



**ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
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GIS AND REMOTE SENSING**



**GIS AND REMOTE SENSING INTEGRATED
MALARIA RISK MAPPING IN
DEMBIA WOREDA, NORTHERN ETHIOPIA,
(MSc.THESIS)**

***A thesis submitted to school of graduate studies
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As partial fulfillment of the requirement for the degree of
Masters of Science in GIS and remote sensing***

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BY

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A THESIS

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List of Acronyms

CSA	Central Statistics Agency
DEM	Digital Elevation Model
ESRI	Environmental System Research Institute
GPS	Global Positioning System
IDW	Inverse Distance Weight
MCE	Multi Criteria Evaluation
MSS	Multi Spectral Scanning
NMA	National Meteorological Agency
WWDSE	Water Works Design and Supervision Enterprise

Abstract

Every year, malaria continues to claim over a million lives around the globe. Attempts have been made to control the disease by eliminating the parasite. However, unknown spatial distribution of mosquito known to cause malaria, eradication of the parasite remains a daunting task. As a result, increased efforts and resources have been channeled towards finding ways of minimizing the disease. There for this investigation is aimed to contribute the concept and methods of the innovative development and application of GIS and RS regarding malaria prevalence in Dembia Woreda. The input data are based on the geospatial factors including climatic aspects, social aspects and Topographic aspects from primary & secondary data. After words The malaria hazard analysis was computed using multi criteria evaluation (MCE). To run MCE, the selected environmental factors such as topographic factors (elevation, , and flow distance to stream, land use/ land cover and aquatic bodies were developed and weighted. Then weighted overlay technique was computed in ArcGIS9.1 Model Builder to generate malaria hazard map. For vulnerability analysis, health station location in Spatial Analyst/ module was used to generate factor maps. For element at risk, land use land cover map was used to generate element at risk map. To generate malaria risk map of the woreda, land use land cover map which is the element at risk in the woreda, the vulnerability map and the hazard map were overlaid using weighted overlay analysis technique in ArcGIS9.1 environment. The final out put based on this approach is a malaria risk map, which is classified in to 3 classes including, High-risk area, moderate risk area and low risk area. This help to plan valuable measures to be taken in early warning, monitor, control and prevent malaria epidemic.

Chapter One

1 Introduction

1.1 BACKGROUND

Malaria, now days, is one of the main health problem in the world. In poor continents like Africa the problem is very much pronounced because of several factors. Poverty, backwardness and political instabilities are the main obstacles in combating the problem and securing sustainable development. Ethiopia, one of the poorest countries in Africa is the victim of malaria epidemic and it is far reaching negative impact. Malaria is one of the main health problems in Ethiopia. However; it should not be narrowly understood as simple health problem. It has an immense impact in the social, economical, political and cultural well being of the society. Olusegun Babaniyi (2005) WHO representative to Ethiopia explained the wider impacts of the epidemic as follows:

It not only does malaria result in loss of life and lost productivity due to illness and premature death, but malaria also hampers children's schooling and social development through both absenteeism and permanent neurological and other damage associated with severe episodes of the disease..... Malaria is known to be both a disease of poverty and a cause of poverty. It accounts for 40% of public health expenditures. .. Malaria severely strains the economic growth of the timely detect, verify and notify malaria epidemic within two weeks of onset and provide adequate management at home and in health facilities Ethiopia bears one of the highest malaria and malaria epidemic burden in Africa with more than 48 million at risk population and 4-5 million clinical cases occurring per year. It cannot be exception to all of these problems...

In Ethiopia malaria cases are one of the highest and it is increasing in an alarming rate. The main reasons given for the increment are ecological and climatic changes. Additionally, in Ethiopia the topography made a fertile ground for the reproduction of the epidemic. As malaria is a leading public health problem in Ethiopia. Almost 75%

of the land is malaria and estimated 48 million (68%) of the population lives in areas at risk of malaria.

There should be a mechanism to prevent or to manage the epidemic. Early detection and monitoring systems must be adopted to mitigate the damages caused by the disease.

GIS and remote sensing is one of the recent tools in identifying, classifying and mapping areas vulnerable to the problem. In reducing the impact of the epidemic proactive measures are more effective and fruitful than post management plans and actions, as prevention is better than cure.

A report on epidemiology underlined that reducing the impact of malaria epidemic largely depends on its early detection and timely targeting of appropriate and effective control measures. Currently, there are no robust forecasting and early warning methods that can guide estimation on the likely burden of malaria with good lead-time to ensure preparedness. As a result epidemics capture health facilities and communities almost unnoticed until the capacity of health facilities is overwhelmed. Apart from this, the existing surveillance system aimed at early detecting, verification, notification and containment of an epidemic occurrence with in two weeks of its onset needs to be strengthened.

In any disease control program, there are several factors involved, namely estimation of disease burden, monitoring of disease trend, identification of risk factors, planning, allocation of resources, implementation etc.

In this regard GIS has a spatial role to play Geographic Information System owing to its inherent ability to manage both spatial and non-spatial information provides an excellent framework for disease monitoring and control

1.2 STATEMENT OF THE PROBLEM

It has been a long time that malaria identified as the major health problem. And malaria epidemic have had a remarkable impact on the social, economical, and political sphere of the society. In poor countries like Ethiopia the problem is more complex and needs thorough investigation and special care as it can be a pretty obstacle to development. A wide range of measures were taken by national and international organizations to reduce the impact of the epidemic but most of the

efforts were invested on managing the results than prevention. Preventive measures are cost and time effective. In addition it is successful in mitigating the far-reaching negative impacts of the problem.

One of the measures to be considered as preventive is to work on the main factors contributing for the development and expansion of the problem. In this regard Geographic Information System and Remote Sensing (GIS AND RS) can best fit to investigate the root problem both spatially and temporally. Aruna Srivastava (2004) summarized the role of GIS and RS in disease control as follows:

“In any disease control program there are several factors involved namely estimation of disease burden, monitoring of disease trend, identification of risk factors, planning, allocation of resources, implementation etc. and a common thread involved in all these activities is Geographic Information System (GIS & RS)”

Generally speaking ecological and climatic anomalies are believed to be the main factors for expansion of the epidemic even to formerly malaria free areas. But specifically question like what components of the ecosystem and climate are in touch with the vector and the agent? How the ecological and climatic components contribute for the occurrence, growth and expansion of the agent and the vector, and how these factors are interrelated? Need to be investigated, analyzed and interpreted.

The main task of this work is to employ advanced techniques like GIS and remote sensing to identify, classify, and map areas vulnerable to malaria epidemic. In addition different factors need to be identified and data layers should be produced, combined and analyzed together in away that foster prevention.

1.3 Malaria situation in Dembia woreda

The occurrence of the malaria epidemics in the study area has been more frequent and wide spread in recent years. Although rainfall associated breeding of the major vector anopheles and abnormal climatic changes are the main causes of rise to major epidemics. These epidemics have usually inflicted high incidence of mortality upon the society. For instance from 1980s up to now 30000-60000 malaria cases registered per year. Which means more than half of the Dembia woreda population is expected to live at risk of malaria .There for sustainable malaria control strategy knowledge about the distribution of the diseases incidence and the relevance of influencing factors in Dembia woreda specific setting is important.

1.4 SIGNIFICANCE OF THE STUDY

Broadly the final outcome of the research is believed to help national and international organizations working in the health and related sectors in organizing their efforts towards the fight against malaria. It also helps policy makers, decision makers, investors and investment plans and other in their career.

Ministry of Health (MOH), in particular, is the main beneficiary in using the findings of the paper as an input meeting the Abuja goals and in its malaria related plan. MOH can also use the result in its effort to identify, monitor and prevent malaria epidemic. Furthermore it helps to implement early detection and warning systems and mobilizing health facilities to control the disease and see the future possibilities of occurrence and trend of the epidemic so as to take pro-active measures and rescue the economic and life loss. And it has a special place to make objective and well informed decisions.

Finally, the findings of the research can serve as an input for further wider investigation in mapping the spatial and temporal malaria distribution in the study area and similar ecosystems at large.



Parents with children suffering from severe malaria and malnutrition seek treatment at Dembia clinic

1.5 Objectives

1.5.1 General Objective

- To assess malaria risk in Dembia woreda using multi criteria evaluation technique in GIS environment

1.5.2 Specific Objectives

- To map areas of Dembia woreda in terms of malaria risk and hazard using multi criteria evaluation technique in GIS environment
- To construct land use/ land cover map for Dembia woreda using LandsatETM satellite image of 2000.
- To identify aquatic bodies using image enhancement techniques for malaria hazard mapping
- To compute topographic factors like elevation, , flow length to stream, wetness index and slope by terrain analysis using DEM (TauDEM) in ArcGIS environment
- To cross tabulate malaria risk map with patient data for Dembia woreda
- To recommend the priority areas for mitigation measures against malaria risk
- To propose valuable measures to be taken in controlling, and preventing malaria epidemic.

1.6 Material and Methods

1.6.1 Material

The data and their sources used to generate malaria risk map of Dembia woreda are reported in Table 1.1

1.6.1.1 Software

Software used in this study is selected based on the capability to work on the existing problems in achieving the predetermined objectives. Hence software package like ERDAS Imagine 8.6 was used for image processing operation on satellite images.

The factor map development was carried out using ArcGIS9.1 software package. The factors that are input to for multi-criteria analysis were preprocessed in accordance to the criteria set to develop malaria hazard analysis. So using Spatial Analyst and 3D Analyst extension, some relevant GIS analyses were undertaken to convert the collected shape files. Eigen vector for the selected factor was computed using Weight module in IDRISI 32 software.

1.6.2 Methods

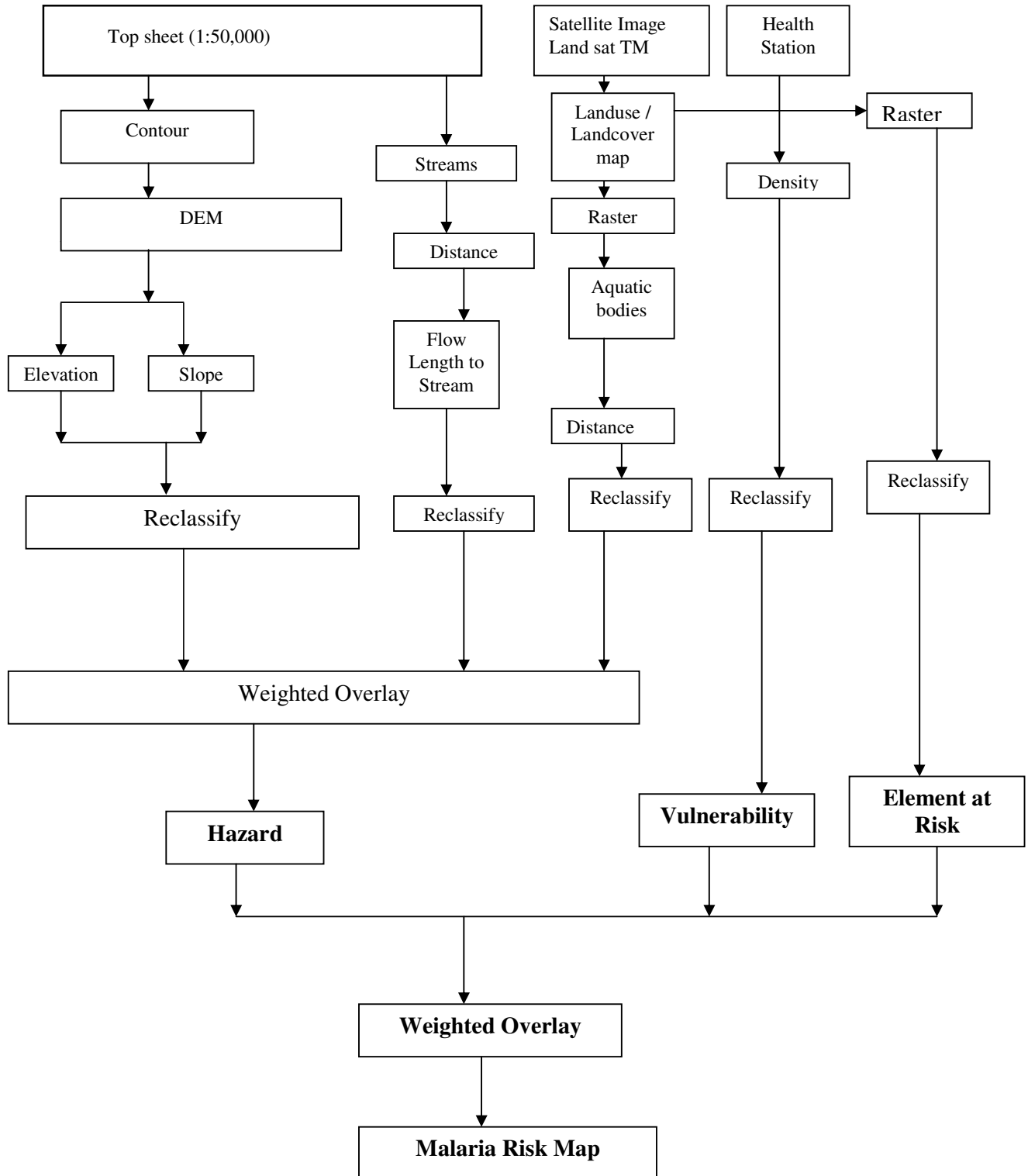
1.6.2.1 Malaria risk analysis in Dembia Woreda

Malaria risk of the woreda was analyzed from the following general risk equation Shook, (1997).

$$\text{Risk} = (\text{Elements at risk}) * (\text{Hazard} * \text{Vulnerability})$$

The malaria hazard analysis was computed using multi criteria evaluation (MCE). To run MCE, the selected environmental factors such as topographic factors (elevation, slope and flow distance to stream), land use/ land cover and aquatic bodies were developed and weighted. Then weighted overlay technique was computed in ArcGIS9.1 Model Builder to generate malaria hazard map. For vulnerability analysis, health station location in Spatial Analyst/ module was used to generate factor maps. For element at risk, land use land cover map was used to generate element at risk map. Finally to generate malaria risk map of the woreda, land use land cover map which is the element at risk in the woreda, the vulnerability map and the hazard map were overlaid using weighted overlay analysis technique in ArcGIS9.1 environment. (Fig 1.1)

Fig 1.1: Work Flow of malaria Risk and malaria Hazard Analysis



1.6.2.2 Computation of land use map of Dembia woreda

Land use/land cover classes of Dembia woreda have been classified using Landsat ETM+ 2000 with a spatial resolution of 28.5m. However, the coarse resolution bands (band4 near infrared and band 7 mid infrared) were spatially merged with high spatial resolution (14.5m) panchromatic band 8 using spatial/merge model in ERDAS 8.6 software. Accordingly, composite bands of 7, 4,2 RGB order were stacked .spatial enhancement technique like tasseled cap was used to identify aquatic bodes . Accordingly the woreda was classified in to six land use land cover classes these are aquatic bodes, cultivated land, barren land, open shrub land, dense vegetation, and settlement.

Ground truth and accuracy assessment point were collected using GPS. Supervised classification method was carried out based on the existing land use land cover map of Dembia woreda developed by woody biomass. Accuracy assessment was computed using Ground truth ROI technique in post classification method in ENVI 4.2 software.

Table1.1 Data and their source for mapping malaria risk in Dembia woreda

Roll No.	Data Type	Scale	Source	Remarks
1	Top sheet	1:50,000	EMA	4 toposheets
2	Landsat ETM (2000)	Resolution: 14.5m	AAU	1 Scene
3	Monthly mean Temperature	-	NMA	20 years
4	Health Station Location	-	CSA	Point data

CHAPTER TWO

Literature Review

2.1 Theoretical Background

2.1.1 What is Geographic Information System (GIS)?

The heart of GIS is the analytical capabilities of the system. What distinguish the GIS from other information systems are its spatial analysis functions. Although the data input is, in general, the most time consuming part, it is for data analysis that GIS is used. The analysis functions use the spatial and non-spatial attributes in the database to answer questions about the real world. Geographic analysis facilitates the study of real-world processes by developing and applying models. Such models illuminate the underlying trends in geographic data and thus make new information available. Results of geographic analysis can be communicated with the help of maps, or both.

The organization of database into map layers is not simply for reasons of organizational clarity; rather it is to provide rapid access to data elements required for geographic analysis. The objective of geographic analysis is to transform data into useful information to satisfy the requirements or objectives of decision-makers at all levels in terms of detail. An important use of the analysis is the possibility of predicting events in another location or at another point in time.

A working Geographic Information System seamlessly integrates five key components: hardware, software, data, people, and methods.



Fig2.1: Components of Geographic Information System

2.1.2 Data Models in GIS

There are two types of data models in GIS. There are two conceptual representations used in GIS: grid (sometimes called 'raster') and vector. These are very different ways of thinking about geography, which lead to very different methods of analysis.

The grid or 'raster' representation of a map assumes that the map area is divided into cells (sometimes erroneously called pixels), normally square or at least rectangular, on a regular grid. Each cell is supposedly homogeneous, in that the map is incapable of providing information at any resolution finer than the individual cell. The map shows exactly one value (land use, elevation, political division, etc.) for each cell. This is a very simple representation in the computer: conceptually, a 2-D matrix of values which correspond to a grid placed over the paper map. (Fig 2.2)

The vector representation of a map is points on a map are stored in the computer with their 'exact' (to the precision of the original map and the storage capacity of the computer) coordinates. Points can be connected to form lines (straight or described by some other parametric function) or chains; can be connected back to the starting point to enclose polygons or areas. (Fig 2.2)

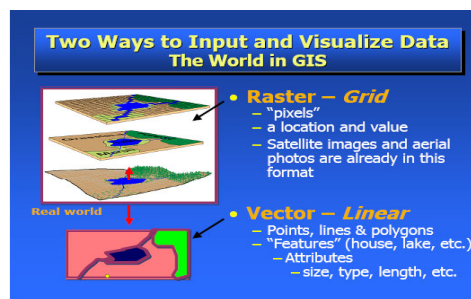


Fig2.2: Data Models in GIS

2.1.3 Raster Data Analysis

2.1.3.1 Raster Overlay

In raster overlay, the pixel or grid cell values in each map are combined using arithmetic and Boolean operators to produce a new value in the composite map. The maps can be treated as arithmetical variables and perform complex algebraic functions. The method is often described as map algebra. The raster GIS provides the ability to perform map layers mathematically. This is particularly important for the modeling in which various maps are combined using various mathematical functions. Conditional operators are the basic mathematical functions that are supported in GIS.

2.1.4 Multi-Criteria Evaluation (MCE)

In Decision theory, Multi-Criteria Evaluation is the process of applying a decision rule to a set of alternatives. A decision rule is a procedure by which criteria are combined to arrive at a particular evaluation, and by which evaluations are compared and acted upon. A decision is a choice between alternatives (such as alternative actions, land allocations, etc.). The basis for a decision is known as a criterion. Criteria may be of two types: factors and constraints. Factors are generally continuous in nature (such as the slope gradient or road proximity factors); they indicate the relative suitability of certain areas. Constraints, on the other hand, are always Boolean in character (such as the reserved lands constraint in the example above). They serve to exclude certain areas from consideration. Factors and constraints can be combined in the MCE module using one of three methods (Boolean intersection, Weighted Linear Combination and Ordered Weighted Average); each method is characterized by different levels of control over tradeoff between factors and the level of risk assumed in the combination procedure.

Trade off is the degree to which one factor can compensate for another; how they compensate is governed by a set of factor weights sometimes called tradeoff weights. Factor weights are given for each factor such that all factor weights, for a set of factors, sum to one; they indicate the relative importance of each factor to the objective under consideration. A factor with a high factor/tradeoff weight may compensate for low suitability in other factors that have lower factor/tradeoff weights.

In a Multi-Criteria Evaluation, an attempt is made to combine a set of criteria to achieve a single composite basis for a decision according to a specific objective. For example, a decision may need to be made about what areas are the most suitable for industrial development. Criteria might include proximity to roads, slope gradient, exclusion of reserved lands, and so on. Through a Multi-Criteria Evaluation, these criteria images representing suitability may be combined to form a single suitability map from which the final choice will be made Eastman (2001).

The second method in MCE is a Weighted Linear Combination (WLC) where criteria may include both weighted factors and constraints. WLC starts by multiplying each factor by its factor/tradeoff weight and then adding the results; constraints are then applied by successive multiplication to "zero out" excluded areas. This procedure is characterized by full tradeoff between factors and average risk. Factor weights, not used at all in the case of Boolean intersection (no tradeoff), are very important in WLC because they determine how individual factors will tradeoff relative to each other. In this case, the higher the factor weight the more influence that factor has on the final suitability map. (Contrast this with method 3 below where the importance of factor weights is variable). Along with full tradeoff, this combination procedure is characterized by an average level of risk, as it is exactly midway between the minimization (AND operation) and maximization (OR operation) of areas to be considered suitable in the final result Eastman (2001).

2.5.1 Remotely Sensing

Remote Sensing is the science and art of acquiring information (spectral, spatial, and temporal) about material objects, area, or phenomenon, without coming in to physical contact with the objects, or area, phenomenon under investigation. Without direct contact, some means of transferring information through space must be utilized. In remote sensing, information transfer is accomplished by use of electromagnetic radiation (Lillesand and Kiefer, 2004).

Image processing and analysis can be defined as the process of examining images for the purpose of identifying objects and judging their significance. Image analysis is the study of remotely sensed data and attempt through logical process in detecting, identifying, classifying, measuring and evaluating the significance of physical and cultural objects, their patterns and spatial relationships.

Digital image consists of discrete picture elements called pixels. Associated with each pixel is a number represented as DN (digital Number) that depicts the average radiance relatively small area with in a scene. The range of DN values being normally 0 to 255. The size of this area affects the reproduction of details with in the scene. As the pixel size is reduced more scene detail is preserved in digital representation (Lillesand ad Kiefer, 2004) Digital image analysis is usually conducted using raster data structure-each image is treated as an array of values. It is easy to find and locate pixels and their values. Disadvantages become apparent when one needs to represent the array of pixels as discrete patches or regions, where as vector data structures use polygonal patches and their boundaries as fundamental units for analysis and manipulation.

2.1.6 Digital Image Processing

Digital image processing involves the manipulation and interpretation of digital images with the aid of computer. The central idea behind digital image processing is quite simple. The digital image is fed into computer one pixel at a time. The computer is programmed to insert an image into an equation, or series of equations, and then store the results of the computation for each pixel. These results form a new digital image that may be displayed or recorded in pictorial format or may be further manipulated by additional programs. Basically all the digital image manipulation can be categorized in to seven broad types of computer assisted operations Lillesand et al. (2000).

In this study only three types of digital image processing operations were used: image rectification and restoration (preprocessing), image enhancement and image classification.

Preprocessing is aimed to correct distorted or degraded data to create a more faithful representation of the original scene. This typically involves the initial processing of raw image data to correct for geometric distortions, to calibrate the data radio metrically, and to eliminate noise present in the data. Image enhancement is a procedure applied to image data in order to more effectively display or record the data for subsequent visual interpretation. Normally, image enhancement involves

techniques for increasing the visual distinction between features in a scene. For instance, Linear Stretch, which is one of the Contrast Stretching techniques, is the uniform expansion of limited image levels range to fill the range of display values (0-255). Subtle variations in input image data values would now be displayed in output tones that would be more readily distinguished by the interpreter. Light tone areas would appear lighter and dark areas would appear darker.

The algorithm for linear stretch that would be applied to each pixel in the image:

$$DN_{ifl} = \left[\frac{DN - MIN}{MAX - MIN} \right] * 255 \dots \dots \dots \text{Equation 2.1}$$

Where:

DN_{ifl} = digital number assigned to pixel in output image

DN = digital number of pixel in input image

MIN = minimum value of input image, to be assigned a value of 0 in the output image

MAX = maximum value of input image, to be assigned a value of 255 in the output image

Image classification is an operation to replace visual analysis of the image data with quantitative techniques for automating the identification of features in a scene. This normally involves the analysis of multispectral image data and the application of statistically based decision rules for determining the land cover identity of each pixel in an image. When these decision rules are based solely on the spectral radiances observed in the data, we refer to the classification process as spectral pattern recognition. In contrast, the decision rules may be based on the geometric shapes, sizes, and patterns present in the image data. These procedures fall into the domain of spatial pattern recognition. In either case, the intent of the classification process is to categorize all pixels in a digital image into one of several land cover classes, or themes. These categorized data may then be used to produce thematic maps of the land cover present in an image and/or produce summary statistics on the areas covered by each land cover type.

A classification is not complete until its accuracy is assessed. A thorough overview of the principles and practices currently in use for assessing classification accuracy has been prepared by Congalton et al. (1999).

2.1.7 Malaria and Related Facts

Malaria poses an enormous problem in Africa. It is estimated that malaria causes 1-2 million deaths and 300-500 million clinical episodes annually (World Health Organization, 1994). Of the global deaths due to malaria about 90% now occur in Africa. A similar picture is seen for clinical episodes. This situation results both from the particular epidemiological situation in Africa and the nearly total absence of systematic control activities during the past decades. As a result, the burden of the disease on societies and economies is tremendous.

Fortunately the situation has recently been receiving renewed attention by national and international health and funding organizations. In particular, the recent call by the new Director-General of the World Health Organization, Dr Brundland, to "Roll back malaria" is encouraging in this respect. The development of continental to district planning tools is therefore very timely.

2.1.8 The Need for Malaria Maps

Mapping malaria endemicity is crucial for a number of reasons. Firstly, areas without risk of malaria need to be identified, while areas with epidemic malaria need to be highlighted and integrated into an adequate early warning system. This is a very fundamental and important undertaking in order to define the size of the malaria problems in each country.

Secondly, in areas of endemic malaria, the pattern of severe malaria disease has been shown to vary according to the intensity of the transmission [Bal Krishnan P. \(1998\)](#). . In areas with lower levels of endemicity the disease pattern was found to be dominated by cerebral disease forms in older children (over 2 years of age) while in areas of very high transmission the disease pattern was dominated by severe malaria anaemia in young children and infants. This age-dependence of malaria disease according to the intensity of malaria transmission has great practical importance for

the preventive and curative services since both the target age group and the clinical care need to be adapted.

2.1.9 Highland malaria: contexts and definitions

There is not a straightforward definition for highland malaria. While it would be simple to describe it as 'malaria which occurs in highlands', the term 'highland' is itself a relative term which can be variously defined depending on the topic and area of interest. In addition, while altitude has long been recognized as an important determinant of malaria endemicity, (*e.g.* Braun *et al.* 1997). it is those transmission factors which are directly or indirectly affected by altitude that are of epidemiological significance, rather than altitude. Probably most important of these is environmental temperature, which effects the development and survival of the vector and, more significantly, the duration of *Plasmodium* development within the invertebrate host. In simple terms the duration of sporogony increases hyperbolically with decreasing environmental temperatures to a point where parasite development ceases altogether.

This critical temperature varies by parasite species; for *P. falciparum* laboratory studies have estimated it to be in the range 16-19 °C and in practice it is commonly assumed that transmission will be limited to months in which the average annual temperature is above this threshold. Field observations generally concord with these findings. In India, Gill (1923) observed that a annual mean temperature of 61.0 °F (16.7 °C) was required for malaria transmission and a similar threshold has been applied in Kenya (Garnham 1948). Given that altitude and environmental temperatures vary inversely (as defined by the environmental lapse rate), it follows that a threshold altitude will exist at which malaria transmission ceases to be possible.

2.1.10 The relationship between altitude and temperature

The relationship between altitude and temperature is often oversimplified and in practice may vary substantially over time and space. At the continental scale the effect of latitude is important and its significance in the context of malaria has long been recognised (*e.g.* Gill 1923). Solar radiation received at the Earth's surface, and consequently mean annual temperature, is greatest in the tropics and declines towards the poles (although aspect may alter this pattern significantly at the local level).

Latitude also influences the relative importance of seasonal and diurnal variations in climate, with the latter tending to predominate in tropical highlands.

Highland temperature regimes are also affected by continentality. Specifically, diurnal and annual temperature ranges tend to become smaller with increasing proximity to large water bodies, while incidence of cloud and mist increases, thereby leading to significant reductions in temperature (the Eastern Usambaras in Tanzania, situated relatively close to the Indian Ocean, offer a good example of this). In Africa, the sheer extent of the upland areas enhances the effect of continentality, creating what some have termed 'continents within continents.'

Finally, the adiabatic lapse rate (ALR), which describes the reduction in day time temperature with increasing elevation, is itself not a constant term, and depends on the degree to which the air is saturated. In completely unsaturated air, the (dry) ALR is $0.98\text{ }^{\circ}\text{C per }100\text{ m}$ but this rate decreases as saturation increases. In reality air is almost always partly saturated, and while lapse rates of around $1\text{ }^{\circ}\text{C per }100\text{ m}$ are most common, spatial and temporal variations in humidity can make lapse rates extremely variable (*e.g. Yohannes 1996*). At night, the situation may be quite different and temperature inversions are not uncommon.

2.1.11 Other risk factors for highland malaria

The discussion has so far assumed implicitly, and for the sake of illustration, that elevation with temperature is the principal factor limiting malaria transmission in highland areas. Indeed this is often assumed to be the case, so that a picture emerges for tropical Africa in which the boundary of endemic malaria is constantly pushing up against its climatological limits. In high altitude areas this assumption may be well grounded, but in more 'marginal' fringe areas a host of other factors may be significant in determining the extent to which transmission occurs. These have been reviewed elsewhere and are outlined only briefly here.

As this report will go on to argue, it is likely that slope, aquatic bodies, flow distance to stream and wetness of the land are critically important in determining the nature and scale of malaria transmission in highland areas. Moreover, from a geographical perspective it is probably significant that (in addition to elevation/temperature because

of elevation is directly related to temperature, which affects mosquito survivorship) slope (measurement of the rate of changes) also another factors include Wetness index or topographic index represents land surface moisture content. It was calculated as $\ln(A/TanB)$ where A was the upslope contributing area and $TanB$ was the local slope. Parametres A and $TanB$ were derived using a multiple flow-direction algorithm. Flow distance-to-stream may affect availability of the aquatic habitat and is calculated as the distance from a grid cell moving downstream to a stream grid cell defined by the Stream Raster grid. The advantage of using flow distance-to-stream rather than simple distance-to-stream is that flow distance takes flow direction and landscape profile into consideration. Slope of the land is another factor which may affect the stability of the aquatic habitat.

2.1.12 Why is Highland Malaria Important?

Recently there has been much speculation on the issue of highland malaria in Africa. Highlands have always been regarded as areas of little or no malaria transmission, mainly because of low temperatures. However, this appears to be changing. There is a lot of recent evidence that shows an increase in the number of epidemics in highland areas, as well as a spread of endemic malaria into the highland fringes. Various reasons for this apparent change in epidemiology have been put forward; most prominent are those arguments that implicate climatic and ecological change. Unfortunately the lack of reliable malaria data for most highland areas has made analysis of these issues difficult.

Epidemic malaria in highland areas represents a significant public health problem. Historically, low risk of infection in highland areas has created little functional immunity in local populations, resulting in relatively high case mortality in adults and children during epidemics. At the same time, national malaria control programmes have not been well equipped to identify and respond to epidemics. There is, therefore, a need for increased scientific understanding of the epidemiology of highland malaria, as well as greater capacity in epidemic surveillance and response. The HIMAL project, which was the product of a TDR workshop on highland malaria in Addis Ababa in 1996, is designed to address these issues.

2.1.13 Malaria transmission in the highland zone of Ethiopia

MALARIA TRANSMISSION IN ETHIOPIA

The map below shows malaria transmission distribution in Ethiopia. Epidemics tend to occur in the parts of the white and pink areas below 2,200 meters, where people have not acquired immunity to malaria. Areas above 2,200 in the white areas are malaria free. Red and green areas are subject to seasonal malaria with transmission of more than three months, leading to acquired immunity among people. Only exceptionally do epidemics occur in these areas.

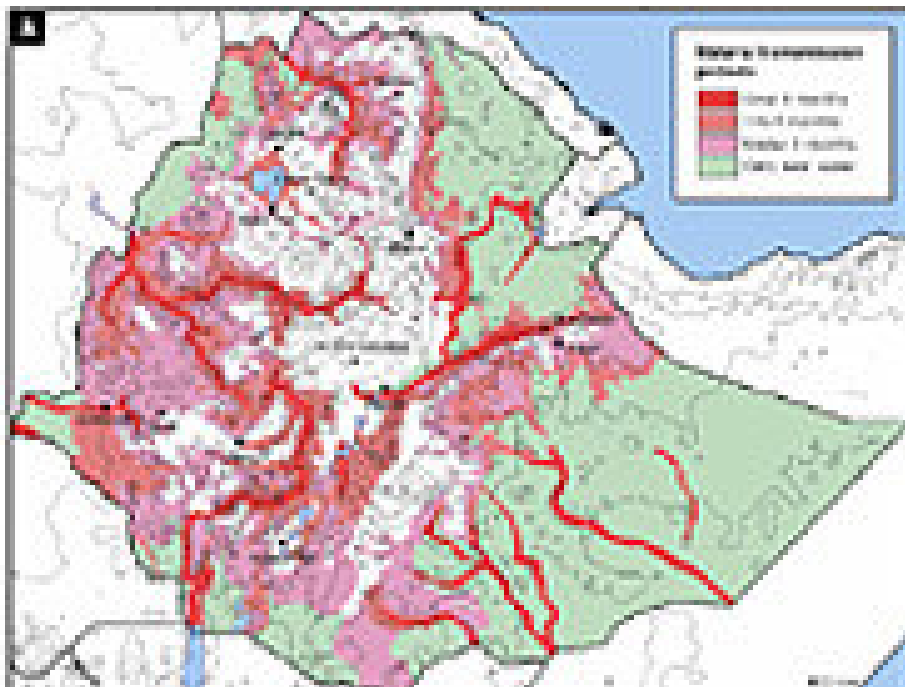


Fig show Malaria distribution map in Ethiopia.

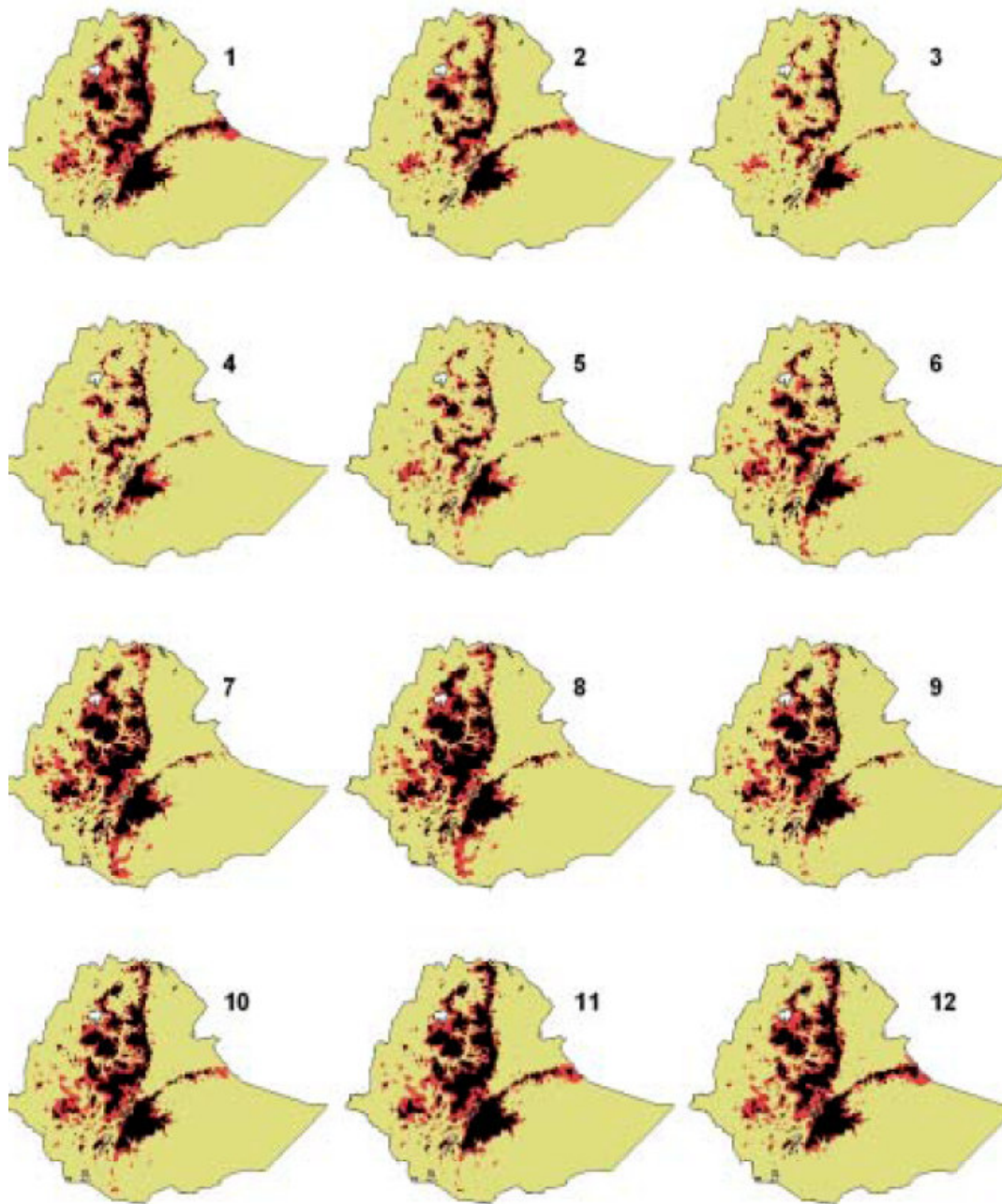


Figure 6.2

Yellow shading indicates areas where temperatures are likely to support malaria transmission in a particular month, while black shading signifies localities where temperatures are likely to be limiting. Red areas are intermediate and probably represent the altitudinal fringes of transmission (see Section 4.1)

2.1.14 LOCATION AND MAJOR CHARACTERISTICS OF EPIDEMIC-

PRONE AREAS

Generally, highlands or highland-fringe areas between 1000 and 2000 meters can be considered as highly epidemic-prone. Desert-fringe or semi-arid areas are also epidemic-prone. Occasionally, areas even above 2000 meters altitude (up to 2400 m) are also affected by seasonal epidemics. Only few areas in western parts of the country (areas bordering the Sudan) have relatively somewhat stable transmission of malaria (although population migrations such as resettlement and labor force movement and agricultural development activities have contributed to appearance of unstable situations in these areas in recent years). Epidemic-prone areas in Ethiopia can be divided into two: areas affected by seasonal malaria epidemics and areas which are affected by occasional or sporadic epidemics. (MOH, Ethiopia, 2000)

2.1.14.1 Areas Affected by Seasonal Epidemics

Epidemic-prone areas with lower altitudes are affected almost every year by seasonal malaria outbreaks, which are mainly associated with rainfall intensity and pattern. During most parts of the year these areas remain malaria-free or with very low transmission near water bodies. When favorable weather conditions occur during malaria seasons,

2.1.14.2 Areas Affected by Periodic Epidemics

These are areas with high altitudes (including those above 2000 meters altitude, which are normally considered as 'non-malarious'). During some years, when climatic conditions (especially increase in air temperature and excess or deficit rainfall) favor the transmission of the disease, severe epidemics occur in these areas. Mortality rates among affected populations are usually very high due to almost complete lack of immunity. Most of these areas are exempted from the regular residual spraying due to absence of disease (in some cases for several years); they may be sprayed during epidemics only. As it has been difficult to forecast the likelihood of malaria epidemics in these areas, occurrence of transmission are mainly detected after large areas had been affected. Also semi-arid areas with lower altitude may be occasionally affected by malaria epidemics due to availability of surface water including development areas, especially development schemes.

CHAPTER THREE

General Description of the study Area

3.1 Location

The study area, Dembia Woreda is located North in the Amhara regional state in the blue Nill river basin which encompasses a total area of 1136 square kilo meter. It is located between N1211093, N1410400 and E253327, E416676 at UTM coordinate system (fig Map of study area)

Tana Lake borders it in the South, South East and South west and Gonder /Azezo town in the north. Dembia woreda is accessible by cars and is about 610 km road distance to the North of the Addis Ababa. the woreda also characterized by a chain of mountains and upland at the foot of the mountain chain covering 30% and low laying flat land accounting for 50 % of the land area (Abebe since, 2004)

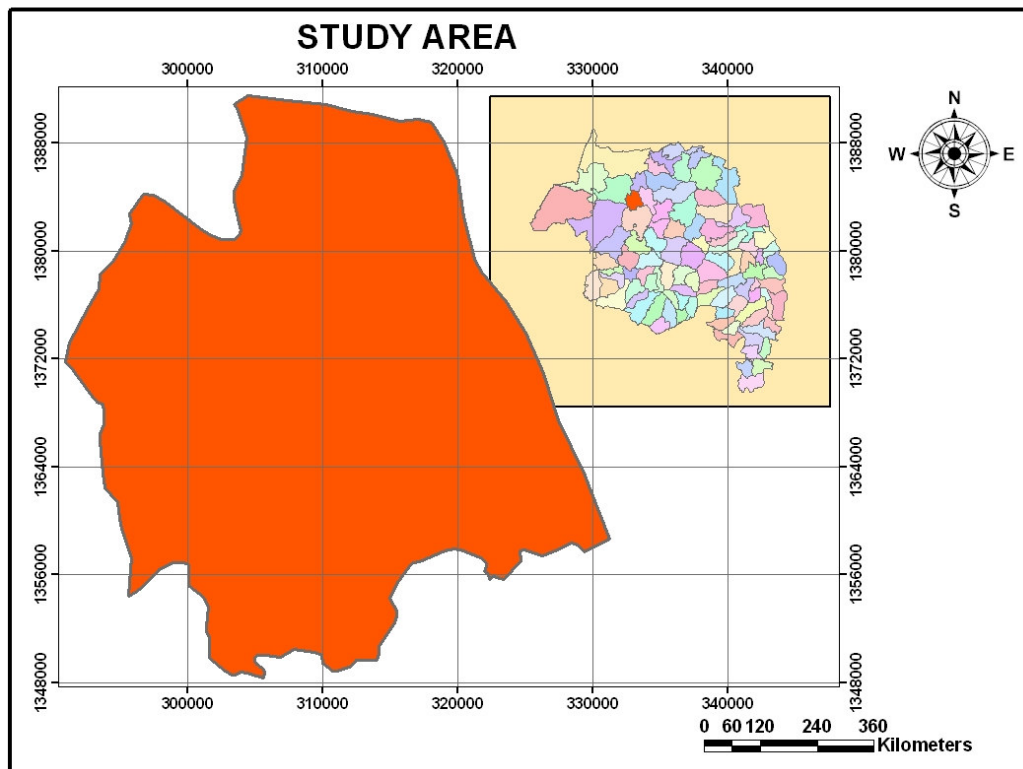


Fig 3.1: Location map of Dembia Woreda for Malaria risk analysis

3.2 TOPOGRAPHIC STRUCTURE

The topographic structure of the study area consists of both flat area and the high mountainous picks it ranges from the lowest point of 1626M up to 2335M. The very high plateau found mostly in the northern wing while the flat land founded in most of the southern part (fig, 3.2)

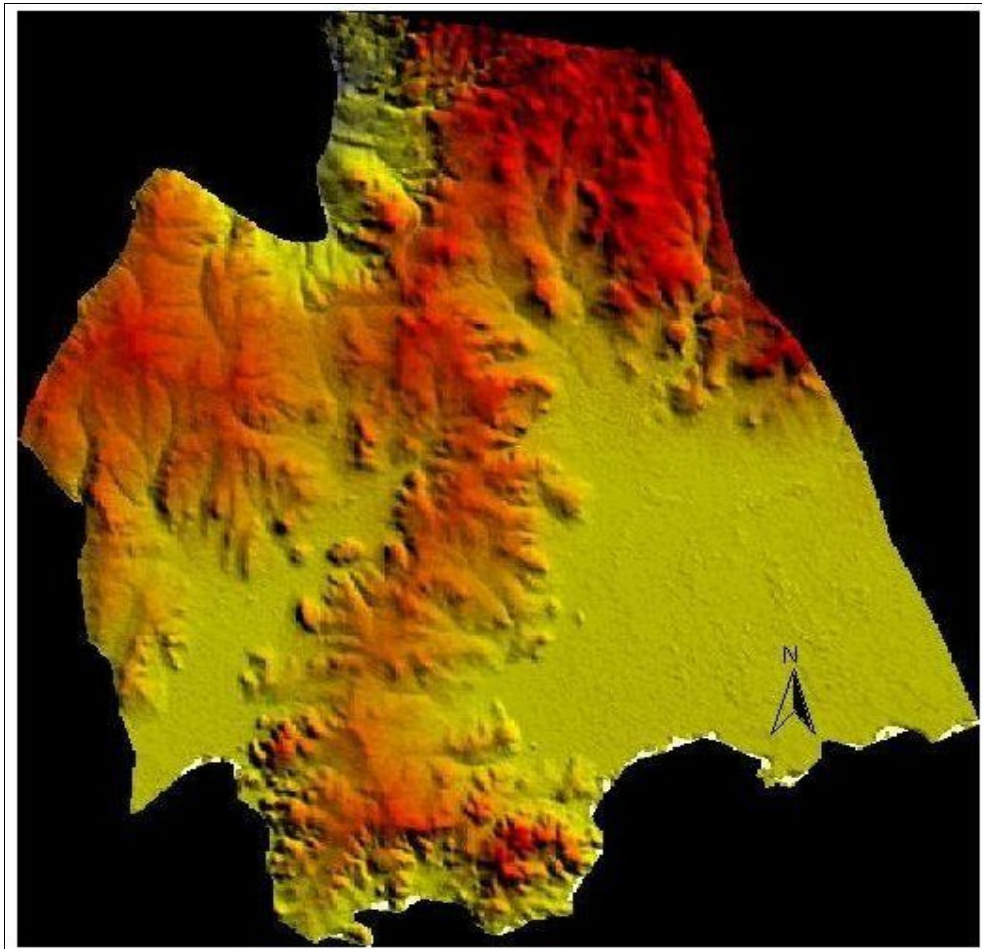


Fig 3.2 Topographic structure of Dembia Woreda for Malaria risk analysis

3.3 Climate

Dembia woreda encompasses a rich Variety of local climates ranging from hot to desert like climate along the northern part and central part , to temperate on the high plateau and cold on the mountain peaks, generally the worda classified under woyena Dega area according to koppen climatic classification.. Annual rain fall varies between about 800mm to 2,2000mm with a mean annual rainfall of about 1420mm. The mean temperature of the area is 18 °c, with minimum and maximum average daily temperature of 11.4 and 26 5 °C respectively (Abeba sine, 2007).

3.4 Population

The total population of Dembia woreda is estimated be 325,299 out of which 85% live in rural areas with out enough health service while the rest 15% live in rural-urban area relatively better health facility area, and out of which 160,497 are females and 164802 are male. The average annual growth rate of the population was 5.2% for the region-during the year 1993-2000. The growth rate due to family planning service declined to 4% for the year between 2000 & 2005 and expected to further go down to 3.5% for the years between 2005-2010 CSA (2006).

3.5 Drainage Density

Dembia woreda is blessed by some large rivers, which flow through out the year and few intermittent and perennial streams predominate the natural water flow system of the region. According to the study made by the agricultural development office the Amahara region in the year 1992 E.C, the region has over 420 springs with different water discharge capacity and over 100 perennial and intermittent streams. The most important intermittent and peremial streams that drain the area lake Beles, Megch, Dabus, and Gemera .WWDSE (2004)

3.6 Lake Tana

Lake Tana, abut 1785 meters above sea level, occupies about 3,000 square km² on the central plateau Ethiopia. It is a relatively shallow ,roughly heart shaped body of water the main tributary rivers are the Gilgel Abbay entering the lake from the souse-east, the Megech river from the North and the Ribb and Gumara rivers from the east side.A number of small drainage systems contribute water to Lake Tana during the rainy season

3.7 General Geology of Woreda

The geology of Dembia woreda comprises various metamorphic, volcanic and sedimentary rocks. The metamorphic rock, which mainly includes gneisses and migmatites, represent the oldest rock type in the area. They are largely of pre-Cambrian origin or basement complex. They mainly exposed in the escarpment zone and limited out crop occur in the vicinity of the woreda. Sedimentary rock of the area includes various sandstone, limestone, alluvia sediments and travertine. The alluvial sediments are composed of sands, silt, and clay (WWDSE 2004)

CHAPTER FOUR

Data Analysis AND Results

4.1 Introduction

The factors that are necessary for the incidence of the malaria catastrophe were reviewed and the local dwellers were interviewed. Accordingly aquatic bodies, elevation, slope, and distance to rivers are listed in order of importance.

To assess malaria risk of the woreda using GIS, Multi-Criteria Evaluation was used. MCE is a procedure which needs several criteria to be evaluated to meet a specific objective. It is most commonly achieved by one of two procedures. The first involves Boolean overlay whereby all criteria are reduced to logical statements of suitability and then combined by means of one or more logical operators such as intersection (AND) and union (OR). The second procedure which was used in the study is known as weighted linear combination (WLC) where continuous criteria (factors) were standardized to a common data model that was raster layer with a resolution of 14.25 m cell size, and then combined by means of a weighted overlay. The result is a continuous mapping of malaria risk and finally threshold to yield a final decision.

The standardized raster layers were weighted using Eigen vector that is important to show the importance of each factor as compared to other in the contribution of malaria hazard. Accordingly, the Eigen vector of the weight of the factors was computed in IDRISI 3.2 software in Analysis menu Decision Support/ Weight module. The Weight module was fed with the pair wise comparison matrix file of the factors in a Pair wise comparison 9 Point continuous scale.

The computed Eigen vector, which is an out put of the pair wise comparison matrix to produce a best fit set of weight, of Weight Module was:

Aqua distance:	__ 0.4389
Elevation:	__0.3263
Slope	__0.1587
Distance to river	__ 0.0761

The critical ratio of the calculated Eigen vector is 0.09 which is acceptable.

The computed Eigen vector is used as a coefficient for the respective factor maps to be combined in Weighted Overlay in Arc GIS environment, whereas in malaria risk assessment all the factors remained accordingly their importance and Weighted Overlay (table 4.2).

Table 4.1: Weighted malaria hazard ranking for Dembia woreda (Hazard Analysis)

<i>Factors</i>	<i>Weight</i>	<i>Value</i>	<i>Ranking</i>
<i>1. Aquatic bodes (meter)</i>	<i>0.4389</i>	<i>0 0 1000</i>	<i>5</i>
		<i>1000 - 1521</i>	<i>3</i>
<i>2. Elevation (meter)</i>	<i>0.3263</i>	<i>1626.7 1 1828.4</i>	<i>5</i>
		<i>1828.4 1 1886.5</i>	<i>4</i>
		<i>1886.5 1 1947.3</i>	<i>3</i>
		<i>1947.3 1 2049.5</i>	<i>2</i>
		<i>2049.5 2 2334.1</i>	<i>1</i>
<i>3. Slope (percent)</i>	<i>0.1587</i>	<i>0 0 1.39</i>	<i>5</i>
		<i>1.39- 5.43</i>	<i>3</i>
		<i>5.43- 7.86</i>	<i>2</i>
		<i>7.86 7 38.59</i>	<i>1</i>
<i>4. Distance to rivers (meter)</i>	<i>0.0761</i>	<i>0 -651.1</i>	<i>5</i>
		<i>651.1- 1574.6</i>	<i>3</i>
		<i>1574.6 1 3732.4</i>	<i>1</i>

Table 4.2: Weighted Malaria risk rankings for Dembia woreda (Risk Analysis)

<i>Factors</i>	<i>Weight</i>	<i>Sub-factors</i>	<i>Ranking</i>
<i>1 Malaria hazard</i>	<i>40%</i>	<i>very low</i>	<i>1</i>
		<i>low</i>	<i>2</i>
		<i>moderate</i>	<i>3</i>
		<i>high</i>	<i>4</i>
		<i>very high</i>	<i>5</i>
<i>2. Land use types</i>	<i>35%</i>	<i>Bare land and dense</i>	<i>1</i>
		<i>vegetation open shrub land</i>	<i>2</i>
		<i>Aquatic bodes</i>	<i>3</i>
		<i>Cultivated land</i>	<i>4</i>
		<i>Settlement area</i>	<i>5</i>
<i>3. health station</i>	<i>25%</i>	<i>very low</i>	<i>1</i>
		<i>low</i>	<i>2</i>
		<i>moderate</i>	<i>3</i>
		<i>high</i>	<i>4</i>
		<i>very high</i>	<i>5</i>

4.2 Factor Development

4.2.1 Aquatic bodies Distance

Aquatic bodies one of the most prominent factor for creating mosquito breeding site and affect malaria transmission through increasing humidity (ministry of health, 1999). And one of environmental covariate significantly related to transmission intensity was distance from the water, indicating high transmission in the areas within 2 km of the water source (malaria journal of 2002). The aquatic bodies Vector layer was extracted from developed land use land cover map of the woreda using raster to vector module in ENVI 4.2 software. Further aquatic bodies shape file was imported in Arc GIS environment for distance Computation in 3D analyst. Then aquatic bodies distance raster layer was generated. Taking heed of the maximum flying distance of anopheles mosquito from the breeding site. (That manse aquatic bodies) which is 2 km as a basis for reclassification of a quadric bodies distance layers (malaria journal of 2002). Then the aquatic bodies distance raster layer was further reclassified using natural breaks (Jank) standard reclassification method in Arc GIS9.1. And the reclassified sub groups of aquatic bodies distance raster were ranked according to mosquitoes flying distance threshold value which means areas out of the flying distance are considered as less malaria hazard area. And new values re-assigned in order of Malria hazard rating (Fig 4.3).



Photo of aquatic bodes from Dembia Woreda.

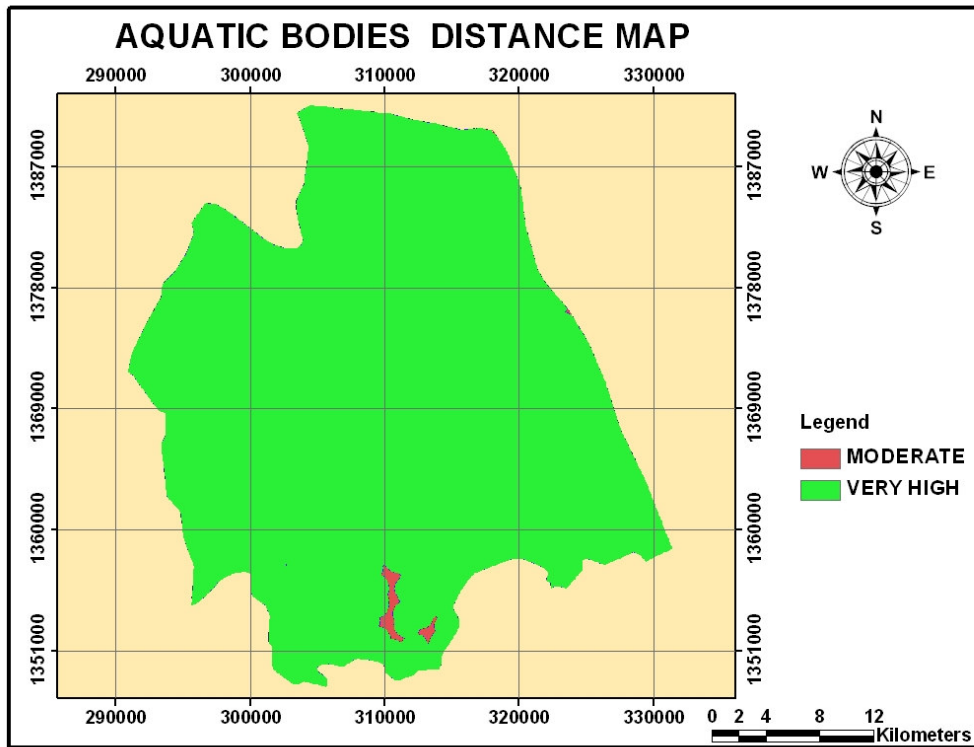


Fig 4.3: Reclassified aquatic bodies layer

4.2.2 Elevation Factor

Elevation is another prominent factors for malaria transmission , this is because of elevation highly determine the amount of Temperature, and temperature in turn affect mosquito breeding as the length of immature stage in life cycle. In high temperature, the egg, larval an pupil stages will be shortened so that the turnover will be increased and also affect the lengthen of the saprogenic cycle of the parasite with in the mosquito host i.e. when Temperature increase, the period of the saprogenic cycle will be shorted (ministry of health, Ethiopia.1999)

The elevation of the woreda was drive from 20 meter contour interval feature class which was digitizing from topographic map of 1:50.000 scales and further rectified in GIS environment. This feature was converted 3D shape fill using 3D analyst in convert feature to 3D module by interpolating contour using an attribute as a source. Further Tin was developed using 3D analyst in create Tin from feature 3D shape tin to raster elevation layer. Elevation was derived using 3D Analyst in tin surface/ tin elevation module. Elevation feature class was further converted raster layer using conversion tool in to raster feature in raster module. The elevation raster layer was

further reclassified in to five sub groups. This reclassification bases on the mean annual average Temperature of the locality by the natural break (jenk) standard reclassification method. For this activity fifteen years mean annual average Temperature of Gorgora and kolaDeba metrological station were used for reclassification of elevation layer in consideration with malaria survival. The fact that Aneophylous mosquito can not survive beyond 17 temperature threshold and was considered as major criteria for the reclassification processes (MARA/ HAMAL Journal. 2000) Accordingly the temperature is highly affected by the Elevation-change. This is supported by adiabatic lapjfs rate of t e nperat ure and elevati on. hence the Turing point for elevation range was taken to be 2050 m.a.s.l which is the area with the minimum Threshold for mosquito survival. And new values re-assigned in order of malaria hazard rating (Fig 4.4).

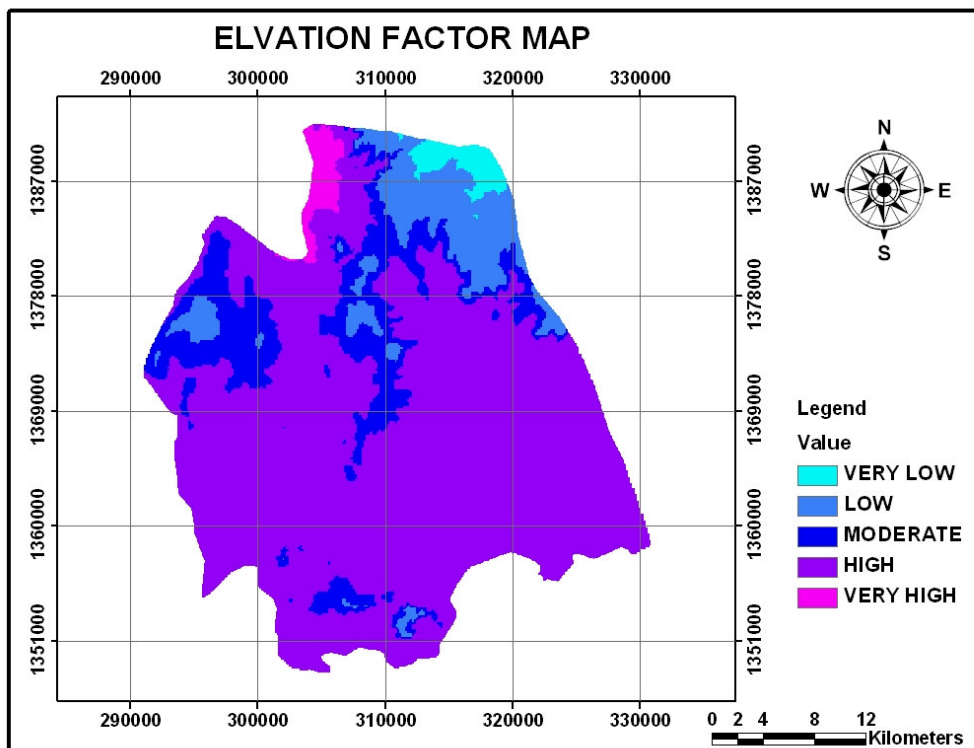


Fig 4.4: Reclassified Elevation layer

4.2.3. Slope factor

Slope is another topographic parameters that may be associated with mosquito larval habitat formation, is the measurement of the rate-change of the land per unit distance which may affect the stability of the aquatic habitat (Stephen Munga,2000)

The slop of the study Area was dived from 20 meter contour intervals feature class which was digitize from topographic map of 1:50,000 scale and further rectified in GIS environment. This feature was converted to 3D shape file using 3D Analyst in convert feature to 3D module by interpolating contours using an attribute as a source .further Tin was developed using 3D analyst increate Tin from feature (3D shape). Slope was derived using 3D analyst in Tin surface /tin slope module. Slope future class was further converted to raster using conversion tool in to raster/ Feature to raster module. The slope raster layer was further reclassified in to 4(four) sub-groups based on slope Guideline by Volli Carucci (WFP, November 2000) by natural break (Juke) standard reclassification technique. So as to compatible in the hazard map with other parameters. The reclassified slop raster layer sub groups where ranked accordingly to the degree of suitable for malaria incidence in the locality. To elaborate the steeper slope values are related to lesser malaria hazard and the gentler slope have high susceptible for malaria incidences. And new values re-assigned in order of Malaria hazard rating (Fig 4.5).

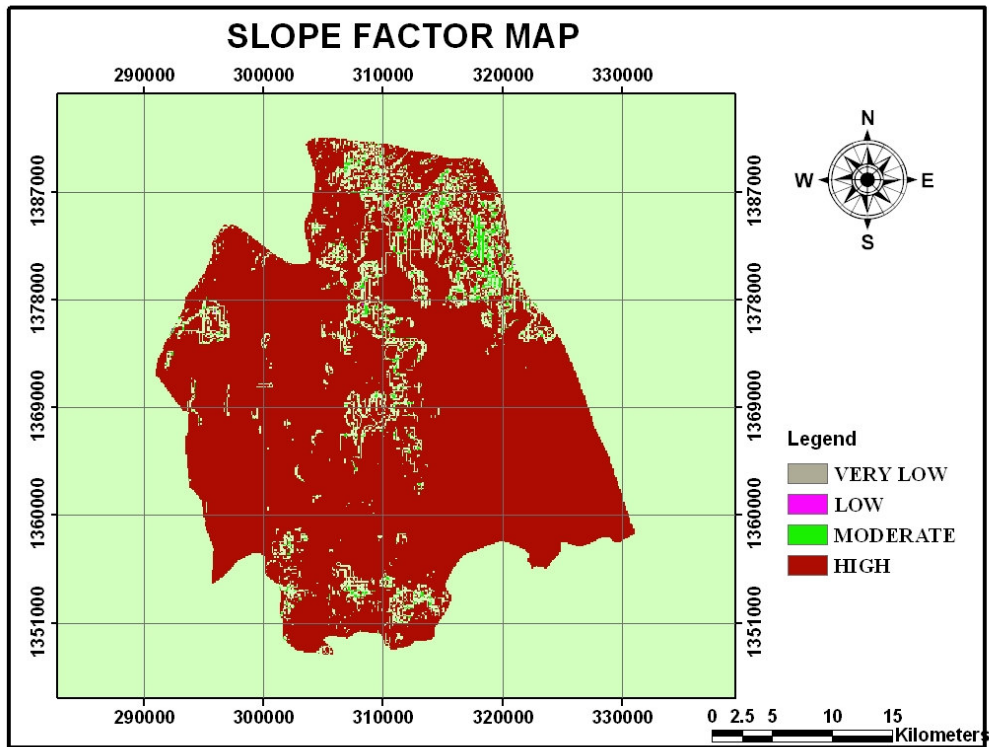


Fig 4.5: Reclassified Slope layer

4.2.4 River distance factor (Flow distance-to-stream)

Flow distance-to-stream may affect availability of the aquatic habitat and is calculated as the distance from a grid cell moving downstream to a stream grid cell defined by the Stream Raster grid. The advantage of using flow distance-to-stream rather than simple distance-to-stream is that flow distance takes flow direction and landscape profile into consideration (Stephen Munga, 2000).

The river network was digitized from topographic map (1:50,000) of the woreda in AGIS environment for the identification of positive malaria breeding site around river network that has an impact on the surrounding area, distance was computed on the 15 meter buffered river networking using spatial analyst in distance module. Taking heed of the maximum flying distance of anopheles mosquito from the 15 meter buffer which is 2 km (journal) as a basis for reclassification river distance layer. Then river distance raster layer was further reclassified using natural break (junk) standard reclassification method in ARC GIS 9.1 software and the reclassified subgroups of river distance raster layer were ranked according to mosquitoes flying distance threshold value, which means areas out of the flying distance threshold are

considered as less malaria risk level .And new values re-assigned in order of Malaria hazard rating (Fig 4.6).

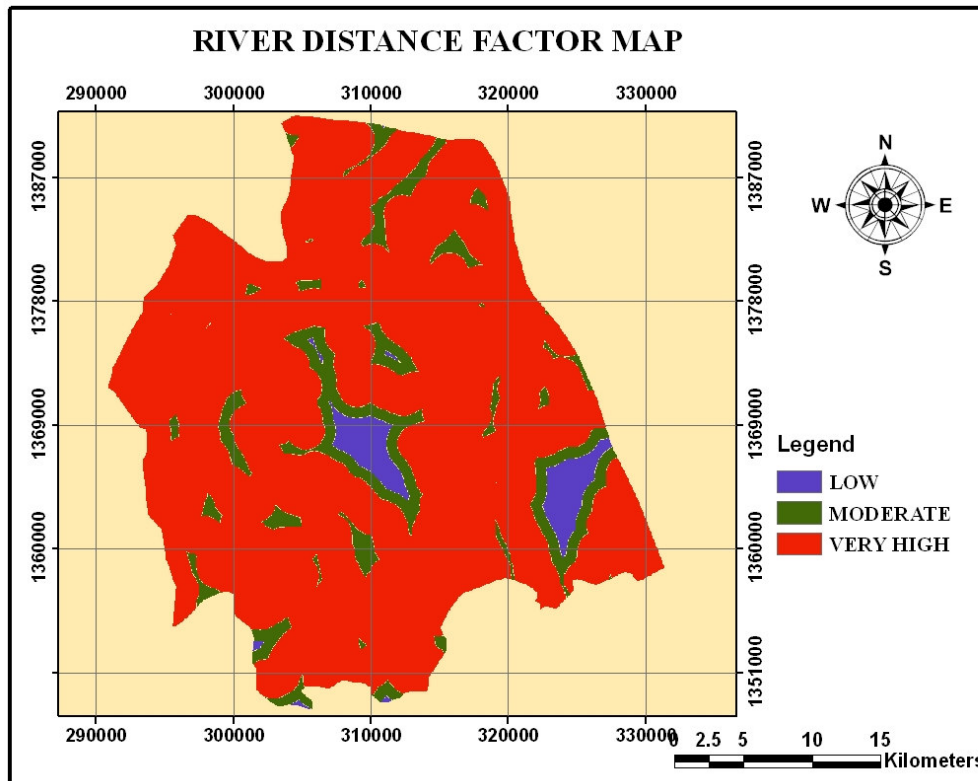


Fig 4.6: Reclassified river distance layer

4.2.6 Land use/ land cover

The land use land cover is taken as element at risk that affect by malaria incidence in the present study area, this is because of lack of good population and administrative boundaries map of the Dembia woreda in terms of kebele level. Land use is the way in which and the purpose for which human beings employ the land and its resources. Land cover by contrast the physical state of the land surface as in as in cropland, mountains or forests (Meyer 1995:25)

The land use /land cover classes of Dembia Woreda have been classified using Land sat ETM+ satellite image with a spatial resolution 28.5m.However the coarse resolution bands(band 4 near infrared and band7 mid infrared) were spatially merged high spatial resolution of (14.5m) panchromatic band 8 to enhance the resolution of the data. Accordingly, composite bands of 7, 4, 2 RGB order were stacked. Supervised classification method was carried out based on the exiting land use land cover map of Dembia woreda developed by woody biomass and spatially

enhancement technique like tasseled cap was used to identify aquatic bodies and histogram equalization. Accordingly the Woreda was classified in to six land use land cover classes namely settlement, cultivation land, aquatic bodies, open shrub land, dense vegetation and bare land.

In addition, Accuracy assessment was carried out on the classified land use/ land cover map by accuracy points collected during the field work using ROI technique in ENVI 4.2 software.

Further the land use/ land cover map was converted raster layer by exporting land use/land cover image format to esri grid format. Besides land use land cover of the Dembia woreda was reclassified in five sub groups in order their susceptibility and suitability for malaria risk. Thus the reclassified version implies 1 to 5, where 1 stands for less affected land use land cover element and 5 for highly affected land use / land cover elements. The weight given for land use land cover classification based on its exposure to malaria incidences.

Table 4.3 element at risk land use land cover

Rank	Class
1	Bare land, dense vegetation
2	Open shrub land
3	Aquatic bodies
4	Cultivated land
5	Settlement

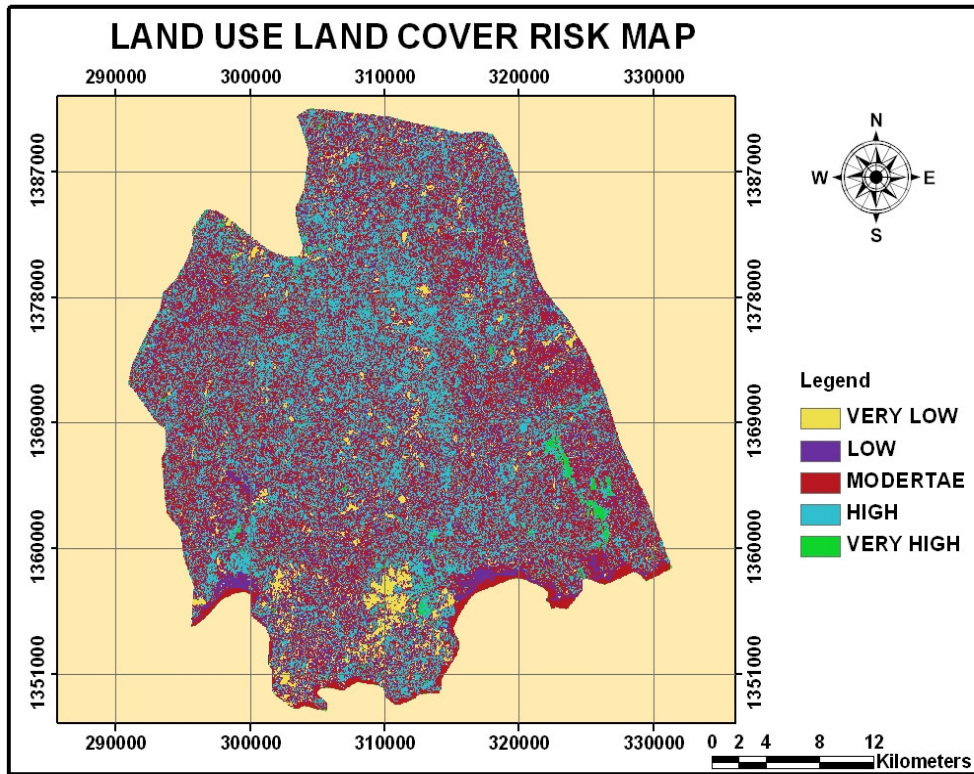


Fig 4.8: Reclassified Land use layer

4.2.7 Health station Distance factor

Health station distribution has a remarkable impact on the vulnerability of the population dwellings in the woreda. Hence proximity of each health station was analyzed using distance module in spatial analyst in arc GIS environment.

Construction of vulnerability map of the woreda was done by computation of distance analysis on the point health station ship file which was collected by GPS device during the field work. Reclassification of health station distance raster layer was computed by reclassified module in 3D analyst in Arc GIS environment. According to WHO (Health journal 1998) vulnerability to malaria incidence in developing countries assumed to be less vulnerable and easily accessible to the existing health station in the area in equation in 3 km radius. Besides vulnerability in area were ranges of distance beyond 3 km radius from existing health station increase parallelly with increase in distance due to distance limitation for health station services. And new values re-assigned in order of Malaria hazard rating (Fig 4.9).

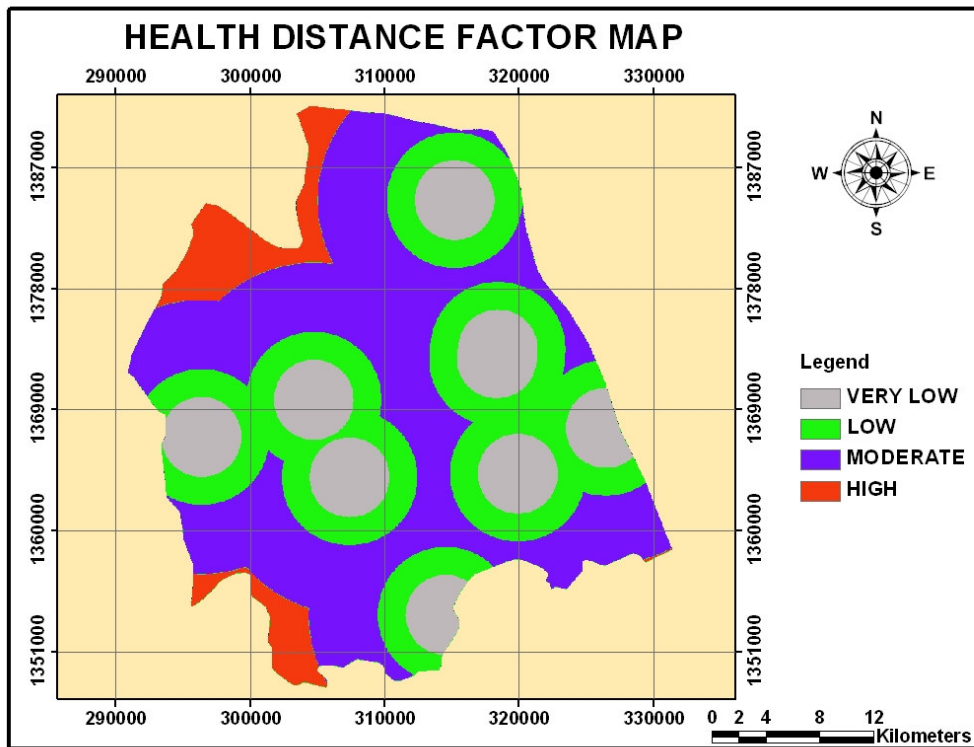


Fig 4.9: Reclassified health station layer

4.3.1 Malaria hazard analysis

Here hazard is the probability of the occurrence of mosquitoes infective with malaria in a certain area. It is approached by assessing the suitability of environmental condition for malaria transmission based on environmental and physical factors.

After preparing all the factor parameters compatible to hazard analysis, estimating weights for hazard parameters is what come next. Running hazard map requires estimating weight for each individual hazard parameters. The following sections demonstrate the procedure of MCDM as a mense of calculating weight for hazard parameters.

To illustrate, the following actions are carried out to estimate weight during the hazard mapping by the ranking method. This method had been taken in to consideration to find hazard location of malaria, under this study, five evaluation criteria have been considered namely aquatic bodies distance ,elevation with temperature ,slope factor, and distance to rivers. The criteria are first ranked according

to what seems aplawisable value for their importance based on the previous studies and consulting local health officials. In this regard, the criteria aquatic bodies distance elevation with temperature, slope, river distance and wetness index are ranked on the basis of importance from most important of least important.

After assigning weight according to their importance for each parameter, the hazard layers was computed by over laying the five selected hazard parameter factors in weighted over cay module in GIS environment. An over view of malaria hazard map is show in the coming section (fig 4.10)

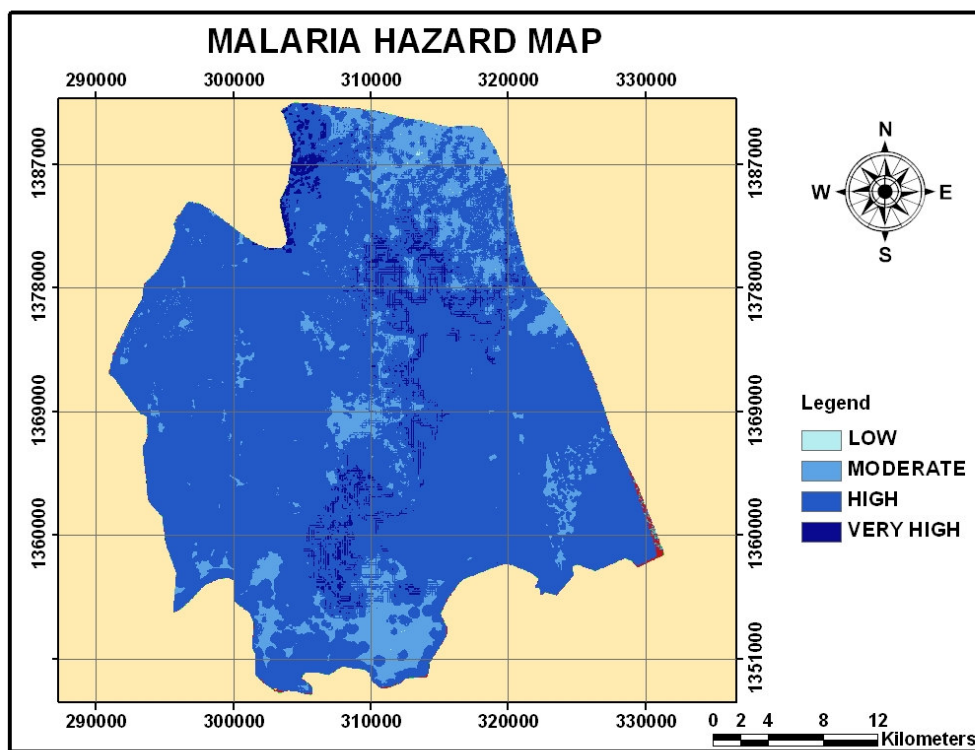


Fig 4.10: malaria hazard analysis map of Dembia woreda

Table 4.4: Area tabulation of malaria hazard map of Dembia woreda

Table2

		Pixel count 1grid	m ² 203.1	km ² 0.000203	%	
4	Low	34524	7010529.8	7.0	0.7	1058.5
2	Moderate	788058	160025027.6	160.0	15.1	1058.5
1	High	4301599	873493446.9	873.5	82.5	1058.5
3	Very High	88696	18010831.5	18.0	1.7	1058.5
						1058.5

According to the above malaria hazard map it was estimated that 82.5% 15.1%, 17%, and 0.7% of the land of the woreda were subjected respectively high, moderate, very high and low hazard zone of malaria.

4.3.2 Malaria Risk Analysis

The development of malaria risk map of the woreda was done on the basis of Risk computation model (shook, 1999)

$$\text{Risk} = \text{Element at risk} * \text{Hazard} * \text{vulnerability}$$

The three components of malaria risk analysis are hazard, element at risk and vulnerability layers. The malaria hazard layers was computed by overlaying the five selected causative factors like aquatic bodies distance, elevation with temperature, slope, and distance to streams raster layer, in weighted over lay module in the arc GIS 9.1 software. The element at risk layer was developed by rasterizing and reclassifying land use/ land cover image file on the basis of malaria susceptibility of each land use/ land cover image file on the basis of malaria susceptibility of each land use/ land cover classes. More over vulnerability layer was developed by computing distance module on the layer was developed by computing distance module on the existing health station distribution point shape file.

In continuation, all the three components of risk were weighted according to what seems a plausible value for their reactive importance for malaria risk. Finally weighted over lay analysis was undertaken for the above mentioned component. An over view on the factors contained in the malaria risk, its weight and area under risk is provided in the coming section.

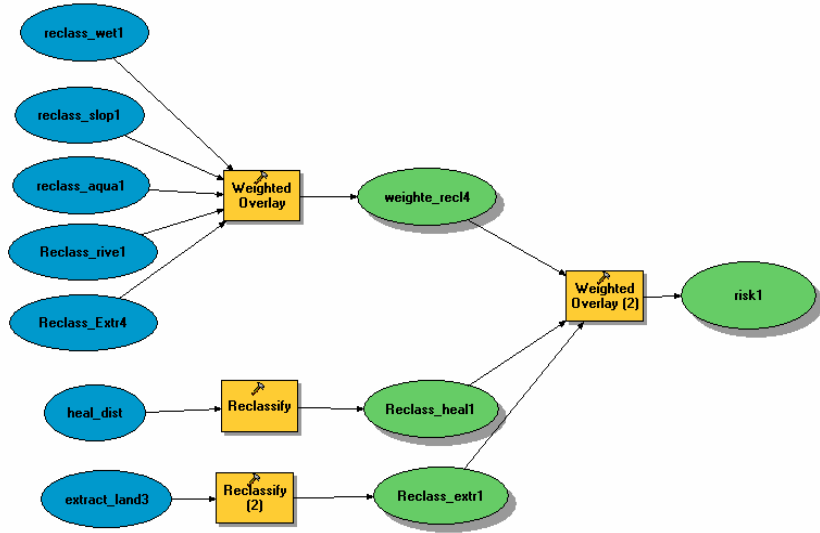


Fig 4.11: Malaria Risk Analysis Model Builder dialogue box

Table 4.5 Weighted Malaria risk for Dembia Woreda

Parameters	Indicators	weight
Hazard	1. Aquatic bodes distance 2. Elevation 3. Slope 4. Distance is rivers	40%
Element at risk	Land use	25%
Vulnerability	Health station	35%

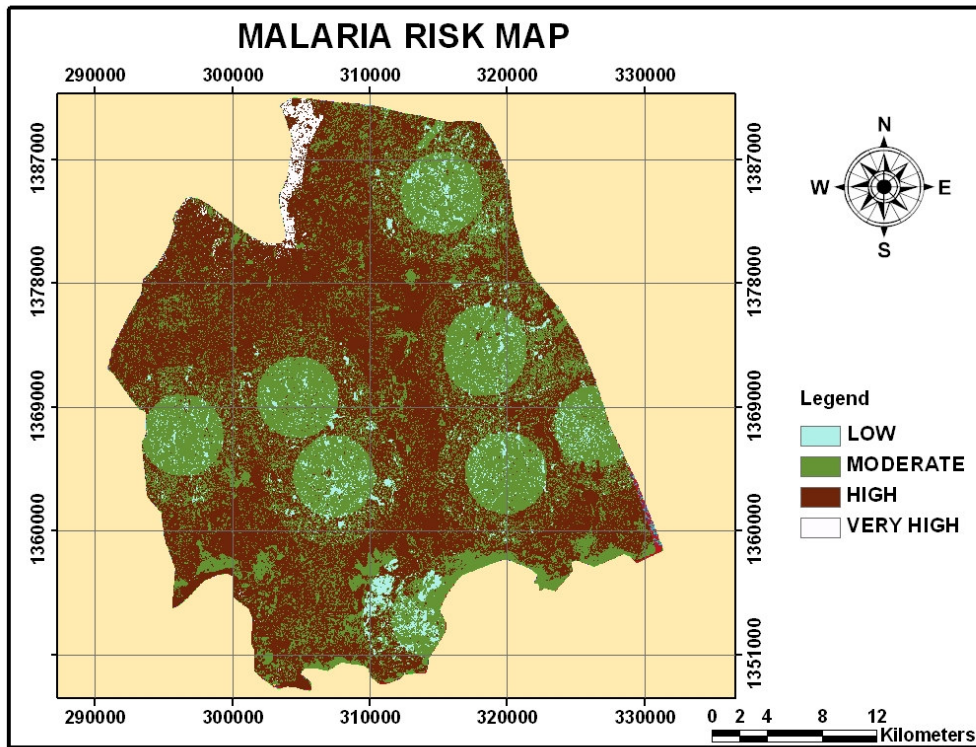


Fig 4.13: malaria risk analysis map of Dembia woreda

Table1 Malaria Risk rating area coverage and Percentage

		Pixel count 1grid	m ² 203.1	km ² 0.000203	%	
3	Low	879546	178602809.6	178.6	16.9	1058.5
2	Moderate	1950414	396055942.9	396.1	37.4	1058.5
1	High	2337388	474635850.8	474.6	44.8	1058.5
4	Very High	45529	9245232.6	9.2	0.9	1058.5
						1058.5

Table 4.6 Malaria Risk rating area coverage and Percentage

Accordingly to malaria risk map (fig 4.13), it was estimated that 16.9 %, 37.4%, 44.8% and 0.9% km² of the land of the woreda were subjected respectively low, moderate , high and very high risk zone of malaria.

Chapter 5

Discussion

5.1 Malaria hazard and Risk of Dembia Woreda

The forth coming result of the research findings are presented based on the spatial modeling. According to the result of malaria hazard, four (4) classes are identified with varying degree of susceptibility ranging from the low hazard area us to the sever one namely low, moderate, high and very high. The study area is dominantly characterized by high malaria hazardous zone and this verified by malaria hazard map result. Accordingly on the result of malaria hazard map, the largest part of he land in the woreda (82.5%)classified as high malarias zone followed by 15.1 %is moderate and the remaining areas covered 0.7% and 1.7% low ,very high respectively.

This computation result show that the area almost full fill all the criteria set for hazard analysis further more the hazard map also show the low hazard zonation cover the smallest portion of the study area. Similarly one of the study carried out on malaria hazard map with the same hazard criteria in western Kenya highland, they get 75 % of the area was categorized under high malarias zone (malaria journal, 2000). From this point of view the malaria hazard incidence rate is similar that of the investigation in Dembia woreda.

The same fashion the malaria risk of the Dembia woreda also characterized by high malaria risk zone (44.8%) followed by moderate risk area (37.4), low (16.9) and very high (0.9%) respectively. As compared to malaria hazard analysis the high risk rating in the risk analysis showed more 45% reduction, the reason behind this reduction is the short distance of settlements to the existing health stations. As a result the vulnerability of settlements to malaria risk is highly reduced which intern highly reduced the high rated risk areas remarkably. Similarly on the same case the risk analysis carried out in western Kenya gets relatively the same results. From this point of view the malaria risk assessment in Dembia woreda relatively reduced due to the existing health station- distribution.

5.2 Malaria risk and Topographic Factors

Malaria Transmission is limited to areas below a certain altitude by Temperature because of Temperature affects mosquito breeding as the length of immature stages in the life cycle depends on it and temperature also Affects the length of the sporogonic cycle of the parasite with in mosquito host, when the Temperature increase, the period of the sporogonic cycle with be shortened and vice versa .generally highlands or highland fringing areas between 1000_ 2100 meter can b e considered as high epidemic prone area (ministry of health, 1999) According to the result mentioned on the elevation hazard parameters of the Dembia worda Transmission seems to start at the annual average Temperature exceeds 17⁰c, so the elevation threshold in the study area to fill fill this condition is 2100meter. In another sense areas at altitude higher than the finding threshold, can be exclude from malaria risk due to low temperature. Apart from elevation, the development of aquatic bodes is another physical factor creating mosquito breeding site and in creasing humidity, which in turn will help to increase the longevity of the adult vectors (ministry of health, 1999) from Dembia worda point of view, out of the total area of land 52 % covered by water ponds .This situation create a suitable condition for malaria breeding sites.

5.3 Malaria risk versus patient Data

This section of the study attempt to compare the malaria risk analysis result which is computed from malaria hazard, vulnerability and element at risk with the existing malaria patient data of the worda for the last 7years. (See table

Table 5.1 Patient data of the worda in terms of district level

Year	South	North	East	West
1992	22000	12200	14000	10080
1993	28000	10200	16100	12120
1994	18000	9480	13201	11200
1995	17180	6330	9400	8000
1996	13643	5880	9354	5480
1997	12140	4860	6188	4630
1998	10322	4000	5090	4020
Total	121285	52950	73333	55530

The table shows the special distribution of the malaria cases from 1992-1998 on the four administrative classes of the woreda, namely the southern branch (14 kebele), East branch (10 kebele), west branch (10 kebele) and North branch (10 Kebele) also referring data from the Dembia woreda health office (DWHO). According to the reported malaria case data shown in graph 5.1 and 5.2 the zone at high malaria case observed in the southern part which is 121000 patients registered in between 1992-1998. In the south malaria case data is high due to low elevated areas and relatively gentler slope than any other part of the woreda; this is true in the factor map of elevation and slope analysis. No scarcity of aquatic breeding place for anopheles mosquito can be expected in most of the southern part of the woreda especially areas near Lake Tana, since irrigation activity is wide-spread. Therefore, sustainable preventive measures should be promoted most urgently in these parts of the woreda, example health education, biological vector control and ITN distribution. While there is a rather low malaria incidence data observed in the Northern part of the woreda, while at high altitude there is no malaria risk because of the altitude highly determine the amount of Temperature. This is also shown in the elevation factor map of the hazard analysis. The latter two branches of the woreda west and East on the graph show that relatively a moderate number of patient data than the southern. However the situation in the east and west should be watched carefully.

The same is true in the malaria hazard and risk analysis of the study showed, the largest area coverage of high malaria hazard and risk found in the southern and low in the northern part of the woreda.

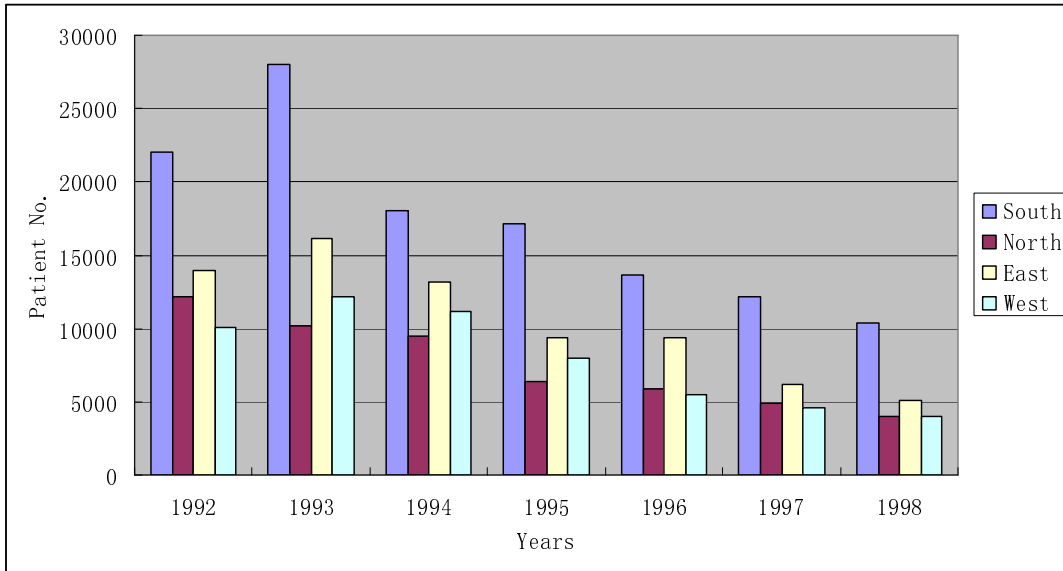


Fig 5.1 graph showing Patient number of Dembia Woreda each year.

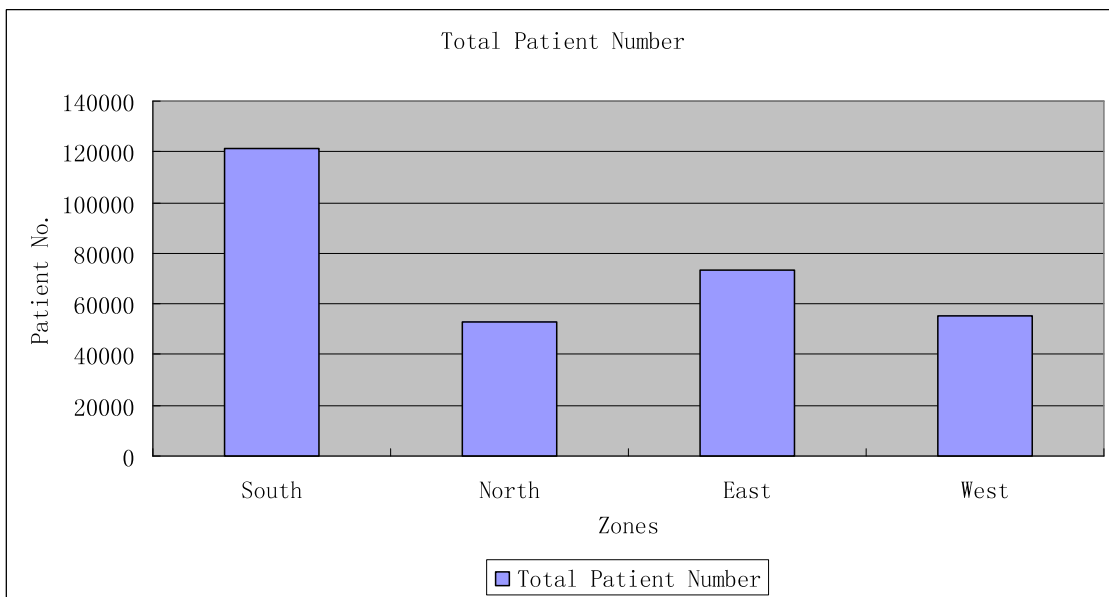


Fig 5.2 graph showing total Patient number of Dembia Woreda.

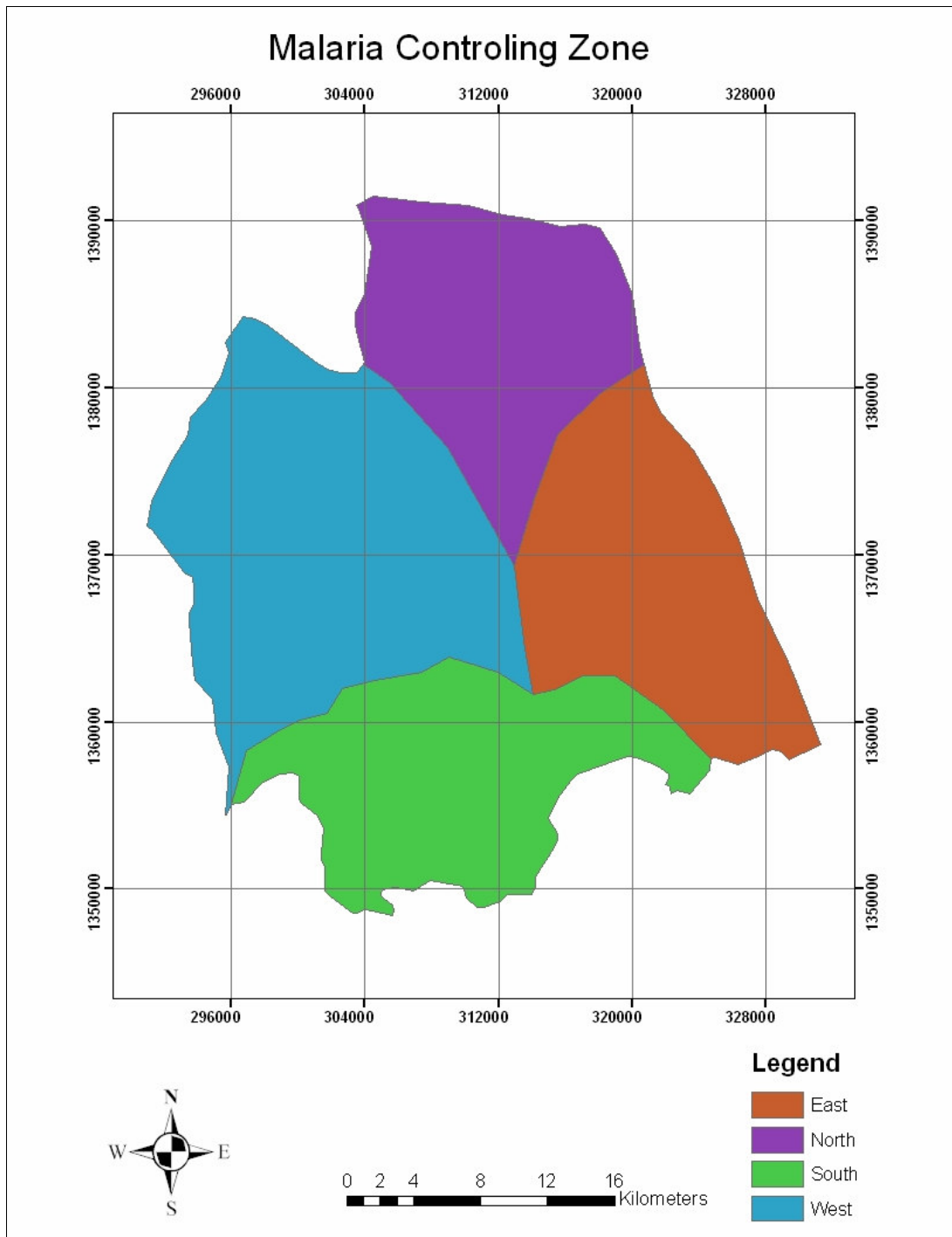


Fig 5.3 Map of malaria controlling zone of the Woreda

Chapter Six

Conclusion and Recommendation

6.1 Conclusion

Reliable maps of the risk area of malaria are urgently needed, especially in endemic areas of Dembia Woreda. Such maps are fundamental for estimating the scale of the problem, and hence the resources needed to combat malaria. They provide benchmarks for assessing the progress of control and indicate which geographic areas should be prioritized.

The study attempted to develop a risk map that could support decision making process in Dembia Woreda, Ethiopia using GIS application. Findings of the study disclose that 48% of the study area is identified as very high risk areas for malaria. Only 16.9% is less risk area of malaria. In other words, according to the result of the findings large area of the Woreda is located on high risk area for malaria.

In this study pair wise comparison method of malaria hazard map generation is a good approach to deduce a sound decision for a forthcoming malaria disaster, provided the required data are standardized to a common scale in personal geodatabase. This research confirmed the method used was capable to integrate all the malaria hazard causative factors and the components of malaria risk as well in a GIS environment. In this fashion, composite maps were generated to assess malaria risk of Dembia woreda.

One of the Multi Criteria Evaluation techniques which is known as Weighted Overlay in GIS environment was shown to be useful for delineating areas at different rating in terms of malaria hazard and malaria risk. Moreover, factor weight computation in Weight module, that is developed by providing a series of pair wise comparisons of the relative importance of factors to the suitability of pixels for the activity being evaluated, has generated valuable information. This could be useful for disaster control in the future. Therefore, it has been shown that MCE GIS based model combination has potentiality to provide rational and non-biased approach in making decisions in disaster studies.

6.2 Recommendation

In line with the findings of this selective parameters based malaria risk assessment the following recommendation are presented.

- Sustained political commitment and involvement of leaders needed at all areas of the Woreda, especially areas that are found in the highest susceptible site, to support the vulnerable group.
- Government, non Governmental and other bilateral organizations needed to promote the establishment and running of health center focus on the provision of medical treatment.
- Based the spatial distribution anophellne mosquito habitats the government, and NGO showed pay special attention for vector control efforts to target the most productive larval habitats.
- This investigation also provides information on malaria hazard and risk at Dembia Woreda that could be used by pertinent decision makers to act up on the current spatial distribution of malaria for in reducing vulnerability to malaria disaster in Dembia Woreda .Thus the responsible bodies of the area, should in corporate the malaria hazard and malaria risk maps in the current ongoing activates related in malaria disaster, as one of the short term intervention recommendation of the Woreda is identification of critical malaria sites
- The woreda health burro should focus on water shed management practice in the lowland plain of the area are crucial in alleviating water ponds.
- Based a the spatial distribution anophellne mosquito habitats the government, and NGO give pay attention for indoor Residual Spraying or ; °appli cai on of long acting chemical insecticides on the walls and roofs of all houses in order to kill adult vector mosquitoes that land and rest on these surfaces and distribution of treated bed nets.
- The government and any other funding agencies give pay attention for vector biology and control research uses Geographic Information Systems [GIS] and Global Positioning System [GPS] data to analyze distribution and abundance of malaria vectors. This data can be used at both local and national levels to target malaria vector control efforts appropriately and utilize resources effectively.

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Annex

Annex 1: Areas coverage of malaria hazard analysis of Dembia woreda

Annex 2: Areas coverage of malaria risk analysis of Dembia woreda

Annex 3: Patient data of the woreda in terms of district level.

Annex 4: Kebela name of the woreda in terms of district level.

Annex 1 Area coverage of malaria hazard map of Dembia woreda

Table2

		Pixel count 1grid	m ² 203.1	km ² 0.000203	%	
4	Low	34524	7010529.8	7.0	0.7	1058.5
2	Moderate	788058	160025027.6	160.0	15.1	1058.5
1	High	4301599	873493446.9	873.5	82.5	1058.5
3	Very High	88696	18010831.5	18.0	1.7	1058.5
1058.5						

Annex 2: Areas coverage of malaria risk analysis of Dembia woreda

Table1 Malaria Risk rating area coverage and Percentage

		Pixel count 1grid	m ² 203.1	km ² 0.000203	%	
3	Low	879546	178602809.6	178.6	16.9	1058.5
2	Moderate	1950414	396055942.9	396.1	37.4	1058.5
1	High	2337388	474635850.8	474.6	44.8	1058.5
4	Very High	45529	9245232.6	9.2	0.9	1058.5
1058.5						

Annex 3: Patient data of the woreda in terms of district level

South kebeles	East Kebles	West kebles	North keblas
1. Gorgora	1. Abanorv	1. DeeraGa	1. Gunna
2. Wubeha	2. Wayna tana	2. konGer	2. Seha merge
3. mange	3. Adisge	3. Hana Mariam	3. Mekuamia Mariam
5. wawa	4. Guramb Bata	4. Sankisa	4. Dirmara
6. Gembera	5. Jangua Mariam	5. Kekeza	5. Balanceeb
7. Bebeha	6. Jangua Abriham	6. Simra	6. Aymba
8. Narcher	7. Gurambia Mchal	7. Gunter	7. Senbet Deber
9. Achera	8. Gubia	8. Wawacha	8. Gendewa
10. Addis Dinga	9. Supankara	9. Konger	9. Teleft
11 Seraba Mariam	10. Kara Duba.	10. Simano	10 Atact.
12. AbirGiha			
13. Meskele kirstos			
14. chahite			

Annex 4: Kebela name of the wreda interms of district level