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DEPARTMENT OF BIOLOGY

TEN YEARS TREND ANALYSIS OF MALARIA PREVALENCE IN RELATION TO CLIMATIC VARIBALES IN SIBU SIRE DISTRICT, EAST WOLLEGA ZONE, OROMIA REGIONAL STATE, WESTERN ETHIOPIA

THESIS SUBMITED TO THE DEPARTMENT OF BIOLOGY IN FULFILLMENT OF THE MASTERS OF SCIENCE IN BIOLOGY (ECOLOGY AND SYSTEMATIC ZOOLOGY)

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Ten Years Trend Analysis of Malaria Prevalence in Relation to Climatic Variables in Sibu Sire District, East Wollega Zone, Oromia Regional State, Western Ethiopia: A retrospective Study.

By: Temesgen Gemechu

Thesis submitted to the department of Biology, Collage of Natural Science and School of Graduate Studies, Jimma University in partial fulfillment of the requirement, for the degree of Master of Science in Biology (Ecology and Systematic zoology).

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List of Acronyms and Abbreviations

ACIPH: Addis Continental Institute of Public Health

ACT: Artemesinin-based Combination Therapy

CDC: Centers for Disease Prevention and Control

DRPK: Democratic Republic People's of Korea

HEWs: Health Extension Workers

IRS: Indoor Residual Spraying

ITNs: Insecticide Treated Nets

LLINs: Long-lasting Insecticidal Nets

MoH: Ministry of Health

MOP: Malaria Operational Plan

NMCP: National Malaria Control Program

RBM: Roll Back Malaria

RDTs: Rapid Diagnostic Tests

RLEPOSSD: Rural Land Environmental Protection Office of Sibu Sire District

SOP: Standard Operating Procedures

Spp: Species

SPSS: Statistical Package for Social Science

SSA: Sub-Saharan Africa

SSAO: Sibu Sire Agricultural Office

SSDA: Sibu Sire District Administration

SSHO: Sibu Sire Health Office

UNICEF: United Nations Children's Education Fund

WHO: World Health Organization

WMR: World Malaria Report

Abstract

Malaria is one of the most devastating diseases in the World and caused by a protozoan parasite of the genus Plasmodium. The species of Plasmodium falciparum and Plasmodium vivax are the two predominant malaria parasite species, distributed in Ethiopia and accounting for 60% and 40% of malaria cases, respectively. The disease remains one of the most important causes of human morbidity and mortality with enormous health, economic and development impact in the world, and in most African countries including Ethiopia. The complexity of the disease transmission and control process, expensiveness of the control program, resistance of the parasite to anti-malarial drugs and vectors to insecticides are some of the challenges. The study was designed to analyze ten years malaria prevalence, its association with climatic variables and determine the level of correlation between meteorological variables and malaria in Sibu Sire district, Western Ethiopia. Ten years malaria clinical and epidemiological data were collected from health facilities and climatic data of the study area were also collected from Ethiopian Meteorological Agency. The data were analyzed using SPSS software package version 16.0. Overall a total of 30,070 blood films were examined for malaria in Sire Health Center from 2004–2013, of this 6036 (20.07%) microscopically confirmed malaria cases were reported. In this study a fluctuating trend of malaria prevalence was observed and P. falciparum accounted for the majority of the cases (66.12%) f5ollowed by P. vivax (30.52%) and mixed infection (3.36%) . 53.6 and 46.4 of the malaria cases were males and females, respectively. The age group with 15-44 years was more affected, with prevalence rate of (48.1%). The infection rates in rural and urban setting were 69.3% and 30.7%, respectively. In addition higher monthly malaria cases were recorded in June. Regression analysis also revealed that minimum temperature, rainfall, and average relative humidity had significant association with malaria prevalence (P<0.001). In general, prevalence of malaria did show a fluctuate trend throughout the study period and become declined. Therefore, detailed ecological and epidemiological studies are needed to assess the true local risk. Moreover, the National Malaria Control Program(NMCP) and other stakeholders should create awareness through health education and to scale-up the coverage of Long-lasting Insecticidal Nets (LLINs) and Indoor Residual Spraying (IRS) for the prevention and control of malaria in the study area.

Keywords: Climate variable, Malaria, *Plasmodium falciparum*, *Plasmodium vivax*, Prevalence, Sibu Sire district and Trend analysis

1. Background

Malaria is one of the most devastating diseases in the World. There are 97 countries and territories with ongoing malaria transmission, and 7 countries in the prevention of reintroduction phase, making a total of 104 countries and territories in which malaria is presently considered endemic and globally, an estimated 3.4 billion people are at risk of malaria (WHO, 2013). Malaria is a protozoan disease caused by parasites of the genus *Plasmodium*. Human malaria is caused by five species of the genus *Plasmodium* namely: *P. falciparum, P. vivax, P.ovale, P. malariae* and *P. knowlesi*. *P. falciparum* is the most virulent of the five human malaria parasites and is responsible for almost all malaria mortality and morbidity in tropical and subtropical countries (WHO, 2011; Jennifer *et al*., 2005; Andare-Neto *et al*., 2004).

The disease remains one of the most important causes of human morbidity and mortality with enormous medical, economic and emotional impact in the world (WHO, 2011), with 2-3 million deaths occurring each year (Snow *et al*., 2005) but WHO (2013) report show that malaria were causes 627,000 deaths and 207 million cases in 2012, mainly in sub-Saharan Africa followed by South East Asia. It is the leading cause of death in children under the age of 5 years and pregnant women in developing countries (Lagerberg, 2008; Martens, 2000). In 2010 there were an estimated 216 million cases of malaria worldwide, of which 91% were due to *P. falciparum*. According to WHO (2011) reports the vast majority of malaria cases (81%) were in the African Region followed by South-East Asia (13%) and Eastern Mediterranean Regions (5%). In most African countries including Ethiopia, the number of cases reported annually fell by at least a quarter and, in some instances, by more than a half, between 2000 and 2010 (WHO, 2011).

Malaria is a huge public health problem in terms of morbidity and burden on health care facilities, accounting for the increasing percentage of outpatient consultations in most health facilities in different regions in Ethiopia (Deressa *et al*., 2003). It is estimated that 68% of the population lives in malarious areas and three quarters of the total landmass is regarded as malarious (MoH, 2008; Adhanom *et al*., 2006). *P. falciparum* and *P. vivax* are the two predominant malaria parasites, distributed all over the country and accounting for 60% and 40% of malaria incidence, respectively (MoH, 2002). *P. malariae* contributes less than 1% of all the cases which is most commonly reported from Arba Minch area, south western Ethiopia (MoH, 2007; Deressa *et al*., 2000). *P. ovale* (first described by Stevens in 1922) is widely distributed across tropical regions in Africa and Asia is one of five *Plasmodium* parasite species that causes human malaria (Rowe *et al*., 2006). Relatively little attention has been paid to *ovale* malaria, which is considered to be uncommon, mild in clinical presentation and easily treated with the conventional anti-malarial Chloroquine (Mueller *et al*., 2007). *P. ovale* dimorphism was proposed to reflect the existence of two fully distinct *ovale* malaria species, which were unexpectedly shown to be broadly sympatric, at the country level, in both Africa and Asia. These two proposed species have been named *P. ovale curtisi* and *P. ovale wallikeri* (Sutherland *et al*., 2010). A study conducted in Northwest Ethiopia by Alemu *et al*. (2013) indicated that *P. falciparum* (66.5%) remains the predominant species followed by *P. vivax* (29.6%) and *P. ovale* (3.9%) at the study site.

Comparatively the epidemiology of malaria in Ethiopia is generally lower than in other sub-Saharan Africa countries and the transmission is heterogeneous with *P. vivax* malaria endemic causing up to 40% of clinical cases (Yeshiwondim *et al*., 2009). The epidemiology of malaria in Ethiopia is also more variable and unstable than in any other country in Africa due to Ethiopia's extremely diverse topography and climatic conditions. Ethiopia has also the highest proportion of *P. vivax* malaria in Africa (MoH, 2007; Deressa *et al*., 2000). Malaria transmission in Ethiopia is seasonal and unstable, depending mostly on altitude and rainfall (Deressa *et al*., 2003). The two main seasons for transmission of malaria in Ethiopia are September to November, sometimes extended to December after heavy summer rains, and March to May, after the light rains (Endeshaw *et al*., 2008).

Malaria is one of the major obstacles to socio-economic development in the country as the main transmission periods coincide with peak agricultural and harvesting periods. Malaria still remains as the major cause of morbidity, mortality and socioeconomic problems in Ethiopia because malaria control is a big challenge due to many factors. According to World Malaria Report (2008), the combination of tools and methods to combat malaria now includes long-lasting insecticidal nets (LLlN) and artemisinin based combination therapy (ACT) supported by indoor residual spraying of insecticide (lRS), and intermittent preventive treatment in pregnancy, presents a new opportunity for large scale malaria control. The idea behind vector control is to reduce the level of mortality and morbidity by reducing transmission of the disease. It was reported that the Global Malaria Action Plan aims to cut deaths and illness by 2010 to half their 2000 levels by scaling up access to Insecticide Treated Nets (ITNs), IRS and treatment, and achieve the near-zero goal through sustained universal coverage (WHO, 2008). The complexity of the disease control process, expensiveness of the control program, resistance of the parasite to anti-malarial drugs and vectors to insecticides are some of the challenges (Deressa, 2006; Oesterholt *et al*., 2006).

The main components of malaria control strategies in Ethiopia included early diagnosis and effective treatment of cases, the application of selective vector control measures like (IRS) and environmental management, strengthening the information system to facilitate the prevention and early detection and control of epidemics (Abose *et al.*,1997). Moreover, community education regarding the use of ITNs and its supply progressed as one major control strategy of malaria in the country (UNICEF, 2004).

Meteorological factors have been considered as important drivers of malaria transmission by affecting both malaria parasites and vectors directly or indirectly (Pemola and Jauhari, 2013). Besides this, other factors, such as any change in land use patterns and construction of water control could have considerable effects on malaria transmission (MOH, 2007). Changes in temperature, rainfall, and relative humidity due to climate change are expected to influence malaria directly by modifying the behavior and geographical distribution of malaria vectors and by changing the length of the life cycle of the parasite. Climate change is also expected to affect malaria in directly by changing ecological relationships that are important to the organisms involved in malaria transmission (Alemu *et al*., 2011).

Because of those challenges malaria is one of the main public health problems in Sibu Sire district. Therefore, this study is initiated to analysis the ten years trend of malaria prevalence and to determine any patterns of correlation existing between meteorological factors and malaria over the last decade in Sibu Sire district.

1.1 Objective of the Study

This study was undertaken with the following general and specific objectives.

1.1.1 General Objective

To assess ten years trends of malaria prevalence and its association with climatic variables in Sibu Sire district, East Wollega Zone of Oromia Regional State, Western Ethiopia.

1.1.2 Specific Objectives

- To assess the ten years trends of malaria Prevalence in Sibu Sire district.
- To assess age specific malaria prevalence in the past ten years in the area.
- To assess the prevalence of malaria by *Plasmodia species* in the past ten years in the study area.
- To assess the sex specific malaria prevalence in the past ten years in the study area.
- To determine the correlation between climatic variables and malaria in the past ten years in the study area.
- To determine the monthly, yearly and seasonal dynamics of malaria in the past ten years in the study area.

1.2 Statement of the Problem

Each year, between 300 – 500 million malaria cases and up to three million deaths occur throughout the world. From this figure Africa accounting for more than 90% of the burden (Breman *et al*., 2004). Over 80% of malaria deaths occur in Africa, while less than 15% of the deaths occur in Asia and Eastern Europe (WHO, 2005).

Currently, it is one of the major tropical diseases adversely affecting the health of the people and the economic development of many developing countries, particularly in sub-Saharan Africa (Breman *et al*., 2004). The stakeholders including international bodies, private sector, religious and community based organizations have supported a number of malaria programs towards fighting the spread of the disease. However Ethiopia, like other Sub-Saharan Africa (SSA) countries, shares the intolerable burden of malaria, which has become a leading public health problem in the country (Deressa *et al*., 2007).

According to Addis Continental Institute of Public Health report, malaria is the most important public health problem in Oromia Region. It is widely distributed in about 82% of the Woredas in the region (ACIPH, 2009). Sibu Sire is one of the malarious areas found in Oromia Regional state. However there is no published information concerning the trend of malaria in the study area. Thus, a retrospective study design was employed to collect malaria prevalence local data from district health services to determine the ten year trend prevalence of malaria at Sire Health Center and climatic variables from Meteorology office.

1.3 Significance of the Study

Malaria is among the major contributors of disease load in Ethiopia. Particularly, in the study area malaria is a serious problem. In this study the past ten years (2004 up to 2013) trends of malaria was assessed to know prevalence and its association with climatic variables in the study area.

Therefore, the result of this study will be helpful for stakeholders to design and to take appropriate action in order to tackle the risk of malaria. The urban and rural dwellers were aware of prevalence of malaria in the study area and improving the future condition that helps them to control the distribution of malaria in their local area. In addition to this it was used as a baseline data or raw information by using this manuscript for further studies in the area.

1.4 Delimitation of the Study

This study was conducted to analysis ten years (2004-2013) trend analysis of malaria prevalence in relation with climatic variable. The study area was limited to one District only: Sibu Sire District, East Wollega Zone in Oromia Region. Even from the four health centers found in the district, only Sire Health Center was taken as a sample. This was because the other three Health Centers had no data for the stated time (i.e. ten years) of study. Because those Health Centers were start duty around two years before this research done.

2. Literature Review

2.1. Overview of Malaria Prevalence

Malaria is a vector-borne disease that is widespread in the tropical and subtropical areas of the world. This has become a serious challenge for most developing countries where between 300 and 500 million people are infected annually. The disease is a leading cause of infant and child mortality in sub-Saharan Africa (WHO, 2003). Malaria is a disease caused by a parasite belonging to the genus *Plasmodium* (WHO, 2008; White 2007). Although over 400 species exist, only four are known to routinely infect humans *P. falciparum*, *P. vivax*, *P. ovale*, and *P. malariae* (White, 2007). Not only does each type of parasite affect its human host differently, but each malaria parasite resides in a different geographic region. *P. falciparum* and *P. vivax* can mostly be found in the tropics and subtropics whereas *P. ovale* and *P. vivax* are more prevalent in West Africa and Southeast Asia (White, 2007). All of the four human malaria parasites species occur in Ethiopia. However, *P. falciparum* is dominant, accounting for 60% to 70% of the cases while 30-40% is attributable to *P. vivax*, which is rare in sub-Saharan Africa except Eritrea (WHO, 2011). In central Ethiopia the report by Woyyessa *et al.*, (2004) shows that the predominance of *P. falciparum* during October while *P. vivax* tends to dominate during November.

The malaria vector requires water to complete its life cycle: egg, larva, pupa, and the adult. While between 200-1000 eggs can be laid, the quantity is influenced by the amount of blood taken in. Blood-feeding usually starts at dusk and continues until dawn (Adugna, 2008). The number of blood meals a mosquito takes from humans is the product of the frequency with which the vector takes a blood meal and the proportion of these blood meals that are taken from humans. The frequency of feeding mostly depends on the rapidity with which a blood meal is digested, which can be calculated by a thermal temperature sum, increasing as temperature rises (Martens *et al.*, 1995).

Biological and social factors also share in influencing vector development and malaria transmission. These factors compiled by Bi *et al.*, (2003) are vector-abundance of the *Anopheles* mosquito species, the propensity and frequency of the mosquitoes to bite humans, the mosquito susceptibility to the parasite, the longevity of the mosquitoes, the rate at which the parasite develops in the mosquitoes, mosquito control measures, and Human behavior, population immunity, and social conditions, such as housing, access to medical care, and land use.

2.2 Global Malaria Burden

Malaria is prime concern of 109 countries, but 35 countries account for 98% of malaria deaths worldwide. Only five of these countries (Nigeria, Democratic Republic of Congo, Uganda, Ethiopia and Tanzania) represent 50% of deaths and 47% of malaria cases (Khaireh *et al*., 2012). Also, the Democratic Republic of the Congo and Nigeria together account for over 40% of the estimated total of malaria deaths globally (WHO, 2011). Even though malaria has been a major public health problem throughout human history, particularly in the tropical and subtropical parts of the world (Raghavendra *et al*., 2011). The global malaria cases in 2010 were estimated at 219 million, with 660,000 deaths. Among these Africans accounted for about 91% of the deaths (WHO, 2012). Malaria is one of the leading causes of illness and death in the world (Lagerberg, 2008). According to world malaria report its complications may account 30-50% of inpatient admission and up to 50% of outpatient visits per year (Donavan, 2005; Cox-Singh, 2008) the difficulty of creating efficient vaccines and also drug resistance by parasites and insecticide. RBM seeks to cut disease from malaria in half by the year 2010. The plan aims to reduce malaria incidence by controlling transmission, using community health workers to help diagnose and treat the disease (Daniel, 1999).

The South East Asia Region is home to about 2.2 billion people potentially at risk of contracting malaria. This equates to approximately 67 percent of the world population at risk of malaria, mainly stemming from the fact that six of the most populous countries in the world are located in this Region, including India, China, Indonesia, Bangladesh, Vietnam and the Philippines (WHO, 2008). In countries such as Bangladesh, India, Indonesia, Myanmar and Vietnam, about 91 per cent of the population lives in areas of high transmission for both *P. vivax* and *P. falciparum* (WHO, 2011). And also in 2009, the South East Asia Region had reported 2.4 million parasitological confirmed malaria cases and 3320 deaths, reflecting a 7 per cent decrease in cases since 2003. India, Myanmar and Indonesia accounted for approximately 94 per cent of the reported malaria cases in the Region in 2008, with India bearing the brunt of the burden at 65 percent (WHO, 2010).

The high human population densities, especially in Asia, it is probably the most prevalent human malaria parasite and although, malaria is a serious health problem in China. *P. vivax* can be found in many locations, and other types of *Plasmodium* can also be found in some epidemic zones. The main vectors are *An. sinensis* and *An. Anthropophagus* (Bi *et al*., 2003). For instance malaria is one of the most important parasitic diseases in People's Republic of China. About 86% of malaria prevalence in the country was located in the Huanghuai valley of central China where the predominant vector mosquito is *An. Sinensis* were found (Pan *et al*., 2012).

A study conducted in India estimated that the number of malaria deaths in India could well be as much as 6-fold higher than the current World Health Organization (WHO) estimates (Dhingra, 2010). In the Dehradun Valley, the main vectors of malaria are *An. stephensi* and *An. fluviatilis.* For the last couple of years vectors-borne diseases are becoming the most dreaded health problems in the state of Uttaranchal because of developmental activities in one or the other ways (Pemola and Jauhari, 2006).

2.3 Malaria Situation in Africa

The number of people at risk of malaria in many parts of Africa south of the Sahara Region grew to over 74% (about 600 million) at the end of the 20th century (Deressa *et al*., 2006). One of four childhood deaths in Africa is caused by malaria and 80% of global malarial morbidity and 90% of malarial deaths occur in Sub Saharan Africa (WHO, 1996). The study done about trend of malaria in Ruwanda show that declines in malaria indicators in children under-5 years during 2007–2010 were more striking than in the older age group. Malaria admissions and deaths in children under-five declined by >70% five years post-intervention while malaria deaths in 5 years and above declined approximately 30%. The larger decline in deaths among children under-may be due, in part, to the fact that this was initially the main target group for ITN distribution (Karema *et al*., 2012).

The annual admission records of malaria incidence showed a significant relationship in the years 1997 – 2007. This explains the endemic status of the disease in this period with an exception of the years 2003 and 2006. The correlation of malaria cases per states showed annual trends of malaria cases in Sudan, 1997 – 2007, a fluctuating trend of malaria cases reported through the years 1997 to 2007 was observed. An increase in malaria occurrence in 2003 and 2006 with peak cases occurring in 2006 and malaria prevalence were reduced the following three consecutive years (2004 and 2007) but a remarkable increase in 2006 was observed. During the study period, a total of 2,860,598 cases were reported in Sudan with the annual mean number of 87,411 malaria cases (Aal and Elshayeb, 2011).

Many studies have shown that malaria is not a common cause of death among children under the age of 6 months and that in malaria endemic areas; very young infants rarely contract malaria (Alonzo, 1993, Akum *et al*., 1996). This protection has mainly been attributed to transplacentally acquired malaria antibodies, as well as to other biological factors. However, after six months of age, unprotected infants suffer repeated and severe attacks that become milder as they grow older. A study in Nigeria; first infections were contracted during the second half of the first year of life (Akum *et al*., 1996). These findings also showed that malaria parasite rates and densities increased rapidly until the age of 6 months and there after decreased gradually until one year of age. Otherwise, the proportion of infected infant's increases with age, with a tendency to plateau after the age of 4 months and the prevalence of hyper parasitaemia also shows an increase with age over the first 6 months in an area of very high transmission intensity (Kitua *et al*., 1996).

The study conducted in Ruwanda by Karema *et al*. (2012) indicate that trends on the malaria outpatient cases, inpatient cases and deaths and no malaria indicators during 2000–2010. Temporally, malaria related indicators (slide positivity rate, in-patient cases and deaths) followed similar trends of decline during 2000–2010 in children under five and 5 years and above. The study conducted in Mvomero, by Xiaochen (2013) showed that, two peaks were observed in 2004 and 2008 both of which were followed by a significant drop in the couple of years.

According to Nigeria National Malaria Control Program in (2012) stated Nigeria alone accounts for a quarter of the malaria burden in Africa. Malaria is endemic in Nigeria, with seasonal peaks during the rainy season. Almost 100% of the population is at risk of malaria infection and approximately 50% of the population will experience at least one episode each year. Malaria accounts for an estimated 66% of all health facilities attendance and is responsible for 30% of deaths among children and 11% of maternal mortality in Nigeria. Thus, the Republic of South Africa National Malaria Control Programme in (2009) also stated the goal of the malaria control programme in South Africa is to reduce morbidity and mortality due to malaria by 10% each year. The target is to have a case mortality rate of less than 0.5% and prevent the re-introduction of new cases in non-endemic areas. In South Africa, malaria is a priority communicable disease and is listed under notifiable diseases.

The integrated malaria management, including ITNs, IRS, ACT and RDTs, has and will continue to have a substantial impact on malaria morbidity and mortality. There was a clear association between the steep decrease in vector abundance and the mass distribution of ITNs (WHO, 2005). In a district in central Kenya, Coverage with ITNs in the area is estimated to be 65%, substantially higher than that reported on the coast, and 35% of households reported use of some mosquito reduction method, such as environmental management or repellents (Wendy *et al.*, 2010).

2.4 Malaria in Ethiopia and Oromia

Malaria is one of the leading public health problems in Ethiopia (Deressa *et al.,* 2003). Its occurrence in most parts of the country is unstable mainly due to the country's topographical and climatic features (Abose *et al.,* 2003). Although the two epidemiologically important malaria parasite species in the country are *P. falciparum* and *P. vivax*, the other two species, *P. malariae* and *P. ovale*, are also reported to occur. *An. arabiensis* is the major malaria vector; *An. pharoensis, An. funestus a*nd *An. nili* are deemed as secondary vectors (Abose *et al.,* 1998). In Ethiopia, the occurrences of epidemics of malaria have been documented since the 1930s and 1940s. The most devastating epidemic was that of 1958 which resulted in an estimated three million cases and 150,000 deaths (Nurhussein and Leonidas, 1985).

In addition malaria is ranked as the leading communicable disease in Ethiopia, accounting for about 30% of the overall daily lost. Approximately 68% of the total populations of 78 million people live in areas at risk of malaria (MoH, 2006). About 75% of the total area of the country is malarious, with more than two thirds of the total population estimated to be at risk of infection. Malaria transmission in Ethiopia is seasonal, depending mostly on altitude and rainfall (MoH, 2004; WHO**,** 2006). In Ethiopia, malaria stands as the leading cause of morbidity and mortality (MoH, 2006). Literature review reveals that malaria is the number one public health problem in Ethiopia and accounts for the major cause of illness and hospitalization (Deressa *et al*., 2006). In (2004- 2005), malaria was reported as the primary cause of health problems in Ethiopia, accounting for 17 percent of outpatient visits, 15 percent of hospital admissions, and 29 percent of in-patient deaths (MoH, 2004/5).

The study conducted by Alemu *et al*.(2012) in Kola Diba Health Center, North Gonder there was a fluctuating trend of malaria within the last decade (2002–2011), with the minimum(285) number of microscopically confirmed malaria cases being reported in 2007 and the maximum (5201) microscopically confirmed cases of malaria being reported in 2002. Regarding the identified *plasmodium species*, both species of plasmodium were reported in each year with *P. falciparum* being the predominant species in the study area and *P. falciparum* and *P. vivax* accounted for 75% and 25% of malaria morbidity, respectively in the area. In the year 2010 to 2011 *P. falciparum* was decreasing but *P. vivax* was increasing, which shows that there was a trend shift from *P. falciparum* to *P. vivax* in the study area. In addition to these throughout the decade (2000-2009) in Butajira, a fluctuating trend of malaria cases was observed with *P. vivax* (62.5%) dominancy. A decrease in malaria cases was observed from 2003 to 2007 and a notable increase was detected in 2008 and 2009 with peak of cases occurring in 2009(Tesfaye *et al*., 2012). The study conducted by Getachew *et al*. (2013) a Seven-Year Retrospective Study from Metema Hospital, Northwest Ethiopia showed that the predominant *Plasmodium species* detected was *P. falciparum*, followed by *P. vivax*.

In Oromia Region malaria is considered to be the most important communicable disease. Three quarters of the Oromia region, i.e. 262 of 297 (88%) districts and 4,237 of 6,765 (63%) municipalities, are considered malarious, accounting for over 17 million persons at risk of infection. There are an estimated 1.5 to 2 million clinical cases per year, with malaria accounting for 20-35% of outpatient consultations, 16% of hospital admissions, and 18-30% of hospital deaths in the region (WHO, 2010). A fluctuating trend of malaria cases reported in Jimma town through the years 2000 to 2009 was observed. *P. vivax* was the predominant *Plasmodium species* in the town. An increase in malaria cases occurrence from 2003-2005 with peak cases occurring in 2005 and malaria cases were reduced the following three consecutive years (2006-2008) but a remarkable increase in 2009 was observed and the study revealed that malaria parasite prevalence was 5.2% of which *P. vivax* accounts for 71.4%, *P. falciparum* 26.2% and mixed infection only accounts 2.4% (Alemu *et al*., 2011).

The study conducted by Geshere *et al*.(2014) stated that despite the apparent fluctuation of malaria trends in the study districts, malaria cases occurred in almost every month and season of the year in Ilu Galan and Bako Tibe, but it fluctuate in Danno district. However, the malaria prevalence decline and remain almost the same throughout 2011 and 2012 in Ilu Galan. The same trends were observed in both Bako Tibe and Danno districts. Although the malaria infection rates vary among the gender year to year the overall record review in the past five years in the districts showed that males were more affected than females in Ijaji (86.18%) and Sayo (91.88%), but in Bako females were more affected than males (51.50%).

The study conducted at Gilgel-Gibe hydro electric dam in Ethiopia by Yewhalaw *et al*.(2009) the *Plasmodium* prevalence near the reservoir was statistically higher as compared to the *Plasmodium* prevalence in more distant communities. The main reason for the higher prevalence of malaria among children living close to the reservoir may be due to the manmade ecological transformations, which may influence the presence of mosquito-breeding site and might have an impact on the behavior, parity rate and longevity of malaria vectors of the study area.

Furthermore, the high influx of non-immune people into malaria endemic areas for social and economic reasons such as resettlement and search for alternative income, and the expansion of agricultural and industrial developments in malarious areas of the country could be some of the reasons for the observed rise in the number of malaria cases during these periods (Adhanom, 2006; Nega, 2006). In addition during the late 1980s malaria prevalence in the country was very high because of high population movements from highlands to lowland malarious areas (Nega, 2006). A hospital-based retrospective study done in Ethiopia revealed that decrement of *P. vivax* where as *P. falciparum* increased over a five-year period (Konchom *et al*., 2003).

The study conducted around Gilgel-Gibe dam show that the proportion of *P. falciparum* and *P. vivax* was almost equivalent throughout the period considered irrespective of the overall variation over time. The *P. falciparum* prevalence was slightly higher than that of *P. vivax* except in 2008 and 2010 when the *P. vivax* prevalence was elevated a little above *P. falciparum* (*Sena,* 2014). Gradual malaria species trend shift was observed from *P. falciparum* to *P. vivax* beginning from 2010 through 2012 in Ilu Galan and Danno, but the trend shift was begun ahead in 2008 in BakoTibe district (Geshere *et al*., 2014).

Significant progress in malaria control has been made over the last decade, with several countries reporting decreased malaria morbidity and mortality through intense malaria control efforts based on early diagnosis and treatment using new artemisinin-based combination therapies (ACTs), the use of long-lasting insecticidal nets and indoor residual spraying (IRS) (WHO, 2010). However, the recent appearance of resistance to ACTs, widespread resistance to pyrethroids and the lack of a highly effective vaccine means there is still much to be done to achieve global malaria control, elimination and eradication (WHO, 2009).

In the last decade, the malaria burden was reduced in Ethiopia following the large scale application of key interventions (ACT, RDT, IRS and LLIN) since 2005 (Barbara, 2014). Malaria is thought to be the disease of antiquity in Ethiopia and its distribution is affected by altitude, topography and climatic factors (Kitaw *et al*., 1989).The usual biting time of mosquitoes and seasonality of malaria could contribute to health extension workers efforts to promote the acceptance and use of ITNs by the community. But the big challenge to day is resistance of *P. vivax* to the commonly used drug (Chloroquine) during these years may have contributed to total malaria case occurrence (Jima *et al*., 2005).

The study conducted around Gilgel Gibe Dam indicated that, higher malaria vector abundance is associated with higher malaria incidence, and mosquito abundance is higher close to the dam, no effect of the distance to the dam is found on malaria incidence. There is indeed a large difference between mosquito density and malaria incidence between the rainy and dry season. In the rainy season, mosquito density is high everywhere, and the higher mosquito number near to the dam is therefore superfluous (Yewhalaw *et al*., 2013).

The study conducted in Serbo Health Centre by Ketema *et al*. (2009) in patients with treatment failure lack of Hemoglobin recovery on day of recurrence indirectly proves the presence of undetectable parasitaemia in their blood after treatment with Chloroquine. The reappeared parasite should be considered as resistant to Chloroquine irrespective of its genotype (relapse, recrudesce or re-infection) and will be classified as chloroquine-resistant *P. vivax.* Chloroquine has been in use both for treatment and prophylaxis in health centers and the communities of Ethiopia. It is an anti-malaria drug recommended by the Ministry of Health of Ethiopia for treatment of *P. vivax* malaria infection in the country. Chloroquine resistant *P. vivax* malaria are coming from different malaria endemic areas of Ethiopia, in the same way in Halaba Kulito Health Center also revealed significantly high treatment failure (Ketema *et al*., 2011).

Artemether-Lumefantrine and Chloroquine are the current first-line anti-malarial drugs for the treatment of uncomplicated *falciparum* and *vivax* malaria, respectively. Indeed the Government of Ethiopia started taking measures through the Health Service Extension Program to improve the prevention and treatment of malaria, distributing Artemether-Lumefantrine, Chloroquine and

Quinine free of charge either after diagnosis using a rapid diagnostic test (RDTs) or through clinical diagnosis by Health Extension Workers at health posts (Yewhalaw *et al*.,2010).

2.5 Malaria and Climate

Global climatic change is a major contributing factor in the recent increase and propagation of malaria in many parts of the world, including Ethiopia. In Ethiopia, both altitude and climate determine endemicity and intensity of the disease. Thus, malaria is varying from place to place and from time to time due to high variability of these variables (Barbara, 2014).

The findings reported by Barbara (2014) on climate variability and change express that the effect of climate change on health is tremendous. Climate variability and changes influence the socio-economic development by affecting human health through extreme weather events and by bringing about changes in the ecology of infectious diseases. Malaria is a major climate sensitive public health problem, and it needs practical tools for predicting malaria epidemics based on weather and climate information. Such tools would be useful in making a more efficient use of the limited resources for malaria control. In this context, understanding the role of climate variability and change is very vital for the ultimate malaria elimination. According to Lindsay *et al*. (1998) idea expressed the climate and ecological diversity; there is variation in the epidemiology of malaria transmission. In the stable transmission, the community usually develops herd immunity to the disease; whereas, in unstable form, immunity is absent, and recurrent epidemics are very common.

The transmission and prevalence of malaria is influenced by many factors, amongst which (variability in) meteorological factors are considered to play a major role. With increasing weather variability and ability to forecast weather, there is an interest in developing systems for malaria forecasting that incorporate weather related factors as explanatory variables (Huang *et al*., 2011). Many factors are known to have significant impacts on the transmission of malaria. These include human population immunity and economic status,vectory biology, behavior and control measures, and environmental factors such as temperature, rainfall and relative humidity (Peng *et al*., 2003). Changes in temperature, rainfall, and relative humidity due to climate change are expected to influence malaria directly by modifying the behavior and geographical distribution of malaria vectors and by changing the length of the life cycle of the parasite.

Climate change is also expected to affect malaria indirectly by changing ecological relationships that are important to the organisms involved in malaria transmission (Gebremariam, 1984).

According to the study conducted in Sudan by Idrees (1992) stated that malaria fever has good correlation with some meteorological factors such as temperature, relative humidity and rainfall. Malaria was found to have strong correlation coefficients with both maximum and minimum temperatures, and strong positive correlation with air pressure. Meteorological variables were the important environmental factors in the transmission of malaria globally. If environmental conditions change in ways that would increase the survival time of mosquitoes, then they would be able to transmit other species of malaria that were not present in that area before. Beside these the major climatic factors that have an impact on malaria transmission due to spatio-temporal changes in malaria vectors are temperature, relative humidity and rainfall (Pampana, 1969).
Global climate change or variability, and extreme climate events have been noted to partially explain malaria prevalence (Gething *et al.,* 2010). The climatic factors frequently considered are temperature, rainfall, precipitation and humidity (Ebi *et al.*, 2005).The study found that high temperature (or low precipitation) decreases daily survival probability of mosquitoes, mosquito abundance, and the fraction of infected mosquitoes that survives an extrinsic incubation period. Also, rainfall is found to increase the abundance of breeding grounds of mosquitoes (Egbendewe-Mondzozo *et al.,* 2011).

Furthermore the study done by Pemola and Jauhari (2013) on meteorological variables and malaria cases based on 12 years data analysis in Dehradun (Uttarakhand) India there was a considerable incidence of malaria in 1999 followed by a declining trend till 2007 and again 2008 onwards, the malaria cases increased to maximum in the year 2010, thus showing a periodic incidence. The study conducted by (Srinivasulu *et al.,*2013) on influence of Climate Change on Malaria Incidence in Mahaboobnagar District of Andhra Pradesh, India stated that Seasonal incidence of malaria 2008- 2011was a remarkable high incidence of malaria in 2010 which showed a declining trend during the last three years and next successive one year. With regard to monthly variations in the incidence of malaria cases the peak seasons were monsoon and post-monsoon (July to October).

The study conducted around the Gilgel-Gibe hydropower reservoir in south-western Ethiopia by Yewhalaw *et al*. (2013) indicated that three malaria incidence climate seasons could be identified consistently over the two years follow up: a high malaria incidence climate season from August to November, a moderate malaria incidence climate season from April to July, and a low malaria incidence climate season from December to March.

The highest of malaria prevalence was observed in 2009 and 2010 during spring (September, October and November); but the malaria prevalence was observed declined in spring season and become relatively high at early summer season in recent years (2011 and 2012); and the minimum malaria cases was observed during winter (December, January and February) season in Ilu Galan, BakoTibe, and Danno Districts of West Shoa Zone, Oromiya Region, Ethiopia (Geshere *et al*., 2014).

The total number of cases of malaria in India has stabilized somewhat over the past ten years, while there has been an increase in the number of *P. falciparum* cases. Results of present study envisage that the climate variability that exert its impact on the incubation rate of *P. vivax* and *P. falciparum* and breeding activities of *Anopheles* is considered as the important environmental contributions to malaria transmission dynamics (Pemola and Jauhari,2013). According to Alemu *et al* .(2011) ten-year trend study carried out in Jimma town, Ethiopia, showed not only fluctuation of number of malaria cases but also changes in the species of *Plasmodium* composition following climatic variables. In Bangladesh the three study areas Rangamati, Sylhet and Faridpur districts were found to have an impacts of Climate Change on Public Health increasing trend in maximum, minimum temperature and humidity and Rangamati was found to have an increasing trend in rainfall while in both Sylhet and Faridpur the trend was declining over the period (Ruhul *et al.*,2011).

According to Ghana Health Service Health Facility data, malaria is the number one cause of morbidity, all deaths in children under five years (MoH, 2012). Due to the pronounced seasonal variations in northern Ghana and a prolonged dry season from September to April, the normal duration of the intense malaria transmission season is about seven months, beginning in April/May and lasting until September (MoH, 2013).

According to McMichael and Martens (1995) contends that climate variability, specifically temperature, impacts the incubation rate and breeding activity of certain species of mosquitoes and is considered one of the key environmental contributors to malaria transmission. However, the levels of malaria risk and transmission intensity exhibit significant spatial and temporal variability related to variations in climate, altitude, topography, and human settlement pattern (Abeku *et al*., 2004).

The strong effect of season was modified through the climatic variables indicating that a strong part of the seasonal effect was based on climate. All climatic variables (rainfall, relative humidity and temperature) were strong predictors of mosquito density (Yewhalaw *et al*., 2013).
As Bi *et al*. (2003) extensive 12-year (1980 to 1991) data analysis of climatic variables and malaria transmission provided evidence of a direct relationship between temperature and the critical stages of mosquito development. And also the study conducted by Craig *et al*.(2004) the temperature during the preceding summer and current spring were also significantly associated with difference, suggesting that the effect is a combination of high rate and prolonged duration of transmission in the previous season, as well as rapid growth of parasite and/or vector populations in early spring.

The only way to explain the strong predictive value of temperature indicator is that temperatures over the entire period, i.e. from the time of peak transmission in the previous season all through winter, up to early spring, play a role in determining the size of the reservoir of parasites and/or mosquito vectors surviving and seeding the following season, consequently making an increase in cases more likely (Craig *et al*., 2004). In addition the study conducted by Gabriel and James (2005) about malaria shows a strong seasonal pattern with a lag time varying from a few weeks at the beginning of the rainy season to more than a month at the end of the rainy season

The thesis worked by Jason (2007) the most evident trend throughout the time frame is the rise in observed malaria incidence and risk during the months starting in June and ending in August. These months occur in Democratic People’s Republic of Korea’s during summer season with sustained higher land surface temperatures and photosynthetic activity, which may contribute to sustained vector development, growth, and proliferation.
Climate seems to be the most important determinant of malaria risk through its influence on mosquito density. Even though, minimum temperature was correlated with higher mosquito density, while maximum temperature showed no effect on mosquito density. Minimum temperature predicts malaria risk mainly due to its direct effect on the survival and feeding frequency of malaria vectors and by shortening the incubation period of the parasite in mosquitoes (Yewhalaw *et al*., 2013).

According to Deressa *et al*. (2003), malaria is seasonal in most parts of Ethiopia, with variable transmission and prevalence patterns affected by the large diversity in altitude and rainfall with a lag time varying from a few weeks before the beginning of the rainy season to more than a month after the end of the rainy season. It was documented that the transmission of malaria was governed by rainfall and fluctuated considerably from year to year according to the rainfall, and heavy rains were associated with malaria epidemics and also meteorological variables were correlated with malaria occurrence (Loevinsohn, 1994). The study conducted in the high land fringe of Butajira by Tesfaye *et al*.(2012) malaria occurrence and rainfall variation in the study area over the last ten years was not significantly correlated with zero and one month lag. Taken together, weather factors had significant influence on occurrence and transmission of malaria in Guangzhou, southern China. A rise in temperature, relative humidity and duration of sunshine may increase the risk of malaria infection (Li *et al*., 2013), time trend analysis was adapted to examine the relation between malaria cases and monthly climatic data, such as temperature, rainfall and relative humidity (Mohammed *et al*., 2012).

The study conducted in Dehradun (Uttarakhand) India shows higher positive correlation between monthly incidence of malaria and monthly minimum temperature, mean temperature and rainfall with one-month lag effect. The correlation coefficient for the association between monthly rainfall and monthly incidence of malaria was found greater than the association between temperature and malaria incidence. This indicates that rainfall seems to play a more important role in the transmission of the disease than temperature does (Pemola and Jauhari, 2013). For the completion of life cycle of the pathogen as well as of vector mosquito, an ambient temperature is required (Craig *et al*., 1999). As the survival of the mosquito is temperature (Jonathan, *et al*., 2006) and rainfall (Alsop, 2007) dependent, thus any change in the range would certainly exert its effect on the mosquito bionomics. In a study on temporal correlation analysis between malaria and meteorological factors in Tibet, it was found that the relative humidity (RH) was the greatest influencing factor, which affected the mosquito survival directly (Huang *et al.*, 2011).

Malaria is considered one of the most deadly diseases in Mozambique, with around six million cases reported each year. Most of these cases are *P. falciparum*. Transmission takes place all year round with a seasonal peak extending from December to April. Many factors affect the dynamics of malaria transmission and infection, ranging from social to natural. Rainfall and temperature can be considered the major natural risk factors affecting the life cycle and mosquito breeding. Relative humidity plays a role in the lifespan of the mosquito. In the presence of high relative humidity values, the parasite would complete the necessary life cycle in order to increase transmission of the infection to more humans. All districts in Maputo province show favorable climatic conditions for development and transmission of malaria (Zacarias and Andersson, 2011). The development rate of mosquito larvae is temperature dependent: below 16°C development of *An. gambiae* mosquito's stops and below 14°C they die. In cold temperatures the larvae develop very slowly and in many cases they may be eaten by predators and may never live to transmit the disease. Once larvae emerge to become adults, the rate at which they feed on man is dependent upon the ambient temperature. At 17°C the female mosquitoes (*An. gambiae*) feed on humans every 4 days while at 25°C they take blood meals from humans every 2 days. Rainfall increases the breeding habitats for mosquitoes leading to increased population sizes and the rate of malaria transmission (Githeko, 2009).

2.6 Irrigation and Malaria burden

The Human Development Index the impact of malaria on agricultural development through the effect on farmers having to spend time to care for the family members or if illness strikes at harvest time as the farmers may not be able to cultivate as much land and engage in intensive farming practices. They may then plant fewer labour-intensive crops and change cropping patterns, perhaps raising crops with a lower return. Generally, the transmission effect of malaria in the planting and harvesting seasons exacerbates the impact of the illness making it particularly damaging (Asenso-Okyere *et al.,* 2011). Higher malaria prevalence in the dry season, as observed in households that use irrigation, could be because irrigation activities continue in the evening when the major malaria vectors' peak biting activities occur. Thus, irrigating farmers would be at higher risk of infective mosquito bites during the dry season (Kibret *et al.*, 2010).

The increasing implementation of irrigation in response to governmental policies causes considerable change in agro-ecosystems, which raises important questions concerning the accompanying changes in malaria transmission dynamics and its association with agricultural practices (Kassahun *et al.*, 2013). Despite these socio-economic benefits, irrigation development schemes can aggravate the problem of mosquito borne diseases by increasing the number of aquatic larval habitats and extending the duration of the transmission Season (Lindsay *et al.*, 1991).

The irrigation schemes generate conditions that enhance mosquito breeding and, hence, contribute to the transmission of malaria (Boelee *et al*., 2002). Agricultural production systems, such as type of farming, farming practices, farming technologies and location of farms, might lead to environmental changes that generate appropriate ecological and climatic conditions for the breeding and survival of the *anopheline* mosquitoes, which transmit the disease (Felix, 2009).

Dams and irrigation schemes

Transform ecosystems and can substantially change the nature of malaria risk proximal to their location. The introduction of irrigation schemes, and associated agricultural practices, are now considered to be among the primary factors driving the increase in the global malaria burden (Baeza *et al*., 2011). In Ethiopia, where three-quarters of the land are potentially malarious, introduction or expansion of irrigation schemes can increase the burden of malaria in the country. In the highlands of Tigray, northern Ethiopia, malaria incidence in young children was seven fold higher in communities near small dams than in those farther away (Ghebreyesus *et al*. 1999).

3. Materials and Methods

3.1 Study Area and Period

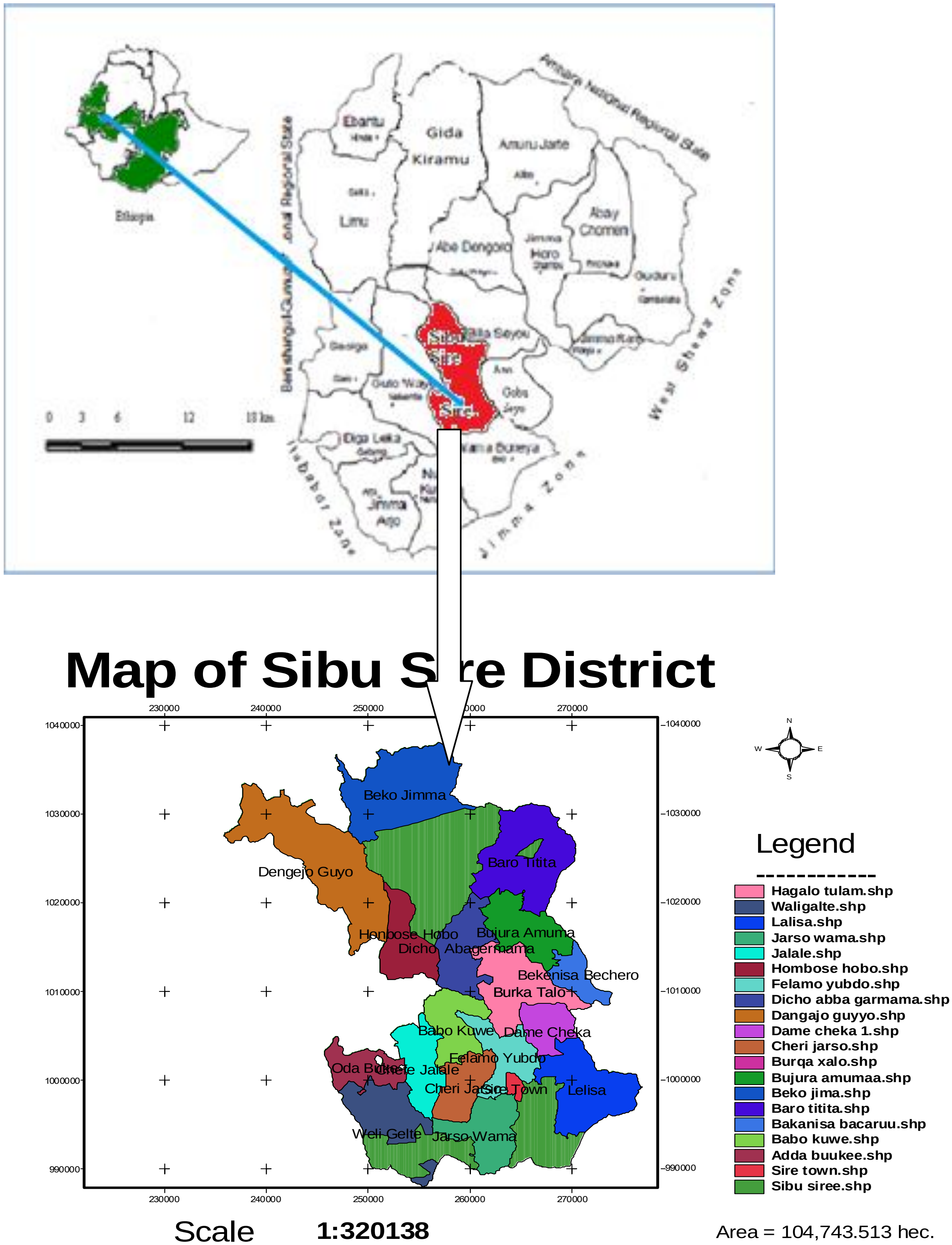
The research was conducted in Sibu Sire district, East Wollega Zone of Oromia Regional State, Western Ethiopia (Figure 1). Sibu Sire is one of the districts in East Wollega Zone and is located 281Km West from Addis Ababa, capital city of Ethiopia and 50km East of Nekemte, the administration town of East Wollega Zone. This district is bordered in the East by Gobu Seyo, in the West by WayuTuka, in the South by Wama Hagalo and Billo Boshe and in the North by Gudeya Bila and Guto Gida district. The district has 22 kebeles of these 19 and 3 rural and urban kebeles, respectively.

3.1.1 Demographics

Out of the total study population 110,606(54,920 female and 55,686) live in rural area where as the rest 13,698(6,744 male and 6,954 females) live in urban area (SSDA, 2013).

3.1.2 Topography and Climate

The altitude of the district ranges between 1360 masl to 2500 masl. This district geographically lies between 9^0 20' N latitude and36^0 53' E longitudes. There are three agro-ecological zones in this district. The majority (74.3%) of the district is classified as mid-land followed by lowland (18.27%) and highland (7.53%). The minimum, maximum and mean temperature of this area were 14.09 ºc, 27.30 ºc, and 22.55 ºc, respectively. The highest temperature occurs in February and March. The lowest temperature occurs in July and August. The annual average rainfall of the district was 1295 mm (RLEPOSSD, 2013).



Source : RLEPOSSD(2013)

Figure 2.Map of Ethiopia showing Oromia Regional State, East Wollega and of the study area (Source: RLEPOSSD, 2013)

3.1.3 Agriculture and Ecological distribution

The total area of land of this district is 1047.44km^2. Out of this 83.49% of the land is cultivable, 8.35% is grazing land 5.79% residence area, 1.85% forest, and 0.52% is swampy, water and other bodies. Sibu sire has different agro ecological zone that help to produce different crops. The main crops produced are maize (55.6%), sorghum (16.8%), teff (12%), finger millet (9.6%) and other different cultivated crops 6 %. Also cash crop like coffee is produced in small quantity. There were 168,979 cattle, 28,879 sheep, 29,136 goats, 19,409 equines and 65,005 poultry in the Sibu Sire district (SSAO, 2013).

3.2. Study Design, Sampling Techniques

A retrospective study was employed to collect malaria epidemiological data from district health service to determine ten years prevalence malaria trend by reviewing blood film malaria records and climatic variables from National Meteorology Agency. A format was prepared for data collection that include demographic information such as date, patient ID, sex, age, place of residence. The result of clinical or laboratory blood diagnoses and drug used information were collected from log books (registration books) of Sire Health Center.

3.3 Sample Size

All records of patients who visited the Health Centers during the timeframe (2004-2013) considered and treated as malaria patients were included in the study.

3.4 Source Population, Study Population

The study participants were all malaria suspected individuals who had complained of febrile illness and screened in the laboratory at Sire Health Center from 2004-2013. The study population include from febrile illness and screened patients all of malaria positive were recorded in registration book from 2004-2013. In this Health Center, peripheral smear examination of a well-prepared and well-Giemsa stained blood film was used as the gold standard in confirming the presence of the malaria parasites as per WHO protocol.

3.5 Data Analysis

All data from meteorological and clinical records were checked for completeness and cleaned for any inconsistencies. The data were analyzed using SPSS version 16.0 software package. Descriptive statistics was employed to present overall malaria prevalence, age and sex specific malaria prevalence, assess correlation of malaria prevalence with climatic variables and parasites prevalence over the last 10 years in the study area.

To observe the correlation between meteorological variables and malaria, the monthly malaria prevalence regarded as the dependent variables, while meteorological variables such as mean monthly maximum, minimum and mean temperature, mean monthly rainfall and mean monthly relative humidity independent variables. To observe the effect of each independent variable on the outcome variable linear regression was fitted and the results were presented in tables and figures.

3.6 Ethical Considerations

Ethical clearance was obtained from College of Natural Science, Jimma University and written consent was sought from the head of Sire district Health Office to undertake the study. Individual information was kept confidential and the names of individuals were removed from the data taken from health center and identified only by identification numbers and the results were communicated in an aggregated manner.

4. Results

4.1 Trends of malaria in Sibu Sire district

Within the last decade (2004–2013) a total of 30,070 blood films were examined for malaria in Sire Health Center and of this 6036 (20.07%) microscopically confirmed malaria prevalence were reported in the district. According to Sire Heath Center report with the annual total malaria infected patients least occurrence was 97 in 2008 and highest recorded was 1881 in 2004 with 603.6 mean annual malaria incidence occurring. The prevalence of malaria between sex, age, month, season, year, and among place of residence, the types of plasmodium species identified and the drug used within these years also varied.

Accordingly malaria infection prevalence was higher in males than females in the study area. Of the infected patients, 53.6% were males and 46.4% were females. However, there was no significant difference in malaria prevalence between sexes ($p > 0.05$) and people from rural areas were more affected by malaria than those from urban but the difference in prevalence was not significant ($p >0.05$). The infection rate among rural people were (69.3%) and urban people were (30.7%) during the study time frame (2004-2013).

As shown in table 1 below, malaria was reported in all age groups in the area but the age group from 15-44 years was more affected, with a prevalence rate of (48.1%), followed by 5 -14 years old (28.2%) and 1-4 years old(15.4%). On the other hand, children below 1years old and people above 64 years old were less affected. The difference in malaria prevalence among different age groups was not also significant ($p > 0.05$).

Table 1 Age specific malaria prevalence in Sire Health Center, Western Ethiopia, (2004-2013)

Age	n	%
Less than 1	139	2.3
1-4	929	15.4
5-14	1702	28.2
15-44	2901	48.1
45-64	306	5.0
Above 64	59	1.0
Total	6036	100.0

n= number of malaria cases

As shown in figure 2, malaria was reported in all years in the study area but in 2004, the prevalence rate was high (31.2%), followed by 2010 (13.7%) and 2005 (13%). Similarly, the prevalence rate of malaria in 2012, 2013 and 2009 was (9.8%), (9.7%) and (9.3%), respectively. But, in the remaining years low percentage of malaria prevalence was reported. There was a decline in *P. falciparum* prevalence from 2004 up to 2008 and again started rising in 2009 and 2010. In contrast to these in 2011 *P. vivax* prevalence was elevated a little above *P. falciparum* in the study area. The prevalence of mixed infection (*P. falciparum and P. vivax*) remained almost the same from 2004 up to 2013. The malaria prevalence at species level to overall years were observed with statistically significant ($p<0.001$) these show that *P. falciparum* greater than *P. vivax* and between each year the malaria prevalence were statistically significant ($p<0.05$) thus, it indicated that *P. falciparum* greater than *P. vivax* but only in 2011 *P. vivax* high case number than *P. falciparum*.

Table2.The malaria confirmed cases within years at Sire Health Center Western Ethiopia, (2004-2013)

Years	Malaria suspected	n	Percent
2004	5617	1881	31.2
2005	3736	784	13.0
2006	1485	204	3.4
2007	1293	141	2.3
2008	1545	97	1.6
2009	4046	559	9.3
2010	4819	824	13.7
2011	2974	369	6.1
2012	2075	590	9.8
2013	2480	587	9.7
Total	30070	6036	100.0

n=number of Malaria cases

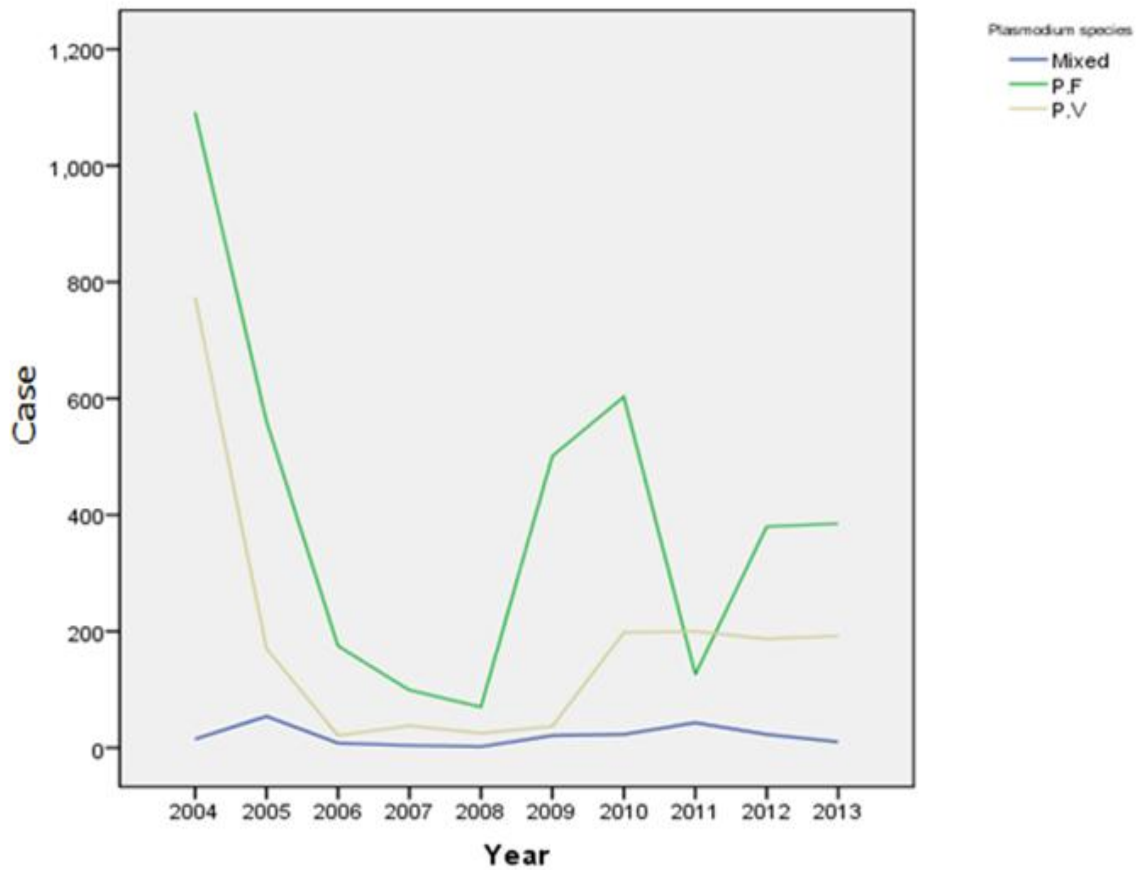


Figure 3 Trend of malaria cases over ten year in Sire Health Center, Western Ethiopia, (2004 – 2013)

Malaria occurred in all months of all years with different fluctuation rate. The highest peak is in June with prevalence rate 18.9%, followed by May, November, and July with prevalence rate 13.3%, 13.2%, and 11.2%, respectively for all year. The prevalence rate in October, August, and September were 9.4%, 8.7%, and 7%, respectively. On other hand, the prevalence of malaria in December, January, February and March were low when compared with other months with prevalence rate of 4.2%, 4.2%, 4% and 2.9%, respectively. Although a seemingly uniform monthly Health Center record, having higher values were recorded in Sibu Sire district starting from May up to November.

Figure 3 below, shows that there was fluctuating trend of cases with *P. falciparum and P. vivax* throughout the year in different months. The peak malaria cases was seen in June and followed by May and November months with high *P. falciparum* and then *P. vivax,* respectively. In contrast, the least malaria incidence was confirmed in March, April, February, December, and

January months, respectively. There was significant difference ($p<0.05$) in malaria species prevalence among months of a year. Maximum prevalence of both *P. vivax* and *P. falciparum* were observed in summer (June, July and August) followed by spring (September, October and November) and the minimum being during winter season (December, January, and February).

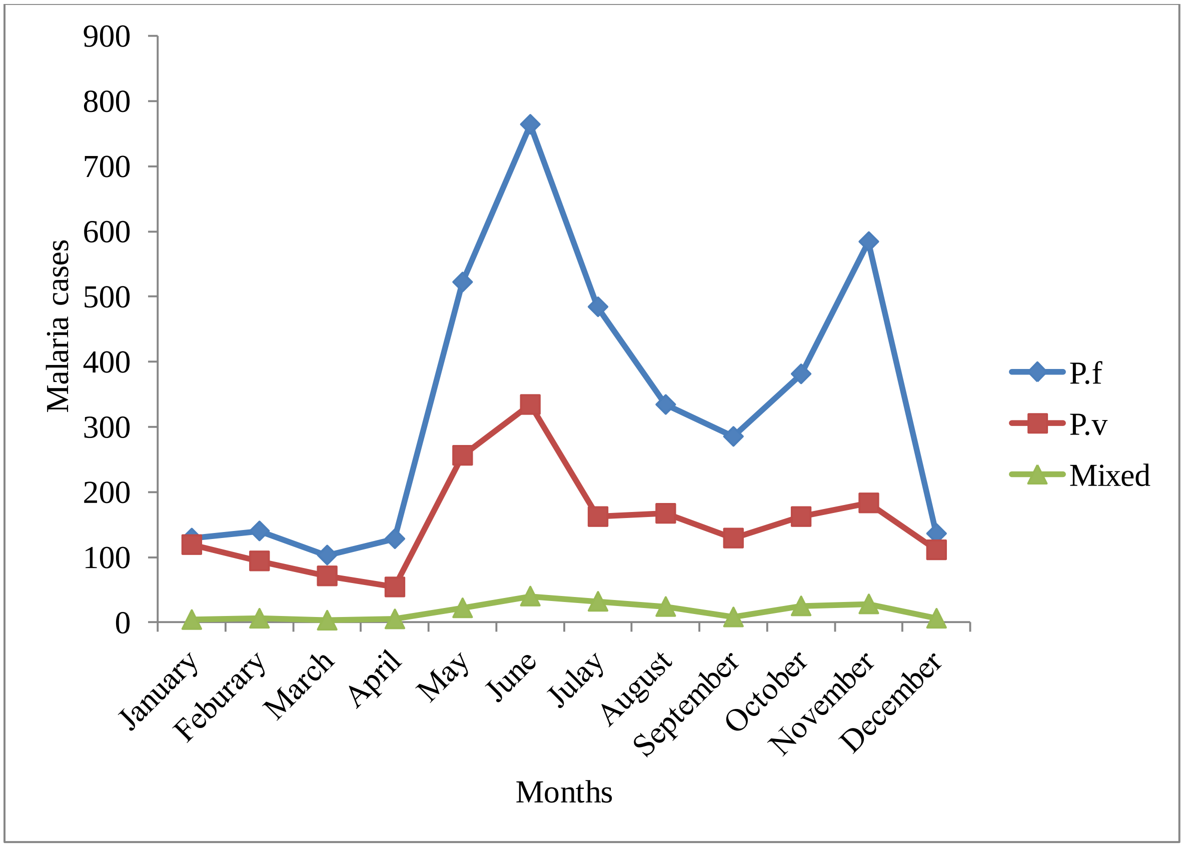


Figure 4 Trend of malaria cases due to *P. falciparum*, *P. vivax* and mixed infection (*P. falciparum* and *P. vivax*) by month in Sire Health Center, Western Ethiopia, (2004 – 2013)

Regarding *Plasmodium* parasite species, both species of *Plasmodium* were reported in each year with *P. falciparum* being the predominant species in the study area and *P. falciparum* and *P. vivax* accounted for 66.12% and 30.52% of malaria prevalence, respectively and the mixed (*P. falciparum* and *P. vivax*) accounted 3.46% of the frequency in the area. In the year 2011 the number of occurrence due to *P. vivax* was increasing, which showed that there was a trend of species shift from *P. falciparum* to *P. vivax* in the study area.

Coartem was the highest drug used for the treatment of malaria infection with a rate of (44.9%) of the predominance followed Chloroquine (30.5%). Fansidar and Quinine were given 15.9%

and 8.7% for the illness of malaria respectively in the study area. Artemether-lumefantrine (Coartem) as first-line treatment for uncomplicated *P. falciparum* malaria was adopted in 2005.

Of those cases diagnosed for malaria from different kebeles the majority (23.7%) of the malaria confirmed occurrence was from Jarso Wama kebele, followed by Sire-02 kebele (16.9%), Sire-01 kebele (13.9%), Bikila kebele (13.2%), Lalisa (9.4%), and Waligalte (7.2%). The patients diagnosed for malaria in Sire Health Center in the remaining kebeles were very low in number (Table 2). There were a significant association between the whole kebeles and Plasmodium species (p=0.017) in general and *P.falciparum* greater number in malaria cases.

Table 3. Distribution of malaria confirmed cases by kebele in Sire Health Center, Western Ethiopia, (2004-2013)

Kebeles	Altitude in (m)	Mean T^o c	Plasmodium species				%	P-value
			P.f	P.v	mixed	n		
J/Wama	1737.5	24.7	926	435	70	1431	23.7	<0.05
Sire02	1828.3	23.9	660	329	33	1022	16.9	
Sire01	1818	24.1	565	254	22	841	13.9	
Bikila	1822	24	521	239	37	797	13.2	
Lalisa	1790.9	24.3	363	184	23	570	9.4	
Walgalte	1703.2	24.9	297	126	6	429	7.1	
Ch/Jarso	1760.2	24.5	166	84	6	256	4.2	
Jalale	1829.2	23.5	101	37	-	138	2.3	
F/Yubdo	1883	23	159	72	3	234	3.9	
D/Cheka	2017	22.4	66	17	-	83	1.4	
B/Talo	1829.2	23.7	83	30	1	114	1.9	
B/Kuwe	2065.1	22.2	45	15	1	61	1.0	
Bujura	1997	22.9	11	4	-	15	0.2	
Ombosse	2411.9	21	8	5	1	14	0.2	
Dicho	2125	21.8	7	3	-	10	0.2	
Dangajo	1446.2	26.2	5	1	-	6	0.1	
B/Becheru	2009.4	22.6	2	1	-	3	0.08	
Hagalo	2085.3	22	3	3	-	6	0.1	
Adabuke	1816.6	24.2	-	1	-	1	0.04	
BaroTitita	1975.5	22.7	2	-	-	2	0.07	
BakoJima	1448.2	26	-	2	-	2	0.07	
Chingi 01	1810	24.3	1	-	-	1	0.04	
Total			3991	1842	203	6036	100.0	

X^2ial=61.083 P-value=0.017

Annual trends of total malaria prevalence in Sibu Sire district showed that a fluctuating trend of malaria reported through the years of 2004 to 2013 was observed. The highest malaria cases were occurred in 2004 and malaria were reduced the following three consecutive years (2006-2008) but a remarkable increase in 2010 was observed and again decreased in 2011. Although in 2012 the malaria cases were increased slightly then after it become almost constant. In general, the over view of the malaria prevalence in Sibu Sire district from 2004 to 2013 shows that it was declined. There were statistically significant inter-annual variation of malaria prevalence occur ($p < 0.05$) between each years in the study area.

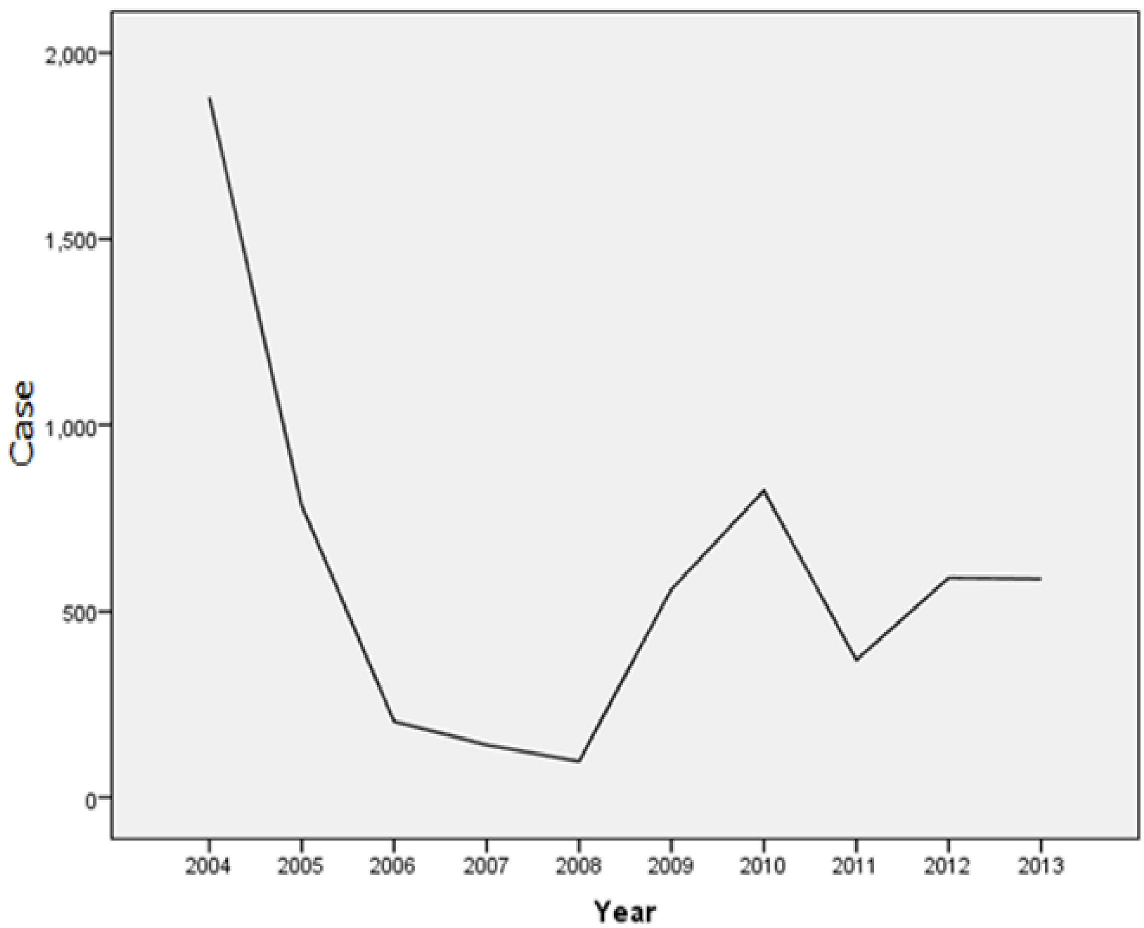


Figure 5 Annual trends of total malaria cases in Sire Health Center, Western Ethiopia, (2004 – 2013)

4.2 Correlation between malaria and meteorological variable

The study area is generally characterized by moderate climate with a mean annual maximum and minimum temperature 27.3 ^{0}c and 14.09 ^{0}c. The annual rainfall ranged from 650mm to 2590mm. The mean annual relative humidity was 68.66% from 2004 to 2013 in study area. An association between monthly malaria prevalence and meteorological variables (temperature, rainfall and relative humidity) was assessed. In general the relationship between malaria cases and meteorological variables were checked by linear regression analyses.

To observe independent effect of each independent variable on malaria prevalence, linear regression was conducted. From all meteorological factors, minimum temperature, rainfall, and average relative humidity showed statistically significant association with malaria prevalence (P< 0.001) however, mean temperature did not show significant association with malaria prevalence in the study area (P = 0.706) (Table-4).

Table 4 Regression analysis between monthly climatic variables and malaria prevalence in Sire Health Center, Western Ethiopia, (2004-2013)

Variable	ß	SE of ß	p-value
Constant	1.132	0 .170	< 0.001*
Minimum temperature	0 .026	0 .006	< 0.001*
Rainfall	0 .014	0 .003	< 0.001*
Relative humidity	-0 .003	0 .000	< 0.001*
Mean temperature	-0 .004	0 .010	0.706

*Significant at p < 0.05 ß= Regression coefficient

SE=standard error

5. Discussion

The result of this study revealed that during the last ten years, a fluctuating trend of occurrence of malaria prevalence was observed in Sibu Sire district almost similar to the study conducted in Kola Diba (North West Ethiopia), Butajira (southern Ethiopia) and Sudan respectively (Alemu *et al*., 2012; Tesfaye *et al*., 2012; Aal and Elshayeb, 2011). An increase in malaria cases with peak in 2004 occurred similar to the findings of a study from Jimma town, Southwestern Ethiopia (Alemu *et al*., 2011). The ministry of health also reported high occurrence of malaria in 2004 in Ethiopia (MoH, 2004/5). Malaria prevalence decreased the following three consecutive years (2006-2008) in the study area. Similar results were reported from a study conducted Dehradun (Uttarakhand), India (Pemola and Jauhari, 2013) in contrast to this a study conducted by Sena, *et al*. (2014) on trends of malaria prevalence around Gilgel-Gibe Hydroelectric Dam were increased (2006-2008). But in Sibu Sire district malaria prevalence was again increased remarkable in 2010. Except for the year 2011, the remarkable increase in total malaria prevalence was mainly due to *P. falciparum*. However, in 2011, *P. vivax* contributed more for total malaria prevalence than *P. falciparum*. This is consistent with the findings of a study conducted in Kola Diba Health Center by Alemu *et al*. (2012).

Malaria prevalence declined during the three consecutive years (2006-2008). It might have coincided with the increased availability of the new drug Coartem for *P. falciparum* malaria at national and local level. The increased attention to malaria preventive and control activities by the NMCP and different stakeholders, increased awareness of the community on use of ITNs and other malaria control interventions, increased accessibility of ITNs to community, increment of budget for prevention and malaria control activities might have contributed to the decline in malaria occurrence in addition to meteorological factors (Alemu *et al*., 2012; Alemu *et al*., 2011).

In this study, the number of males affected by malaria was slightly higher than the number of females. This could be due to the fact that males spend out door in the evening for different activities when mosquito becomes active to find blood meal from potential hosts. The results were similar with other earlier studies conducted in Ilu Galan and Danno Districts of West Showa, Central Ethiopia (Geshere *et al*., 2014), Metama Hospital, Northwest, Ethiopia (Getachew *et al*., 2013) and Kola Diba North Gonder, Northwest Ethiopia (Alemu *et al*., 2012) and University Hospital Kuala Lumpur, Malasyia (Jamaiah *et al*., 1998).

Malaria prevalence was higher in rural than urban settings because rural communities mostly they do not use bed net appropriately in steady of as bed net the people used for different purpose like for carrying grass. Other reason may be due to a difference in housing structure, availability of potential mosquito breeding sites, level of awareness in using personal protection measures (Alemu *et al*., 2011).

The age group 15-44 years was most affected with malaria in the study area. This could be attributed to the fact that people in this age group stay outside till late evening for work as they are at active productive age. This is consistent with a the study conducted by Alemu *et al*. (2012) in Kola Diba, North Gonder, North West Ethiopia. Also it may be explained by the inadequate coverage of ITNs as each household received only 2 nets and most often only children and pregnant women slept inside the nets in majority of the cases, which leave individuals in this age group exposed to high risk of infection (this individual information).

The cases of malaria varied year to year. The highest peak was in 2004 which could be attributed to climatic factors of that particular year (Getachew 2006; MoH 2004). But afterwards (from 2005 to 2008) a decreasing pattern was observed in *P. falciparum* cases. This decline in malaria prevalence rate may be due to scaling up of the distribution of ITNs/LLINs and high coverage of indoor residual spraying (IRS) by the NMCP and other organizations working on malaria prevention and control in Ethiopia (WHO, 2010: WHO, 2009). Furthermore, artemisinin-based combination therapy as first-line anti-malarial drug had been recommended for the treatment of uncomplicated *P. falciparum* and mixed infection in the study district similar to other parts of the country because of the development of resistance in *P. falciparum* to SP (Fansidar) (MoH, 2008).

Malaria occurred in almost every season of the year. The highest peak of malaria cases was observed from April to June and from September to November) similar to the other areas in the country (Yewhalaw *et al*, 2013). The district had high irrigation farming which may increase the abundance of malaria transmitting mosquitoes for dry season. Similar findings had been reported from East Wollega, Western Ethiopia and from Zeway, Central Ethiopia, (Jaleta *et al.*, 2013; Kibret *et al*., 2010). Malaria occurred throughout the year in Sibu Sire district although with higher number of malaria cases during following the short and long rainy seasons, which showed that malaria is seasonal in the study area similar to other parts of the country.

P. falciparum was the predominant species followed by *P. vivax* in the study area. The study conducted in Metema Hospital, Kola Diba and Butajira Health Center (Ethiopia) showed similar results (Getachew *et al*., 2013; Alemu *et al*., 2012; Tesfaye *et al*., 2012). Other earlier studies have also documented the predominance of *P. falciparum* species in many areas in Ethiopia .This study also showed that in 2011the prevalence of *P. falciparum* was declining but prevalence of *P. vivax* was slightly increasing, which indicates a trend in parasite species shift in the study area. This trend shift in parasite species is similar to the result of another similar study carried out in BakoTibe district, Western Ethiopia (Geshere *et al*., 2014) and in Kola Diba, North West Ethiopia (Alemu *et al*., 2012). This trend in shift from *P. falciparum* to *P. vivax* could be due to the prevention and control activities of malaria as guided by the National Strategic Plan (2006–2010) which mainly focuses on *P. falciparum* because it is assumed to be more prevalent and fatal in the country. Other possible reasons might be climate variability and *P. vivax* might have developed resistance for the currently used drug (Chloroquine) (Alemu *et al*., 2011; Ketema *et al*., 2009; Jima *et al*., 2005).

The kebeles with more malaria prevalence were Jarso Wama kebele and followed by Sire-02, Sire-01, Bikila, Lalisa and Waligalte, respectively. Jarso Wama kebele was found in low land area and there was a state farm in this area in the past time, most people who lived in state farm area might have come from malaria free high land areas, because of these the people could be more susceptible to malaria infection (Adhanom 2006; Nega 2006). And recently is situated within a large-scale irrigated sugarcane plantation in Jarso Wama because of these, there was a strong positive correlation between malaria prevalence and sugarcane irrigation as introduced by Jaleta *et al*. (2013).

In the present findings, there was a considerable increase in malaria prevalence in 2004 followed by a declining trend until 2008. This finding was related to the periodic epidemics of malaria which occurs every five to eight years in Ethiopia. Malaria epidemics may occur due to changes in climatic, non-climatic and biological factors (Huang *et al*., 2011).
Meteorological variables are considered as the environmental factors for increased risk of malaria because of their impacts on the Plasmodium incubation rate and mosquito vector longevity. The major climatic factors that have an impact on malaria transmission due to spatio-temporal changes in malaria vectors are temperature, relative humidity and rainfall. Regression analyses suggests that temperature, rainfall and relative humidity act on yearly malaria

prevalence. These indicate that Plasmodium parasite and mosquitoes vectors need temperature, rainfall and relative humidity for proliferation and life cycle of malaria causing species. In lowlands, the factors that contribute to malaria transmission dynamics are microclimate variation due to anthropogenic effects and other non- climatic factors like, health system, population growth, population movement and others (Abeku *et al*., 2004; Gebere-Mariam, 1984).

Malaria is one of the major obstacles to socio-economic development in the country as the main transmission periods coincide with peak agricultural and harvesting periods (Asenso-Okyere *et al.*, 2011; WHO, 2008). In the same way malaria in Sibu Sire districts is not only a public health problem, but it also hinders socioeconomic development because the main malaria burden was from May to June and September to November which are the most agricultural production seasons.

In general, there was a fluctuation in malaria prevalence during the last ten years in Sibu Sire district. On the other hand the association between malaria prevalence and climatic variables during last ten years was significant. Still many factors might be responsible for malaria prevalence changes which include: parasite, vector and host interactions, social and economic determinants such as change in health care infrastructure. Social, biological and economic factors, mosquito control measures, population immunity, local ecological environment, governmental policy, and drug and insecticide resistance also have an impact on malaria prevalence. Although there were malaria control activities in each year, such as indoor residual spraying, environmental management, health education, large scale distribution of LLINs and anti-malarial drugs and other activities to reduce mortality and morbidity of malaria, malaria is still a problem in the study area. Community health education on the use of ITNs and acceptance of IRS should be strengthened. In general, there is still much to be done to achieve effective malaria control in the study area. So the society, state and stakeholders work together to overcome these problem.

6. Conclusion and Recommendation

6.1 Conclusion

In the past ten years (2004 up to 2013) malaria prevalence in Sibu Sire district showed that a fluctuating trend. The study indicated that malaria prevalence declined over the study period, with *P. falciparum* predominance. Because malaria control activities in each year, such as indoor residual spraying, environmental management, health education, large scale distribution of LLINs and anti-malarial drugs and other activities used to reduce malaria parasites and vectors. In relation to sexes the males were more affected than females in malaria infections and 15-44 years age groups were also more infected by the disease suggesting not higher susceptibility level but higher exposure status due to less attention given to the other age groups. This study has also revealed that malaria prevalence might be depending on year, season and month of the past ten years. The highest peak of malaria occurrence in almost all year was observed during the wet seasons.

Climate variability is widely considered to be a driver of inter-annual variability of malaria incidence in the study area. If the climate assessment is integrated with socio-economic factors including agricultural practices, water availability, urbanization and deforestation, it would be a holistic approach in finding out a specific cause in the malaria prevalence and transmission in the study area. The relationships of variability in rainfall, temperatures and relative humidity to malaria prevalence had impacts on the *Plasmodium* incubation rate and mosquito vector longevity.

In general, transmission of malaria is very complicated and detailed ecological and epidemiological studies are still needed to assess the true local risk of proliferation of *Plasmodium* species and mosquitoes life cycle. Therefore, we hope that the changing pattern of malaria prevalence in the study area and the possible causes will encourage more detailed work in the future to overcome the challenge.

6.2. Recommendation

Based on the findings of this research, the following recommendations are suggested and may be used in controlling and reducing the prevalence of malaria in Sibu Sire district.

- Proper awareness creation for appropriate utilization of ITNs and get them treated regularly. Distribution of ITN should also consider the size of family and should aware how long the ITN is effective since many stop using it assuming that it has lost its effectiveness. Proper utilization of ITN can be ensured through availing ITN which is adequate for all members of the family, providing adequate information during distribution preferably by health workers on how to use it, possible side effect and benefit. One major reason for improper use of ITN is doubt about its effectiveness especially after they use it for some time. So people should know for how long ITN will stay effective once it is distributed and the things which should be done while using it, such as re-socking. Therefore, distributing ITN through the health workers might increase its utilization.
- Health Extension Workers and Kebele Administration mobilizing Community for environmental manipulation where possible removing the stagnant water that was not used by community.
- The Minister of Health, NMCP and government should expand on health service delivery and bring the services near to the population.
- Establishing a culture for LLINs, including increased demand for its ownership, correct and consistent use, especially among the most vulnerable groups such as children under the age of five years and pregnant women.
- Increasing community awareness and knowledge regarding malaria diagnosis, treatment, prevention, and control by Health Extension Workers.
- The NMCP allocating adequate funds for malaria control and health systems for early diagnosis and treatment.
- By trained people Spray chemicals appropriates in malarious kebeles indoor and outdoor before malaria become epidemic.
- The stake holders improve the quality of malaria diagnosis and treatment in different health facilities.

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Annex 1. Format used to collect recorded data of malaria from Sire health center, 2004-2013.

Date	Patient	Sex	Age	Address	Result			Drug used				Remark
					Positive		Negative	chloroquine	Quinine	Coartem	SP	
					P.f	P.v						

Annex-2. Guide line for data collection in Sibu Sire district (from 2004- 2o13)

Catagorie	Years		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013	
	Species		Pf	Pv	Pf	Pv	Pf	Pv	Pf	Pv	Pf	Pv	Pf	Pv	Pf	Pv	Pf	Pv	Pf	Pv	Pf	Pv
Resident	Rular	M																				
		F																				
		T																				
	Urban	M																				
		F																				
		T																				
Age	Blow1year																					
	1-4year																					
	5-14year																					
	15-44year																					
	45-64year																					
	≥65year																					
Season	Spring																					
	Winter																					
	Autumn																					
	Summer																					
Drug distribution	Chloroquin																					
	Quinine																					
	Coartem																					
	Sp																					

Key M-male F-female T-total
Pf-Plasmodium falciparum Pv-Plasmodium vivax
Sp-sulfadoxine-pyrimethamine

Annex-3 Table for meteorological data collection

Meteorological Variables	Years									
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Maximum temperature										
Minimum temperature										
Mean temperature										
Rain fall										
Average relative humidity										