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Case Study

An assessment of weather and climate change impact on human health in the case of Addis Ababa City, Ethiopia

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Abstract

It is well known that weather conditions could aggravate factors for climate-sensitive disease. This paper assesses on the effects of extreme temperature and rainfall events on human health in Addis Ababa City. Health statistics of different seasons was utilized for the assessment of health impact on urban population in Addis Ababa. Surface temperatures pattern were analyzed to investigate the urban warming effect. Finding of this study indicates that, in every ten year, increase in anomalies of annual mean maximum temperature is larger than minimum temperature. The spatial variation of malarial case treated in Addis Ababa by sub-cities health centers shows that, lowland areas of the city like; Akaki sub-city have highest proportion of malaria morbidity. In the city during major rainy season (June-September) malaria transmission increase and reduce during October to February months. The morbidity of malaria also increases during short rainy seasons (February to May). The increasing rate of maximum temperature anomalies was higher at urban Addis Ababa Observatory (OBS) station than Bole International Airport station (0.55^0C and 0.27^0C respectively), the Epidemic Typhus after rainy season (September to November) was very high. The study recommends adaptation measures for the identified vulnerable areas in Woreda or local city administration level is essential for the control of outbreaks infectious or epidemics preparedness.

Keywords: Urban warming, health impact and adaptation measures.

Introduction

In most case the pattern of mortality rate is affected by climate change from exposure to extreme weather events[1]. However, the relation on the effect on disease burden are not quantified, the extent of deaths during thermal extremes events are in sick persons who would have died[2-4]. Today, Malaria is mostly restricted in tropical and subtropical regions and it is sensitive to climate and associated weather event like El Niño where higher temperatures and/or rainfall may increase transmission of malaria[5,6]. In most sub-Saharan developing countries, peoples are highly prone to epidemics while weather conditions facilitate transmission[5].

The urban climate is the most modification result of land use change that will form urban heat island UHI and will have an adverse health effects from exposure to extreme temperature[4,8]. During hot weather condition an increase in mortality rate observed particularly in densely urban areas[4]. The urban heat island has obviously exacerbated the heat-related mortality. The use of available mortality data will allow the evaluation on the impact of weather outcome. It can assume that thermal conditions are significant predictors of morbidity and general human well-being[4]. The investigation in relation with health and climate data from the stations will use on record the maximum and minimum temperate on respected year of health information record. The spatial variation of health statues of the city will also analyse. Quarterly proportion of climate related health status like malaria cases was determined. The ratio of cases was computed using the method applied in Kenya[5].

A study in Nairobi has been shown that a small increase in ambient temperature has an exponential effect of the mosquito habitat. Transmission of malaria with the mosquitoes, which survive for about 18 days, will take place at mean air temperature of 23°C when it takes 16 days to mature. The parasites at 27°C require about 10 days becoming infectious[5]. In this study the departures of temperatures and rainfall with monthly malaria proportion and epidemic typhus cases values were compared to long-term mean values.

This study is vital to understand the citizen's health with climate and weather related in Addis Ababa. Also the assessment is providing the information for researcher, health policy maker and adaptive actions makers. This study is also devoted to study the Effect of the changing climate factors (temperature and precipitation) on human health based on available literature and data. The paper also highlights the various changes in seasonal trends in morbidity and mortality of cases relation with climate and weather related disease.

Objectives: The main objective of the study is to find evidence on the relation between health problem and annual temperature and rainfall change.

The specific objectives were: i. To study the city climate and its change through identifying the city temperature and rainfall analysis, ii. To assess the sub-city seasonal trends in morbidity and mortality of cases malaria and other relation with climate and weather related disease, iii. To suggest adaptation strategy for the impact of identified health related cases in the city.

Methodology

The study area: Addis Ababa the capital city of Ethiopia was established in 1889. And located 9°1′48″- 8°8′32″N Latitude and 38°44′24″- 38°9′05″E Longitude and located in the central highlands of the country and with an area of nearly 526 km^2 with a population of 2.9 million[9,10]. The city is self-governing and administratively divided into ten sub-cities and 116 kebeles (Figure-1). The 10 sub-cities and 116 kebeles are responsible for performing regulatory facilities and social services[11]. In Addis Ababa 27% of Ethiopia's urban population lives and this will have created substantial pressure on the city's housing, infrastructure and municipal services[12]. The average maximum temperature is about 24.5°C and the extreme maximum temperature is about 31°C. The average minimum temperature is about 12.0°C and the extreme minimum is about 7°C. The total rainfall in a year is about 1255.2mm[17]. In the city of Addis Ababa the infant mortality rate in 2010 is 81/1000 live births; maternal mortality rate is 556 per 100,000 live births; In the city the top leading causes of Hospital and Health Centers Morbidity cases of 2006/2007 indicates that acute upper respiratory infection had the highest case of percentage in the city (16%).

Data and methods: The study using monthly health data (2005/06-2007/08) Malaria, Epidemic Typhus and Relapsing Fever and other data were obtained from Addis Ababa Health Office for the period 2005-2007. The health services comprised of 729 health centers in the city. The city climate extremes examined by temperature and rainfall data, which obtained from the National Meteorological Agency (1965-2009). The stations are Bole International Airport and Addis Ababa Observatory (OBS) meteorological Stations. The OBS station is situated in the central urban-built area of the city. The Addis Ababa Bole international Airport station is located in suburban area. The mean monthly anomalies for minimum, maximum temperatures and rainfall were analyzed using more than 40-year climatology (1965-2009) data.

Trend analysis was used to determine changes in seasonal morbidity and mortality of cases of malaria, Epidemic Typhus and Relapsing Fever. The annual mean proportion of the above cases was calculated using the method of monthly anomaly (incidence) of Malaria, Epidemic Typhus and Relapsing Fever cases.

Results and discussion

Evidence of urban climate change: The highest rainfall occurs during June, July, August and September with highest pick level of rainfall and it is during these four months that all major flash floods have occurred in Addis Ababa see Figure-2.

Rainfall Trend and Variability: Baseline climate data of precipitation and temperature from 1971-2000 for the city Bole Airport and OBS stations in Figure-6 shows that variability of rainfall expressed in rainfall anomaly for the stations. Over the last sixty (60) years the city has experienced both wet and dry years. Figure-3 shows years like 1951, 1953, 1956, 1960, 1962, 1965, 1972, 1975, 1978, 1984, 1991, 1994, 1997, 1999 and 2002 were dry while 1958, 1961, 1968, 1969, 1977, 1993, 1996, 1998, 2001, 2005 and 2006 years are wet. Studies made at Ethiopian NMA have shown the link between ElNino and LaNina experience in Ethiopian rainfall[13].

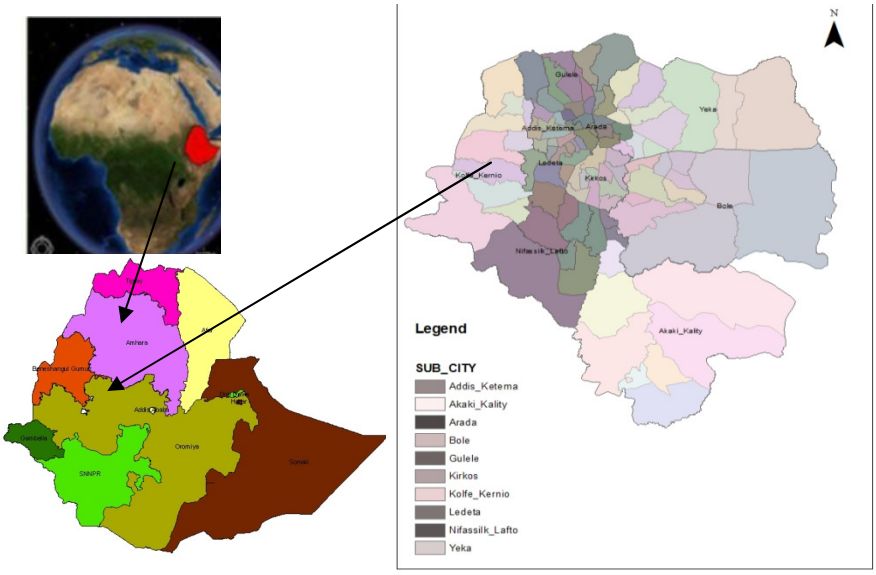
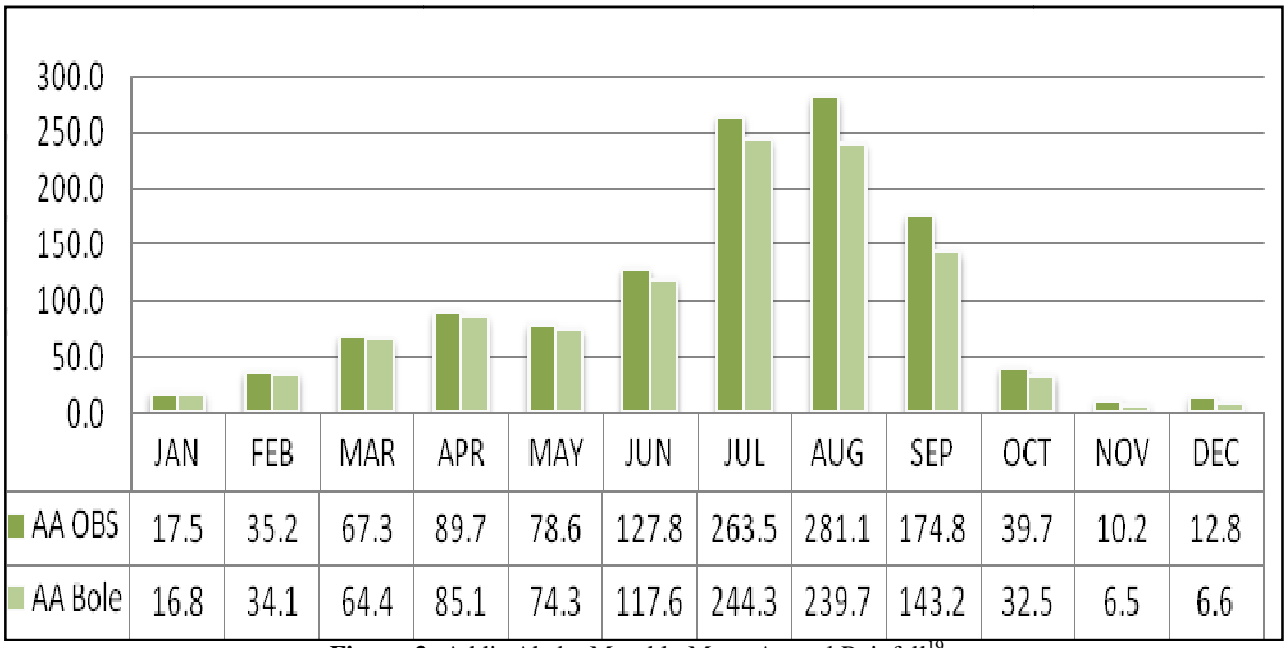


Figure-1: Location and map of Addis Ababa[19].



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
AA OBS	17.5	35.2	67.3	89.7	78.6	127.8	263.5	281.1	174.8	39.7	10.2	12.8
AA Bole	16.8	34.1	64.4	85.1	74.3	117.6	244.3	239.7	143.2	32.5	6.5	6.6

Figure-2: Addis Ababa Monthly Mean Annual Rainfall[19].

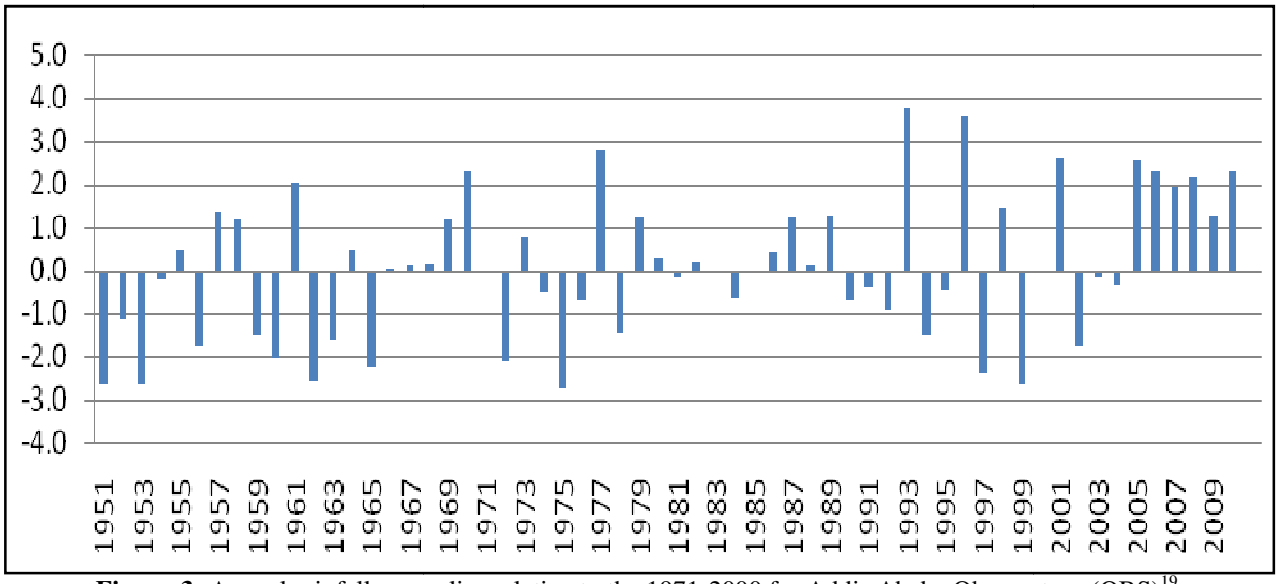
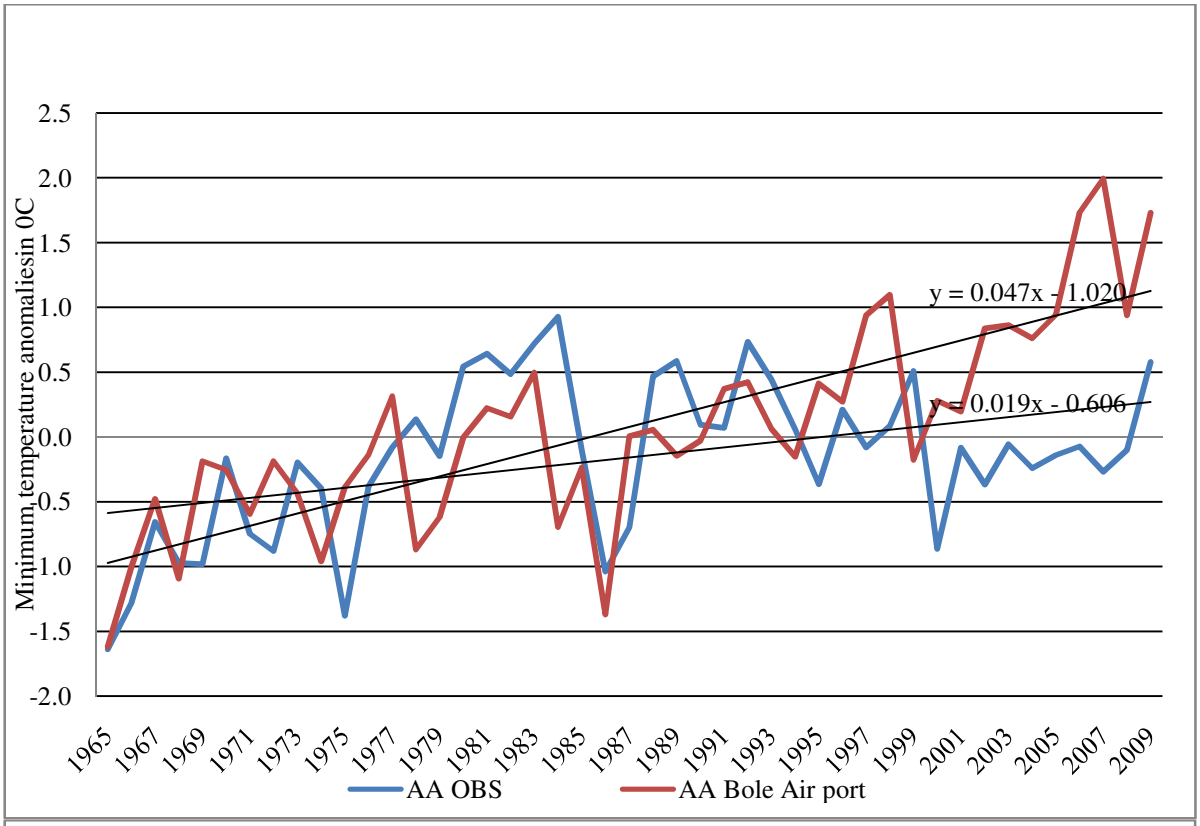


Figure-3: Annual rainfall anomalies relative to the 1971-2000 for Addis Ababa Observatory (OBS)[19].

Temperature anomalies in the city of Addis Ababa: Result of the figure 4a-b: bellow shows annual average minimum temperature and maximum temperature anomalies for Addis Ababa Bole Airport and Observatory stations from 1965 to 2009. Figure-4.a-b shows the annual and seasonal mean change trends for 1965- 2009. Substantial warming on both maximum and minimum temperature on both Observatory (OBS) and Bole international airport station for the period 1965 to 1983, and the warming at Observatory (OBS) Station is bigger than that at the Bole Airport station. In every ten year, increase in maximum with the rates for Observatory (OBS) Station and the Bole Airport station was 0.55°C and 0.27°C respectively, and minimum temperature rate is about 0.47°C and 0.19°C respectively.

The change at the station Observatory urban center (OBS) for the periods of 1965-2009 and 1981-2009 show that the change is very large, particularly in nighttime temperature. The result of the trends analysis for both minimum and maximum are 0.45 and 0.15 °C for the historic period of 1965-2009 and mean max temperature anomalies raise to 0.71 and 0.52°C in the for the period 1981-2009[14]. During the seasons, the: warming is more evident in dry season and short rainy season.



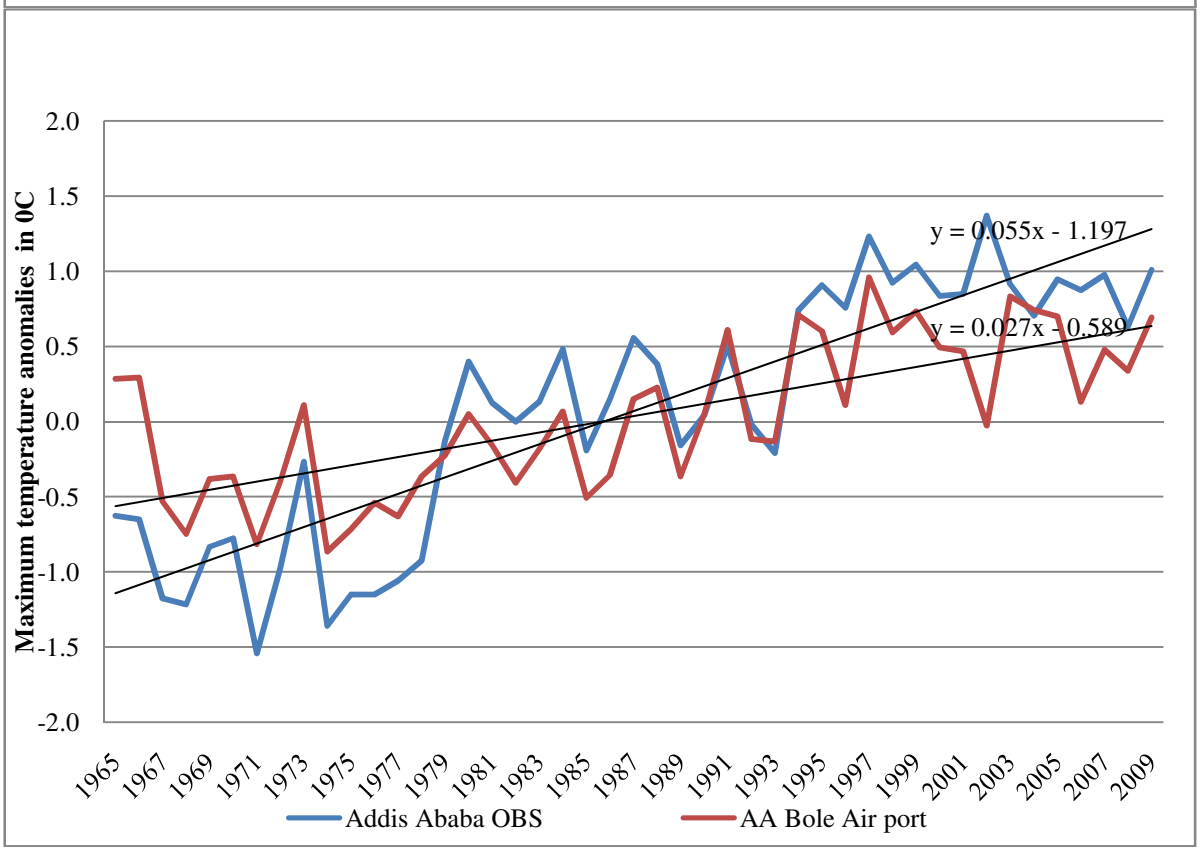


Figure-4a-b: The (a) the minimum, (b) the maximum temperature anomalies at Addis Ababa Bole Airport and Observatory (OBS) stations as compared from the year 1971–2000 base period[14].

Future projected temperature using climate model of HadGEM2-AO for Addis Ababa city using scenarios of RCP4.5 and RCP8.5 for the years in between 1951 to 2099 is in the Figure 5. Minimum temperatures will show significant warming on the scenario with RCP8.5 for both Observatory and Bole International Airport station for the period (2063 to 2099). The temperature warming shows in the Observatory OBS station higher than Bole International Airport station. For the period 2071 to 2099, the city center (OBS) station morning temperature expected to rise by 4.6 to 5.3 °C using RCP 4.5 scenario. And rise up to 6.4 to 8.5°C for RCP 8.5 scenario from the normal minimum temperature value. The projected minimum temperature change rate for both stations is about 0.6°C per decade (Figure-5a)[20]. The change for maximum temperature rate under RCP8.5 scenario (Figure-5b) for both Stations is about 0.4°C per decade.

Table-1: Trends of temperature series for every ten year, for the period 1952-2003 and 1981-2003 at Addis Ababa (OBS) Station[18].

		Dry Season (Bega) Oct-Jan	Short Rainy Season (Beleg) Feb -May	Rainy seaon Keremt Jun-Sep	Year average For every ten year
1965-2009	Average	-0.39	-0.32	-0.21	-0.31
	Minimum	0.52	0.45	0.38	0.45
	Maximum	0.14	0.14	0.18	0.15
1981-2009	Average	0.83	1.02	0.26	0.71
	Minimum	-0.23	-0.29	-0.03	-0.18
	Maximum	0.59	0.73	0.23	0.52

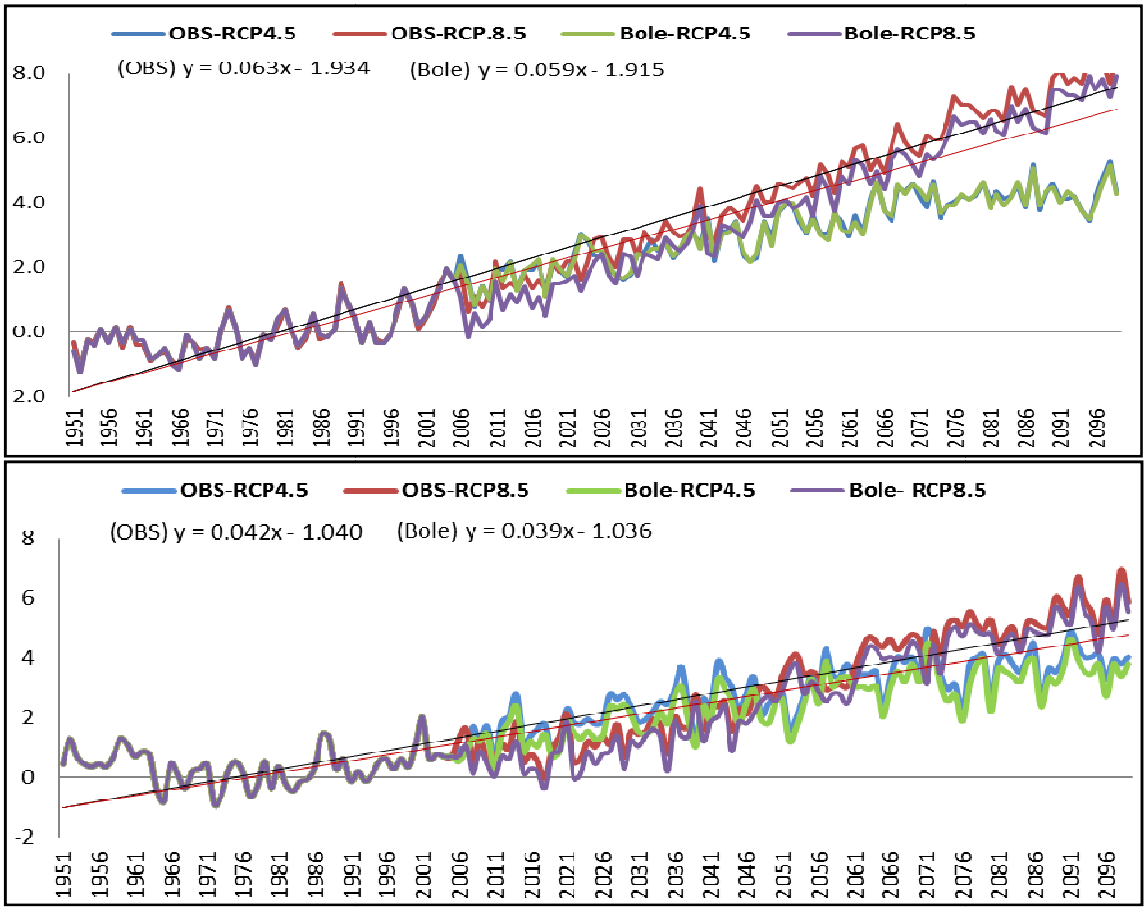


Figure-5a-b: Projected Annual averages a) minimum and b) maximum temperature anomalies from HadGEM2 AO for the period 1951–2099 (compared with 1951to 2000 average). Bole Air port and Observatory station[20].

Result on health problem: A number of climate related disease like epidemic typhus, typhoid fever and malaria cases were described in this study for defined period. Thus, these seasonal relate diseases are one of the major reasons of morbidity health services in the city. The trend of malaria increase in the mid and late 1990s is the overall prototype of the disease in low-lying Ethiopia. Previous study shows that about 28,906 cases of malaria were treated at different health facilities in Addis Ababa from 1993 to 1999. An increase trend cases of malaria was observed during this time. The rise in mean annual maximum temperature and malaria cases become more prominent. The seasonal variation of malaria from July 2005 to June 2008 showed that the case was reaching its pick in July and November. This Study shows that total of 3,731 cases of malaria were treated at different health centers in Addis Ababa. The spatial variation of malarial case treated in Addis Ababa by sub-cities (2005/06) shows in the Figure-6-a that, over lowlands of Addis Ababa (like Akaki Sub-city) the highest proportion of malaria morbidity. The outbreak of malaria during 2005/06 in Akaki and its surrounding is in concord with the malaria outbreak in many areas of the country. The acute upper respiratory infectious diseases and typhoid fever (Figure-6-b) cases were very high over densely populated and poor environmental facility available areas.

Rainfall induce the transmission by the mosquito life cycle, while temperature performs as a regulatory force. Rainfall is mainly responsible for allowing sufficient water for mosquito to breeding. Increased rainfall may washed out the breeding sites and reduce the mosquito populations.

In Figure-7 shows that on major (Kiremt) rainy season (June-September) malaria transmission increase and become less October to February and the morbidity of all cases of malaria increase in short rainy season.

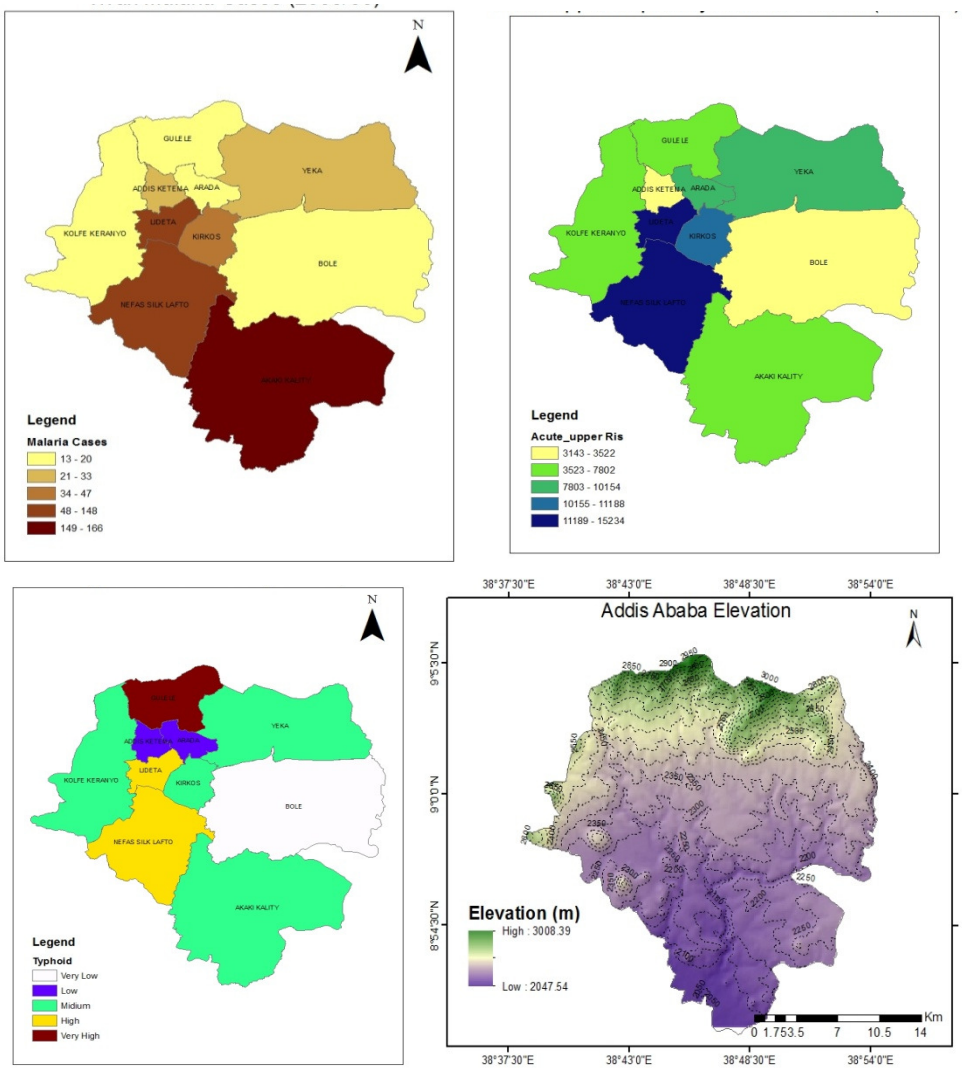


Figure-6: Addis Ababa Sub city Distribution of (a) Vivax Malaria (b) Acute upper respiratory infections (c) Typhoid Fever disease Cases for the year 2005/2006. (d) Addis Ababa Elevation map[18].

The study shows that anomalies of ≥ 1.5°C in Addis Ababa OBS station altitudes of 2333 meters (Figure-6d) have the potential increased malaria transmission. In August, these conditions occurred only once, and in October and April twice, this was highly related with maximum temperature increase. These climate events are coherent with the malaria outbreaks. Occurrence of increase in the maximum temperatures followed by onset of rainfall may support for malaria epidemic (Figure-7 and Figure-8). Epidemic Typhus (Figure-9) in and out patent in 2005/06 and 2007/08 after rainy season September to November is very high with seasonal temperature increase with less rainfall may support Epidemic Typhus spread.

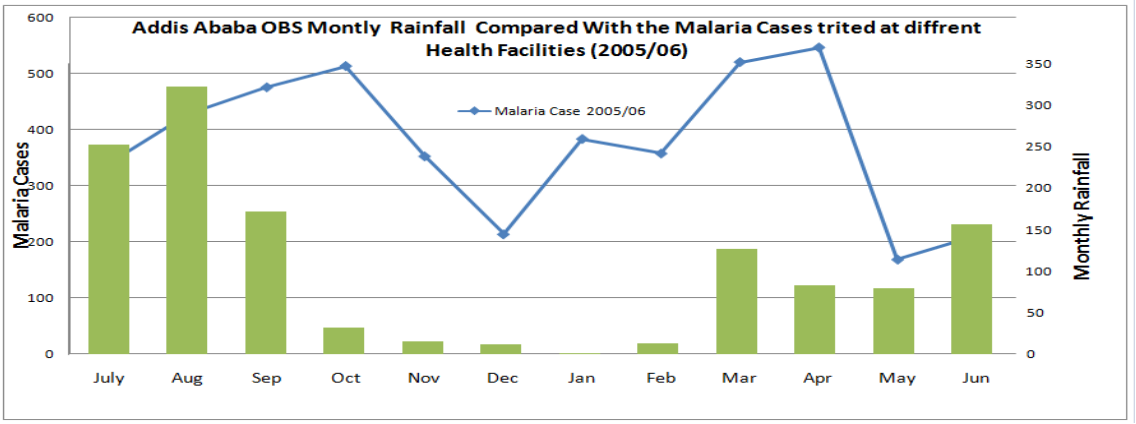


Figure-7: Addis Ababa monthly rainfall compared with malaria cases treated at different health facilities for the year 2005/06[18].

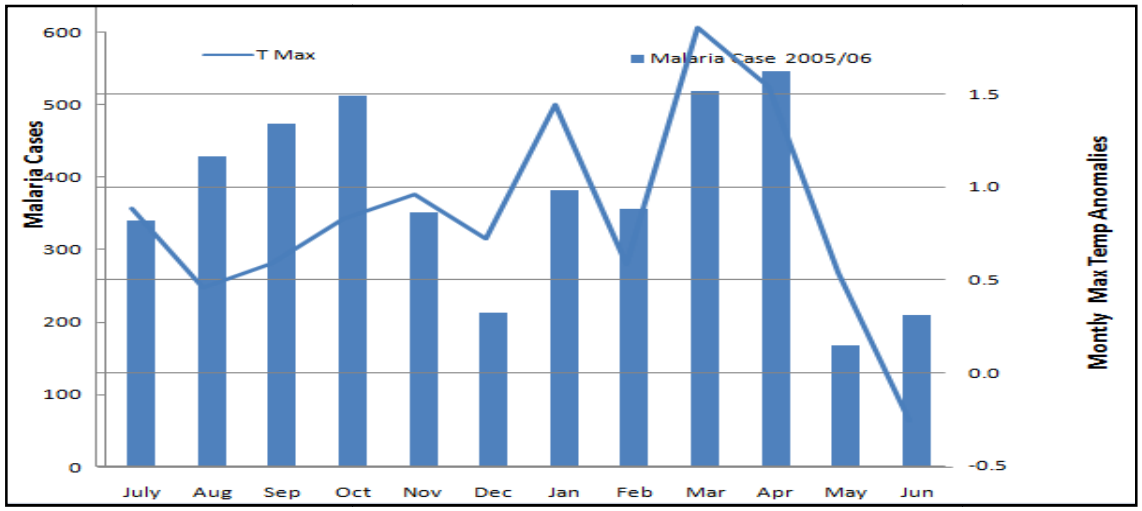


Figure-8: Addis Ababa OBS monthly maximum temperature anomalies compared with malaria cases for the year (2005/06)[18].

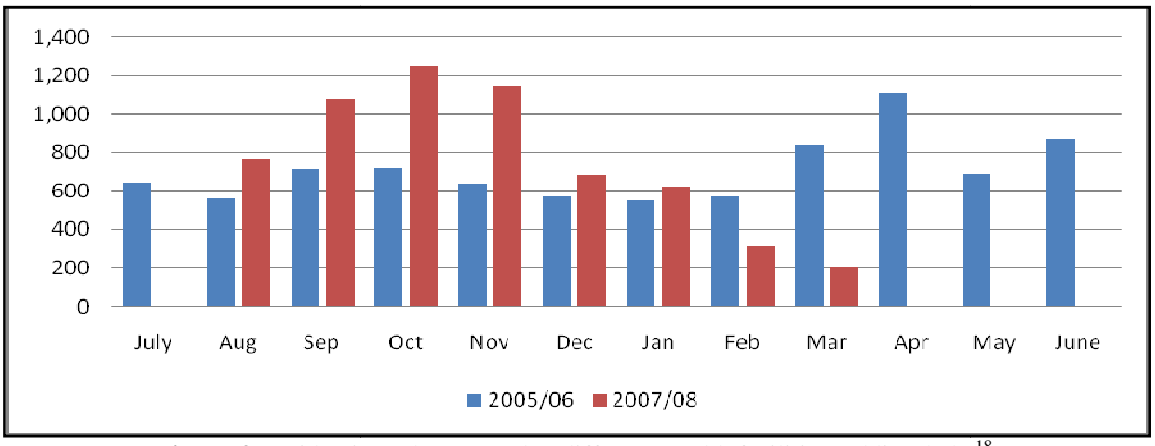


Figure-9: Epidemic typhus treated at different Health facilities Addis Ababa[18].

Key vulnerabilities: The low vegetation cover and poor river corridor management of Addis Ababa will causes vulnerable to possible adverse climate change and health impacts. The lowland areas of the city will considered most vulnerable to climate change because of less green space, shortage of water supply and health service facility. Climate change results of extreme weather events enhancing the spread of vector borne disease like malaria, and infectious diseases like typhoid and typhus, etc. Therefore city health sector's primary role is forming emergency preparedness for control vulnerable areas due to adverse climate change.

Adaptation practices and options: To reduce future change of climate vulnerability on health risks in the coming decades adaptation strategy is needed to minimize the impact. Vulnerability of malaria in the sub-cites like Akaki, Nefasilk Lafto and Kirkos implementation of woreda level regular awareness program and surveillance programmes to identify and respond to outbreaks of malaria. River corridors rehabilitation and access to clean potable water and improved sanitation will help to reduce epidemic typhoid, and other infectious diseases. Pro-active adaptation strategies, policies and measures need to be implemented by Addis Ababa city administration at all level[15]. Regular emphasis need to place on malaria surveillance, preparedness for control of infectious outbreaks or epidemics. The identified health impacts of climate change at local scale diverse to promote the uptake effective public-health and clinical interventions in the city of Addis Ababa.

Funding for seasonal epidemic health programs will be crucial step to reducing climate vulnerability. Monitoring the public health institutions at Woreda level with base line data; private health sector need to treating people fairly on climate related epidemics; providing adequate climate change education and public weather forecast for health sectors.

Conclusion

There is an evidence of warming on both minimum and maximum temperature occurred from 1965 to 1983, and the warming at Addis Ababa (OBS) is larger than that at the Bole station. In every ten year, increase in maximum with the rates for Addis (OBS) and the Bole being 0.55°C and 0.27°C respectively, and the rates of minimum temperature is about 0.47°C and 0.19°C respectively. The spatial variation of malarial case treated in Addis Ababa by sub-cities (2005/06) shows that Akaki Sub-city the highest proportion of malaria morbidity. Anomalies of ≥ 1.5°C in Addis Ababa OBS station altitudes of 2,333 meters have the potential increased malaria transmission provided there is sufficient rainfall. In December 2005 the greatest negative anomaly, on temperature about -2.5°C was recorded. Occurrence of positive anomalies in the maximum temperatures followed by rainfall may support a large malaria epidemic. Weather and climate can directly have an impact on spread of vector borne (malaria) and infectious (typhoid and typhus) diseases.

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