2. RESEARCH METHODOLOGY

Research design is the blue print for conducting a study that maximizes control over factors that could interfere with the validity of findings. Precisely, it is the strategy by which we can minimize errors in data collection and analysis and it will guide us to achieve the intended objective (Treece and Treece, 1999, Polit and Hungler, 1999). This section details out the research methodology of the present study.

The objective of this study was to explore the anthropogenic land use changes on Anopheline mosquitoes. This involved wide area survey, land use changes and site identification, area measurement, meteorological data and specimen collection. The study also involved to uncover any correlation assessment between land use or land cover and Anopheline mosquito abundance, diversity and richness. Thus, various methodologies namely land use data collection through literature survey, ground trusting of Global Imaginary system (GIS) result, sampling of specimen were chosen for data collection and for its effect assessment multiple logistic regression model were used. This section illustrates the study area and study site description, used instrument and software description, data collection and data analysis procedures of the study.
2.1 STUDY AREA

Meghalaya “abode (Alaya) of the clouds (Megh)” situated in the North-eastern corner of India, came into existence as full-fledged state on 21st January 1972. The State has an area of 22429 sq. km. It is a prominent geomorphic unit stretching across the Garo, Khasi and Jaintia hills in the east-west direction (Fig. 2.1). It is bounded by the Brahmaputra valley of Assam in the North-west and Cachar area of Assam in the east. The Surma valley (Bangladesh), borders it in the south and partly in the south-west (Murthy et al., 1976, Mazumdar, 1986).

At the time of formation, it had only three districts viz. Khasi Hills, Jaintia Hills and Garo Hills. Later it was divided into more small districts. At present the State has eleven administrative districts. When the study was started in 2008 there were only seven districts these are – East Khasi Hills, West Khasi Hills, Jaintia Hills, Ri-Bhoi, East Garo Hills, West Garo Hills and South Garo Hills and in the description of the study, same nomenclature of seven districts is being used. Among these, West Khasi Hills is the largest districts with geographical area 5247 sq. km. and South Garo hills is the smallest districts (Fig 2.1). These districts are predominantly inhabited by three major ethnic groups e.g. the Khasis, the Jaintias and the Garos. These tribal communities are the descendents of very ancient people having distinctive traits and ethnic origins. They follow the matrilineal system.
2.1.1 Demography

According to census 2011, the population of Meghalaya State is 29.64 lakhs with about 80% population living in rural or forested areas. The population density of the State is about 132 persons per sq km and the literacy rate is 75.48% which is above national literacy rate. Majority of the population of Meghalaya are tribal.
(about 80%) in which the Khasis are the largest group followed by the Garos and the Jaintias. Several other small tribal group like Koch, Syntang, Hajong, Dimasa, Rajbongshi and Rabha are also inhabited.

**2.1.2 Topography of Meghalaya**

Meghalaya is topographically termed a plateau (Shillong Plateau or the Meghalaya Plateau) except for narrow strip of plain in the northern, western and southern part. Its elevation varies from 150m to 1960m above the mean sea level. The physical feature of Meghalaya is well defined in three different regions - the Khasi Hills in the central part of Meghalaya, Jaintia Hills in the eastern part of Meghalaya and Garo Hills, which form the western part of Meghalaya. The Khasi Hills and Jaintia Hills that form the central and eastern part of Meghalaya are an imposing plateau with rolling grassland, hills and river valleys. Deep gorges and abrupt slopes mark the southern face of the plateau. Water-falls rush down steep slopes and curve deep valleys through which swift-flowing rivers descend to the plains (Fig. 2.2.a, b, c and d). At the foot of these slopes, a narrow strip of plain land runs along the international border with Bangladesh. The height of the central plateau of the Khasi Hills ranges from 600 to 1900 m with the Shillong peak (1965m), the highest point in the plateau. The Khasi hills are popularly known as the ‘Scotland of the East’ with the pine trees, rolling hills and a numerous waterfalls.
Figure 2.2: Some representative photographs showing the topographical features of study area. Figure A, B, C and D is showing plateau type topography of highland area and figure E, G and H are showing plane area of foot hills and valley.
The northern section of the plateau has an undulating topography with a series of hills rising to almost the same height, extending northwards to slope gradually, merging with the plains of Assam. The accordant height of these hills varies from 170 m to 1000 m. Nokrek (1412m), east of Tura town is the highest peak in western Meghalaya (State of forest report 2005). The boundaries of Garo Hills in north – south and west have more or less plain areas with thick alluvium cover.

### 2.1.3 Climate and rainfall

The climate of Meghalaya belongs to the regime of monsoonal climate of subtropical belt with dry winter and hot and wet summer and is directly influenced by the southwest monsoon and the northeastern winter winds. However, on the basis of short dry period and low temperature, the annual climate of Meghalaya has been broadly classified into four seasons:

1. **I.** The spring summer (March - April)
2. **II.** The rainy season (May - September)
3. **III.** The autumn (October - November)
4. **IV.** The winter season (December – February)

The spring season (March – April) and autumn season are characterized by moderate temperature ranging from 17-26°C, occasional thunderstorms, and high velocity wind. Rainy-summer season is the wettest period of the year and about
three-fourth of the annual rainfall is received during this period. During rainy season humidity is around 80-85%. The winter season is the coldest period of the year and usual temperature of 3–6 °C on the top of hills but in low land and mid land areas it is in between 7 -17°C (Marak, 2007).

**Figure 2.3:** Rainfall variability in Meghalaya. This is the hypothetical model based on old available data. Yellow color dotted line is showing international boundary and red color line is showing district boundaries).

Meghalaya receives average 2000–5000mm rainfall annually. The distribution of rainfall is very uneven in terms of time and space. It is showing substantial decrease in rainfall from south to the north. The Mawsynaram and
Cherrapunjee plateau located in the Southern part of the State receives the highest (11465mm) rainfall in the world (Fig. 2.3). The rainfall in the State is however, confined mostly to a period beginning from April to mid of October and is rather scanty in dry winter months from November to February (Rai et al., 1998; Roy and Tomar, 2001).

2.2 STUDY SITES

2.2.1 Site selection (Design of transects)

To identify suitable locations for study, a reconnaissance field survey was carried out in 2008 and assigned all anthropogenic disturb areas of Meghalaya using geo-rectified multi-spectral satellite imagery. It was initially classified into two broad categories, natural and artificial. The natural type was further subdivided into two categories: Natural forest area (NFA) (essentially consisting areas with typical natural vegetation covers) and Open forest area (OFA) (An area with little human interference). The artificial land use type was subdivided into three categories: Farm land area (FLA); urban land area (ULA) and pasture land area (PLA) (Olayemi, 2008). Total 35 sites (5 sites from each district) were selected for studies which are pointed out in map (Fig 2.4). Selection of study sites was based on the objective and on pragmatic factor such as the distance to be travelled; transportation facility and accommodation. Five sites selected from each district were representing a land use
category of NFA, FLA, ULA, PLA or OFA. The hand held geographical positioning system (GPS: Garmin 12) was used to record the geo-coordinates (latitude, longitude and altitudes) of all sampling sites (Table 2.1).

Table 2.1: General description of study sites and associated land use and land cover types

<table>
<thead>
<tr>
<th>Site (abbreviation)</th>
<th>Habitat</th>
<th>Site Coordinates</th>
<th>Elevation (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Latitude</td>
<td>Longitude</td>
</tr>
<tr>
<td><strong>East Khasi Hills (EKH)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mawlayi</td>
<td>Semi-Urban</td>
<td>25°36’41”</td>
<td>90°54’16”</td>
</tr>
<tr>
<td>Mawlayi-Mawiong</td>
<td>Natural Forest</td>
<td>25°37’28”</td>
<td>91°52’59”</td>
</tr>
<tr>
<td>Pynthorumkhrah</td>
<td>Semi-Urban</td>
<td>25°33’55”</td>
<td>91°56’07”</td>
</tr>
<tr>
<td>Rynjah</td>
<td>Urban</td>
<td>25°54’03”</td>
<td>91°42’24”</td>
</tr>
<tr>
<td>Malki</td>
<td>Open Forest</td>
<td>25°64’03”</td>
<td>91°49’44”</td>
</tr>
<tr>
<td><strong>West Khasi Hills (WKH)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nongstoi</td>
<td>Urban</td>
<td>25°31’32”</td>
<td>91°15’33”</td>
</tr>
<tr>
<td>Mairang</td>
<td>Pasture land</td>
<td>25°33’49”</td>
<td>91°39’57”</td>
</tr>
<tr>
<td>Mawkyrwat</td>
<td>O forest area</td>
<td>25°21’35”</td>
<td>91°20’31”</td>
</tr>
</tbody>
</table>
## RESEARCH METHODOLOGY

<table>
<thead>
<tr>
<th>Location</th>
<th>Type</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Population</th>
</tr>
</thead>
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<td>Kynshi</td>
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<td>25°30'31&quot;</td>
<td>91°31'45&quot;</td>
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<tr>
<td>Sohpian</td>
<td>N Forest area</td>
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<td>91°18'45&quot;</td>
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</tr>
<tr>
<td><strong>Jaintia Hills (JH)</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Jowai Town</td>
<td>Urban</td>
<td>25°26'32&quot;</td>
<td>92°12'03&quot;</td>
<td>4317</td>
</tr>
<tr>
<td>Nartiang</td>
<td>Rural area</td>
<td>25°34'34&quot;</td>
<td>92°13'04&quot;</td>
<td>3966</td>
</tr>
<tr>
<td>Mynso</td>
<td>Pasture land</td>
<td>25°31'56&quot;</td>
<td>92°17'34&quot;</td>
<td>4392</td>
</tr>
<tr>
<td>Iallong</td>
<td>Forest area</td>
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<td>92°15'12&quot;</td>
<td>4391</td>
</tr>
<tr>
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<td>92°8'57&quot;</td>
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<tr>
<td><strong>Ri-Bhoi</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>Byrnihat</td>
<td>Urban</td>
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<td>91°52'02&quot;</td>
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<tr>
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<td>91°85'41&quot;</td>
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<td>91°52'24&quot;</td>
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<td>Lailad</td>
<td>N Forest area</td>
<td>25°58'38&quot;</td>
<td>91°49'39&quot;</td>
<td>1010</td>
</tr>
<tr>
<td>Jorabat</td>
<td>Pasture land</td>
<td>26°11'40&quot;</td>
<td>91°72'41&quot;</td>
<td>594</td>
</tr>
<tr>
<td><strong>East Garo Hills (EGH)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td>Type</td>
<td>Latitude</td>
<td>Longitude</td>
<td>Population</td>
</tr>
<tr>
<td>----------------</td>
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</tr>
<tr>
<td>Williamnagar</td>
<td>Urban</td>
<td>25°33'60&quot;</td>
<td>90°35'70&quot;</td>
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<tr>
<td>Darugre</td>
<td>Rural area</td>
<td>25°39'44&quot;</td>
<td>90°47'38&quot;</td>
<td>431</td>
</tr>
<tr>
<td>Songsak</td>
<td>Open forest</td>
<td>25°28'00&quot;</td>
<td>90°42'00&quot;</td>
<td>929</td>
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<tr>
<td>Rongrengre</td>
<td>Forest area</td>
<td>25°30'00&quot;</td>
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<td>902</td>
</tr>
<tr>
<td>Dainadubi</td>
<td>Semi-Rural</td>
<td>25°36'00&quot;</td>
<td>94°47'00&quot;</td>
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<tr>
<td><strong>West Garo Hills (WGH)</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Tura town</td>
<td>Urban</td>
<td>25°31'27&quot;</td>
<td>90°11'50&quot;</td>
<td>827</td>
</tr>
<tr>
<td>Dalu</td>
<td>Semi-Urban</td>
<td>25°13'24&quot;</td>
<td>90°12'45&quot;</td>
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<tr>
<td>Garobada</td>
<td>Rural area</td>
<td>25°40'36&quot;</td>
<td>90°08'33&quot;</td>
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<tr>
<td>Tura Peak</td>
<td>Natural Forest</td>
<td>25°31'05&quot;</td>
<td>90°15'24&quot;</td>
<td>4149</td>
</tr>
<tr>
<td>Selsella</td>
<td>Open Forest</td>
<td>25°29'55&quot;</td>
<td>90°00'49&quot;</td>
<td>835</td>
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<tr>
<td><strong>South Garo Hills (SGH)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baghmara</td>
<td>Urban</td>
<td>25°12'20&quot;</td>
<td>90°37'41&quot;</td>
<td>270</td>
</tr>
<tr>
<td>Rongara</td>
<td>Rural area</td>
<td>25°11'50&quot;</td>
<td>90°25'36&quot;</td>
<td>107</td>
</tr>
<tr>
<td>Nongalbibra</td>
<td>Rural area</td>
<td>25°27'49&quot;</td>
<td>90°42'26&quot;</td>
<td>123</td>
</tr>
</tbody>
</table>
### RESEARCH METHODOLOGY

<table>
<thead>
<tr>
<th>Location</th>
<th>Type</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asugre Rural area</td>
<td>25°13'36&quot;</td>
<td>90°11'33&quot;</td>
<td>304</td>
<td></td>
</tr>
<tr>
<td>Balpakram National Park Natural Forest</td>
<td>25°15'53&quot;</td>
<td>90°51'16&quot;</td>
<td>892</td>
<td></td>
</tr>
</tbody>
</table>
Figure 2.4: A schematic map of Meghalaya showing the sampling sites (red board pins) for Anopheline mosquitoes in different districts. The mosquitoes samples were collected from 35 selected sampling sites. Source: Google Earth, http://www.google.com/earth/download/ge/agree.html
2.3 METEOROLOGICAL DATA

In each village, one thermometer and relative humidity data loggers (Onset Computer Corporation, Bourne, MA, USA) were placed (Fig. 2.4) and one person was appointed to record temperature and humidity daily. Rainfall data were collected from the Meteorological department of India, Shillong for the years 2008 -2012 and monthly average was calculated for each year.

2.4 DETERMINATION OF LAND USE AND LAND COVER (LULC) CHANGES

The detail procedure followed during study has been described in Figure 2.5. The LULC changes detection was achieved by using prepared LULC maps 2008–12, procured from open source ISRO’s new web portal “Bhuvan” (http://www.isro.co.in), Google earth (http://www.google.com/earth), Bhoosampada (http://www.bhoosampada.nrsc.gov.in) and from literature. All procured maps were in image format. These maps were re-projected using Erdas Imagine 9.1 (Leica Geosystem Geospatial Imaging, LLC) software to give map properties to the images.

LULC types were classified from aerial photographs of 2008 and Landset image of 2005 in five main dominant land use categories viz Natural forest area, open forest area, Farm land area, Pasture land area and urban land area. The verification of these land use types was done through field surveys in both the rainy as well as dry
seasons for four years from 2008 to 2012, using handheld global positioning system (GPS) devices (Garmin 12). The geographical rectified image of each year was re-digitized to obtain polygons for the respective classifications of LULC. This was on the basis of spectral signature of each of the five classes (mentioned above) using ArcGIS 9.2 software (ESRI). In order to calculate the area of each class of LULC map, the calculated geometry function in attribute table of ArcGIS 9.2 software was used. The changes in LULC of each class were obtained by comparing the area in 2008 with that in 2012.

Figure 2.5: Flow chart illustrating the methodology of Digital Image Processing (model was created using MS power point, Source: Mas, 1999: Areendran et al., 2005).
2.5 ENTOMOLOGICAL INVESTIGATION

2.5.1 Anopheline larval and adult habitat identification and characterization

In the starting of study the whole study area was surveyed and potential larval and adult habitats were mapped using hand held GPS for further investigation (Fig. 2.6). A sketch map was also drawn to show the position of the breeding and resting sites relative to villages and settlements. This preliminary sketch maps were verified, corrected and formalized. On the basis of this map a satellite map of breeding and resting of the mosquito of each sampling site was developed using Google-earth (http://www.google-earth.co.in). Each breeding place was numbered and the location, type of breeding site, number of dips made or time spent sampling and date was recorded (Fig 2.6). If, during the study any larval habitat were dry it was recorded as Anopheline negative habitat and new introduced habitat were not included in the study. All these larval habitats were classified into several small subcategories as mentioned below.

a. Natural (rive or erosion pit) or artificial (irrigation channel, small man made ponds man made or domestic water tank)

b. Large or medium size habitats
c. **Permanent** (Held water for long time around 2 to 3 month) or **temporary**
   (Held water for short period around 15 days)

d. **Habitat type** (Pond, pools, erosion pit, rice paddy field, tire-track, animal hoof mark, Seepages, reservoirs, well or leaking tap)

e. **Domestic** habitats

---

**Figure 2.6:** Examining larval breeding in tree hole and rice field.
Vegetations were broadly grouped into algae, grass, pine, agricultural crop, tea leaves and other. Habitat without any vegetation was grouped under ‘no vegetation’.

During each survey, environmental variables recorded for each habitat were: size, water temperature, pH, dissolved oxygen, water turbidity, distance from colony, canopy cover, aquatic animals and substrate type. Substrate type was classified as muddy, sandy with gravel and soil, and artificial without soil. Water pH, temperature, conductivity, dissolved oxygen, turbidity, and light intensity of larval habitat were recorded by means of portable instrument. The estimation of dissolve oxygen was done by modified Wrinkler’s method.

Adult anopheline mosquitoes habitats were also classified into two broad categories:

1. Human dwelling
2. Mixed dwelling
2.5.2 Larval and adult sampling

Sampling of mosquitoes in each selected area was done at least once approximately at the mid of a season during a year. The collection was done during early morning at about 6 to 8 am.

During each survey all identified larval habitats (including water containers in and outside of the houses) were thoroughly searched, for collecting the maximum number of specimen. Immature forms of mosquitoes were collected by standard dipping technique as described by Reuben (1978) and Service (1993) and *Anopheles* mosquitoes were separated from collected mosquitoes samplings on the basis of following characters:

1. Anopheles larvae float parallel to the surface of the water as opposed to hanging down at an angle
2. Absence of siphon
3. Hair no 1 is modified like fan (palmate hair on abdomen)

Larvae were collected from different habitats, with the help of dipper or Pasteur pipette (Fig 2.7). The number of dips taken from each habitat was dependent on the perimeter of the larval habitat. Larvae and sample of water from each larval habitat were placed in plastic bags and transported to the laboratory for further analysis and processing. Anopheline larvae were separated from Culicine larvae. All collected
larvae and pupae were kept in a rearing tray for the emergence of adults. Larvae were fed upon yeast and biscuit powder mixture. The emerged adults were preserved in glass and plastic vials (Fig. 2.7).

**Figure 2.7:** Various instruments used for larvae and adult mosquitoes collection, rearing and preservation

For adult mosquitoes collection, in each village 10 houses were normally examined and the worst ventilated room was selected for sampling as these surroundings usually have a large number of breeding grounds for mosquitoes. Special attention was paid to the sleeping areas and bathrooms. Collection was made with the
help of hand net and suction tube (Fig. 2.7). All caught adult anopheline mosquitoes were distinguished and separated from *Aedes* and *Culex* mosquito on the basis of following characters:

1. *Anopheles* have patterned wings
2. Adults rest on surfaces with their head lower that the abdomen while *Aedes* and *Culex* species rest with the head and abdomen parallel to the surface
3. The scutellum is rounded, (Culicine scutellum is trilobed).

Adult *Anopheles* females have palps that are almost as long as their proboscis

### 2.5.3 Identification

Adult and larval forms of mosquitoes were morphologically identified using catalogues of Christophers (1933), Gillies and Coetzee (1987), Das. *et al.*, (1990) and Nagpal and Sharma (1995).

### 2.6 STATISTICAL DATA ANALYSIS

Data were recorded and entered into a database. Average relative humidity, air temperature and water temperature were and rainfalls were determined for each month. Anopheline community structure was examined and divided into alpha (α) and beta (β) component with the aim to provide a meaningful comparison of its distribution and abundance in all seven districts of Meghalaya. Precisely, it is used for community comparison but here we used as indicators for changes in community.
this study NFA of each district was used as control and compared with other type of land use like OFA, FLA, PLA and ULA.

Alpha diversity refers to the diversity within a particular area or ecosystem and is usually expressed by the number of species (Whittaker, 1972). The ecological parameters like population abundance, species richness, species evenness (Pileou’s index), diversity of species (Shannon–Wiener index), wealth of mosquitoes (Margalef index) and species dominance (Barger–Parker index) were used for alpha diversity indices calculation in each district. Population abundance at each district was defined as the sum of individuals of a particular species, counted at each site (Montes, 2005). The number of species found at each study site during the study period expresses species richness. Diversity indices were calculated by using following formula:

## 2.6.1 Species evenness

The species evenness refers to how close in number each species is in an environment are. The evenness of a community can be represented by Pielou evenness index.

\[
J' = \frac{H'}{H'_{max}} \quad \text{(Pielous, 1975)}
\]

Whereas, \(H' = \) Derived from the Shannon diversity index

\[
H'_{max} = \text{Maximum value of } H'
\]
2.6.2 Species diversity

Collected data were utilized to calculate larval and adult density of each mosquito species separately using following diversity indices mentioned below. Average seasonally and village wise larval and adult densities were calculated.

Shannon’s index:

\[ H' = - \sum pi \ln pi \] (Ludwig and Reynolds, 1988)

Whereas, \( pi = n/N \)

\( n = \) density of individual species

\( N = \) total density

2.6.3 Wealth of mosquitoes

The wealth of a community may be represented by Margalef index. It is calculated from the total number of species or total numbers of individuals are present in community (Montes, 2005).

\[ D_a = \frac{(S-1)}{\log_{e} N} \]

Where, \( D_a = \) margalef index
S = the number of species

N = the total number of individuals

**Dominance**

**Berger-Parker’s index:** (Berger-Parker, 1970)

\[
d = \frac{N_{\text{max}}}{N}
\]

Whereas, \( N_{\text{max}} \) = density of most abundant species

\( N \) = total density

**2.6.4 Beta diversity**

Ecosystem or “β diversity, is generally defined as variation in the identities of species between or among sites. It provides a direct link between biodiversity at local scale (\( \alpha \) diversity) and the broader regional species pool (\( \Upsilon \) diversity)” (Anderson et al., 2011). In this study Whittakers index (\( \beta_w \)) and Jaccard Index (\( I_J \)) β diversity indices were used.

**Whittakers index**

\[
\beta_w = \left(\frac{S}{\alpha}\right)^{-1}
\]
Whereas

**Jaccard Index**

\[ I_J = \frac{c}{a + b - c} \]

Manually, all diversity indices were calculated and for cross correction software PAST 2.16. under public domain (Hammer et al., 2001) were also used.

### 2.6.5 Rarefaction

Within a community, the species diversity may not be equal due to the mobility of individual (Magurran, 1998) and their numbers are increasing with sampling size and sampling effort. Though, the rarefaction curve technique was used with the aim of observing the asymptotic trends of number of species in the strata and for an evaluation of similarity. The rarefaction curves were developed using the software PAST (Hammer et al., 2001) under public domain.

### 2.6.6 Cluster analysis and Principal Component analysis

Five LULC types are involved in this study, so for similarity assessment the Cluster analysis and Principal Component Analysis (PCA) were used. Cluster analysis starts with a matrix exhibiting the similarity between pair of sites (Magurran, 1998).
The two most similar sites are combined to form a single cluster and later to form a dendrogram for visual inspection (Magurran, 1998).

A principal Component analysis was used to condense variables into factor group. Larval abundance was used for estimation and to find out which land use type are predictors of suitable habitat.

The Jolliffe cut-off var-covar was also calculated for PCA to know the degree of reliability of the classification system used. The cluster analysis and Principal Component analysis was also developed by using software PAST (Hammer et al., 2001) under public.

### 2.6.7 Analysis of Variance (ANOVA)

Among the meteorological factors, rainfall and temperature were used for further analysis. Multivariate analysis of variance were used to find the effect of seasonal rainfall and temperature effects on larvae and pupa abundance. One way and two ways Analysis of Variance (ANOVA) were also performed to perceive significance of quantitative variation of *Anopheles* between the season and between sampling sites. All results are presented as mean ± SE.