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# Study on the satellite based assessment of malaria mosquitogenic conditions in and around Dehradun

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**Abstract**
The relevant satellite data after procuring from National Remote Sensing Agency (NRSA) was analysed using ERDAS Imagine version 8.6 and IDRISI version 2. Based on supervised classification and land use patterns, the mosquitogenic conditions have been verified in the study area by using satellite imagery (PAN, LISS-III and WIFS) as well as by paying a visit to the field. On the basis of mosquito breeding in various habitats, it concludes that the river beds, rain water collection, pools, flooded agricultural fields, canals, ponds, marshy areas have been found to be the potent breeding habitats of mosquitoes. The survey work conducted during the year 2004 and 2005 reveals occurrence of 15 species of *Anopheles* (*An. aconitus, An. annularis, An. culicifacies, An. fluviatilis, An. gigas, An. jeyporiensis, An. lindesayi, An. maculatus, An. nigerrimus, An. splendidus, An. stephensi, An. subpictus, An. theobaldi, An. vagus* and *An. varuna*), besides *Aedes* sp., *Culex* sp., *Armigeres* sp. and *Uranotaenia* sp. in three study belts namely, Kalsi-Vikasnagar, Sahaspur-Selaqui and Raipur-Doiwala belt in district Dehradun. Considering, the population of Anophelines as harboured in all the three different belts, it was maximum at Raipur-Doiwala belt followed by Sahaspur-Selaqui and Kalsi-Vikasnagar belts in succession. At Kalsi-Vikasnagar and Raipur-Doiwala belt, 12 species of *Anopheles* were found as adults. However, the immature density was recorded more in Kalsi-Vikasnagar belt (11) than Raipur-Doiwala belt (9). In Sahaspur-Selaqui belt, 11 species of adult *Anopheles* and only 9 species of immature forms were recorded.

**Keywords:** Satellite data, mosquitogenic condition, anopheline species

## 1. Introduction
Larval habitats of mosquitoes are increasing day by day due to anthropogenic activities [1]. The larvae of anopheline mosquitoes found in shallow surface water. The habitats of the anopheles mosquitoes and chances of malaria risk to human population can be detected by remote sensing and GIS.

As far as the research work on the mosquitoes from Dehradun region and its nearby areas is concerned, it is almost based on taxonomy and systematics with an addition of ecological notes on them. There are a number of localities where the chances of survey application are most difficult because of their geographic location either in depth or in remote areas. Remote Sensing and GIS could be very useful in assessing the biodiversity of mosquitoes in inaccessible areas, which have never been explored from the point of view of faunistic survey. Now a day's many scientists are using these technologies for accessing mosquito's habitats, changes in environment and malaria prevalence [2-14]. The use of remote sensing, GIS and GPS are not only limited for mapping the habitats of mosquitoes, but are also used for the spatial relationship between the malaria cases and the environmental changes of the particular areas [15-18].

The present study was done during the period of 2004-2005 for a perios of one year, and the objectives are to study the block wise mosquitogenic conditions in the Dehradun, mapping of mosquito species as surveillance of malaria disease in Dehra Dun, mapping of mosquito species as per habitats, predicting the distribution of malaria vectors based on habitat requirement, forecasting and modeling and developing malaria information system so as to decipher the ecological succession in mosquito diversity.

## 2. Study Area

Dehradun lies between lat. 29º57′ and 31º2′N and long. 77º 20′ in East. Its elevation ranges from 315 to 2500 m while the gradient varies between 7 to 10 m/km. This synclinal trough receives about 200 cm rainfall annually depending upon other climatic factors. The maximum summer temperature ranges between 35.9 to 36.7 ºC and in the winter months the minimum temperature varies between 2.5 to 3.5 ºC.

Epidemiological investigation is based upon the parasitological data collected in collaboration with the district Malaria office. On the basis of malaria incidence in the last 3 years as well as changing scenario of the areas, it was decided to undertake studies in the following 3 belts, namely, Kalsi-Vikasnagar, Sahaspur-Selaqui and Raipur-Doiwala.

**Table 1:** Geographic details about the study sites

| Name of localities | Coordinates | | Land use pattern | Water bodies |
|---|---|---|---|---|
| | Lat. | Long. | | |
| **Kalsi-Vikasnagar** | | | | |
| Vikasnagar | 30º28′ | 77º46′ | Urban settlements | River, pond, wells |
| Rudrapur | 30º27′ | 77º48′ | Forest | Pond |
| Harbatpur | 30º26′ | 77º43′ | Urban settlements | Rice field, channels |
| Horawala | 30º25′ | 77º51′ | Forest | Streams, pond |
| **Sahaspur-Selaqui** | | | | |
| Sahaspur | 30º33′ | 77º49′ | Forest | Streams, ponds |
| Rampura | 30º22′ | 77º51′ | Arable land | River, rice fields, wells |
| Selaqui | 30º21′ | 77º52′ | -do- | Ponds, rice fields |
| Jhajra | 30º21′ | 77º55′ | -do- | River, channels |
| Premnagar | 30º32′ | 77º58′ | Urban settlements | Ponds, wells, tanks |
| **Raipur-Doiwala** | | | | |
| Raipur | 30º18′ | 78º04′ | Arable land | Streams, ponds |
| Gujronwali | 30º17′ | 78º06′ | -do- | River, steams |
| Harrawala | 30º16′ | 78º03′ | Forest | Steams, ponds |
| Gularghati | 30º13′ | 78º08′ | Arable land | River, ponds |
| Basantpur | 30º14′ | 78º12′ | -do- | River, channels |
| Bhogpur | 30º13′ | 78º13′ | -do- | River, ponds |
| Ranipokhari | 30º10′ | 78º12′ | -do- | Well, ponds |
| Lacchiwala | 30º11′ | 78º06′ | -do- | River, steams |
| Doiwala | 30º10′ | 78º06′ | -do- | River, ponds, tanks |

## 3. Materials & Methods

The relevant satellite data after procurement from National Remote Sensing Agency (NRSA), Hyderabad (A.P.) was analysed using ERDAS Imagine version 8.6 and IDRISI version 2. The satellite data after loading on the Silicon Graphics computer, it was corrected with important ground points which are investigated from the field. To remove any misrepresentation in the satellite data the images (March, 2004 and April, 2005) were recorded to the coordinate system. FCC was produced with band 3, 2, 1 for the investigation area. Before doing the supervised classification and analysis the images were optically analysed. Accuracy of image classification was assessed by performing a common practice of creating an error matrix. The following major classes *viz*., dense Sal forest, thick vegetation, marshy areas, water body, human settlement, degraded forest, wet soil, agriculture fallow, agriculture growing and grassy patches were recorded. The Radiance image was made for each land use class by converting the DN values to absolute radiance values. The NDVI value will be calculated by using the following formula:

$$NDVI = (NIR-Red)/(NIR + Red)$$

For GIS visualization Topo maps of the respective area on the scale 1:50,000 were obtained from SOI and were used to digitize the base maps after undergoing scanning registration and mosaicking. A matrix consisting of attribute data for each theme *viz*., temperature, rainfall, water bodies and human settlement was prepared to generate the thematic maps. Each thematic map was stratified in three potential zones *i.e.,* high, medium and low according to favourable conditions for water logging and in turn mosquito breeding. Overlaying operation included superimposition, proximity searches, topography analysis and aggregation of areas.

For the mosquito sampling, different study sites *viz.,* Kalsi-Vikasnagar belt, Sahaspur and Doiwala-Raipur belt in District Dehradun were selected and the adult collection was done using an aspirator, test-tube, hand net and drop net during the morning hours between 06.00 h-08.00 h. from human dwelling, cattle shed, mixed dwelling and random collection were chosen as per the prevailing situation and 15 minutes time was given at each spot while two persons were involved. A survey was conducted to study the possible breeding sites in and around the selected localities. For the collection of immature 3 methods, namely, dipping, netting and pipetting were commonly used. Soon after collection, different morphological stages *viz.,* I, II, III and IV instar larvae and pupae of Anopheline mosquitoes were sorted out. The collected larvae were brought to the laboratory for their emergence into adults. Only the IVth instar larvae and pupae were kept in bowls along with the same water from where they were collected. These bowls were kept in the cages made up of iron frames and muslin clothes. For identification purpose the procedures as adopted by previous workers were followed [19-21]. The *Culex* species present in the collection were identified as per procedure [32].

## 4. Results & Discussion

The study was aimed to identify the possible mosquito breeding sites like seepage pools, riverbeds, rice fields, tanks, forest pools/ponds, ditches, streams, intra domestic containers

and shallow pits. The total surface areas of each land marks were correctly calculated and the data was attached to the site based map of the Dehradun.

False colour composites (FCC) were generated for the study area. Fig. 1A and 1B showed the False Colour Composite images of the study area during the study period.

The following major classes *viz*., dense Sal forest, thick vegetation, marshy areas, water body, human settlement, degraded forest, wet soil, agriculture fallow, agriculture growing and grassy patches were recorded (Fig. 2A and B). Of these, the following classes, namely, thick vegetation, marshy area, water bodies-lakes, ponds and wet soil were found to have immature mosquitoes. Fig. 3 showed the comparison of area ($km^2$) for the year 2004 and 2005 in district Dehradun.

Table 2 represents the radiance values of the following 6 classes viz., dense (Sal) forest, thick vegetation, marshy area, water body, human settlements and degraded (open forest) in all the three bands like band 2, 3 and 4 of study sites in district Dehradun. There was a fluctuation in the values as recovered in all the three bands. For water body it was maximum in 2 band followed by 3 band and 4 band in succession. As far as the values in respect of human settlement are concerned, it was maximum in band 4 than band 2 and 3. Fig. 4 represents band vs. radiance values ($mw/cm^2$ Sr/m) of all land use classes in district Dehradun for the study period.

Based on the supervised classification and land use patterns, the mosquitogenic conditions have been verified in the study area by using satellite imagery (PAN, LISS-III and WIFS) as well as by paying a visit to the field. The survey work reveals occurrence of 15 species of *Anopheles* (*An. aconitus, An. annularis, An. culicifacies, An. fluviatilis, An. gigas, An. jeyporiensis, An. lindesayi, An. maculatus, An. nigerrimus, An. splendidus, An. stephensi, An. subpictus, An. theobaldi, An. vagus* and *An. varuna*), besides *Aedes* sp., *Culex* sp., *Armigeres* sp. and *Uranotaenia* sp. in three study belts namely, Kalsi-Vikasnagar, Sahaspur-Selaqui and Raipur-Doiwala belt in district Dehradun (Fig. 5). There are different views regarding the breeding status, which alter species to species. These results can be comparable with the present investigation. The breeding has been recorded in river and river beds [23, 24], in tanks [25], in pits [26, 27], in canal and streams [28, 29], intra domestic containers [26], ponds, rice fields [25, 30, 31, 32, 33] and drains [23].

The population of Anopheline was maximum at Raipur-Doiwala belt followed by Sahaspur-Selaqui and Kalsi-Vikasnagar belts in succession. At Kalsi-Vikasnagar and Raipur-Doiwala belt, 12 species of *Anopheles* were found as adults (Fig. 6). However, the immature density was recorded more in Kalsi-Vikasnagar belt than Raipur-Doiwala belt. In Sahaspur-Selaqui belt, 11 species of adult *Anopheles* and only 9 species of immature forms were recorded. Occurrence of different Anopheline species in four different seasons of the year *i.e*., summer, monsoon, post monsoon and winter has been worked out based on the numbers collected during respective season. It has been found that the mosquitoes preferred indoor shelters than the outdoor. The results are comparable with the work of [34, 35, 36, 37].

The negative values of NDVI indicate the presence of water. In 2004, there was an increased value of NDVI, hence the washing away of mosquito habitats was observed. This resulted in a decrease in mosquito breeding habitats and hence less abundance of mosquitoes (Fig. 7 A and B). The GIS has been used to calculate the proportion of each landscape element within 1km (radius) buffer surrounding each study site of district Dehradun. This 1km radius is based on the typical flight range of an adult Anopheline mosquito, as within this flight range she must find blood meals, resting sites and larval habitat in order to reproduce.

Some earlier workers established a relationship between NDVI and density of *Anopheles* and malaria cases The NDVI was the representative index of the first common factor of *Anopheles* density evaluation. Gray correlation analysis showed that in rainy season NDVI had a high gray correlation with A*nopheles* density and malaria incidence rate [38, 39, 40].

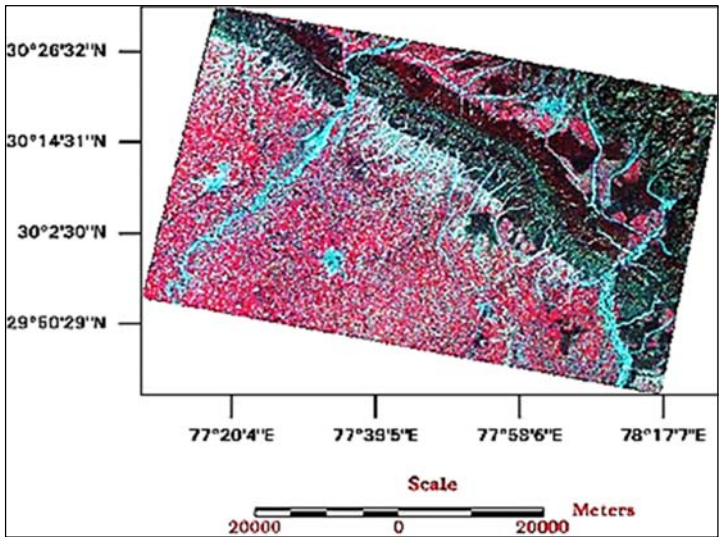



**Fig 1 A:** False Colour Composite (FCC) of parts of district Dehradun covering the study sites during March 2004

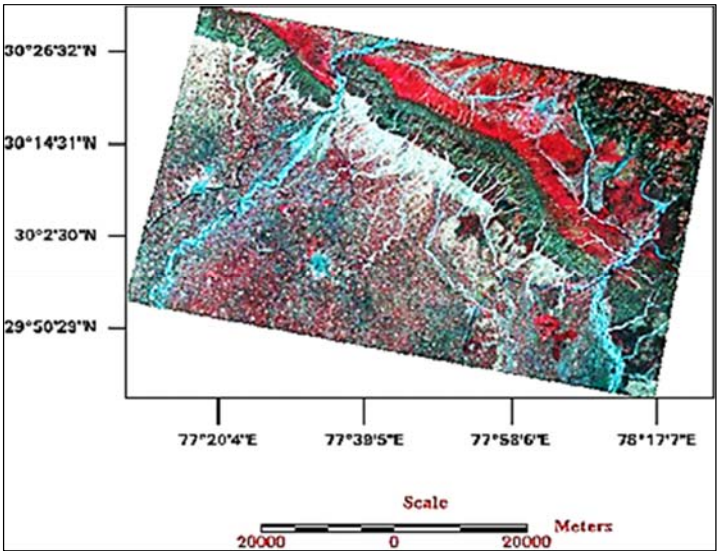



**Fig 1(B):** False Colour Composite (FCC) of parts of district Dehradun covering the study sites during April 2005

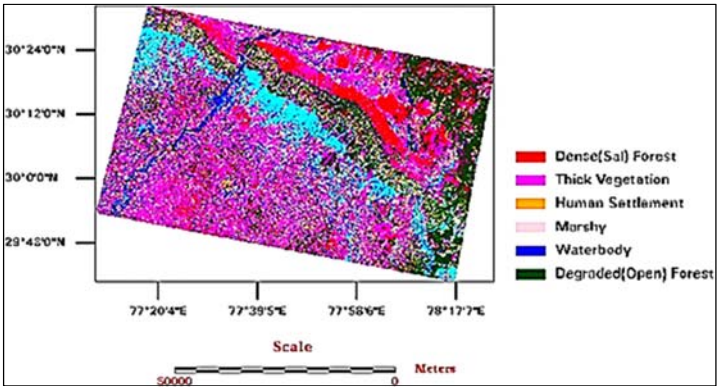



**Fig 2(A):** Supervised classification of parts of district Dehradun covering the study sites based on mosquitogenic conditions during March 2004

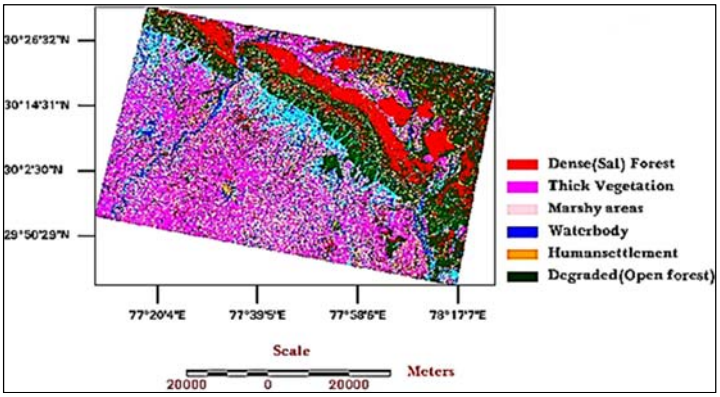



**Fig 2(B):** Supervised Classification of parts of district Dehradun covering the study sites based on mosquitogenic conditions during April 2005

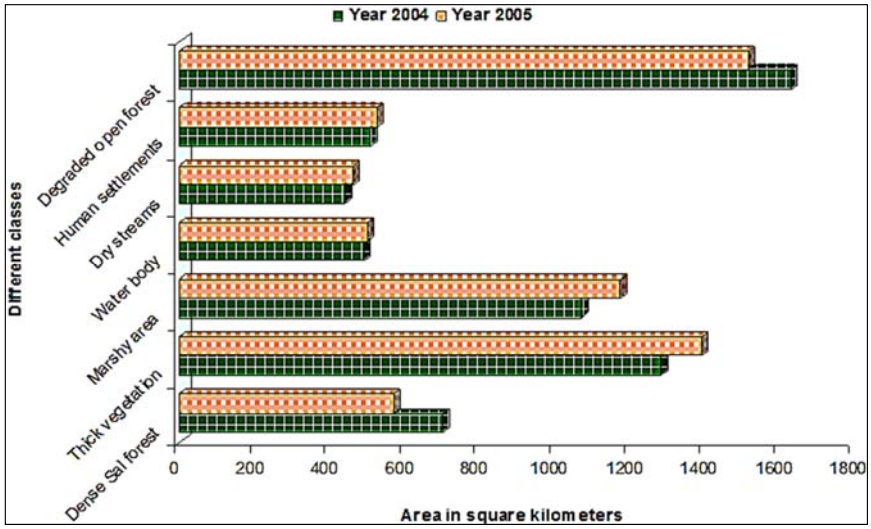



**Fig 3:** Comparison of Area ($km^2$) for all land use classes for the year 2004 and 2005 in district Dehradun

**Table 2:** Values of radiance of different classes of Doon valley

| Class names | Band-2 | Band-3 | Band-4 |
|---|---|---|---|
| Dense (Sal) forest | 4.45 | 3.35 | 5.41 |
| Degraded (open) forest | 5.32 | 4.12 | 5.2 |
| Thick vegetation | 5.04 | 3.51 | 8.05 |
| Marshy areas | 5.76 | 4.53 | 6.25 |
| Water body | 9.37 | 8.21 | 7.23 |
| Human settlement | 6.04 | 5.12 | 6.31 |

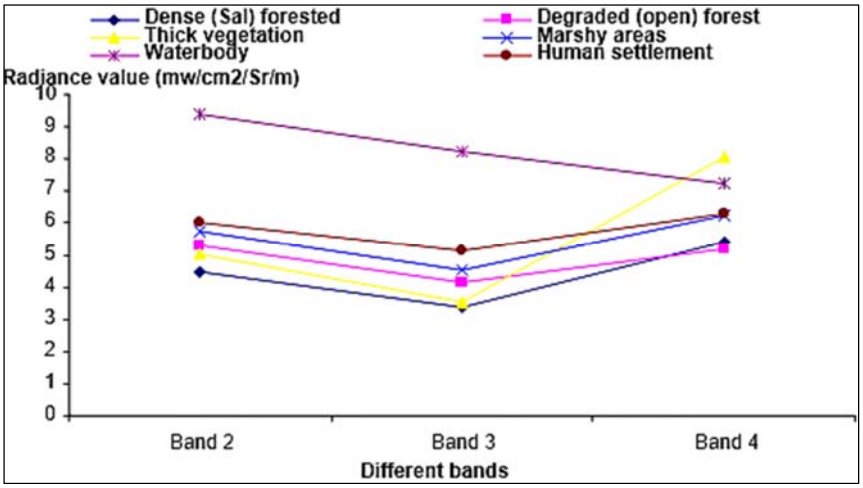
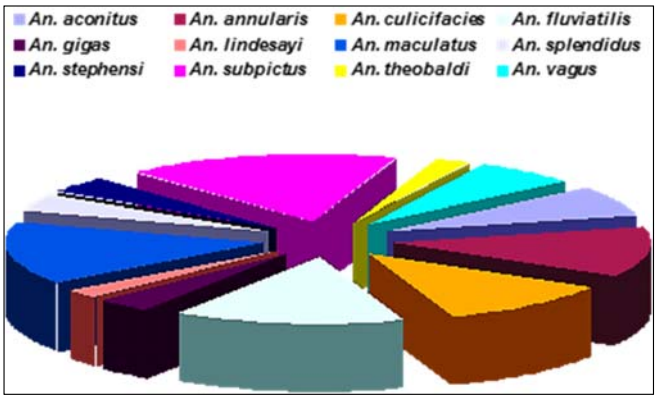
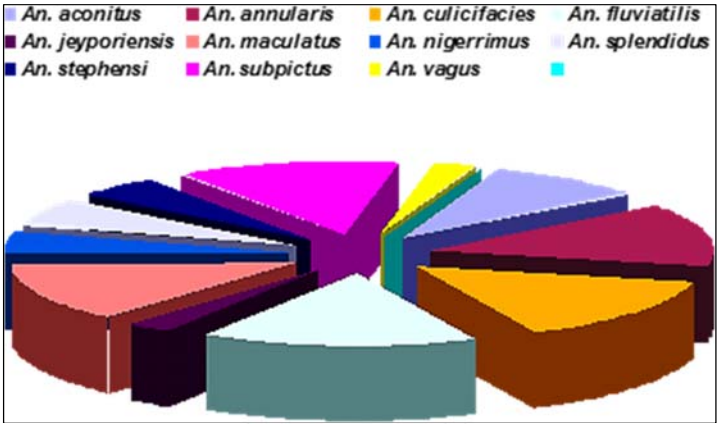


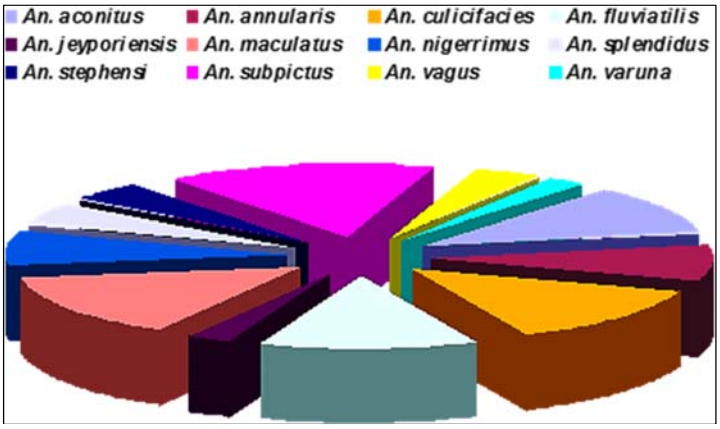

**Fig 4:** Bands vs. Radiance values of all land use classes for the study period in district Dehradun




**(i) At Kalsi-Vikasnagar**




**(ii) At Sahaspur-Selaqui**




**(iii) At Raipur-Doiwala**

**Fig 5(i, ii, iii):** Composition of Anopheline species in three different selected belts of district Dehradun during the study period (2004-05)

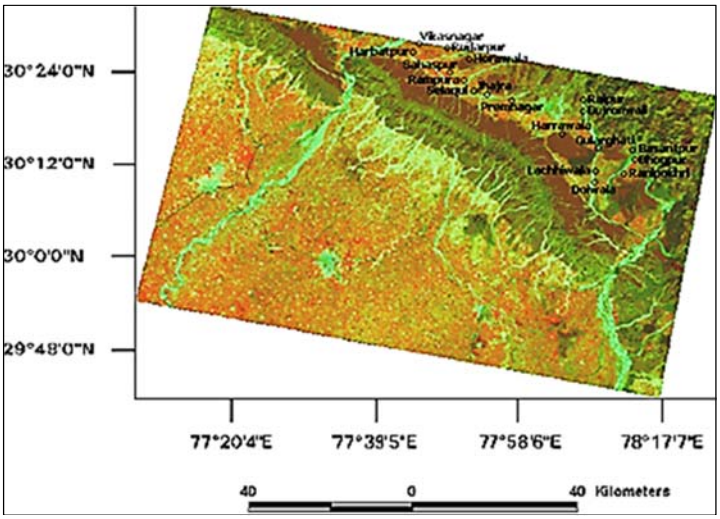



**Fig 6:** Image of district Dehradun showing the location of mosquito breeding spots

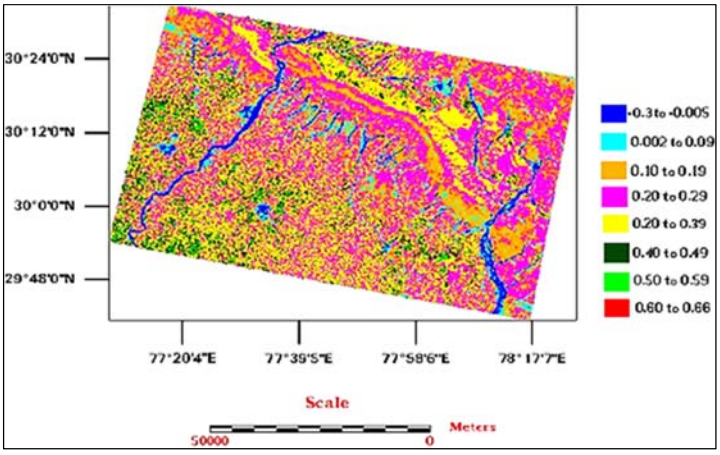



**Fig 7:** NDVI of parts of district Dehradun covering the study sites during March 2004

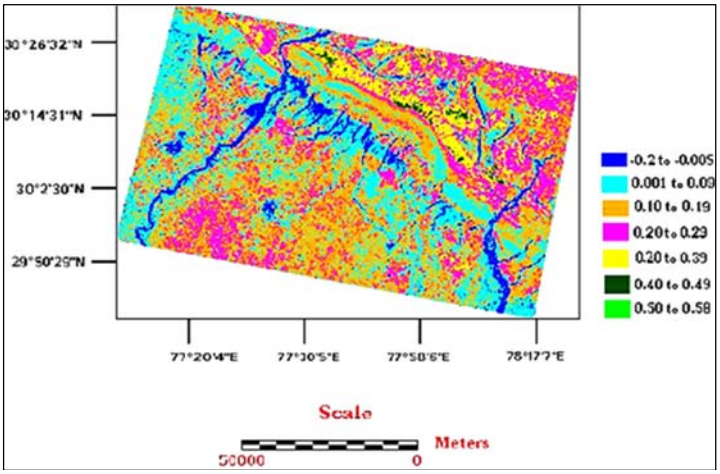



**Fig 7(B):** NDVI of parts of district Dehradun covering the Study sites during April 2005

## 5. Conclusion

The foregoing account illustrates that remote sensing technology can be helpful in identification and mapping of breeding habitats of mosquitoes and other vector-borne diseases. By undertaking such studies, the macro stratification of the area in respect of mosquitogenic potential can be assessed for prioritizing the sites for mosquito control programme.

## 6. Acknowledgements

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