Communities' Perceptions on the Relationship between Climate Variability and the Incidence of Malaria and Coping Strategies to Prevent Malaria Infection in Arsi Nagelle District, Oromia Regional State, Ethiopia

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Abstract
Climate change and variability can lead to an expansion of the areas suitable for malaria transmission, and thus increase risk of the disease. The purpose of the current study was to examine communities' perception on the association between climate variability and malaria incidence and coping strategies to prevent malaria infection in Arsi Nagelle district, Oromia Region, Ethiopia. The study was conducted in three rural kebeles, (Haadha-Boso, Kersa-ilala and Meraro-hawilo) which were purposively selected as representatives of lowland, midland and highland agro-ecological zones of the district respectively. Quantitative data were collected through household questionnaire survey, while qualitative data were collected through key informant interviews and focus group discussion. In an effort to make this research more valid, creditable and applicable secondary sources which are important to the study were reviewed. For the questionnaire survey, 143 rural households were randomly selected from the three rural kebeles. The data was analyzed by using descriptive statistics. An average of 65% of the respondents perceived that there has been increasing in temperature and decreasing in rainfall in the district. However, there was significant difference between lowland and highland dwellers on the perception of the climatic variability. Majority of the respondents in the lowland and midland kebeles (95.70% and 81.80%, respectively) perceived that the increasing of the temperature is causing malaria incidence in their area, while only (59.60%) of the highland household respondents had a similar attitude. Spraying houses with insecticides and the use of insecticide treated mosquito nets were the predominantly adopted preventive strategies against malaria infection practiced in the study area.
Key Words/Phrases: Climate variability, household's perception, Malaria incidence, coping strategies

Introduction and Background of the study

Malaria is one of the most important public health problems in the world. It has been ranked as one of the top three killers among communicable diseases (Sachs and Malaney, 2002).

The estimated annual mortality attributed to malaria ranges from 700,000-2.7 million worldwide and more than 75% of them are African children and expectant mothers who have less immunity (Kumar *et al*., 2007). This disease is mainly confined to the poorer countries in the tropical and subtropical regions of the world. Sub-Saharan Africa (SSA) and South and Southeast Asia are the most malaria-affected regions. The geographical distribution and incidence of malaria are hugely influenced by the climate and ecology. Changes in climate factors such as temperature, precipitation, humidity and sea level rise affect the reproduction, development, behavior and population dynamics of Mosquito (Gage *et al*., 2008). Temperature plays a fundamental role in the rate of multiplication of the parasite in the mosquito (National Research Council, 2001). Both vector (i.e., female anopheles mosquito) and parasite of this disease are sensitive to changes in temperature, as temperatures rise the malaria parasites develop and multiple more quickly in the mosquito vectors, thereby increasing the proportion of infective vectors (Ambu *et al*., 2003). Higher temperatures increase the number of blood meals taken and the number of times mosquitoes lay eggs (Martens *et al.*, 1995). The minimum temperature for mosquitoes development is between 8-10ºC, the minimum temperature for parasite development is between 14-19ºC. The optimum temperature for mosquito development is 25-27ºC, and the maximum temperature for both vectors and parasites development is 40ºC (McMichael *et al*., 1998).

Increased rainfall leads to increase the number and quality of breeding sites (such as mud-pools, marshes and natural ponds) for malaria vectors e.g., mosquitoes increases in the humidity, which enhances survival and vector capacity and henceforth the transmission of the parasites (Ambu *et al*., 2003; Snow *et al*., 1999). Similarly, in North-East Panjub, one of the states of India, malaria epidemics increased five-folds in the year following an El-Nino event while in Sri Lanka the risk of malaria epidemics increased four-folds during the El-Nino year (Githeko *et al*., 2000). Himeidan *et al*. (2005) also found that malaria transmission depends on seasonal variation and reaches its peak during rainy season (August-October) in eastern Sudan. In fact, global malaria outbreaks have been regularly linked to temperature and/or rainfall variations brought about by El-Nino events (Bouma and Van Der Kaay, 1994; Bouma *et al*., 1994; Kovats *et al*., 2003; Berrang-Ford *et al*., 2009). Sea level rise can also play an important role in malaria transmission. Global warming leads to melt polar ice caps and consequently a rise in sea level which would cause coastal flooding in many areas. Salt-water intrusion into fresh water of coastal areas can extend breeding sites for mosquitoes and enhance transmission of the disease. For example, *Anopheles sundaicus* is a malaria vector which breeds in brackish water in the coastal areas of Peninsular Malaysia (Ambu *et al*., 2003).

Malaria is one of the leading public health problems in Ethiopia. Almost 75% of the landmass of Ethiopia is estimated to be affected by malaria, and about 68% of the population of Ethiopia corresponding to the human population living in areas below 2000 m elevation (approximately 52 million people in 2007) is at risk of malaria (FDRE,MOH.2007/8, Jima *et al.,* 2007 & Deressa, *et al.,* 2003). Malaria transmission is seasonal in Ethiopia and varies across the country depending on climatic and ecological factors favorable for both the vector and parasite development, including elevation, rainfall, and temperature (FDRE, MOH.2007/8, Deressa *et al.,* 2003 & Graves *et al.,* 2009).

The major malaria transmission season occurs primarily during September to December following the main rainy season, which occurs from June to September with peak precipitation in July and August (IBD).

In Arsi Nagelle district, malaria has been expanding its geographic and climatic fronts of occurrences. For instance, its incidence has become high in lowland areas such as Haadha-Boso, where it used to be of moderate occurrence; and it became of moderate occurrence in areas such as Kersa-Ilala, where it used to be of low occurrence. It is also being reported from highland areas such as Meraro-Hawulo, where its incidence was not known.

Thus, there is a pressing need to develop climate-based malaria early warning to enhance public health decision making for control and prevention of malaria epidemics in the study area.

Statement of the problem

Arsi Nagelle is a district that encompasses areas that were known to be suitable for malaria occurrence and also areas that were not known to be malaria prone. Currently malaria has been increasing besides the changing of the climate in all the three agro-ecological zones of the district. In the study area, communities' perceptions on the relationship between climate variability and the incidence of malaria and coping strategies to prevent malaria infection was not studied despite increased occurrence of malaria. Also, there is no coping and climate-based epidemic early warning, prevention and response strategy in the district. Therefore, this thesis intended to assess communities' perceptions toward climate variability and the incidence of malaria as well as coping strategies to prevent malaria infection

Materials and Methods

Description of the Study Area

Location

Arsi-Negele district is located in West Arsi zone of the Oromia Regional State. The district capital is about 225 km south of the capital Addis Ababa. Geographically, it is situated in the Ethiopian central rift valley system at 7^0 09'-7^0 41' N and 38^0 25'-$38^0$54' E. It is bordered in the South by Shashamene district, in the southwest by Bulbula woreda which separates it from Seraro, on the west from the Southern Nations, Nationalities and Peoples Regional state, on the North by Adami Tullu and Jido Kombolcha districts with which it shares the shores of Lakes Abijatta and Langano. On the East, it is bordered by the Arsi Zone (ORS, 2004). The altitude of the district ranges from 1500-2300 masl. Lakes Langano, Abijata and Shala partly lie in the Arsi Nagelle district. Most of the malaria transmission occurs between September and December, after the main rainy season from June to August (MOP, 2013).

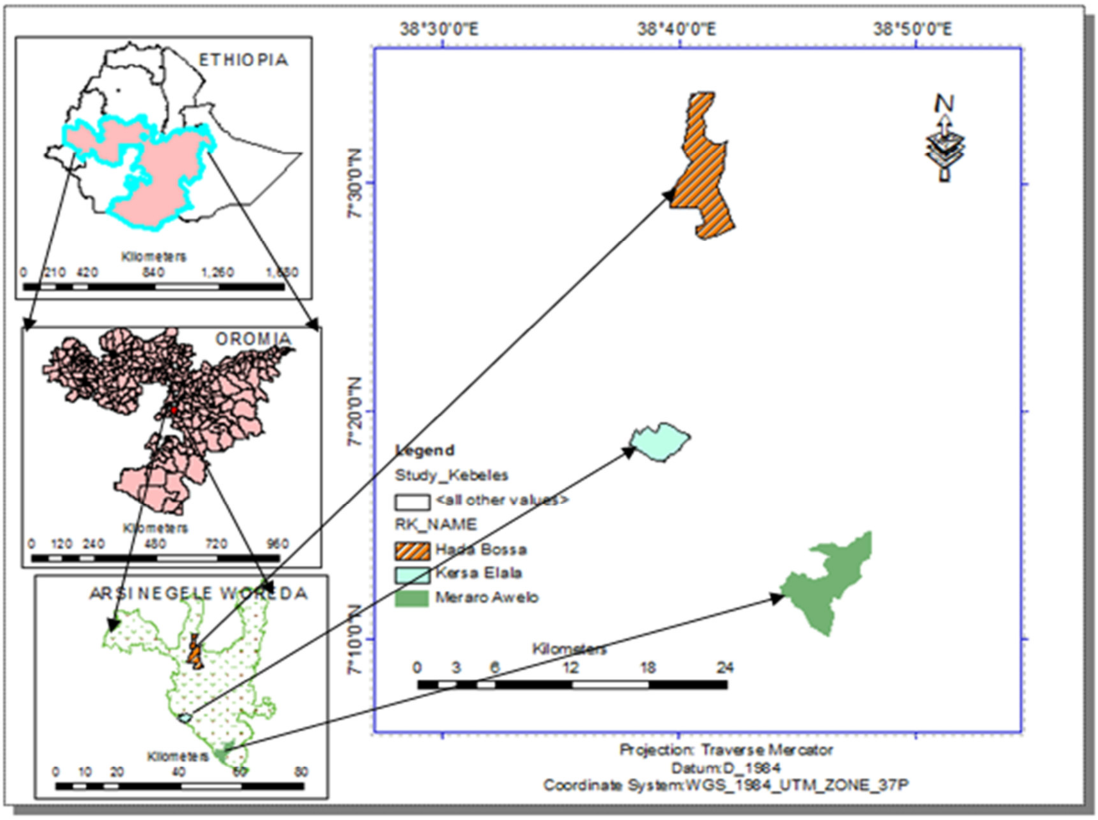

Figure 1 Map of the study area

Climate and Agro-ecology

The study area covers three agro-ecological zones (low, mid and high land) based on temperature, rainfall, altitude and vegetation and that ranges from 1500-2300 masl (ICRA, 2002). The high altitude zone occupies the largest area followed by mid and low altitude climatic zones, respectively. Average annual temperature varies from 10-25 C^o while annual rainfall varies between 500-1000mm (ORS, 2004). About 80% of the district is sub-tropical, while 20% belongs to the temperate agro-climatic zone.

Topography

The topography of the study area is slightly undulating, especially in the highlands and is almost flat in the lowlands. The area has relatively fairly good agricultural potential, which is reflected in the diversity of crops and its animal resources. Some parts of the highlands in the study area are still covered by natural forest, bush lands and shrub lands. Large water bodies from the three inland Lakes: Abijata, Shalla and Langano cover large part of the study area (ORS, 2004).

Population and Farming System

The district has 43 rural and 4 urban peasant associations/kebeles. The total population of the district is estimated to be 260,129 of which 80.2% is rural with an average density of 105.4 persons per km^2 (CSA, 2007). Rain-fed agriculture mainly cereal cropping along with livestock raring are the major sources of food and income for maintaining the livelihoods. The traditional farming system, integrating crop production and animal rearing is common practice in the area. The cattle provide labor service in their farming activities like drought and threshing power. There is interaction between animals and crop production. Animals improve the soil quality through manure and slurry provision, and the crop residue is provided for animals as fodder, thereby increase the productivity per unit area and supports household economy. Grazing is mainly carried out in communal land and under plantations. The major annual crops produced include different varieties of barley (*Hordeum vulgare*), wheat (*Triticum sp.*), millet (*Eleusine coracana*), maize (*Zea mays*), teff (*Eragrostis tef*), sorghum (*Sorghum vulgare*), onion (*Allium cepa*), potato (*Solanum tuberosum*), and perennial crops includes sugarcane (*Saccharum officinarum*), *Coffea arabica* and Enset (*Ensete ventricosum)* (Asferachew, 2004).

Livelihoods

The livelihood of the people in the study area is dominated by mixed farming like most part of Ethiopia**.** Land is an important asset of households for production of crops and rearing of livestock. Livestock serves as a source of manure and fuel, pay land tax, fertilizers and as a saving to buffer bleak seasons of food/seed shortage (Abate, 2009). Oxen are the major ploughing engines. Donkeys, horses and mules play a significant role in transportation of people, water, and goods. Though mixed farming is the dominant livelihood system there are arid and semiarid predominantly pastoralist in some mid and lowlands, and highland pastoralist-perennial crop livelihood systems. Crop production decreases with increasing altitude with the exception of some vegetables and enset (*Ensete ventricosum*), and animal husbandry takes the ranking. The most commonly produced crops in the zone are annual crops such as barley, wheat, teff, maize, haricot beans, horse bean, field peas and linseeds, and perennial crops like potato. The wealth classification criteria for some districts were not clearly set. As in all other rural parts of Ethiopia, livestock ownership and land holding are the two most important criteria for one's wealth and status measure in the society. The household size is also included in wealth ranking criteria; large family households are considered as better-offs. The number of eucalyptus tree and beehives are also considered in the classification. However, the agricultural production is predominantly subsistent and it is difficult to estimate the household yearly income. Nevertheless, it is clear that most of the produced crops and livestock or livestock products are used for household consumption. The remaining used to cover seed and sold to pay credits, taxes, purchase of fertilizer, household financial expenses and others (CSA2, 2008).

Vegetation

The farm lands are endowed with scattered remnant trees from the natural forest which gives the agricultural landscape a parkland Agro-forestry structure. Coniferous forests of podocarpus variety, woodland, and broadleaf forests prevail in the district. At the Rift Valley plain, open *Acacia* woodland dominates, and this gradually turns into dry open deciduous woodland of a transitional vegetation type (Eriksson *et al*., 2003). At mid and high altitude i.e. between 2000-2300 m above sea level tropical dry evergreen montane forest dominates. Different plant communities comprise this section. At the lower sub-humid part a *Podocarpus falcatus - Croton macrostachyus* mixed forest exists, which gradually converts into the humid zone dominated by *Podocarpus falcatus* forest. These vegetation communities are all referred to as 'Montane forests' in many classification systems (Brown and Cocheme, 1969).

The vegetation of the woodland at lowland part can be classified mainly as Acacia-Balanites with some thorny shrublands occurring around the lakes. The characteristics species of woody plants include various types of trees, shrub, sub-shrub and climbers with different distribution and abundance. Small area of woodland surrounding the head quarter of the National Park (which is protected from human interference) exhibits the initial complex of plant species diversity in the study area (Pichi-Sermolli, 1975).

Besides, there are also plantation species, which are exotic. The main species include *Cupressus lustanica, Pinus patula, Eucalyptus globules (E.globules), E. grandis, and E. viminalis.*

Methods of data collection and analysis

Study site selection

In the first stage, the District was classified into three strata of Lowland (kola) hot, Midland (woyna-dega) medium and Highland (dega) colder agro-ecological zones based on their altitudinal difference. From each agro-ecology one target kebele was purposively selected. These kebeles represent the type of living conditions of people about their socio-economic conditions, perceptions on the impacts of climate variability on malaria distribution and the existences of malaria prevention strategies, climate problems and disasters besides topographic features.

Sampling design and sample size determination

Haadha-Boso, Kersa-Ilala and Meraro-Hawulo kebeles were purposively selected from the three Agro-ecological zones respectively. The number of households in each target kebeles was identified and sample size was determined for the random sampling. Accordingly, Haadha-Bosso kebele consisted of 556 households, Kersa-Ilala kebele consisted of 514 households and Meralo-hawlio kebele consisted of 616 households making a total of 1,686 target households. Among several approaches to determine a sample size this study applied a simplified formula provided by Yamane (Yamane, 1967 cited in: Israel, 1992) to determine the required sample size at 95% confidence level, degree of variability=0.05 and level of precision= 8%

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

Where'' n'' is the sample size, ''N'' is the population size (total household heads size), and ''e'' is the level of precision.

Accordingly, a total of 143 sample households were studied. Proportionately distributing the sample size to the three kebeles; 47 households from the Hada-Bosso, 44 households from the Kersa-ilala and 52 households from the Meralo-hawlio was sampled. Finally, the respective sample households from each kebele were identified and contacted for the studies of socio-economic and perception on the malaria incidence beside climate variability.

Data collection Methods

Primary data collection

In order to collect the robust data needed to achieve the objectives of the research, a multi-source data collection method through stratified random sampling (SRS) was employed.

The primary data collection involved household survey, 6 key informants interview and 3 focus group discussions.

Household survey-The necessary data required for the study was gathered through administering questionnaire to selected household respondents. The questionnaire was pre- tested on randomly selected household heads before the formal survey is conducted, and modified slightly for clarity. The questionnaire was used to collect qualitative and quantitative data from the household heads having both structured and non-structured forms. The generated data from the survey included, the living conditions of people, malaria incidences, about their socio-economic conditions, disease history and perception of peoples on malaria incidence in relation to climate variability, age groups which are mostly infected by malaria, types of strategies taken to control malaria outbreaks in the study area.

Focus group Discussion: One focus group was organized in each of the selected kebeles, and the discussion was guided by the researcher using a checklist of issues on which in-depth information is needed.

Participants were identified purposively from inhabitants of the each kebele in consultation with the enumerators. The purpose of the focus group discussion was to generate in-depth information on some of the survey findings and other issues that may not have been adequately captured by the structured questionnaire survey. Discussions were facilitated by the researcher and assisted by note-takers.

Secondary data collection

The use of secondary sources plays a major role in the field work research, especially at the study area. In an effort to make this research more valid, creditable and applicable secondary sources which are important to the study were reviewed. For this purpose, both published and unpublished sources were investigated systematically especially books, web pages, policy directives, reports, project papers, annual and action plans, etc which support communities' perceptions on the relationship between climate variability and the incidence of malaria and coping strategies to prevent malaria infection.

Data Analysis

In this study, descriptive statistics was used to explain socio-demographic characteristics of sampled household. These include mean, percentage and frequency of the dependent and independent variables was analyzed. Statistical software such as STATA11, Microsoft Excel and Statistical Package for Social Sciences (SPSS) version 20.0 were used to analyse the data from the household socio-economic survey in order to understand the impact of the underlying socio-economic variables determining the perception and traditional knowledge of the local communities on the association between climate variability and malaria incidence as well as their corresponding coping strategies. Finally, the results were summarized and presented as Tables or graphs.

Results and Discussion

Demographic and socio-economic characteristics of households

The demographic characteristics of respondents are summarized and presented in Table 1, a total of 143 respondents were included in this study, of which 114 (79.72%) were males and the rest 29 (20.3%) were females. About 11% of the respondents were 18-25 years old, 37.067% were 26-35 years old, 25.2% were 36-45 years old,16.8% were 46-55 years old, 9.8% were 56 and above years old. The mean age of the participants was 28 years. All the participants were the residents of the area.

About 64 (44.75%) of the respondents had no formal education; whereas, 79(55.25%) had Attended formal education.

The mean annual income of respondents is found to be birr 7208.68, however it ranges between 1540 to 17620 birr. Agricultural production, off-farm activities like petty trade were important income sources for sample households. Agriculture is the main source of income and it constitutes 85.4% of total income per annum. Livestock availability is the second generating income for the households and it accounts 10.28% of the total income.

Non-farm activities such as petty trade rank third in generating income for the households and it accounts 3.09% of the total income. Tourism related activities were also another income generating structure and it covers 1.21% of the total income of households in the study area. The result shows that among the household's income sources, it is the farm income that stands first whereas; the income from non-farm activities is very low.

Table 2 Demographic and Socio-economic characteristics of studied households (N=143)

Variables	Type	Number	Per cent
Sex of HH	male	114	79.7%
	Female	29	20.3%
Age of HH	18-25	16	11.2%
	26-35	53	37%
	36-45	36	25.2%
	46-55	24	16.8%
	Above 56	14	9.8%
Educational status of HH	Attended formal education	79	55.2%
	Didn't attend formal education	64	44.7%
Occupational status of HH	farmers	108	75.5%
	Petty trader and farmer	6	4.2%
	Farmer and Gov. Employer	15	10.5%
	Causal workers	2	1.4%
	Had no job	12	8.4%
Annual income sources of HH	Crop	122	85.4%
	Livestock	15	10.3%
	Non-farm income	4	3%
	Tourism Income	2	1.2%

Households' knowledge and awareness on climate variability and its impacts on the incidence of malaria

Majority of the households in the lowland and midland kebeles (76.59% and 72.72%, respectively) perceived that temperature has been increasing while only 46.15%, of the respondents from the highland kebele perceived increase in temperature. In a similar manner, 82.98% and 70.45% of the respondents from the lowland and midland kebeles respectively, perceived that rainfall has been decreasing while only 44.23% of respondents from the highland kebele perceived the same (Table 2). The variation in the perception of the respondents was statistically significant (p value 0.00) between the lowland, midland and highland kebeles.

The agro-ecological setting of households influences the perception of households to climate change. According to the findings of Diggs (1991), households living in drier (lowland) areas with more frequent droughts are more likely to describe the climate change and variability to be warmer and drier climate than households living in highland areas with less frequent droughts and relatively lower temperature. In Ethiopia, particularly in the Central Rift Valley, lowland areas are drier with higher drought frequency than other areas (Bezabih *et al.,* 2010).

Table 3 Households' perception on the trends of climatic factors (temperature and rainfall) over the last two decade (N=143)

	Agro-ecology						
Response	Lowland (n=47)(%)		Midland (n = 44) (%)		Highland (n = 52) (%)		p value
	RF	Temp	RF	Temp	RF	Temp	
Increasing	17.02	76.59	27.27	72.72	42.30	46.15	
Decreasing	82.98	23.40	70.45	22.72	44.23	40.38	
No change	-	-	2.27	2.27	13.46	13.46	
Total	100	100	100	100	100	100	0.00

Most of the households from all the three kebeles and agro-ecological zones indicated that malaria occurs in their area. However, there was variation among the agro-ecological zones in terms of the proportion of respondents that indicated the presence of malaria in their areas, the highest (95.7%) being from the lowland agro-ecology represented by Haadha-Boso kebele and the lowest (69.2%) was from the highland agro-ecology represented by Meraro-Hawulo kebele. Moreover, the proportion of respondents from the midland agro-ecology (88.6%) (Kersa-Ilala) kebele was closer to that of the lowland agro-ecology. This might be due to the warmer temperature in midland area similar to lowland area, which might be suitable for malaria distribution. The variation in the perception of the respondents was statistically significant (p value = 0.001) between the lowland, midland and highland kebeles (Table 3).

This is due to the fact that Haadha-Boso kebele is located at altitude between (1500-1750) masl, where flooding commonly occurs and temperature is usually warm and therefore creates conditions suitable for the breeding of mosquitoes compared to the midland (Kersa-Ilala) located between (1750-2000) masl and highland (Meraro-Hawulo) kebele which is located between (2000-2300) masl. The findings of the current study were consistent with similar studies from eastern Nepal (Dhimal *et al.,* 2014) noted that the people settled at lower altitude had been vulnerable to malaria incidence and perceived more as compared to those settled in the middle and upper altitudes. Also, another study on the prevalence of malaria infection in Butajira area reported that more children had malaria in the low altitude areas, and hence more households perceived malaria in lowland than in midland and highland areas (Woyessa *et al.,* 2012).

Table 4 Perception of households in three agro-ecological zones on the incidence of malaria

Response	Agro-ecology				
	Lowland (n=47)	Midland (n = 44)	Highland (n = 52)	Total (N =143)	p- value
Present	95.70%	88.60%	69.20%	83.90%	
Absent	4.30%	11.40%	30.80%	16.10%	
Total	100%	100%	100%	100%	0.001

Majority of the respondents in the lowland and midland kebeles (95.70% and 81.80%, respectively) perceived that the increasing of the temperature is causing malaria incidence in their area, while a lesser percentage of respondents (59.60%) from the highland kebele perceived the same.

The variation in the perception of the respondents was statistically significant (p value 0.00) among the lowland, midland and highland kebeles. On average, 78.03% of the respondents perceived that climate variability is causing malaria incidence in their area (Table 4).

This was shown only in their understanding that malaria outbreaks occurs more often during hot (warmer temperature) and end of rainy season when flooded areas and stagnant waters become available**.** They believed that, unusually long and erratic rainfall occurring as the result of climate variability in the area could create flooding which increased the rate of occurrence of diseases like malaria, cholera, and typhoid fever especially in the lower slope. They also stated that high rainfall periods do not usually have many mosquitoes because breeding grounds are disturbed and washed away by the heavy rains. Rainy periods usually are cooler periods of the year, the mosquito population increases significantly as temperature increases after the rains.

The findings of the current study are consistent with the studies from Uganda (Caroline, 2012) which revealed that most respondents in lowland areas perceived the increasing of the temperature is impacting malaria outbreaks than those in midland and highland areas.

Table 5 Perception of households on the impacts of climate variability on the incidence of malaria

Response	Agro-ecology				
	Lowland (n=47)	midland (n=44)	highland (n=52)	Total (N=143)	p value
Yes	95.70%	81.80%	59.60%	78.30%	
No	4.30%	18.20%	40.40%	21.70%	
Total	100%	100%	100%	100%	0.00

Response of households on the treatment and prevention of the occurrence of malaria in the study area

The result of the survey showed that all of the households (100%) have some knowledge of where to seek the treatment of malaria. Moreover, 98% of the respondents indicated that they would seek treatment in health facilities and only 2% mentioned the use of traditional medicines (Table 5). This indicates that communities have good access to health facilities. Similar results were reported from the study conducted in Abeshge, South-Central Ethiopia (yimer *et al.,* 2015), and those from Indonesia (Sanjana *et al*., 2006) and from Swaziland (Hongawana *et al*., 2009).

About 64.9% of the respondents indicated that they use ITNs (insecticide treated mosquito bed nets) as primary methods of malaria prevention followed by 25.2% who indicated the spraying of houses with prophylactic chemical (Table 5). Generally about (90%) of the inhabitants of those kebeles used ITNs and prophylactic chemical sprays of homes as major means of prevention of malarial infection.

And the rest (10%) of the inhabitants were used Environmental sanitation, Smoke from burning of leaves and Planting eucalyptus trees as the preventions of malaria outbreaks. The findings of the study are consistent with those of Mengistu and Wakgari (2009); Sanjana *et al*., (2006); Mazigo *et al*., (2010).

Table 6 Respondents' knowledge about the treatment and prevention of malaria in the study area

Variables	Means of treatment	Number of respondents	(%)
Treatment of malaria	traditional medicine	3	2%
	Visit health facilities/ institutions	140	98%
Knowledge about preventability of malaria	Yes	134	93.7%
	No	9	6.3%
Methods used to prevent malaria incidence	Household spray with prophylactic chemicals	36	25.2%
	Use of ITNs (bed net)	92	64.3%
	Environmental sanitation (like, draining stagnant water near house)	7	4.9%
	Smoke from burning leaves and animal products	3	2.1%
	Planting eucalyptus trees to drain the flooded area that harbours mosquitoes.	5	3.3%

Conclusion and Recommendations

Conclusion

From the current study, the following conclusions were drawn:

- Majority of the respondents in the study area perceived that there has been variability in the important climatic factors (temperature and rainfall) in their area. However, the perception of the households has been influenced by the agro-ecological zone of their kebele. That is, majority of the households living in lowland areas believed that there has been variability in temperature and rainfall.
- Educational status, income, perception, quality of house to live and access to mosquito nets were negatively correlated to the incidence and transmission of malaria in the study area.
- Spraying houses with insecticides and the use of insecticide treated mosquito nets were the predominantly adopted preventive strategies against malaria infection practiced in the study area.

Recommendations

On the basis of the conclusions made above, the following recommendations are forwarded.

- ✓ The local governmental officials and other relevant stakeholders should actively engage in providing intensive training on environmental sanitation and housekeeping to control malaria incidence.
- ✓ More attentions should be given for the education in the study area to improve the perception of the community concerning the impact of climate change on the incidence of malaria in the district. This can be done by giving trainings related to environment and climate change and how to care in protecting themselves against malaria.

- ✓ Moreover, concerted efforts should be made by the district health office and supporting organizations to distribute mosquito nets and awareness creation on how to use them.
- ✓ The local government of the district should encourage and support health care centers to collect and manage all relevant records on the incidence of malaria in order to provide important data that may be needed for better planning of disease management and also support research in the field.
- ✓ District local government should encourage local communities to build drainage channels that could easily let rain water out rather than flooding, manipulate and control the local habitats by removing hollows, small ponds, pools containing water for breeding, conduct regular cleaning campaigns for sites and places where mosquito vector is abundant.
- ✓ There is a need of health education and awareness campaigns at the community and individual levels. This will help bring positive behaviours at work and leisure at home towards malaria prevention and control. For example proper dressing behaviours while going to the garden in the morning, in the evening hours at home and when going to sleep, early and proper treatment seeking, vector control, and moving at good times of the day when mosquitoes are not active. Whenever possible it is important to wear suitable clothing's especially after dusk, thorough check inside houses in the evening and use bed nets to avoid Anopheles mosquito bites.
- ✓ National government should plan funding for various district activities in time such that they as district leaders in charge of health can try to handle the climate variation impacts in case they occur.

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