.13.4 Health Vulnerability Index

The final vulnerability indexes for the regions have been calculated by combining all the three components of exposure, sensitivity and adaptive capacity. The results produce measures of exposure, sensitivity, and adaptive capacity, which all differ systematically across regions (Table 19 and Figure 35). Based on the equations of LVI-IPCC (Eq. 5), it is evident that high values of exposure relative to adaptive capacity yield positive vulnerability scores (Belay et al., 2014). On the other hand, low values of exposure relative to adaptive capacity yield negative vulnerability scores. Sensitivity acts as a multiplier, such that high sensitivity in a region for which exposure exceeds adaptive capacity will result in a large positive (i.e., high vulnerability) HVI-IPCC score. The values lie between _1 and +1. The lesser the value, the lesser is the vulnerability of the region.

The calculated HVI values ranged from -0.247 (Dire Dawa, less vulnerable) to 0.279 (Gambella, highly vulnerable) (Fig. 35). The final values are divided into four groups for ease of understanding the results for the policy makers in the health sector. The two urban regions (Dire Dawa and Harari) having less than -0.2 values are categorized as least vulnerable. Oromia, Addis Ababa, Tigray, and Amhara Regions with a value of -0.2 to 0.0 medium vulnerable. SNNP with a value of 0.033 is categorized as highly vulnerable and those with greater than 0.1 (Afar, Somali, Gambella and BenishangulGumuz) are very highly vulnerable.

All the emerging regions are very highly vulnerable to the impacts of climate change sensitive health issues. This result indicates that an adaptive capacity is in deficit and high exposure relative to other regions. The opposite is true for the less vulnerable regions, in which adaptive capacity exceeds exposure and overall vulnerability is deemed to be low.

Table 19: Calculated indices for contributing factors and the Health Vulnerability Index

Region	Exposure	Sensitivity	Adaptive Capacity	HVI
Addis Ababa	0.120	0.230	0.650	-0.122
Afar	0.450	0.930	0.240	0.195
Amhara	0.260	0.720	0.377	-0.084
Ben-Gum	0.640	0.800	0.365	0.220
Dire Dawa	0.180	0.680	0.543	-0.247
Gambella	0.690	0.870	0.369	0.279
Harari	0.360	0.740	0.650	-0.215
Oromia	0.130	0.740	0.328	-0.147
SNNPR	0.430	0.800	0.389	0.033
Somali	0.510	0.830	0.208	0.251
Tigray	0.290	0.800	0.410	-0.096
Average	0.369	0.740	0.412	0.006
Max	0.690	0.930	0.650	0.279
Min	0.120	0.230	0.208	-0.247

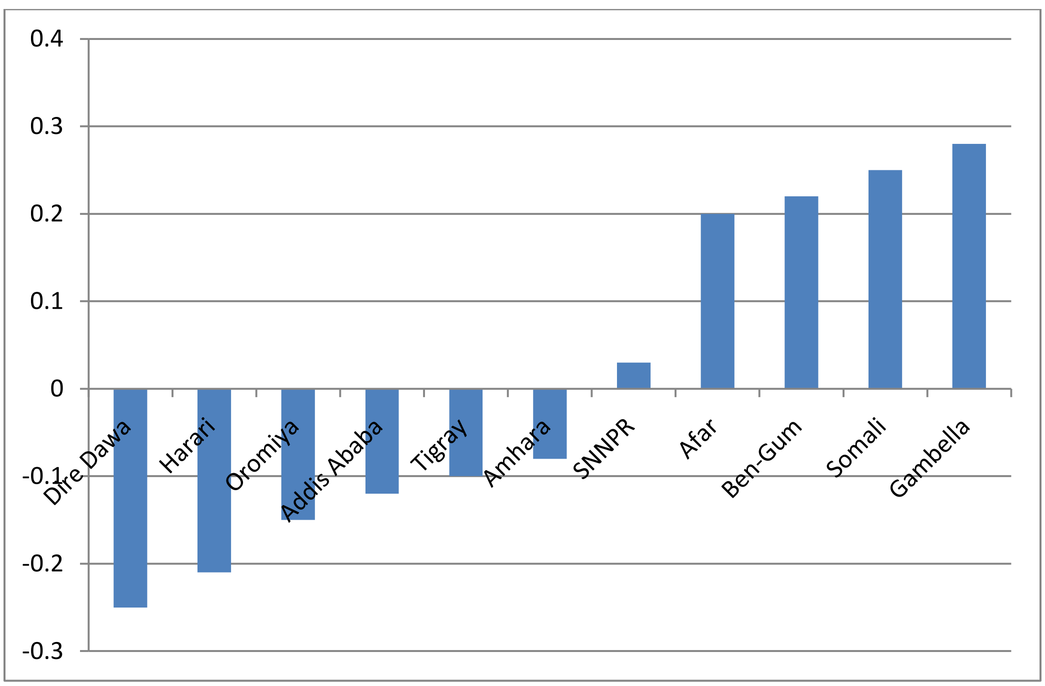


Figure 35: Calculated indices for the Health Vulnerability Index

Putting in geographical context, the results of estimating HVI concludes that 0.6 % of the total land mass (Harari and Dire Dawa) only is relatively least vulnerable to climate change sensitive diseases (Fig. 36). 49.95 % of the land mass (Oromia, Addis Ababa, Amhara and Tigrai) are relatively moderately vulnerable. While 10.35% (SNNP) of the land mass is categorized as highly vulnerable, the rest 39.5 % of the total land mass (Afar, Benishangul-Gumuz, Somali and Gambella) is categorized as having very high relative vulnerability (Table 20).

Table 20: Area coverage and population of Ethiopia by vulnerability classes

vulnerability classes	**Regions**	**Area coverage (KM2)/%**		**Population (mlns)/%**	
Least Vulnerable	Dire Dawa and Harari	1901	0.6	0.635	0.74
Moderately Vulnerable	Oromia, Addis Ababa, Amhara andTigrai	565875	49.95	59.562	69.48
Highly Vulnerable	SNNP	117263	10.35	17.403	20.3
Very HighlyVulnerable	Afar, Benishangul-Gumuz, Somali and Gambella	447855	39.95	8.129	9.48

Consideration the population 0.74 % of the total population (0.07 million) who live in Harari and Dire Dawa are relatively least vulnerable to climate change sensitive diseases while, 69.48 % of the population (Oromia, Addis Ababa, Amhara and Tigray) are moderately vulnerable (Figure 36). 20.3% of the total population (SNNP) is highly vulnerable. 9.48% of the populations are categorized as very highly vulnerable. These are people who live in the lowland regions of Afar, Benishangul-Gumuz, Somali and Gambella.

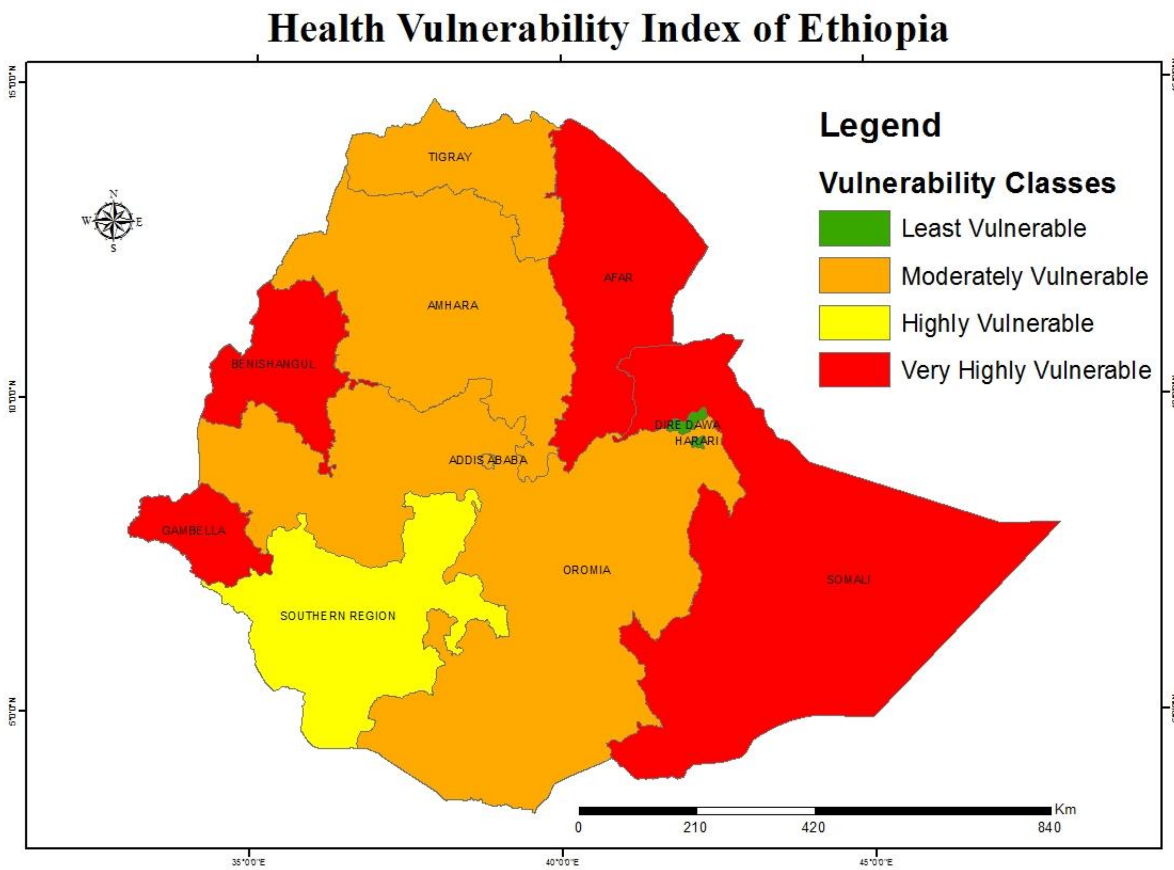


Figure 36: Relative Health Vulnerability Index Ethiopia by Region.

6.14. Adaptation strategy

As discussed in the previous sections, climate change in Ethiopia is posing a threat to human health. Available document though scanty reveals excess mortality and morbidity due to drought, flood and consequent changing patterns of infectious diseases. In order to cope with the looming threat from climate change, and evident impacts, the heath sector requires developing its own adaptation strategies.

Adaptation includes the strategies, policies and measures undertaken now and in the future to reduce potential adverse health effects. Adaptive capacity describes the general ability of institutions, systems and individuals to adjust to potential damages, to take advantage of opportunities and to cope with the consequences. The primary goal of building adaptive capacity is to reduce future vulnerability to climate variability and change. Coping capacity describes what could be implemented now to minimize negative effects of climate variability and change. In other words, coping capacity encompasses the interventions that are feasible to implement today (in a specific population), and adaptive capacity encompasses the strategies, policies and measures that have the potential to expand future coping capacity. Increasing the adaptive capacity of a population shares similar goals with sustainable development – increasing the ability of countries, communities and individuals to effectively and efficiently cope with the changes and challenges of climate change.

It is useful to consider health-related adaptive strategies as being divided into *autonomous* and *planned* adaptation as defined by the IPCC (2007) (IPCC, 2007b). A*utonomous adaptation* actions are responses that will be implemented by individual health professionals, communities, and individuals depending on perceived or real climate change in the coming decades, and without intervention and/or co-ordination by regional and national governments and international agreements. Whereas, *planned adaptation* includes changes in policies, institutions and dedicated infrastructure, which will be required to facilitate and maximize long-term benefits of adaptation responses to climate change. This strategy is mainly focusing on planned adaptation.

Based on the preceding evidences, successful adaptation strategy for the health system needs to, among others, explore on available opportunities and priority focuses of interventions in the face of looming challenges from climate change (Goowin, 2010). Vulnerability analysis presented in this document provides a broad identification of current level of vulnerability of regions. Drawing on this analysis, the following adaptation strategies are proposed:

In addition, understanding the possible impacts of climate change in other sectors could help decision makers to identify contexts where impacts in another sector such as water, agriculture and other sectors could adversely affect population health. Many of the possible health sector adaptation measures to climate change lie primarily outside the direct control of the health sector. They are embedded in areas such as sanitation and water supply, education, agriculture, trade, tourism, transport, development, urban planning, housing and so on. This calls for inter-sectoral and cross-sectoral adaptation strategies to reduce the potential health impacts of climate change and to optimize adaptive responses.

Climate change does not create new health problems but may worsen known clinical problems and alter geographic patterns of disease occurrence. Consequently, adaptation policy recommendations related to climate change and public health reflect the need to sustain and refine current measures to enhance their sensitivity to climate change. Adaptation actions related to protecting health from climate change should include:

1. **Improve public health surveillance systems:** Make certain that existing public health surveillance systems are sufficiently comprehensive and sensitive to detect climate-sensitive diseases. Strengthening PHEM at each region and City Administrations could help to capture the burden of existing and emerging and re-emerging climate-sensitive diseases. It is important tointegrate environment and health surveillance:
    - Risk mapping and establishment of early warning systems for climate sensitive risks;
    - Integration of environment and health monitoring, and response plans.

2. **Establish health and climate data management system:** There is generally lack of appropriate and quality data for disease cases. The FMoH and other organizations working with data generation and management should improve the way data is collected, quality assurance, storage and management. There is a critical shortage of time series data regarding

the health system and it determinants in Ethiopia to make objective analysis of vulnerability and adaptation strategies in sufficient details. This shows that there is poor data management which in turn indicates that there is poor data use at all levels. Therefore; strengthening data use, and integrating climate data and health data to properly manage the health system effectively and efficiently is very important to Ethiopia.

3. **Strengthening early warning systems:** Strengthen and implement early warning systems and take steps to increase public awareness of consequences of climate sensitive diseases. To be effective, public health must move from a focus on surveillance and response to a greater emphasis on prediction and prevention. Linking the increasing skill of meteorologists in forecasting extreme events with effective public health interventions can improve disaster management. Projections of more frequent and more intense extreme events in a changing climate increase the importance of designing and implementing early warning systems that take into consideration the possibility of extremes outside the historic range. This is a key recommendation for both climate and health specialists/scientists/experts.

4. **Improved public health services:** The adaptive action to reduce health impacts includes the promotion of public health as the primary strategy. The public health effort in terms of providing access to basic health services through PHCUs to serve the grass root population at large is greatly appreciated. The provision of district hospitals as the next hierarchy of health infrastructure with in the regional structure seems yet slowly progressing. Similar trend exists in areas of providing regional and referral hospital services. The quality of health services to the level of client's satisfaction needs to be strengthened in parallel to building the capacity of health infrastructures. The provisions of drugs, lab services, improving client-provider relationship, and strengthening human resource development to the level to meet national targets are strategic actions to improve the quality of health services in addition to strengthening the physical facilities.

5. **Improved Water, Sanitation, and Hygiene system:** The health impact of climate change on diarrhea mediating through Water, Sanitation, and Hygiene is well defined. Extreme climate events, such as flooding and drought negatively affect water supply in terms of its quality and quantity. Flooding is known to damage technologically weak sanitation infrastructures that

could extend to pollute water sources. Open defecation and unstandardized latrine structures are hazards that will persist for years to come. The existing poor behavior of population to wards cleanliness of oneself and his immediate environment is an area of great concern. The following adaptation measures are useful to consider reducing the adverse effect of climate change on WASH infrastructures.

- The promotion of behavioral change towards reducing open defecation using behavior change communication (BCC) tools need to be strengthened. A major change in human behavior towards sanitation must be visible. BCC should be integrated with CLTSH at community level. The HEP is a strategic service to improve the awareness and knowledge of community members.
- Increasing the access to clean water, latrines, and hand hygiene facilities is an area of concern. The construction of WASH facilities should be required to meet optimal standards that could stand against the effect of flooding and drought; in other wards climate resilient WASH technology must be an improved option over the traditional practices.
- Tracking the quality of WASH facilities to deliver quality services should be linked to causes of hazards such as diarrhea. The development of data base based on periodical surveys is a national necessity. The data base is useful to generate evidences that could be linked to the effect of climate change and WASH facilities.
- Ensuring the quality of WASH services, such as the supply of safe drinking water, from the source until it reaches the mouth is of a concern. This requires a systematic well designed actions targeting sanitary surveillance of WASH facilities and services at the grass root level of public health administration.
- The public health relevance of our living environment has become complex in the face of urbanization and industrialization. National policies and strategies are social instruments to neutralize or reduce the impact of the changing environmental our health. While such policies in Ethiopia seem adequate, the implementation of the provisions should be in harmony in human capacity and organizational structures of various ministries. The initiative to build country wide partnership around one WASH is a good start. Monitoring and evaluation of

the provisions of policy documents is advised in order to define related impacts or changes.

6. **Human resource for health development:**.Many of the projected impacts of climate change on health are avoidable or controllable through the application of well-known and well-tested public health and health service interventions, such as public education, disease surveillance, disaster preparedness, vector control, food hygiene and inspection, nutritional supplementation, vaccines, primary mental health care, provision WASH services and training. To provide these services, adequate and qualified health professionals are critically needed. There has been a huge disparity in the distribution of human resources for health among the regions. Most of the health personnel were concentrated in city administrations such as Addis Ababa, and Dire Dawa, including Harari Regional State. The FMoH should address such disparity and inequity in the distribution of the health personnel through training and deploying adequate number of the required health personnel to regions with inadequate number of health professionals. Most health professionals particularly physicians are very rare in the emerging regions and those regions that have predominantly rural population. There should be adequate and sustainable mechanisms to attract such highly qualified health professionals to serve those underserved regions. The larger regions such as Oromia, Amhara and SNNPR have the lowest health personnel to population ratio despite being home for more that three-quarter of the population of the country. The FMOH should give adequate focus for such regions in terms of health professional's assignment. For some of the emerging and remerging climate-sensitive diseases such as Dengue Fever and Yellow Fever there are no diagnostic capacity in terms of human resource capacity and laboratory capacity. We have to think of Partnership and Collaboration with institutions with better setting in both capacities to cope with situations of outbreaks as experienced recently in those diseases.

7. **Enhanced advocacy and public awareness and attitudes:** Measure public awareness and attitudes towards current and projected adverse and inequitable health impacts of climate change, as well as the potential for significant health benefits and consequent cost savings from well-conceived climate control policies. Develop communication and social marketing plans to address perceptual and behavioral obstacles to address policy-/decision-makers,

implementers/line department/program and community levels separately. May include mobilizing people to plant trees, fruits and vegetables in their garden so that the waste water to be reused, to get cooling effect and shading as well as to full some food subsistence. Moreover, people have to mobilize to have their own water source like rain water harvesting to be used during scarcity of water. Promoting walking on foot and bike use for transportation having triple advantages (promoting health, low cost and carbon emission).

8. **Targeted intervention to regional contexts by enhanced financial resources:** Evidences on financial expenditure of health allocation and the different social determinants is not totally in line with conclusions on vulnerability to climate sensitive diseases. Nonetheless, consistent with vulnerability analysis, among other regions, Afar, Somali, Gambella and Benishangul-Gumuz were found to host the largest proportion of the poor in the country. In view of the fact that this facilitates vulnerability of the regions, specific poverty reduction mechanism needs to be put in place targeting these regions. Similarly, the most vulnerable regions to climate sensitive diseases were found to spend much less and this may have to do with limitation of capacity at this regions. Furthermore, these regions were found to host proportionally more uneducated population as compared to others. Thus, conscious investment on capacity building including improved education services is believed to help mitigate vulnerability of the regions.

9. **Partnership, coordination and collaboration**: There are different GOs, NGOs and institutions that are working in the health sector in Ethiopia. In many cases, these institutions are operating independently and sometimes with different approaches and modalities. This has a negative impact to the national effort of improving the health status. This calls for a practical partnership, coordination and collaboration of the different efforts at both national and grass root levels.

Suggested adaptation options by vulnerability categories are presented in Table 21. The theoretical range of choice would include measures to improve vector control by eliminating mosquito breeding sites, measures to improve disease surveillance, development of an early warning system based on weather and environmental variables, development of a malaria vaccine and genetic engineering of mosquitoes to prevent replication of the malaria pathogen.

Table 21: Suggested health adaptation options by vulnerability categories

No	Adaptation Options	Vulnerability Category			
		Low	**Medium**	**High**	**Very High**
1	Improve public health surveillance systems	***	***	***	***
2	Establish Health and Climate data management system	***	***	***	***
3	Strengthening Early warning systems:	***	***	***	***
4	Improved Public Health Services	*	**	***	***
5	Improved Water, Sanitation, and Hygiene system	*	**	***	***
6	Human Resource Development	*	**	***	***
7	Enhanced public awareness and attitudes	***	***	***	***
8	Targeted intervention to regional contexts by enhanced financial resources	*	**	***	***
9	Partnership, coordination and collaboration	***	***	***	***

*** High priority, ** Priority, * Less priority

7. Limitation of the study

This assessment has a number of strengths. One of the key strengths is the fact that this is the first attempt in analyzing available secondary evidences to determine the level of vulnerability to climate change in the health sector and development of adaptive strategy. More particularly, this has helped to realize regional variations and more importantly identified the most vulnerable regions. An important strength of this assessment is the fact that it has benefitted from multi-disciplinary team with rich experiences that has helped to pull diverse scientific perspectives.

Despite the above strengths, this assessment has also a number of limitations. The assessment was carried out using aggregated data from different sources, which has the potential to mask evident variations within the regions especially those that are exhibiting diverse geographical and ecological characteristics. For example, Oromia, Amhara and SNNPR have vast and heterogeneous ecological features which were aggregated in this particular analysis due to lack of evidences for the inter-regional variation. Furthermore, this assessment did not benefit from local perceptions of vulnerability and adaptive capacity which limits the potential strength of this assessment. This makes it difficult to gauge trends of adaptive capacity over time. This compels the team to generate general recommendations for adaptive strategy with an assumption that regions could be lured to develop their specific adaptation strategy.

- Weather data was available for 20 years only, but time series analysis often require more years (30 years is recommended). NMA should be able to organize and provide data as necessary.
- Met stations used by NMA follow the old way of provincial naming and they did not categorize the stations by current regional states. Therefore, doing this took unnecessarily long time. NMA should associate its stations with regions and provide data with this information.
- Met stations currently used by NMA are not fairly distributed across regions and ecologic zones. In regions like Afar, Somali, Gambella, and Benishangul-Gumuz very few stations are available. This may lead to under/over estimation of rainfall amount and temperature.
- NMA did not organize data based on agro-ecology classification of the country. This should be done in the future in order to help analysis by agro-ecology which is more sensible for climate related studies.

- There is generally lack of appropriate and quality data for disease cases. The FMoH and other organizations working with data generation and management should improve the way data is collected, quality assurance, storage and management.
- Only a maximum of 10 years disease data was obtained. For some disease, it is even less than 10 years. Some of them are missing or were not complete and was difficult to analyze the data.
- One of the difficulties when fitting time series models were that weather data was collected on monthly basis while disease data was on annual basis. In fact the health data must have been first collected on daily/monthly basis and aggregated to annual level, but such data could not be obtained. For this reason, seasonality and period occurrences of disease that parallel that of weather could be established.
- While analysis made on data obtained from the FMoH health data for long duration was unavailable, monthly health data were unavailable and data on some climate sensitive diseases such as shistosomiasis and leishminiasis were unavailable. This indicates poor data management, record keeping and management at all levels. Therefore, strengthening data use, and integrating climate data and health data to management the health system effectively and efficiently.

8. Conclusions and recommendations

8.1 Conclusions

Analysis of available data on the current state of education, dependency ratio, health budget allocation and per capita health expenditure were grossly assumed to increase vulnerability. However, these also provide opportunities to determine priority focuses of intervention to build adaptive capacity. As such, reviewing all indicators presented above, adaptive strategy is recommended:

- Prioritization of regions: Bigger regions that constitute over three quarter of the population and land mass as well as emerging regions were found to have limited educational accomplishments, higher dependency ratio and weak capacity to utilize available resources for health. Consequently, these regions are vulnerable to climate induced health problems at least in the long term. Thus, adaptation strategy is expected to ensure firstly region specific data is available for planning and secondly interventions prioritize the most vulnerable ones.
- Gender targeted interventions: Women are generally found to be in a disadvantaged position which increases their vulnerability. In view of this, adaptation strategy is expected to consciously target women for interventions.
- Residence: The steady expansion of urbanization contributes to increased level of vulnerability to climate sensitive health problems. In view of this, adaptation strategy is expected to consider urban settings.
- Addressing poverty: Recent evidence reveals that over 43% of the population lives in a poor state of life and 58% of children under five are stunted[1]. This has long term implication on vulnerability of the population and the health and productivity of future development architects. In view of this, adaptation strategy is expected to target addressing poverty and echo friendly food production.
- Capacity of health care planners and implementers: Findings on per-capita expenditure shows that regions were not in a position to make use of allocated resources. This is mainly the reflection of weak capacity of the health human resources. Adaptive strategy is expected to pay due attention to building the capacity of health human resources.

[1] Stunting is taken as a proxy indicator for food insecurity

- Data management and sharing: Both PHEM and HMIS work for tracking health data and there is a need for harmonizing and aligning their contents in every level of reporting.

8.2. Recommendations

Mainstreaming climate change adaptation into the national health planning process. Every country will have to define its own process, through which mainstreaming of climate change adaptation policies and programmes into specific public health programmes will be undertaken. It is particularly timely for Ethiopia given the health sector is in a process of revising its health policy and developing its long term Health Sector Transformation Plan (HSTP). Therefore, strategies and actions to build resilience through these programmes have to be reflected in these strategic documents to guide implementation plans at operational levels.

Establish multi-sectoral processes to oversee climate change and health policy development. Utilize health impact assessments to evaluate social and economic costs of threats and prioritize action and investment areas. Provide a coordinated approach and functional cooperation between the sectors and the relevant institutions in terms of effective and efficient use of available resources (agriculture, water, health and environment).

Strengthening disaster preparedness, response and recovery actions: Uncertainties in predicting the occurrence of climate extreme events and its associated health impacts in Ethiopia is complex. This implies the need of strengthening disaster preparedness, response and recovery actions in areas of health service management. Building the capacity in terms of responding to diseases outbreaks, and residuals of the health impact, such as malnutrition among children and mothers is the necessity at times of flooding and drought. The status of adaptive capacity is well defined if there is a sound HMIS. The existing HMIS for example in areas of WASH coverage does not provide valid data that is consistent with EDHS. Enhancing the design of data base based on regional and national surveys needs to complement the national HMIS. Interim surveys between two EDHS could alleviate the inconsistency and thereby improve data estimates.

Research: We believe that there are several public health related programmes and measures that are as effective as desired both at federal and regional levels. Understanding the extent to which current public health and health care policies and programmes are effective, and the reasons for limits to effectiveness, is a first step in understanding what modifications are needed to address the risks of a changing climate.

- Stakeholder driven research, focusing on cost effectiveness, equity and sustainability.
- Describing how the risks of climate-sensitive health outcomes, including the most vulnerable populations and regions, may change over coming decades, irrespective of climate change;
- Estimating the possible additional burden of adverse health outcomes due to climate change.
- Climate and health vulnerability and adaptation assessments at Regional levels;
- Assessments of programme capacity;
- Definition of monitoring and evaluation frameworks.

10. References

ABEBE, A., TEKA, T., KASSA, T., SEHERI, M., BEYENE, B., TESHOME, B., KEBEDE, F., HABTAMU, A., MAAKE, L., KASSAHUN, A., GETAHUN, M., MITIKU, K. & MWENDA, J. M. 2014. Hospital-based surveillance for rotavirus gastroenteritis in children younger than 5 years of age in Ethiopia: 2007-2012. *Pediatr Infect Dis J,* 33 Suppl 1**,** S28-33.

ADHANOM, T., DERESSA, W. & WITTEN, K. 2006. Malaria In: Berhane Y, Haile-Mariam D and Kloos H., editor. Epidemiology and ecology of health and disease in Ethiopia. Ethiopia, Addis Ababa, Shama Books. 556-76.

ALEMSEGED, T. H., KOEN, K. & NEGASH, W. 2013. Loss and damage from flooding in the Gambela region, Ethiopia *Int. J. of Global Warming,* 5**,** 483-497.

ALEXANDER, K. A., CARZOLIO, M., GOODIN, D. & VANCE, E. 2013. Climate change is likely to worsen the public health threat of diarrheal disease in Botswana. *Int J Environ Res Public Health,* 10**,** 1202-30.

AYALEW, D., TESFAYE, K., MAMO, G., YITAFERU, B. & BAYU, W. 2012. Outlook of future climate in northwestern Ethiopia *Agricultural Sciences,* 3**,** 608-624.

BELAY, S., BENJAMIN, F. & JEREMY, D. F. 2014. Agroecosystem-specific climate vulnerability analysis: application of the livelihood vulnerability index to a tropical highland region. Mitig and Adapt Strateg Global Change 2014. DOI 10.1007/s11027-014-9568-1.

BEZATU, M., YEMANE, B. & ALEMAYEHU, W. 2013. Prevalence of diarrhea and associated risk factors among children under-five years of age in Eastern Ethiopia: A cross-sectional study. *Open Journal of Preventive Medicine,* 3**,** 446-453.

BHANDARI, G. P., GURUNG, S., DHIMAL, M. & BHUSAL, C. L. 2012. Climate change and occurrence of diarrheal diseases: evolving facts from Nepal. *J Nepal Health Res Counc,* 10**,** 181-6.

CENTRAL STATISTICAL AGENCY, ADDIS ABABA ETHIOPIA, 2013. Population Projection of Ethiopia for All Regions. AA: CSA.

CENTRAL STATISTICAL AGENCY ADDIS ABABA ETHIOPIA 2014. Ethiopia mini Demographic and Health Survey 2014. July 2014.

CENTRAL STATISTICAL AGENCY ADDIS ABABA ETHIOPIA & ICF INTERNATIONAL CALVERTON M, U. 2006. Ethiopia Demographic and Health Survey 2005.

CENTRAL STATISTICAL AGENCY ADDIS ABABA ETHIOPIA & ICF INTERNATIONAL CALVERTON MARYLAND USA 2012 March. Ethiopia Demographic and Health Survey 2011.

CENTRAL STATISTICAL AGENCY ADDIS ABABA ETHIOPIA, I. I. C. M., USA, 2001. Ethiopia Demographic and Health Survey 2000.

CENTRAL STATISTICAL AGENCY ADDIS ABABA ETHIOPIA, I. I. C. M., USA, 2012. Ethiopia Demographic and Health Survey 2011.

CÉSAR, E. 2013. Ethiopia Environmental and Climate Change Policy Brief.Sida's Helpdesk for Environment and Climate Change.

CEZAR, E. & ANDERS, E. 2013. Ethiopia Environmental and Climate Change Policy Brief. Sida’s heldesk for environment and climate change.

CHAMBERS, R. & CONWAY, G. R. 1992. Sustainable Rural Livelihoods: Practical Concepts for the 21st Century. *Discussion Paper 296.* Brighton, UK: Institute of Development Studies.

CHOU, W. C., WU, J. L., WANG, Y. C., HUANG, H., SUNG, F. C. & CHUANG, C. Y. 2010. Modeling the impact of climate variability on diarrhea-associated diseases in Taiwan (1996-2007). *Sci Total Environ,* 409**,** 43-51.

CHOW, V. T., MAIDMENT, R. D. & MAYS, W. L. 1988. *Applied Hydrology*, McGraw-Hill.

CONWAY, D., LISA, E. & SCHIPPER, F. 2010. Adaptation to climate change in Africa: Challenges and opportunities identified from Ethiopia. Global Environmental Change.

CONWAY, D., MOULD, C. & BEWKET, W. 2004. Over one century of rainfall and temperature observations in Addis Ababa, Ethiopia. *Int. J. Climatol,* 24**,** 77 – 91.

CRAIG, M., SNOW, R. & D., L. S. 199. A climate-based distribution model of malaria transmission in Sub-Saharan Africa. *Parasitology Today,* 15**,** 105-111.

DAVIES, G. I., MCIVER, L., KIM, Y., HASHIZUME, M., IDDINGS, S. & CHAN, V. 2015. Water-borne diseases and extreme weather events in Cambodia: review of impacts and implications of climate change. *Int J Environ Res Public Health,* 12**,** 191-213.

DIREDAWA ADMINSITARTION 2011. Program of Adapation to Climate Change.

EDITORIALS 2008. Population growth and climate change. *BMJ* 337:a576.

EDWARDS, C. D. & MCKEE, T. B. 1997. Characteristics of 20th century drought in the United States at multiple time scales. *Climatology Report.* Department of Atmospheric Sciences, Colorado State University.

ETHIOPIA SPA PLUS Census 2014.

FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA 2008. National Nutrition Strategy.

FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA 2011. Ethiopia's Climate-Resilient Green Economy Green economy strategy. Addis Ababa.

FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA 2012. National strategy and action plan for the Implementation of the great green wall Initiative in Ethiopia.

FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA September 2014. Acute watery diarrhoea prevention and control strategy.

FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA MINISTRY OF HEALTH 2010. Health Sector Development Programme IV.

FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA MINISTRY OF HEALTH 2011. Health and health related indicators.

FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA MINISTRY OF WATER RESOURCES AND NATIONAL METEOROLOGY AGENCY 2007. Climate Change National Adaptation Programme of Action (NAPA) of Ethiopia.

FEDERAL MINISTRY OF FINANCE AND ECONOMIC DEVELOPMENT (MOFED) 2010. Growth and Transformation Plan (GTP). Ethiopia's Growth and Transformation Plan (GTP), 2011/12-2014/15. Addis Ababa.

FEDERAL MINISTRY OF HEALT 2014. Health Sector Development programme IV annual performance report of year 2006 (2013/14). .

FEDERAL MINISTRY OF HEALTH ETHIOPIA 2012. Health and health related indicators.

FEDERAL SEMOCRATIC REPUBLIC OF ETHIOPIA 1997. Environmental Policy of Ethiopia. The Resource base and the need for a policy.

GEDLU, E. & ASEFFA, A. 1996. Campylobacter enteritis among children in north-west Ethiopia: a 1-year prospective study. *Ann Trop Paediatr,* 16**,** 207-12.

GHEBREYESUS, T., TADESE, Z., JIMA, D., BEKELE, E., MIHRETIE, A., YIHDEGO, Y., DINKU, T., CONNOR, S. & ROGERS, D. 2008. Public health and weather services–climate information for the health sector. *WMO Bulletin,* 57**,** 258-261.

GOOWIN, N. R. 2010. "A New Economics for the 21st Century, Forthcoming in World Futures Review".

GRAVES, P., RICHARDS, F. & NGONDI, J. 2009. Individual, household and environmental risk factors for malaria infection in Amhara, Oromia and SNNP regions of Ethiopia. *Trans R Soc Trop Med Hyg,* 103**,** 1121-1120.

HAHN, M., RIEDERER, A. & FOSTER, S. 2009. The Livelihood Vulnerability Index: A pragmatic approach to assessing risks from climate variability and change—A case study in Mozambique. Global Environmental Change 19, 74-88.

HELMUT, K. & ZERIHUN, W. 2005. The physical and biotic environment: it features and health implications. *In:* BERHANE, Y., HAILEMARIAM, D. & HE;MUT, K. (eds.) *Epidemiology and ecology of health and disease in Ethiopia.* Addis Ababa: Shama Books.

HIMEIDAN, Y. E. & KWEKA, E. J. 2012. Malaria in East African highlands during the past 30 years: impact of environmental changes. *Front Physiol,* 3**,** 315.
HUNTER, P. R. 2003. Climate change and waterborne and vector-borne disease. *Journal of Applied Microbiology,* 94**,** 37-46.
HUTTON, G. 2011. The economics of health and climate change: key evidence for decision making. *Globalization and Health* 7:18.
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, G. 2014. Climate Change Synthesis Report . Geneva.
INTERNATIONAL FEDERATION OF RED CROSS AND RED CRSECENT SOCIETIES 30 August 2007. Egthiopia acute watery diarrhea outbreak. *DREF Bulletin no. MDRET004 GLIDE no. EP-2007-000142-ETH*.
IPCC 2007a. Summary for Policymakers. *In:* SOLOMON, S., QIN, D., MANNING, M., CHEN, Z., MARQUIS, M., AVERYT, K. B., TIGNOR, M. & MILLER, H. L. (eds.) *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* Cambridge, UK and New York, USA: Cambridge University Press.
IPCC 2007b. Summary for Policymakers. In: SOLOMON, S., QIN, D., MANNING, M., CHEN, Z., MARQUIS, M., AVERYT, K. B., TIGNOR, M. & MILLER, H. L. (eds.) Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change Cambridge, UK and New York, USA: Cambridge University Press.
IPCC 2014. Climate Change 2014: Synthesis Report; Summary for Policymakers.
JI, L. & PETERS, A. J. 2003. Assessing vegetation response to drought in the northern Great Plains using vegetation and drought indices. *Remote Sensing of Environment,* 87**,** 85 - 98.
KELLER, M. 2009. *Climate Risks and Development Projects: Assessment Report for a Community-Level Project in Guduru, Oromia, Ethiopia* [Online]. Available: https://www.iisd.org/cristaltool/documents/BFA-Ethiopia-Assessment-Report-Eng.pdf.
KIM, K. H., KABIR, E. & ARA JAHAN, S. 2014. A review of the consequences of global climate change on human health. *J Environ Sci Health C Environ Carcinog Ecotoxicol Rev,* 32**,** 299-318.
KONDO, H., SEO, N., YASUDA, T. & ET AL 2002. Postflood-infectious diseases in Mozambique. *Prehosp. Disaster Med,* 17**,** 126-133.
LYSENKO, A. & SEMASHKO, I. 1968. Geographyof malaria. A medico-geographic profileo f an ancient disease. In: Lebedew AW, editor. ItogiNauki: Medicinskaja Geografija. Academy of Sciences, USSR; Moscow. Pp.25-146.
MARTENS, P., KOVATS, R., NIJHOF, S., DE VRIES, P., LIVERMORE, M. & MCMICHAEL, A. 1999. Climate change and future populations at risk of malaria. *Global Environ Change,* 9**,** S89-107.
MARTENS, W., NIESSEN, L., ROTMANS, J., JETTEN, T. & MCMICHAEL, A. 1995. Potential impact of global climate change on malaria risk. *Environ. Health Perspect,* 10**,** 458-464.
MARTENS, W., THEO, H. J. & FOCKS, D. 1997. "Sensitivity of malaria, schistosomiasis and dengue to global warming". *Climatic Change,* 35**,** 145-56.
MARTIN, M. & LEFEBVRE, G. 1995. Malaria and climate sensitivity of malaria potential transmission to climate. *Ambio,* 24**,** 200-207.
MCKEE, T. 1997. Characteristics of 20th century drought in the United States at multiple time scales. Climatology Report, Department of Atmospheric Sciences, Colorado State University.
MCMICHAEL AJ 2013. Globalization, climate change and human health. The New England *Journal of Medicine***,** 1335-1343.
MOLINEAUX, L. 1988. The epidemiology of malaria as an explanation of its distribution, including some implications for its control. In: Wernsdorfer W, editor. Malaria Principles and practice of malariology Great Britain, Churchill Livingstone: Sir McGregor Eds. 913-918.

MOORS, E., SINGH, T., SIDERIUS, C., BALAKRISHNAN, S. & MISHRA, A. 2013. Climate change and waterborne diarrhoea in northern India: impacts and adaptation strategies. *Sci Total Environ,* 468-469 Suppl**,** S139-51.
NODEN, B., KENT, M. & BEIER, J. 1995. The impact of variations in temperatur eo nearly Plasmodium falciparum developmentin Anophelesstephensi. *Parasitolog,* 111**,** 539-545.
NTALE, H. & GAN, T. 2003. Drought indices and their application to east Africa. *International Journal of climatology,* 23**,** 1335 **-** 1357.
OAU 24-27 April 2001. African summit on HIV/AIDS, Tuberculosis and other related infections diseases. Abuja, Nigeria.
OCHA. 2014. *Ethiopia reports increase in meningococcal meningitis. UN Office for the Coordination of Humanitarian Affairs (OCHA).Accessed September 4, 2015* [Online]. Available: http://outbreaknewstoday.com/ethiopia-reports-increase-in-meningococcal-meningitis-19846/.
OLSON, S., GANGNON, R., , E., E, DURIEUX, L., GUÉGAN, J., FOLEY, J. & PATZJ, A. 2009. Linksbetween climate, malaria, andwetlands inthe Amazon Basin. *Emerging InfectiousDiseases,* 15**,** 659-662.
PAAIJMANS, K., BLANFORD, S., BELLA, S., BLANFORD, J., READ, A. & THOMAS, M. 2010. Influenceofclimateonmalariatransmissiondependsondailytemperaturevariation. *PNAS,* 107**,** 15135–15139.
PATZ, J., GRACZYK, T., GELLER, N. & VITTOR, A. 2000. Effects of environmental change on emerging parasitic diseases. *International Journal of Parasitology,* 30**,** 395-1405.
PATZ JA, CAMPBELL-LENDRUM D, HOLLOWAY T & JA, F. 2005. Impact of regional climate change on human health. *Nature***,** 310-317.
PHUNG, D., HUANG, C., RUTHERFORD, S., CHU, C., WANG, X., NGUYEN, M., NGUYEN, N. H., MANH, C. D. & NGUYEN, T. H. 2014. Association between climate factors and diarrhoea in a Mekong Delta area. *Int J Biometeorol*.
PORTIER, C. J., THIGPEN, T. K., CARTER, S., DILWORTH, C., GRAMBSCH, A., GOHLKE, J., HESS, J., HOWARD, S., LUBER, G. & LUTZ, J. 2010. A Human Health Perspective On Climate Change: A Report Outlining the Research Needs on the Human Health Effects of Climate Change. *Environmental Health Perspectives*.
QADRI, F., KHAN, A., FURUQUE, A. & AL., E. 2005. Enterotoxigenic Escherichia coli and Vibrio cholerae diarrhea, Bangladesh. Emerg *Infect. Dis. ,* 11**,** 1104–1107.
RUSSELL, P. 1998. World-widemalariadistribution,prevalenceandcontrol.AmJTrop MedHyg.1956; 5:937–56. Russell RC "Mosquito-borne es in Australia: the current scene and implications of climate change for human health. . *International Journal for Parasitology,* 28**,** 955-969.
SNOVER, A. K., WHITELY BINDER, L., LOPEZ, J., WILLMOTT, E., KAY, J., HOWELL, D. & SIMMONDS, J. 2007. Preparing for Climate Change: A guidebook for local, regional and state governments. Oakland, CA.
TADEGE, A. 2007a. Climate Change National Adaptation Programme of Action (NAPA) of Ethiopia. Addis Ababa, Ethiopia: The Federal Democratic Republic of Ethiopia Ministry of Water Resources and National Meteorology Agency.
TADEGE, A. 2007b. Climate Change National Adaptation Programme of Action (NAPA) of Ethiopia. Addis Ababa, Ethiopia: The Federal Democratic Republic of Ethiopia Ministry of Water Resources and National Meteorology Agency.
TAFESSE, A., AYELE, G., KETEMA, M. & GETA, E. 2013. Adaptation to Climate Change and Variability in eastern Ethiopia. *Journal of Economics and Sustainable Development,* 4**,** 91-103.
TAMIRU, A. H., KUSTERS, K. & WAGESHO, N. 2013. Loss and damage from flooding in the Gambela region, Ethiopia. *Int. J. Global Warming,* 5**,** 483-497.
TANSER, F. C., SHARP, B. & SUEUR, D. L. 2003. Potential effect of climate change on malaria transmission in Africa. *THE LANCET* 362.

TESFAYE, S., BELYHUN, Y. & TEKLU, T. 2011. Malaria prevalence pattern observed in the highland fringe of Butajira, Southern Ethiopia: a longitudinal study from parasitological and entomological survey. *Malar J,* 10.

THOMPSON, A. A., MATAMALE, L. & KHARIDZA, S. D. 2012. Impact of climate change on children's health in Limpopo Province, South Africa. *Int J Environ Res Public Health,* 9**,** 831-54.

TRANSTIONAL GOVERNMENT OF ETHIOPIA 1993. Health Policy of the Transtional Government of Ethiopia.

UNDP 2008. Human development report 2007. Fighting climate change: Human solidarity in a divided world.

UNDP 2011. Framework for UNDP Ethiopia's Climate Change, Environment and Disaster Risk Management Portfolio.

UNL 2000. Weekly SPI Users Manual. National Drought Mitigation Center, University of Nebraska-Lincoln.

USAID 2012. A Climate Trend Analysis of Ethiopia Famine Early Warning Systems Network—Informing Climate Change Adaptation Series.Fact Sheet 2012–3053. April 2012.

VAN KLEEF, E., H, B. & HALES, S. 2010. The geographic distribution of dengue fever and the potential influence of global climate change. TropIKA 1–18.

WAKUMA, S. A., MANDERE, N. & EWALD, G. 2009. *RE: Floods and health in Gambella region, Ethiopia: a qualitative assessment of the strengths and weaknesses of coping mechanisms. C-action publishing.*

WHO. 2015. *Ethiopia: A serious outbreak in the African meningitis belt. Accessed September 4, 2015* [Online]. Available: http://www.who.int/csr/outbreaknetwork/ethiopia/en/.

WHO & UNICEF 2010. Rapid assessment of drinking water Quality in the federal Democratic republic of Ethiopia: Country report of the pilot project Implementation in 2004-2005. WHO and UNICEF 2010.

WHO & UNICEF 2013. Progress on sanitation and drinking-water - 2013 JMP update. Geneva.

WHO AND UNICEF JOINT MONITORING PROGRAM 2006. Core questions on drinking-water and sanitation for household surveys.

WOLLD HEALTH ORGANIZATION & UNICEF 2014. Progress on sanitation and drinking-water - 2014 JMP update. Geneva.

WORLD HEALTH ORGANIZATION. 2008. *Protecting health from climate change* [Online]. Available: http://www.who.int/world-health-day/toolkit/report_web.pdf.

WORLD HEALTH ORGANIZATION 2014. World Health Survey: Report of Ethiopia.

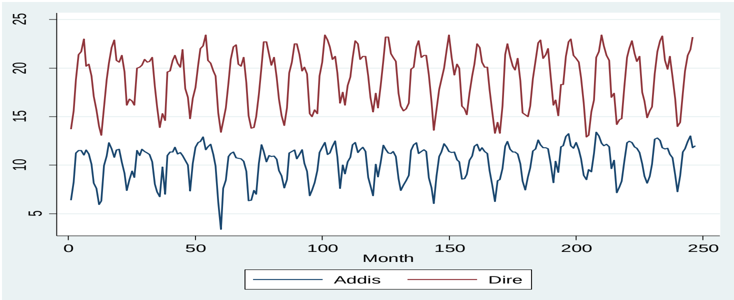
WORLD HEALTH ORGANIZATION & UNICEF. 2014. *Joint Monitoring for Water Supply and Sanitation* [Online]. Available: http://www.wssinfo.org/.

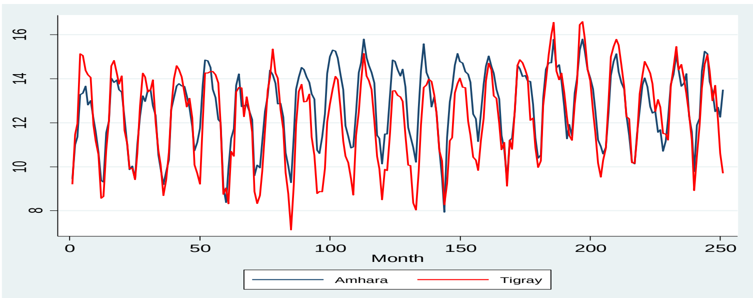
WORLD HEALTH ORGANIZATION (WHO) 2003. Health impacts of climate extremes: in Climate change and human health: Risks and Responses.

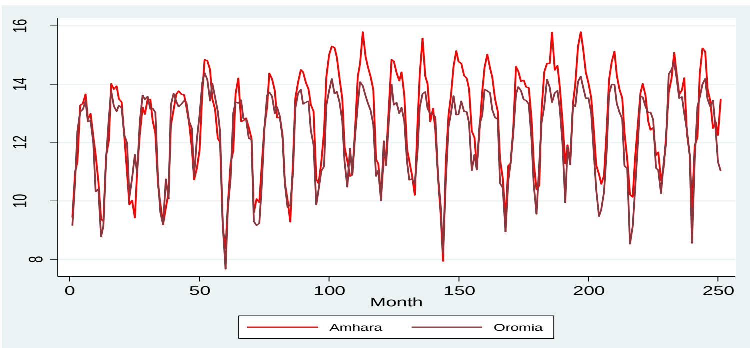
WORLD HEALTH ORGANIZATION ETHIOPIA 2014. A review and analysis of the trends of household drinking water and sanitation coverages using EDHS data in relation to diarrheal disease morbidity- the perspective in Ethiopia.

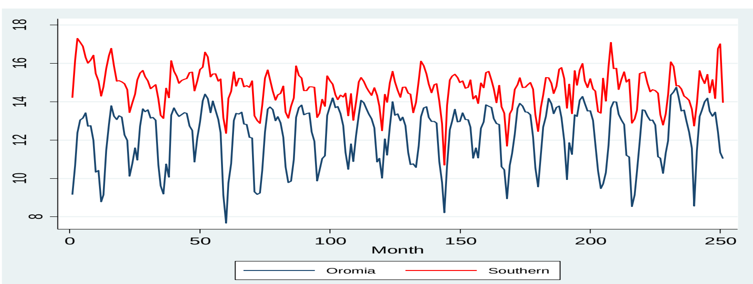
Annex

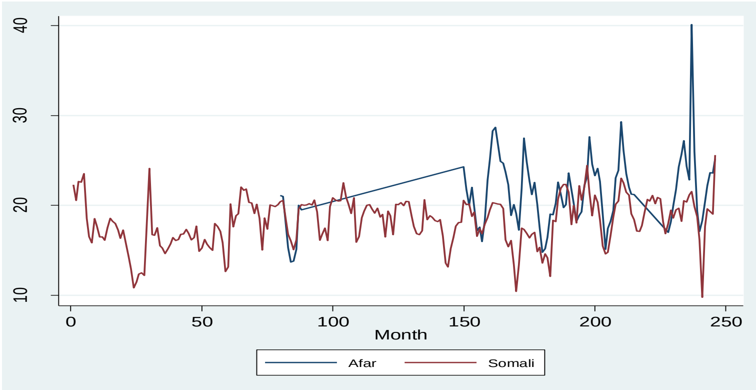
Annex 1: Time series twin plots for Minimum Temperature comparing Regions

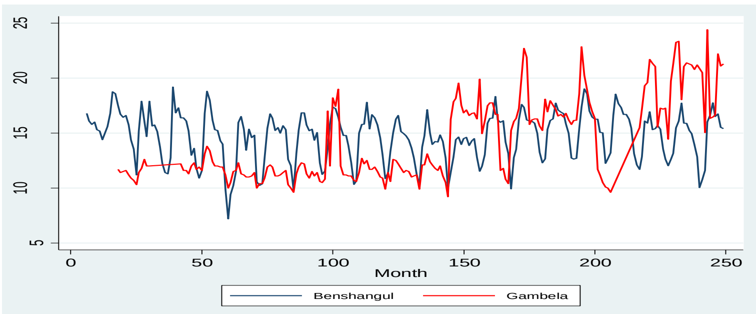


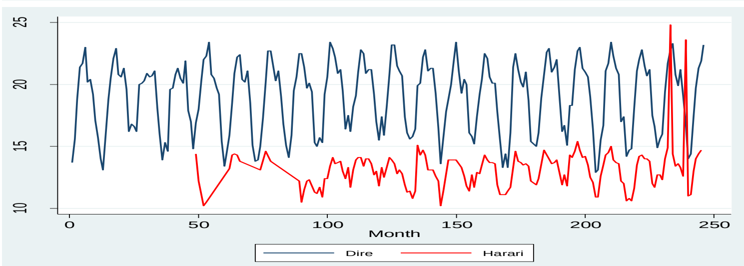




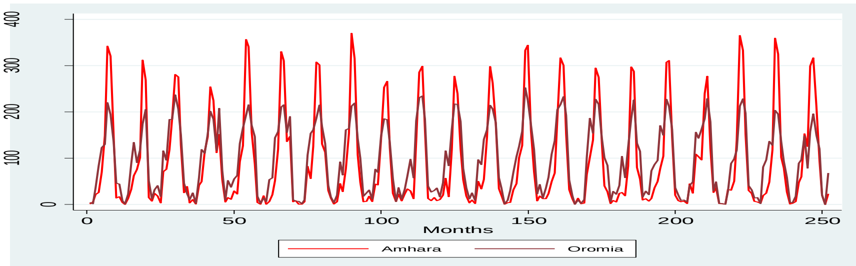


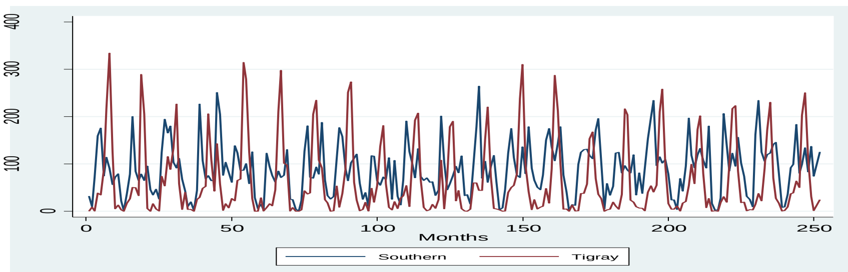

40
30
20
10
0
50
100
150
200
250
Month
Afar
Somali

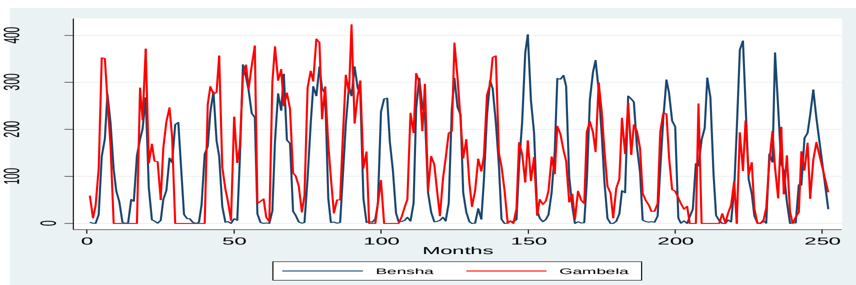

25
20
15
10
5
0
50
100
150
200
250
Month
Benshangul
Gambela

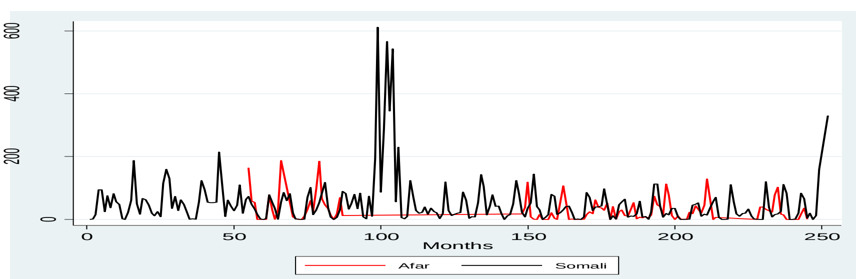

25
20
15
10
0
50
100
150
200
250
Month
Dire
Harari

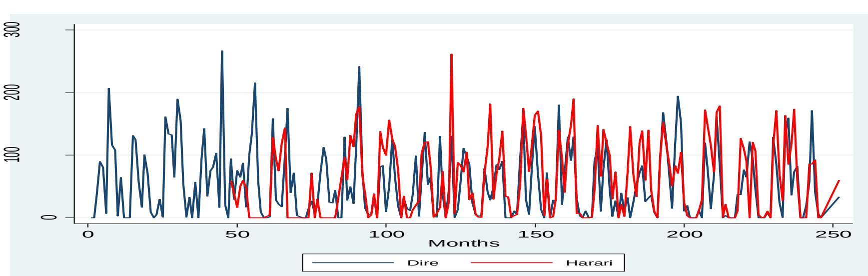
Annex 2: Time series twin plots for rainfall comparing Regions

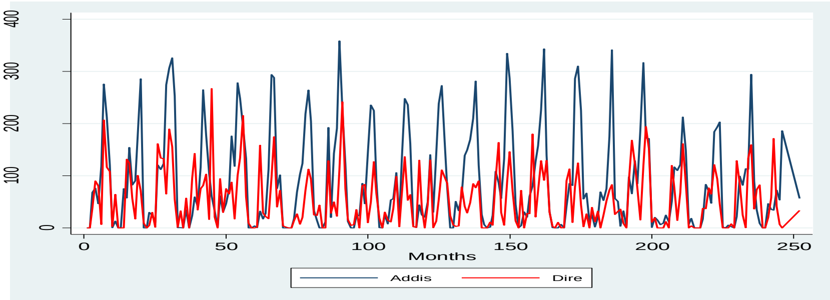




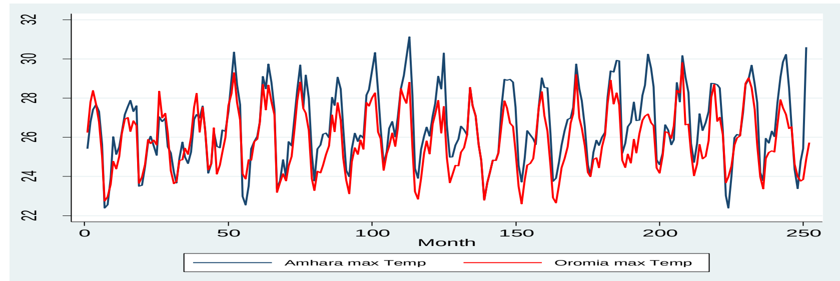


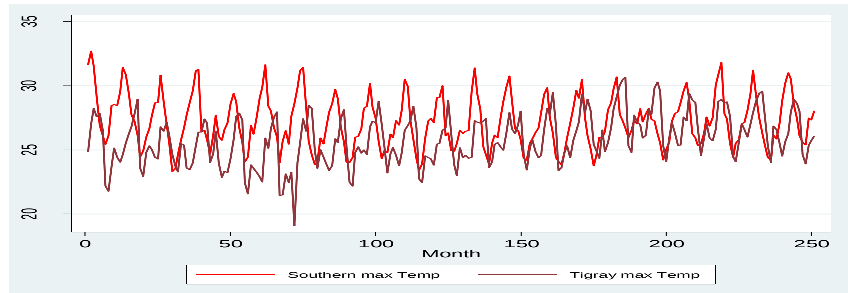


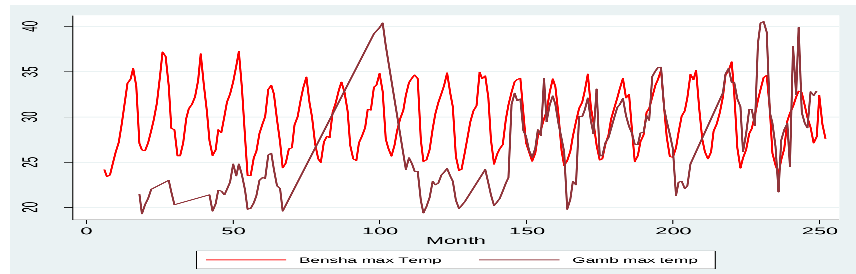


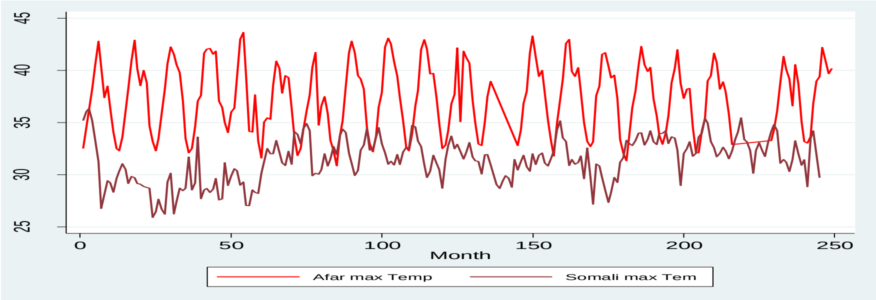


Annex 3: Time series twin plots for Maximum Temperature comparing Regions

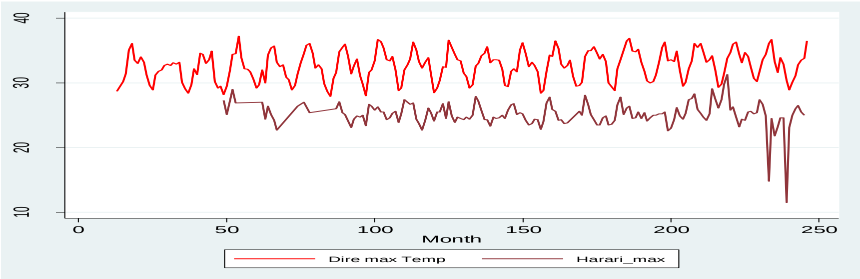




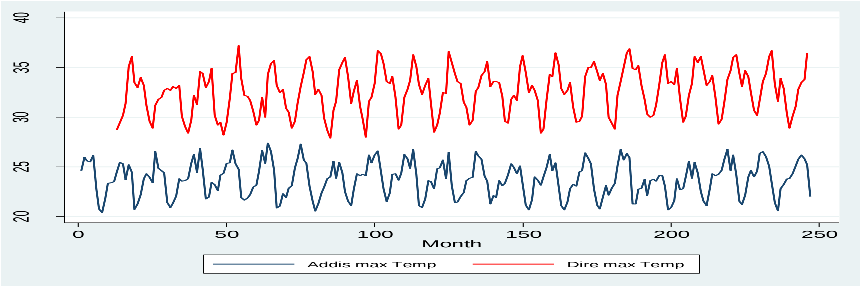




45
40
35
30
25
0
50
100
150
200
250
Month
Afar max Temp
Somali max Tem



40
30
20
10
0
50
100
150
200
250
Month
Dire max Temp
Harari_max



40
35
30
25
20
0
50
100
150
200
250
Month
Addis max Temp
Dire max Temp

Annex 4: Autocorrelation Function (ACF) for weather variables (1994 – 2014, a total of 252 months).

Autocorrelation is a tool that helps to identify if there is possible relationship between two time points in a time series data that are ***nmonths*** apart. For example, whether there is correlation between two rainfall records in consecutive months, or between two minimum temperature of same location but in two consecutive months, etc... If two observations which are say 6 months apart are correlated then it means that the data shows evidence of periodic occurrence. In this document ACF is fitted to rainfall data for each region (Table 2), ACF for Maximum Temp (table 3), and Minimum Temp (table 4) are presented. There are 252 months in the data (21 years) hence provide a range of lag distances. For each region ACF tables and graphs were produced (sample is shown in table 1 and figure 1 for Addis Ababa rainfall) in SPSS, but as several tables and graphs were produced and are not manageable, the results are summarized in to tables 2-4 for few significant ACF (out of the 16 lag distances initially fitted). The tables provide statistical tests for existence of the true autocorrelation coefficient and the graph is meant to depict possible periodic occurrence.

The result shows that very similar trend is observed for all regions regarding rainfall. Firstly, the entire 16 lag ACFs show highly significant difference from zero in all regions (although only few lags are presented in summary tables). Secondly, the magnitude of lag1 and lag12 ACFs are often very similar and highest. This shows that the amount of rain every consecutive month is highly related. The high value for lag12 shows the presence of strong seasonal effect every 12 months apart. This goes with the natural occurrence of rainy and dry seasons which shows periodic occurrence.

There is a very striking phenomenon in the values of the ACF which is most probably related to Climate Change. The ACF estimates for lags 11, 12 and 13 are positive and high for the entire regions. This shows that the length of the period for occurrence of rainfall may not always 12 months and it may also occur every 11 months or even 13 months apart. This could be evident that rain onset and off set may change from time to time and the length of stay may vary. For Addis Ababa, for example, the ACF values of lag11, lag12 and lag13 are 0.59, 0.76 and 0.61 respectively. These values are high and very close indicating presence of 3 possible seasonal periods for occurrence of rain/dry spell, an indication of a possible shift in the rainfall patterns in the last two decades. This could be taken as an evidence of presence of climate change over the last two decades and what remains is to see how these changes affect occurrence and magnitude of disease cases.

The 5th, 6th and 7th lags also show relatively high ACF for the entire regions but with negative values. This is also an indication of presence of sub-periodic occurrence of rain or related phenomenon. It is evident that, periods 5 to 7 months apart show negative relationship. This is because periods that are six months apart show opposite situation regarding rainfall scenario. Once again, the fact that 5th, 6th and 7th lags have similar ACF is an indication of changing rainfall situation over the decades.

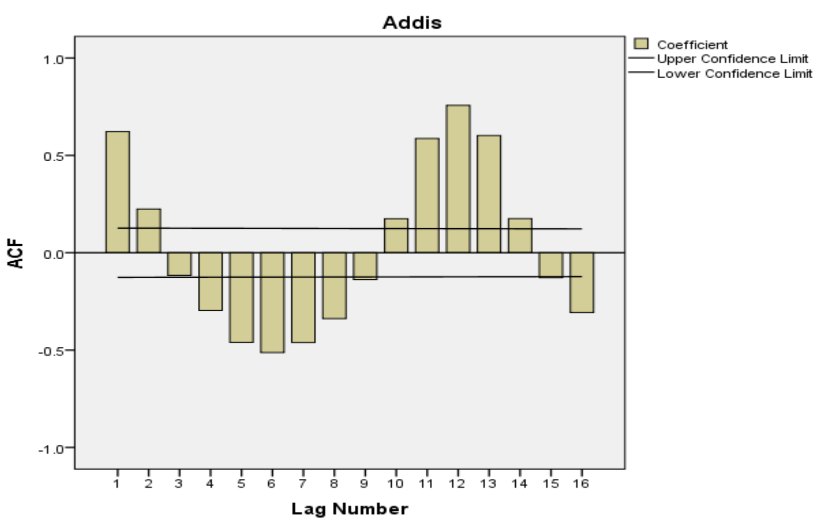
Gambella and Benishangul-Gumuz regions show slightly different ACF pattern. Here, Lag1 and lag2 ACF values are positive and high which shows longer rainy period. The periodic occurrence of rain also spread over longer period, from 10th lag to 14th lag. This shows that rain often stay longer mostly up to 5 months with some shift in onset. Rainfall in Afar seems more erratic as the largest positive ACF is at 13th lag.

A periodogram and results from *spectra analysis* using *Fourier frequencies* is presented to help in determining the period effect or the cycle in the occurrence of rain. The periodogram is a useful graphical statistic for uncovering the important frequencies in a time series. We used Oromia rainfall data for demonstration as it does not have missing value. Frequencies are plotted from 0 to 0.5. The cycles are determined by the picks in graph and determined by 1/F (where F is frequency). Consequently, the result shows that the first pick occurs at about 0.08 frequency on the periodogram, hence the periodic cycle occurs at about 12 months (1/0.08). This agrees with results from ACF. The second pick occurs at about 0.17, giving the second cycle of 6 months. This approach basically confirms results already obtained from ACF. Periodogram for other regions were fitted but since the result agrees with results from ACF, we felt that it may not be important to present it for all regions.

Once again the ACF for minimum and maximum temperature shows similar pattern with that of rainfall. Lags 1 and lags 11-13 are relatively very high and positive, indicating shifting periodic occurrence of high/low maximum temperature. The difference in this case is that the first two lags are often relatively high and positive for most regions. Except for Gambella and Somali, the remaining regions have similar pattern of ACF. The ACF for the two regions is unique in the sense that all ACF values are positive. This shows that high maximum temperature prevails throughout the year, a process that was evolving over the decades. More spread of high positive ACF values over 2010 to 2014 was observed indicating gradual reduction of the lag length (increased frequency) for occurrence of high maximum temperature.

The ACF values for lags 1, 2, 11, 12 and 13 are summarized into three tables, each for rainfall, min temp and max temp, to show the significant ACF for ease of interpretation. Direct ACF SPSS output table and graph are included for just one region (Addis Ababa) to help in understanding the range of the 16 lag distances. In the Table 4.1-4.3, the Autocorrelation values, corresponding standard errors and significance levels for each lag is shown. Lags here represent months. For example, lag 1 means consecutive months, lag2 means period which are two months apart, etc... The graphs very often shows the long (12th lag) and the short (6th lag) period occurrence of rain.

Annex 5: Plot of autocorrelation function for rainfall



Annex 6: Summary of Autocorrelation values for Rainfall, for selected lags by region

	Lag Distances				
Region	**1**	**2**	**11**	**12**	**13**
AA	0.62	0.22	0.59	0.76	0.60
Afar	0.28	0.11	0.59	0.76	0.60
Amhara	0.69	0.20	0.2	0.64	0.90
Benishangul-G	0.78	0.41	0.74	0.88	0.72
Dire	0.25	0.06	0.21	0.40	0.23
Gambella	0.66	0.43	0.46	0.55	0.56
Harari	0.41	0.15	0.29	0.40	0.30
Oromia	0.74	0.38	0.71	0.86	0.70
Somalia	0.33	0.11	0.21	0.54	0.21
Southern	0.41	0.02	0.29	0.56	0.27
Tigray	0.58	0.08	0.53	0.81	0.52

Annex 7: Summary of Autocorrelation values for Minimum Temperature, for selected lags by region

	Lag Distances				
Region	**1**	**2**	**11**	**12**	**13**
AA	**0.70**	**0.35**	**0.61**	**0.73**	**0.57**
Afar	**0.62**	**0.31**	**0.20**	**0.25**	**0.18**
Amhara	**0.79**	**0.46**	**0.68**	**0.78**	**0.64**
Benishangul-G	**0.73**	**0.36**	**0.62**	**0.77**	**0.63**
Dire	**0.78**	**0.38**	**0.69**	**0.83**	**0.68**
Gambela	**0.79**	**0.73**	**0.47**	**0.47**	**0.63**
Harari	**0.32**	**0.14**	**0.22**	**0.24**	**0.15**
Oromia	**0.74**	**0.38**	**0.65**	**0.74**	**0.58**
Somalia	**0.70**	**0.49**	**0.30**	**0.32**	**0.32**
Southern	**0.60**	**0.28**	**0.43**	**0.51**	**0.38**
Tigray	**0.80**	**0.47**	**0.74**	**0.84**	**0.71**

Annex 8: Summary of Autocorrelation values for Minimum Temperature, for selected lags by region

	Lag Distances				
Region	**1**	**2**	**11**	**12**	**13**
AA	0.65	0.28	0.58	0.75	0.60
Afar	0.73	0.37	0.64	0.76	0.63
Amhara	0.70	0.30	0.57	0.74	0.56
Benishangul	0.80	0.42	0.72	0.86	0.71
Dire	0.65	0.27	0.62	0.79	0.60
Gambella	0.77	0.65	0.35	0.37	0.29
Harari	0.33	0.10	0.17	0.22	0.11
Oromia	0.72	0.37	0.61	0.78	0.62
Somalia	0.75	0.58	0.33	0.39	0.34
Southern	0.76	0.39	0.64	0.77	0.63
Tigray	0.66	0.27	0.56	0.78	0.57

Annex 9: Results from Generalized Linear Models (GLM)

Autocorroraltion function of various orders was fitted to each of the weather and disease related data. The data mostly showed presence of first and/or second order autocorrelations but only some were selected and fitted into the GLM. Model selection was done and only those explanatory variables which contributed significantly to variations in disease related data were included. In all regions, all the three weather variables were found to significantly affect disease outcome. The only exception is that dysentery does not depend on weather variables in Amhara and Harari regional states. Thus variability in weather variables and changes in climate greatly affect disease outcome. Results from fitted models were not presented for brevity.

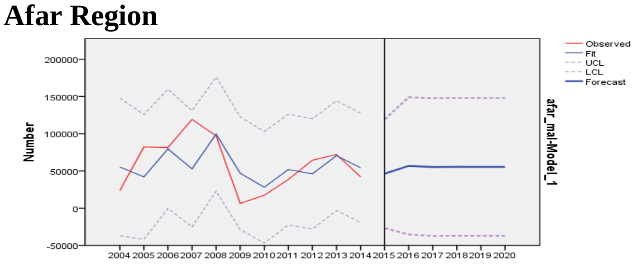
The importance of the weather variables in explaining the disease outcome is judged by the magnitude of the regression coefficient (B), of course given that the parameter is significantly different from zero. Weather variables associated with large B contribute more in increasing/decreasing the burden of disease. The B may not be directly interpreted, but changed to a different scale. For example, considering Malaria in Amhara region, B=0.028 for rainfall and it is highly significantly different from zero. Hence Exponentiation of this (exp[0.028]) gives 1.029. This value is known as Rate Ration (RR) for the rain and interpreted as the estimated percentage change in malaria for a 1 mm increase in the Rain is 2.9%, which shows that high rainfall increases malaria infection. But association of burden of malaria and maximum Temperature is reverse, as B value is negative. For a one Degree celiac increase in maximum temperature, malaria infection decreases by about 1.7%. The relationship between Malaria and weather variables varies from region to region. Even if we are not interested in the numerical estimates due to few number of years and lack of monthly data, there is significant relationship between the two groups which provide a hint on importance of considering weather variable to accommodate climate change issues in future planning.

Annex 10: predicting Malaria for 2015-2020 based on the 2004-20014 incidence rate of Malaria by Region, Ethiopia.

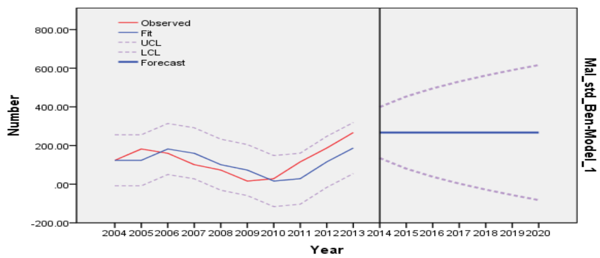
From fitting Generalized Linear Model (GLM) to the disease data as response and weather data as predictors, the former was found to depend significantly on the later. Therefore it was decided to use Rainfall, RH, minimum and maximum temperature variables of each region as predictor variables in order to forecast disease out come through 2020. Various models such as ARIMA with different parameters (i.e, different AR, Differencing and MA values) and a number of smoothing methods were fitted and the best fitting models selected based on results of model diagnostics. Predictions may not be reliable unless the existing series (2004 – 2014) is sufficiently smoothed. For this reason the observed time series was smoothed using best chosen model so that forecasts can easily be made in to the future. However, since the length of the observed data is short (only about 11), the forecast depends only on a single decade series. For some regions it was not possible to forecast disease outcome due to failure in the models.

The following figures for each region is shows plot of observed data (in red colour), fitted curve with 95% C.I in the first panel and forecast line with its C.I. in the second panel for Malaria and diarrheal disease data by region. The confidence Intervals are often very wide due to high variability in the disease cases from year to year which is associated with high standard error of the mean. It is safer to refer to confidence limit than considering a single value as forecast because we are 95% sure that disease cases will lie between those intervals in the years ahead.

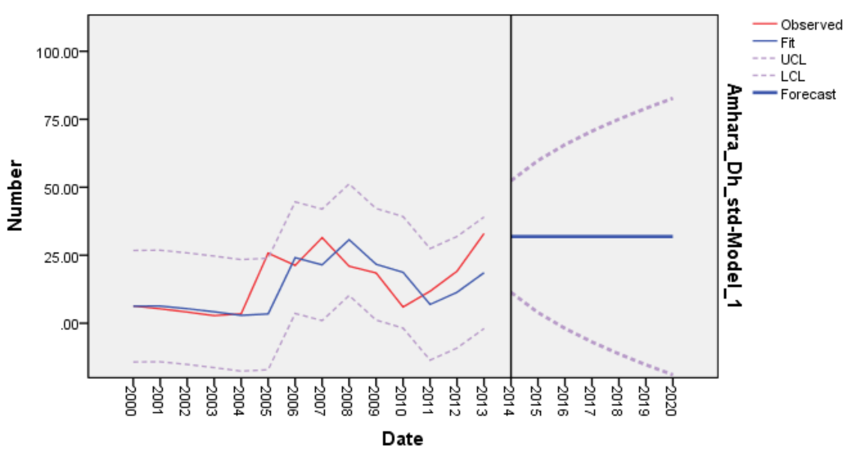
1. Afar Region



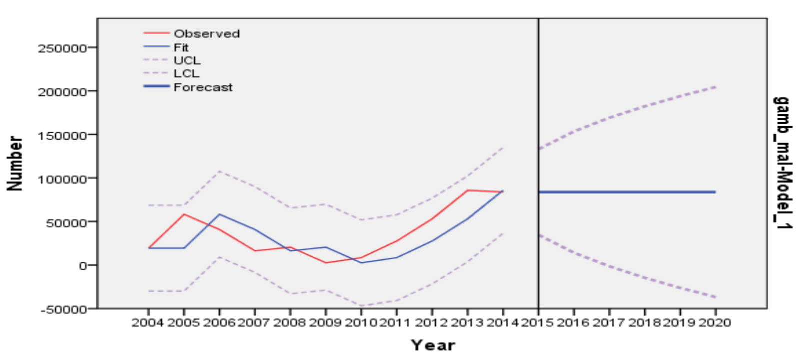
2. Benishangul-Gumuz Region



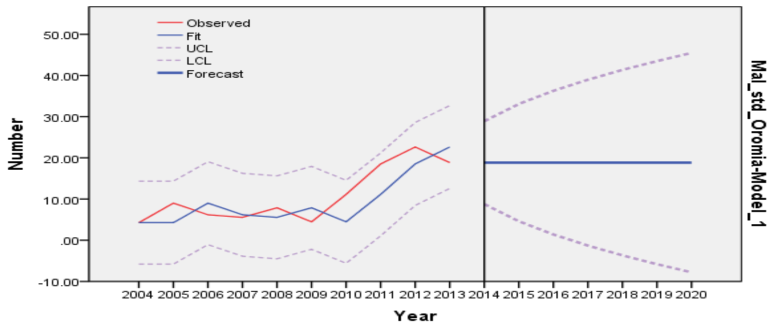
3. Amhara Region



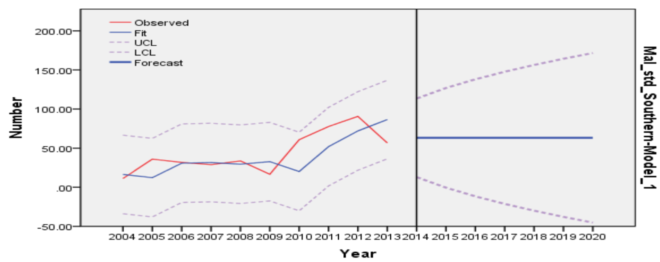
4. Gambella Region



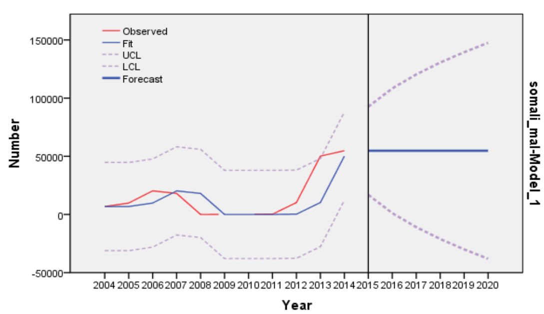
5. Oromia Region



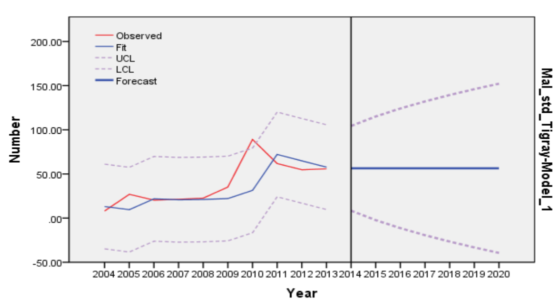
6. SNNP Region



7. Somali Region



8. Tigray Region



Annex 11: Regional distribution of prevalence of diarrheal diseases among under-five children, Ethiopia, EDHS 2000-2011

Region	**EDHS 2000**			**EDHS 2005**			**EDHS 2011**		
	Total, #	Diarrhea, #	%	Total, #	Diarrhea, #	%	Total, #	Diarrhea, #	%
Tigray	1004	178	17.7	915	122	13.3	1123	152	13.5
Affar	540	88	16.3	521	65	12.5	1031	128	12.4
Amhara	1409	265	18.8	1289	191	14.8	1201	172	14.3
Oromiya	1900	482	25.4	1765	317	18.0	1637	195	11.9
Somali	597	115	19.3	601	68	11.3	951	179	18.8
Ben-Gumz	713	192	26.9	631	130	20.6	922	204	22.1
SNNPR	1403	415	29.6	1567	396	25.3	1488	255	17.1
Gambela	522	140	26.8	478	74	15.5	781	177	22.7
Harari	504	119	23.6	481	91	18.9	616	73	11.9
Addis Ababa	468	60	12.8	360	46	12.8	384	36	9.4
Dire Dawa	488	104	21.3	380	45	11.8	659	49	7.4
Total	9548	2158	22.6	8988	1545	17.2	10793	1620	15.0
Prevalence data was generated by running frequency of diarrhea (H11) by Region (V024). Total prevalence is for the unweighted number of children									

Annex 12: Regional distribution of drinking water supply coverage, EDHS 2000-2014

Region	EDHS 2000			EDHS 2005			EDHS 2011			EDHS 2014		
	Total	Access to water	%	Total	Access to water	%	Total	Access to water	%	Total	Access to water	%
Tigray	1117	302	27.0	980	339	34.6	1202	690	57.4	719	402	55.9
Affar	640	60	9.4	574	105	18.3	1130	367	32.5	637	198	31.1
Amhara	1619	242	14.9	1458	397	27.2	1294	601	46.4	993	480	48.3
Oromiya	2188	378	17.3	1938	438	22.6	1761	706	40.1	994	507	51.0
Somali	675	208	30.8	663	161	24.3	1027	434	42.3	662	123	18.6
Ben-Gumz	805	141	17.5	698	205	29.4	1020	529	51.9	694	502	72.3
SNNPR	1591	274	17.2	1730	614	35.5	1614	630	39.0	1000	611	61.1
Gambela	606	187	30.9	515	264	51.3	851	457	53.7	663	491	74.1
Harari	559	266	47.6	514	280	54.5	659	481	73.0	710	624	87.9
Addis Ababa	513	478	93.2	380	332	87.4	400	395	98.8	699	684	97.9
Dire Dawa	560	395	70.5	411	284	69.1	696	458	65.8	704	583	82.8
Total	**10873**	**2931**	**27.0**	**9861**	**3419**	**34.7**	**11654**	**5748**	**49.3**	**8475**	**5205**	**61.4**

Improved water includes: piped into a dwelling, compound, outside compound), public standpipe, borehole, tube well, protected dug well, protected spring, rainwater collection or bottled water;
Total frequency is unweight

Annex 13: Regional distribution of sanitation coverage, Ethiopia, EDHS 2000-2014

Region	EDHS 2000			EDHS 2005			EDHS 2011			EDHS 2014		
	Total	Access to sanitation	%	Total	Access to sanitation	%	Total	Access to sanitation	%	Total	Access to sanitation	%
Tigray	1117	71	6.4	980	46	13.2	1202	548	45.6	719	413	57.4
Affar	640	21	3.3	574	25	6.4	1130	128	11.3	637	119	18.7
Amhara	1619	58	3.6	1458	90	28.8	1294	662	51.2	993	562	56.6
Oromiya	2188	317	14.5	1938	101	20.0	1761	891	50.6	994	680	68.4
Somali	675	106	15.7	663	73	16.0	1027	363	35.3	662	180	27.2
Ben-Gumz	805	222	27.6	698	41	39.0	1020	549	53.8	694	489	70.5
SNNPR	1591	250	15.7	1730	257	66.2	1614	1174	72.7	1000	763	76.3
Gambela	606	162	26.7	515	37	27.6	851	226	26.6	663	292	44.0
Harari	559	161	28.8	514	123	35.4	659	305	46.3	710	587	82.7
Addis Ababa	513	414	80.7	380	236	80.3	400	365	91.3	699	615	87.9
Dire Dawa	560	256	45.7	411	160	44.0	696	256	36.8	704	487	69.2
Total	**10873**	**2038**	**18.7**	**9861**	**1189**	**33.5**	**11654**	**5467**	**46.9**	**8475**	**5187**	**61.2**

Sanitation: improved sanitation, pit latrine with and without slab, shared latrines;
Total frequency is unweight

Annex 14: number of diarrheal cases (Dysentery+AWD +Under5 Diarrhea), health and Health related indicator 1992-2005EFY (1999-2013), Ethiopia

Year, EFY	Addis Ababa	Afar	Amahara	Benishangul-Gumuz	DireDawa	Gambella	Harari	Oromia	SNNPR	Somali	Tigray	Sum
1992	2819	1019	10336	3957	1501	748	1239	9654	10853	10758	10741	63625
1993	1013	236	8834	3928	3538	388	1154	12428	10570	12374	8261	62724
1994	2435	8527	7052	2846	581	6443	308	18966	2335	8297	12682	70472
1995	2926	5538	4936	3963	1264	2388	642	16981	4542	17906	31545	92631
1996	4479	2400	6252	2271	987	571	1193	15095	5665	4080	19813	62806
1997	24934	2974	47985	14902	3285	5769	2860	64635	40156	3511	21096	232107
1998	24035	2557	40624	10339	2500	8695	2104	58440	38928	5597	21047	214866
1999	23217	14304	61754	6610	2628	4019	16995	94507	57663	12184	22425	316306
2000	13687	13245	42197	6475	5218	3131	934	81563	60621	2716	24647	254434
2001	22754	3574	32925	3016	4348	2472	262	78830	52144	0	26959	227284
2002	14833	2503	11000	60	46	0	399	21345	5902	1405	12969	70462
2003	11812	2704	21646	2293	683	714	351	40890	39754	126	21896	142869
2004	16174	6713	36085	7450	1084	1389	404	67798	49828	610	22828	210363
2005	16644	5957	64656	12591	2724	1354	529	75382	43200	7514	32906	263457
Source: Annual health and health related indicator reports, Ministry of Health, Ethiopia, 1992-2005; Total frequency is unweight												

Annex 15: Estimated incidence rate of reported diarrheal cases (per 10,000 population) by regions, Ethiopia, 1992-2005EFY (1999-2013), Ethiopia

Year	Addis Ababa	Afar	Amhara	Bensahngul_G	DireDawa	GAMBELLA	Harari	Oromia	SNNPR	Somali	Tigray	Mean
1992	11.3	8.4	6.3	73.7	47.3	35.4	77.3	4.3	8.7	29.1	29.1	30.1
1993	3.9	1.9	5.3	71.3	107.2	18.0	69.5	5.4	8.2	32.6	21.8	31.4
1994	9.2	67.0	4.1	50.4	17.0	290.2	17.9	8.0	1.8	21.3	32.5	47.2
1995	10.7	42.6	2.8	68.3	35.4	104.7	36.1	7.0	3.3	44.7	78.7	39.5
1996	16.0	18.0	3.4	38.2	26.7	24.4	64.5	6.0	4.0	9.9	48.2	23.6
1997	86.3	21.9	25.8	244.5	85.7	240.0	150.9	25.0	27.7	8.3	50.0	87.8
1998	80.8	18.4	21.2	165.4	62.8	352.0	107.3	22.0	26.1	12.9	48.6	83.4
1999	75.9	100.9	31.5	103.3	63.8	158.9	837.2	34.6	37.6	27.4	50.4	138.3
2000	43.5	91.4	21.0	98.7	121.9	120.9	44.7	29.1	38.5	6.0	54.0	60.9
2001	79.7	24.2	18.5	42.4	120.7	74.3	13.6	27.4	32.7	0.0	59.5	44.8
2002	50.9	16.6	6.0	0.8	1.2	0.0	20.1	7.2	3.6	2.9	27.9	11.7
2003	39.7	17.6	11.8	30.4	18.0	19.8	17.3	13.4	23.6	0.3	46.0	21.6
2004	53.2	41.9	19.1	75.9	28.0	36.0	19.2	21.7	28.7	1.2	46.3	33.7
2005	53.3	36.5	32.9	133.0	65.6	35.4	24.0	23.6	24.8	14.5	67.6	46.5
Mean	**43.9**	**36.2**	**15.0**	**85.4**	**57.2**	**107.9**	**107.1**	**16.8**	**19.2**	**15.1**	**46.6**	**50.0**

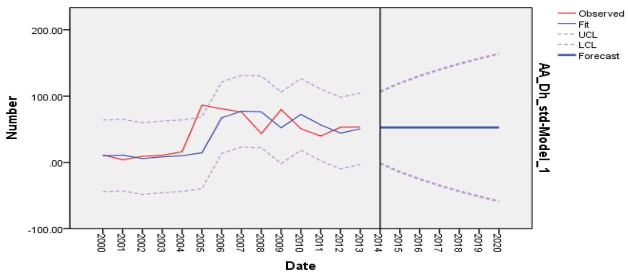
Annex 16: Regional distribution of population, 1992-2005 EFY (1999-2013), Ethiopia, (Source Health and health related indicators, annual reports)

Year	Addis Ababa	Afar	Amhara	Bensahngul	Dirdawa	Gambella	Harari	Oromia	SNNPR	Somali	Tigray	National
1992	2495837	1215809	16295514	536619	317484	211312	160233	22353506	12515599	3698144	3694650	63494707
1993	2570000	1243000	16748000	551000	330000	216000	166000	23023000	12903000	3797000	3797000	65344000
1994	2646000	1272000	17205000	565000	342000	222000	172000	23704000	13293000	3898000	3901000	67220000
1995	2725002	1301001	17669006	580000	357000	228002	178000	24395000	13686002	4002000	4006008	69127021
1996	2805000	1330000	18143000	594000	370000	234000	185000	25098000	14085000	4109000	4113000	71066000
1997	2887615	1358718	18626047	609509	383529	240394	189550	25817132	14489705	4218297	4223014	73043510
1998	2973000	1389000	19120000	625000	398000	247000	196000	26553000	14902000	4329000	4335000	75067000
1999	3059000	1418000	19624000	640000	412000	253000	203000	27304000	15321000	4444000	4449000	77127000
2000	3147000	1449000	20136000	656000	428000	259000	209000	28067000	15745000	4560000	4565000	79221000
2001	2854462	1473863	17804309	711702	360183	332599	193002	28756503	15927649	4672984	4532875	77812236
2002	2914406	1506288	18406943	733053	369187	346236	198020	29590441	16389550	4794481	4646197	79894802
2003	2975608	1539426	18414801	755044	378417	360431	203168	30448564	16864847	4919138	4762352	81911074
2004	3041002	1602995	18866002	982004	387000	385997	210000	31294992	17359008	5148989	4929999	84320987
2005	3122000	1634000	19626000	947000	415000	383000	220000	31948000	17403000	5165000	4866000	85729000

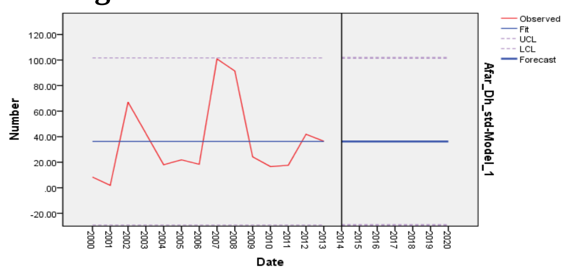
Data source: Health and health related indicators 1992-2005

Annex 17: predicting diarrhea for 2015-2020 based on the 2000-20014 incidence rate of diarrhoea by Region, Ethiopia.

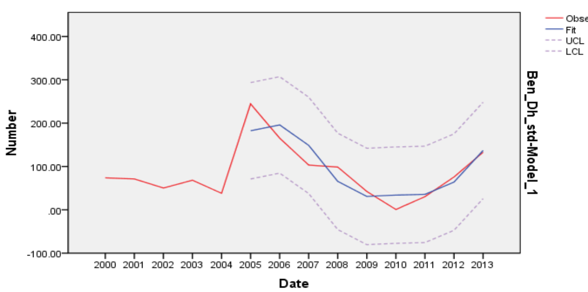
9. Addis Ababa City Administration



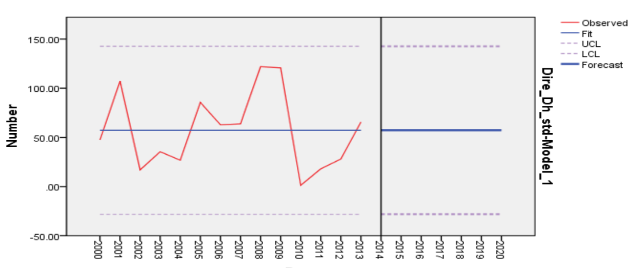
10. Afar Region



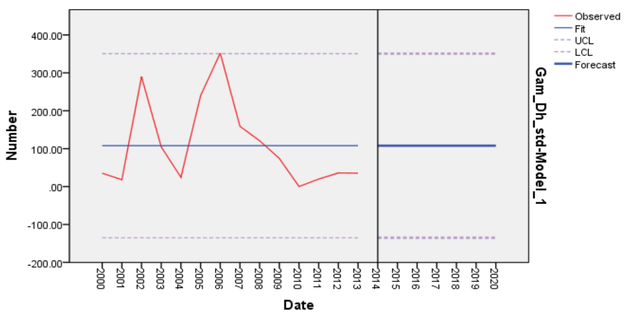
11. Benishangul-Gumuz Region



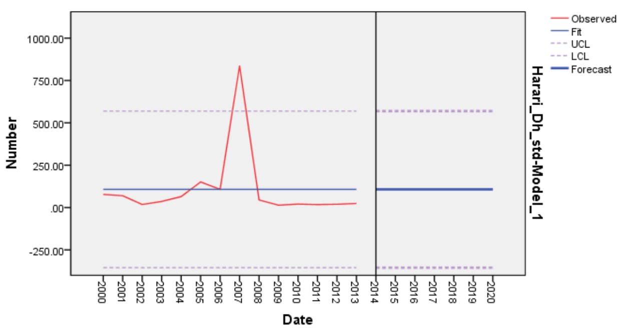
12. Dire Dawa City Administration



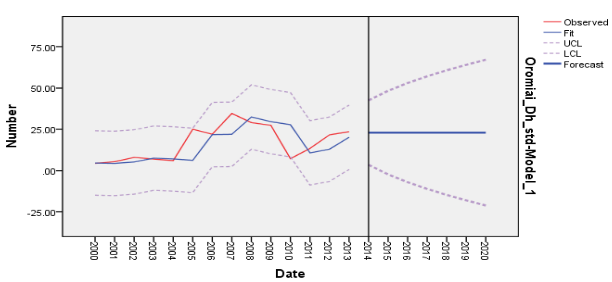
13. Gambella Region



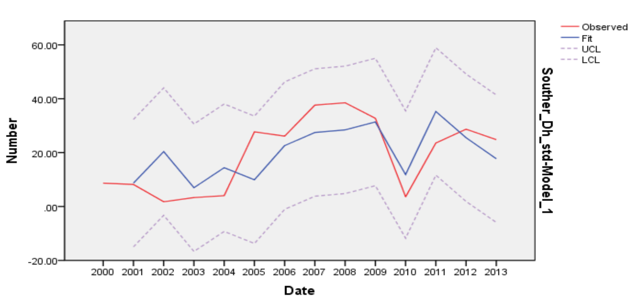
14. Harari Region



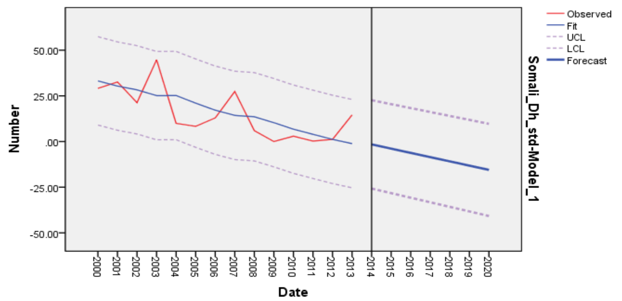
15. Oromia Region



16. SNNP Region



17. **Somali Region**



18. Tigray Region