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GIS based malaria risk assessment

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Abstract

Malaria is grave and long-lasting disease instigated by a protozoan parasite of the plasmodium species. It is the root cause of one million deaths annually throughout the world. From this, 90% of death is experienced by young children in the South of the Sahara, in Africa. In Ethiopia, malaria is found in about 75% of the total area of the country and more than 68% of the total population is at risk of infection. The main objective of this study was to assess and map the risk of malaria in Kewet Woreda, North Shewa Zone, Amhara Region. For the last few years, the outbreak of malaria in the study area started to decrease. But still, malaria was the top ten disease which is the cause for high morbidity and mortality in the Woreda. To assess and map the risk of malaria, nine determining factors included elevation, rainfall, wetland, and swamp area, river, temperature, distance from the health centers, slope, land use/cover, and population density was selected. These factor maps were combined by using Weighted Multi-Criteria Evaluation on IDRISI 17.0 environment. To assess the socio-economic aspect household survey was carried out. To do so, 137 respondents were systematically selected from five kebeles. Malaria risk map of the study area showed that almost all kebele within Kewet Woreda highly affected by Malaria. Almost 3/4 of the areas fall in the very high (25%), high (45.4%), and moderate (22.9%) malaria risk levels and the remaining only 6.7% of the area labeled as malaria-free. Regarding the impact of malaria in the study area almost all respondents systematically selected from five kebeles indicated that their families were highly affected by malaria, and they use ITBN and insecticide spraying as coping mechanisms. GIS and remote sensing play a great role in enhancing malaria risk zone mapping. Therefore, to minimize the risk of malaria in the area, the Woreda health office should use GIS and Remote sensing technology, could aware of the people about the importance of drainage and effective use of ITBN, construct health centers at a very high and high-risk area.

Keywords: Malaria, GIS, RS, MCE, Kewet, Woreda

Introduction

World Health Organization (2008) defines malaria as a serious disease caused by plasmodium. Cunningham et al. (2005) noted that malaria as grave and long-lasting disease instigated by a protozoan parasite of the plasmodium species (plasmodium malariae, plasmodium ovale, plasmodium vivax, and plasmodium falciparum). Besides, the prevalence of epidemic disease was explained by “Miasma Theory” at the time of Hippocrates at about 450 BC. Accordingly, malaria defined as a “Bad Air”. It is essentially an environmental disease since the vectors require specific habitats with surface water for reproduction, humidity for adult mosquito survival and the development rates of both the vector and parasite populations are influenced by temperature. It is caught by being bitten with an infected mosquito that is carrying the malaria parasites in its saliva.

Based on the scientists' discovery in 1880, one cell parasite is the major cause of malaria which is called “plasmodium”. After a while, they discovered that the parasite is transmitted from one person to another through the bite of a female Anopheles mosquito, which requires blood to nurture her eggs. According to WHO (2008) report malaria is a root cause for one million deaths annually throughout the world. From this, 90% of death is experienced by young children in South of the Sahara, Africa. As compared to AIDS (Acquired Immune Deficiency Syndrome), the number of people killed by malaria is twofold. As many as half a billion people worldwide are left with chronic anemia due to malaria infection. Currently, nearly 90% of all malaria deaths occur across the tropical and sub-tropical regions of the world, where Plasmodium falciparum, the most lethal species of the malaria parasite, predominates and responsible for as many as 198 million illnesses (ranges 124-238 million) and 589,000 death (ranges 367,000 - 755,000) world wide in 2013.

Most of the world countries could control malaria from 1950-1960s, but the incidence of malaria increase again in the 1970s across the globe as a re-emerging disease. Especially in SSA the rate of malaria transmission increases at an alarming rate. The eradication of malaria transmission became more complex due to the resistance of disease to the drugs used for treatment. Its scourge is all-encompassing. According to WHO (2008) report, there are numerous and intricate factors for the spread of malaria. That makes the eradication of malaria difficult and time taking. It is obvious that co-infection, population dynamics, drug, and insecticide resistance are the major cause for the increment and transmission of malaria cases. Malaria is a major public health problem in Ethiopia. Also it is the leading cause of outpatient consultations, admissions, and death. In most parts of Ethiopia, malaria is seasonal with the periodic transmission that leads to the outbreak of an epidemic. The transmission patterns and intensity vary greatly due to the large diversity in altitude, rainfall and population migration. In Ethiopia, areas below 2,000 m.a.s.l. elevation are considered to be areas with malaria risk or potential area with malaria risk. These areas are home to approximately 68% of the Ethiopian population.

In kewet Woreda, malaria is one of the top ten diseases which are responsible for high morbidity and mortality. Seasonal rainfall, presence of unplanned small scale irrigation and land feature of the area create a conducive environment for the development of mosquito breeding sites. The severity of malaria increases at the rainy seasons putting challenging on the activity of the local people whose livelihood is dependent on crop farming. It reduces labor, time for on-farm follow up, and children's school attendance that in turn results in the decline of agricultural production, the economic dependency of vulnerable individuals on others, high school dropouts, and social crisis. To prevent malaria more of the larvae assessment system and reports from different kebeles of the study area were used by the health office. However, the mechanisms employed above are time-consuming and impede quick response in a time of the occurrence of epidemics which in turn deteriorate the living standard and to the extent death upon people residing in the study area. Thus, there is a need for a malaria prevention and control system supported by more efficient methods that can contribute to alleviating the problem in the study area.

The development of malaria in an area is the result of climatic and topographic factors, like rainfall, temperature, altitude, and slope. GIS and remote sensing can be used to associate such variables and the distribution of mosquito responsible for malaria transmission. Other factors like population density, land-use/cover, and proximity to different malaria causing or preventing factors can be also associated with the effect they do have on malaria prevalence using the same tools. Therefore, GIS and remote sensing are the appropriate tools to aid malaria control and prevention system through assessing the potential malaria risk level of an area. Additionally, GIS and remote sensing enable us to produce different thematic and attribute maps for malaria causing factors and malaria risk levels for the study area. This, in turn, helps in the malaria control and prevention system of emergency response, preparedness preventive measures, community awareness, identification of health facility accessibility and location.

In the study area, particularly in Shewa Robit town, some researches were conducted in relation to malaria. For instance, research conducted by Andargi et al. (2013) focused on community knowledge, attitude, and practice about malaria in a low endemic setting of Shewa Robit town. However, the study didn't do malaria risk mapping and risk level identification. As a result, in the study area, the risk level of malaria based on environmental factors was not identified. Doing so could facilitate malaria prevention and control activities in the study area. Therefore, in order to fill the above gaps, this study aimed to to assess and map the risk of malaria using Geographic information system and Remote sensing techniques in Kewet Woreda, North Shewa Zone of Ethiopia. Specifically, the study was design to investigate the environmental and socio-economic factors that aggravate mosquito breeding, generate malaria risk map, and identify highly vulnerable areas for taking mitigation measures against the population at risk of malaria.

MATERIALS AND METHODS

Research Methodology

The study aims to assess and map malaria risk in Kewet Woreda, North Shewa Zone, Amhara National Regional State. To map the risk area, nine environmental and socio-economic factors were selected using the information collected from the Kewet woreda health office, researcher Previous kenowledge and related works. Accordingly, slope, elevation, rainfall, temperature, land use/cover, proximity to water bodies, population density and distance from health centers are taken as major environmental factors for malaria prevalence in the study area. For each environmental factors listed above maps were generated and then reclassified depending on their suitability for malaria breeding. In the course of the reclassification, new values 1, 2, 3, 4, and 5 were assigned and were labeled as very low, low, moderate, high and very high malaria risk level respectively and for some factors, the researcher may use the revers. Then, weight was given to each risk factor in MCE on IDRISI software. To understand the influence of each factor, weighted overlay were carried out using Arc Map 10.1 to generate the final malaria risk map of the study area. On the another hand, information obtained from key informants in the study area was narrative and qualitative in nature and analyzed qualitatively to support GIS-related data.

Methods Used for Analysis of Factors

Different researches and articles have shown that malaria disease is influenced by environmental and climatic factors such as topography, temperature, rainfall; land-use/cover, population density and proximity to water bodies have a profound influence on the temporal and spatial distribution of malaria vectors (Arega, 2009, Prosper, 2011, Aster, 2010). Especially, temperature and rainfall act as the major limiting factors on the development of Anopheles mosquitoes which are the intermediate hosts in the transmission of malaria parasites. Malaria transmission intensity, along with its temporal and spatial distribution in Ethiopia, is mainly determined by the diverse climatic conditions. Climatic factors including rainfall, temperature and humidity shows high variability. These factors differ as a result of altitude (FMoH, 2009). Therefore, for this study relevant parameters which can be used for mapping malaria-prone areas were extracted from the previous works, and data collected through interview and observation.

RESULTS AND DISCUSSION

Climate-Related Malaria Risk

To identify areas with high malaria risk in the study area, temperature and rainfall data were interpolated from seven nearest meteorological stations surrounding the study area. Among this one station is found within the study area while the remaining six stations are outside the study the area within its surroundings. The closest among the six stations are found within 16km distance while the farthest within 178km distance. The data was collected from the National Metrological Agency for each station namely: Ataye, Jeweha, Majete, Debre Sina, Debre Berhan, Mehal Meda, and Shewa Robit.

Temperature Related Risk of Malaria

To generate a temperature map, seven years mean monthly maximum and mean monthly minimum temperature data of seven stations were analyzed. From the mean monthly maximum and minimum temperature of the stations, mean monthly temperature of each station was calculated. Then, a single average value is computed for seven years. Finally, a single average value of each station used for surface interpolation in Arc GIS spatial analyst tools. The technique used to interpolate the data was the Kriging interpolation technique. The method is an advanced geostatistical one, which estimates investigated area from a dispersed set of meteorological stations with different altitudes (z value). The method involves interactive investigation of the spatial behavior of data analyzed before selecting the best method of assessment for the derivation of the output area. It is more acceptable than other spatial interpolation methods, because of its fast data processing, high precision in calculating climatic data and adaptability to the relief configuration.

The temperature map was reclassified by spatial analyst tools in Arc GIS. The study area was reclassified into five classes based on its suitability to mosquito breeding. New values 1, 2, 3, 4 and 5 were assigned to temperature class 15-17, 17-19, 19-21, 21-22 and 22-23, respectively. Then, the classes were labeled as a very low, low, moderate, high and very high malaria risk level respectively. Thus, the majority of the study area has a temperature value between 18℃- 23℃, which indicates the area has a conducive temperature for malaria breeding.

Rainfall Related Risk of Malaria

Rainfall, irrigation canals, rivers, swamps, and other water bodies play a significant role in creating favorable ground for mosquito breeding. Thus, the area with a high source of water is more comfortable for malaria breeding. Even though, an increase in temperature and rainfall increases mosquito breeding, it should be known that this is up to some maximum limit beyond which the relationship could be reversed. High rainfall may destroy mosquito larvae from its stable habitat or interrupt the process of breeding.

The rainfall map of the study area was also generated from seven (7) years monthly rainfall data of seven stations. Annual rainfall of each station calculated from monthly rainfall data and the average annual rainfall computed for each station. Then, a single seven years average value was computed for each station. This value was finally used for surface interpolation using Arc GIS spatial analyst tools. The rainfall map was then reclassified to five classes based on its suitability to mosquito breeding. New values 5, 4, 3, 2 and 1 were assigned to rainfall class 133-144mm, 144-153mm, 153-163mm, 163-174mm, and 174-193mm, respectively. Then the classes were labeled as very high, high, moderate, low and very low malaria risk levels, respectively.

Based on their degree of vulnerability, in the weight overlay table also, the new scale values were given as 5, 4, 3, 2 and 1 for class very high, high, moderate, low and very low respectively. The scale value „5‟ given for class very low rain means that this amount of rainfall is ideally favorable for malaria breeding so that this is more vulnerable for a breeding site whereas the scale value „1‟ given for class very high rain, this means that previous findings indicated that as rainfall is higher, it has a probability of washing down the breeding sites so that it has no chance for malaria breeding rest. That is why the lowest scale value was given to those areas which are less vulnerable to malaria breeding sites.

Topographical Factors

Elevation

Elevation is an important factor for the development of malaria in a particular area, this is because of elevation highly determines the amount of temperature and temperature in turn effect mosquito breeding as the length of the immature stage in the life cycle. In high temperature, the egg, larval and pupil stages will be shortened so that the turnover will be increased and also affect the length of the saprogenic cycle of the parasite within the mosquito host i.e. when temperature increase, the period of the saprogenic cycle will be shorted.

The area which is found below 2,200 a.m.s.l in Ethiopia are highly affected by various type of vector born disease like malaria. UNICEF (2008) states that areas found above 2,200m are considered to be malaria-free. But other researcher agreed that the areas located between 1000- 2000m are most vulnerable to malaria (Tulu, 1993). Currently, the area up to 2,500m which were previously malaria-free, are included under malarious. Elevation of the study area was derived from SRTM data of 30m resolution and reclassified based on the extent of malaria prevalence at different altitudes given by UNICEF (2008). The the layer was reclassified into five classes and new values were assigned to each class and based on this classification, 5, 4, 3, 2 and 1 value given to elevation ranges of 1047-2000m, 2000-2,200m, 2,200-2,500, 2,500-2,832 and 2,832-3164 respectively. These values were seen associated with elevation related malaria risk levels of very high, high, moderate, low and very low malaria risk level respectively.

Slope

Slope is also another topographic factor that may affect the existence of mosquito larval habitat in a certain area. It is the measurement of the rate of change of elevation of the land per unit distance. It affects the constancy of aquatic habitats; steeper slopes are slopes that allow the fast movement of water. Hence, they don‟t allow the development of stagnant water bodies which can be conducive for breeding of mosquito. Relative to steeper slopes, gentler slopes are slopes where surface water movement is stagnant and this creates a suitable condition for mosquito breeding. Therefore, identifying gentler slopes can help to detect the relative importance of areas for mosquito breeding. The slope of the study area was reclassified into five classes using natural break standard reclassification technique.

The natural break (Jenks) method is a widely accepted method and it has the logic which is very most consistent with the purpose of data classification that is forming groups that are internally homogeneous while assuring heterogeneity among classes (Tsega, 2011). Areas with gentle slope are usually typical characteristics of a plain, plateau, and suitable the physical area of the earth for malaria breedings. This creates a favorable condition for mosquito breeding. It allows the formations of various pond areas that are comfortable for mosquitoes to lay eggs and progress to the next development cycle. Slope classes 0-5%, 5-8%, 8-15%, 15-30%, and >30% are the correct classes to indicate the level of existence of water body or marshy area and vegetation within a particular area (FAO, 1976). So, the areas with slopes 0-5% have a high probability to have water bodies and swamp areas and vegetation whereas as the slope above this is not favorable for mosquito breeding. Therefore, the new classes (0-5, 5-8, 8-15, 15-30, and >30), were seen associated with slope malaria risk levels of very high, high, medium, low and very low respectively based on the the relative degree of suitability of the slope class for malaria incidence.

Hydrological Factors

Proximity to Rivers

One of the various water bodies which are used for mosquito breeding is the. For breeding, Mosquito needs stagnant or slow-moving water to lay its eggs and to complete its life cycle to be an adult. Unlike other water bodies, the river is not conducive to this since it disturbs and destroys the eggs and larvae during the downslope movement. But when the water is diverted from rivers for different purposes and in case of flood inundations it decreases its speed and becomes comfortable for mosquito egg-laying. This condition may affect a particular area by increasing mosquito breeding sites and malaria prevalence. Proximity to rivers is generated by using Euclidean distance in spatial analyst tools of Arc Map. According to Abdulhakim (2014) and Hoek et al. (2003), the maximum flight range of Anopheles mosquitos is 2km. Thus, based on the flight range of mosquito the study area was reclassified into five. i.e. < 500m, 500m – 1000m, 1000m-1500m, 1500m-2000m and above 2000m and these classes were assigned new values 5, 4, 3, 2 and 1 respectively. Based on malaria risk levels, these classes were designated as very high, high, moderate, low, and very low river-related malaria risk levels respectively.

Distance from Wetlands and Swamps

Wetlands and swamp area are an important place for the development of malaria in a certain area. Therefore, identifying swamps or ponds and wetlands are useful to know the source of malaria vectors. Since the fly range of mosquitoes is limited and breeding should be done in water, the abundance of mosquitoes can be found around the places where there are patches of standing waters and wetlands.

The premise for assessing areas at risk of malaria infection is based on the maximum distance a a malaria-carrying mosquito can travel from its breeding ground to infect human hosts. For this the study, the swamp and wetland factors were considered to be the most favorable to mosquito larval breeding. Two-kilometer distances around swamps and wetlands larval breeding grounds were taken as an area with high malaria transmission with the increasing transmission. With this evidence, new classes of the wetland and swamp layer were generated to show the highest mosquito density near these areas.

The layer was extracted from the Topographic map of the study area and field data using GPS. Then, distance calculation from these areas and reclassification was done on the layer in Arc GIS environment. Values were assigned for the reclassified map based on mosquitoes flying distance threshold value. Areas out of the maximum flying distance threshold were considered to be less malaria-prone. Therefore, areas found within and outside the two-kilometer distance was reclassified in to five classes as 0-500m, 500-1000m, 1000m-1500m, 1500m-2000m and > 2000m since all the area cannot have an equal and uniform distribution of mosquitoes.

Socio-Economic Factors

To fight malaria and to give attention to the prevention of malaria, we need to map not only natural conditions but also socio-economic factors like health centers distribution, population density, and land use/cover. One can better site the areas with a high risk of malaria and in association with several people that can be affected and preventive measures taken by the nearby health centers.

Distance from Health Centers

Identifying the location and distribution of health centers is important, not only to map risky areas but also to assess the potential needs and the location of existing health centers. The locations of health centers in the study area were obtained from the Kewet Woreda health office and through the ground survey. The map illustrates the sphere of influence of health centers in the study area. This was done by calculating distance from each health center and by reclassifying the distances into 5 classes based on the lowest easily accessible distance.

WHO (2003) States that areas found within 3 Km radius from health centers are assumed to be at lesser malaria risk than areas found outside this distance. Hence, classes of distances; <3000m, 3000-4000m, 4000-5000m, 5000-6000m and >6000m were computed. The classes were given values of 1, 2, 3, 4 and 5 were labeled as very low, low, moderate, high and very high malaria risk level respectively.

Population Density

Growth of population is another factor in the determination of health events such as epidemics of malaria. When the population rapidly increases, it opens doors to new habitats for the malaria vector. Prakash (2014) also indicated that higher population density can lead to more efficient transmission of the virus and thus increased exposure to infection.

To map the population at risk of malaria in the study area, the population density of each kebele was computed on the Arc map after the population of each kebeles was fill on the Microsoft- excel sheet. Then using layer property of population data the final population density map produced. The population density at the kebele level was used because there is no detail population spatial data less than the kebele level. The population density layer was reclassified into five classes as very low, low, moderate, high, and very high. The value very high is assigned to the denser kebeles and the value very low was labelled to less dense kebeles. Therefore, the densely populated kebeles were labelled as highly susceptible for malaria.

Land Use/ Land Cover

It is obvious, the ecological disturbance is unavoidable. When the environment changes from one land use to another, favourable environments might be created for mosquito breeding. In the malaria-mosquito disease-vector combination, there is an association between land cover and vector density on the one hand, and vector density and disease risk on the other side. In the case of the land cover and mosquito population, Munga et al. (2009) indicated that anopheles mosquito complex larvae were mainly confined to valley bottoms during both the dry and wet seasons. They were also located in man-made habitats where riparian forests and natural swamps had been cleared. The association between land cover type and occurrence of Anopheles larvae was statistically significant. It is generally understood that proximity to the water body is important, particularly in the breeding phase of mosquito. Afrane et al. (2005) stated that proximity to the water body has been associated with increased vector density. Thus, the residences which are close to the water bodies are highly affected by malaria than the farthest one.

However, many other related land use/covers make the spread of mosquito increase in a certain area. Such as irrigated farms, settlement, forest area, and others. Brooker et al. (2004) stated that settlement areas are open doors to new habitats for the malaria vector, because not only more people in the city, but also more places which are created by the residence for different purposes later which changes into ponds. Prakash (2014) also indicated that higher population density and interconnection of houses could lead to more efficient transmission of the virus and thus increased exposure to infection. Therefore, the settlement is one of the major causes for the spread of malaria.

According to Boelee (2003), an irrigation system can also lead to the continuous availability of surface water where vectors can breed without restraint. In the irrigated fields mosquito abundance will increase and if these mosquitoes have enough food source in the breeding sites they can be increased in number. The resulting adult mosquitoes may live longer and allow malaria parasites to complete their life cycle so that they can be passed on to another host. Forested areas are areas with high humid conditions which favor the ecological reproduction and transmission of the malaria parasite. Thus, from the above literature, one can understand that each land use/cover have their contribution to the development of malaria in a certain area. Therefore, based on this evidence, the land use/cover map of the study area was reclassified in to five sub-groups based on susceptibility and suitability for malaria risk. So, the reclassified version implies 5 to 1 values, where 5 stands for high prone land use/cover and 1 for less prone land use /cover of malaria risk. Due to their suitability for malaria, water bodies were considered as very high risk in terms of malaria breeding and resting sites in the study area and the remaining settlement and irrigated farm, forest land, rain feed farmland, and bare land were labeled as high, moderate, low and very low malaria risk respectively.

Accuracy Assessment

Accuracy assessment is an essential phase in the land use/ cover classification process. The goal is to quantitatively determine how effectively pixels were grouped into the correct feature classes in the area under investigation. It is derived from the map produced from Land sat and field data. Additionally, a coefficient of agreement between classified image data and ground truth data were calculated using Kappa and its variance.

It is important to measure the agreement between the land use/cover types derived from the Land sat-5 (TM) and the value observed in the field. Kappa statistics are an estimate to measure the agreement between the predicted value and the reference value. It varies between 0(no agreement) and 1(perfect agreement). A kappa value above 0.80 represents a strong agreement, value between 0.40 & 0.80 represent a moderate agreement, while the value below 0.40 represent a poor agreement. It might need reclassification. Accordingly, the confusion matrix was prepared using ground truth points which were collected during the ground survey and the final classified land use/cover map. The result indicated that an overall classification accuracy of 77.9% and kappa statistics of 73%. Thus, the result of kappa coefficient revealed that there is an agreement between the classified map and the reality.

Weight Derivation

All factors which are causes for the breeding of malaria in a certain area must weight based on their influence. Therefore, the factors stated above are ranked based on the level of their impact on malaria breeding and their appropriateness for the development of mosquito. It is obvious that these factors are varying spatially. Thus, based on previous works and the information that collected through interviews with world health office, weight were assigned for each factor. Weights are assigned by pairwise comparison 9 points continuous rating scale on IDRISI Selva 17.0 and factor weights were calculated by comparing two factors at a time depending on their importance.

Weight Derivation for Environmental and Socio-Economic Factors

The malaria risk level of the study area was recognized by assigning weight for all environmental and socio-economic factors. These are: temperature, elevation, rainfall, proximity to water bodies, slope, land use/cover, distance from health centers and population density. The significance of these factors for malaria breeding was explained in chapter two under literature review part. Therefore, based on their importance for the development of mosquito in the study area, weight is

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computed using pairwise comparison 9 points continuous rating scale on IDRISI Selva 17.0.

To assign a weight for each factor, as already described in the Criterion Weighting method in chapter three, the researcher uses previous malaria-related researches and the current condition of the study area. To consider the current local condition, field observation and discussion with woreda health Officials were made. Therefore, based on this, elevation determines the incubation rate and breeding activity of mosquito given the highest weight followed by rainfall and proximity to wet and swamp area.

The area is found in the altitude between 1047-3164. However, most of Kewet Woreda is dominated by lower altitude. It makes the area become the home of vector born disease including malaria and the remaining factors proximity to the river, temperature, proximity to the health facility, slope, land use/land cover and population density were assigned as fourth, fifth, sixth, seventh, eighth and ninth factors respectively.

Malaria Risk Map

Malaria risk map of the study area was produced on Arc GIS 10.1 spatial analyses tools using weighted overlay. Therefore, all environmental and socio-economic factors mentioned above, proximity to water bodies, proximity to the health facility, temperature, rainfall, elevation, slope, land use/cover, and population density overlaid based on their weights. To identify the malaria risk area, in this study; elevation, temperature, rainfall, distribution of health center, population density, proximity to the river, swamp area and wetland, slope and land use/ cover were used as input factors for malaria risk mapping. Therefore, around 36.5 (25%) of the total study area is subjected to very high, 66.4 (45.4%) labeled as high malaria risk, and the remaining 33.5 (22.9) and 9.83 (6.7%) area has moderate and low malaria risk level respectively. Thus, from this, it is possible to conclude that more than 70% of the area is under high risk of malaria.

Comparing Malaria Risk Level among Kebeles

At kebele level, malaria risk map was generated by overlaying malaria risk level map of the study area and kebele boundary map. Thus, from the entire kebele of the study area Shewa Robit town, Deberena jegol, Yelen, and Yemegist den were labeled as very high malaria risk area, Abay atir, Kure beret, Jimderena gur, Medina, Korebeta, Mariyena insirt, Abomsana wuruba, Birbirina jegol, Alolo Wenberya, Jib Amba, Agam Ber, Sefibert and Mengisiti ena wodaj were subjected to high malaria risk and the remaining six and one kebeles were found to have moderate to low malaria risk respectively. Whereas the areas that fall under very high and high were highly vulnerable to mosquito breeding. Those areas fall under moderate and low exhibit less vulnerability due to the factors mentioned in the previous section.

Conclusion

The main objective of this study was to assess and map the risk of malaria using GIS and remote sensing in Kewet Woreda, North Shewa Zone, Amhara region. To generate the malaria risk maps several factors like environmental factors (elevation. Slope, proximity to the river, swamp and wetlands, climatic factors (rainfall and temperature) and socio-economic factors (proximity to health facilities, land use/cover and population density) were considered and the maps were reclassified based on their suitability for malaria breeding and incidence. Depending on the amount of influence of each factor, weight was computed for each factor by using pairwise comparison 9 points continuous rating scale on IDRISI. Then weighted overlay was undertaken on Arc GIS 10.1 environment to produce the final malaria risk map. The final malaria risk map of the study area indicated that 25% of the study area is in very high malaria risk, 45.4% of the an area in high and the remaining 22.9% and 6.7% of the area in moderate to low malaria risk respectively.

At kebele level, the entire area of Shewa Robit town, Yelen, Deberena Jegol and Yemengist Den are very highly affected by malaria and more than half area of 14 rural kebeles fall under high malaria risk. The remaining six and one kebeles were labeled as the moderate and low affected area respectively. Therefore, the existence of a suitable climatic condition, lower elevation, river, swamp, and wetland plays a great role in the spread of malaria in the study area. Moderate and low-risk levels are confined to areas that are far from water bodies. The result confirmed that such technology is important tools for the analysis of malaria risk levels in an area considering several environmental and soci-economic factors. It is vital tool for the health sector, government and other concerned body to facilitate vector born disease control and prevention program by establishing early warning system.

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