Temporal changes in land cover types and the incidence of malaria in Mangalore, India

Background

Malaria is a complex and one of the most serious vector-borne diseases world-wide. About half of the world's population is at risk. Large areas of Africa and South Asia and parts of Central and South America, the Caribbean, Southeast Asia, the Middle East, and Oceania are the areas with highest transmission for malaria. The World Health Organization (WHO) estimates that in 2008, 190 - 311 million clinical cases of malaria occurred and more than a million people died due to the disease. The vectors for transmission of malaria are mosquitoes and they need water to complete their life cycle. This water can range in quality from melted snow water to sewage effluent, artificial or fresh water collections like salt marshes, sewage effluent ponds, irrigated pastures, rain water ponds, etc. Each species of mosquito has unique environmental requirements for the maintenance of its lifecycle.

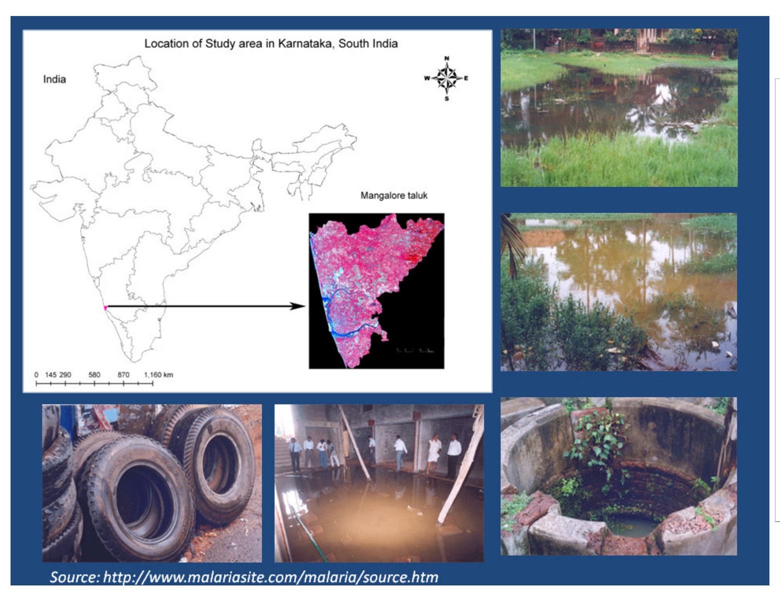
India greatly contributes to about 60% of Southeast Asian malaria incidence. The plethora of various species of malaria vectors, a hospitable environment for growth and proliferation of the parasites and vectors and a malaria-susceptible human lineage have established India as a hotspot for malaria infection.

Objectives

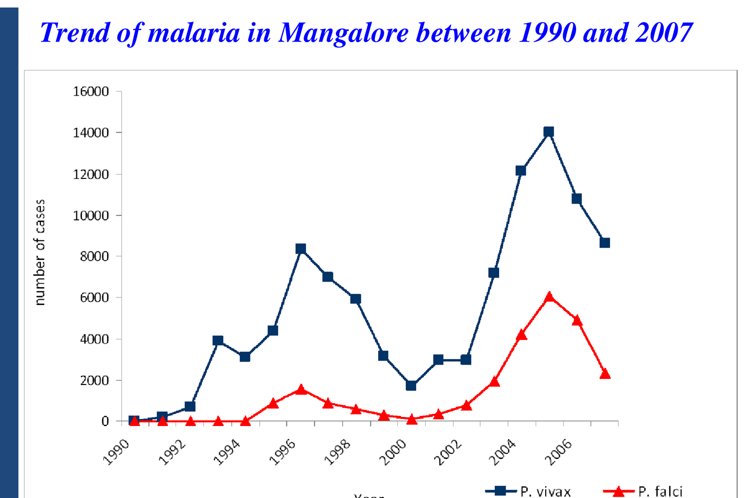
1. Estimate the major land cover types in Mangalore taluk of the State of Karnataka in South India using remote sensing imagery.
2. Detect changes in the land cover types which favor mosquito breeding between for the years 2000 and 2003 in this region.
3. Study the incidence of Malaria in the region for the same period.
4. Assess relationship between the natural resource indices and the burden of malaria in this region.

Methodology

Study area: Mangalore taluk, on the western coast of Karnataka in South India spans an area of around 854 km^2, situated between $13^0 8$'0.11"N and $76^0 46$'24.23"E coordinates. As per the 2001 census, the total population of the taluk was 882856 with 68.08 % of the population living in urban areas. The density of population in the taluk is 1048 persons per Sq.km. This geographic region bordered by the Arabian Sea on its West, by the thick forested area on its east is rich with natural resources. The availability of favorable natural habitats and increasing artificial water collections due to construction related activities has rendered this region more susceptible to malaria. The city of Mangalore has experienced a spurt in industrialization and construction activities since 1990. The incidence of malaria in this region has been increasing over the same time period.



Trend of malaria in Mangalore between 1990 and 2007



Source: National Vector Borne Disease Control Program, India

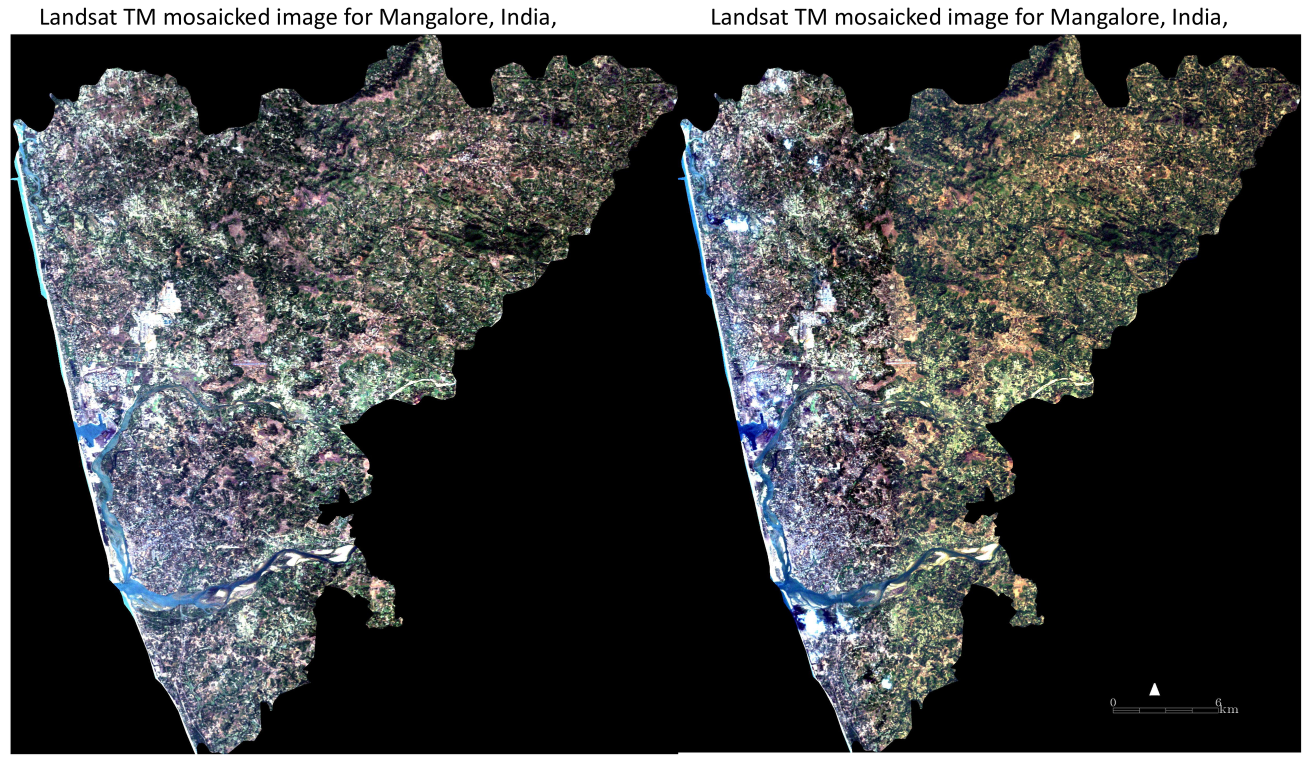
Study period: Change detection of the land cover types assessed for the years 2000 and 2003. The malaria incidences in the region for the period 1990 to 2007 were obtained from the National Vector Borne Diseases Control Program division of the State Public Health Department of Karnataka.

Remote sensing (RS) data for the region were obtained as Landsat TM images for the years 2000 (dated 14th April and 20th December 2000) and 2003 (dated 23rd April and 27th January 2003) from the U.S. Geological Survey data repository. The RS data was processed and analyzed using the software ENVI 4.6. Initially, the RS images were mosaicked after layer stacking, and were clipped using the shape file for the study area. Initially unsupervised classification was performed using K-means algorithm after Principal Component analysis for one year and compared with the supervised maximum likelihood classification done for four major classes of land cover types (urban, Water, Vegetation, Mountain) with a minimum of 15 ROI polygons for each class and a minimum of 300 ROI points for each class for accuracy assessment. Based on the accuracy reports and commission and omission errors between the two methods, supervised maximum likelihood classification was performed on all further images. Change detection statistics was performed using the post classification comparison method.

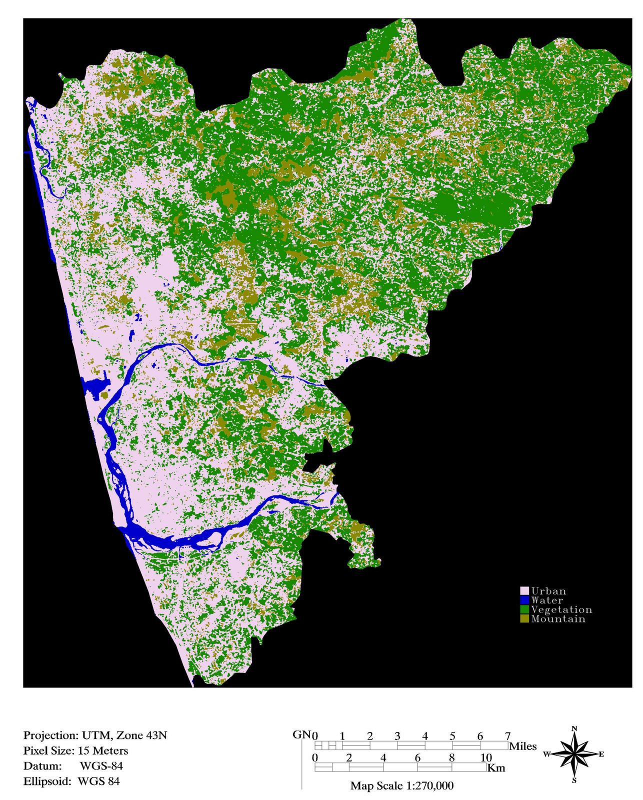
Comparison of accuracy reports between the unsupervised and supervised classification methods

Parameter	Unsupervised classification	Supervised classification
Overall accuracy	73%	98%
Kappa coefficient	0.63	0.97
User accuracy-Urban class	42%	92%
User accuracy-Vegetation class	97%	100%
User accuracy-Water class	56%	100%
User accuracy-Mountain class	88%	100%

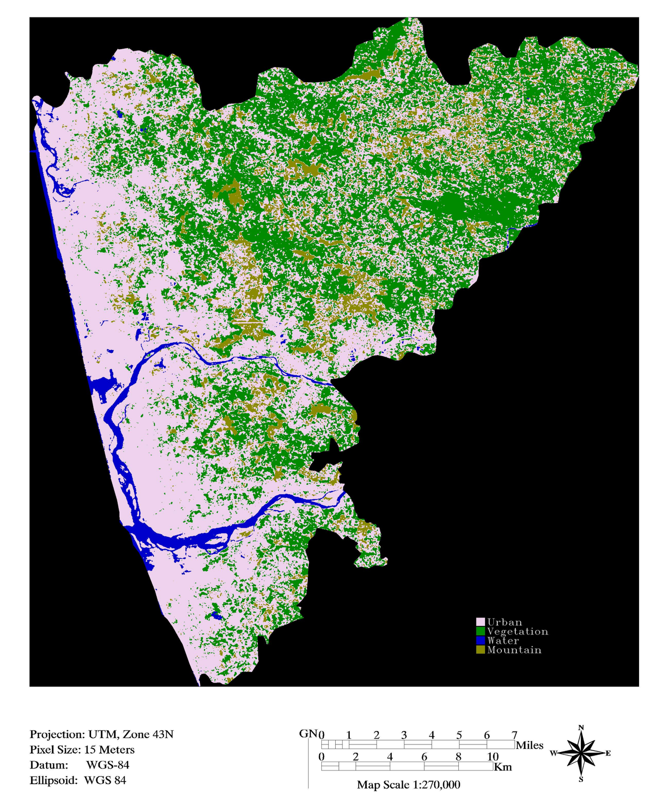
Landsat TM mosaicked image for Mangalore, India, Landsat TM mosaicked image for Mangalore, India,

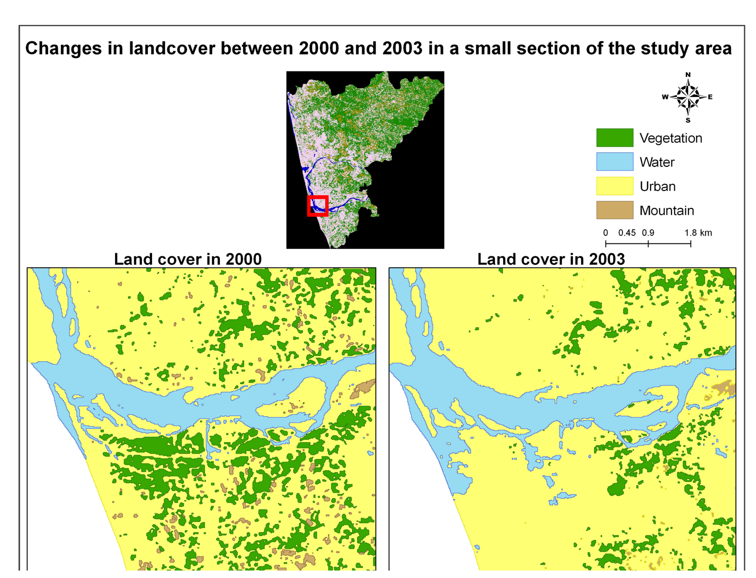


Classified map of Mangalore, India, 2000



Classified map of Mangalore, India, 2003



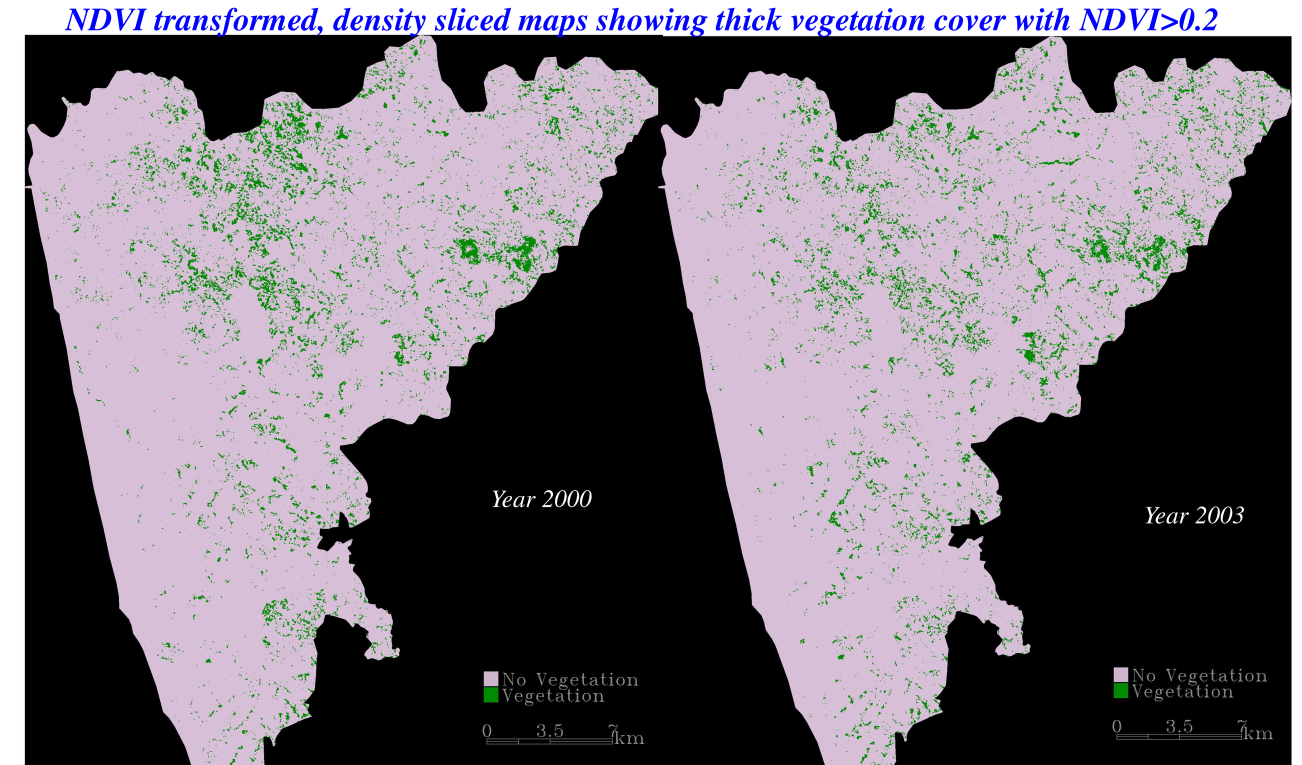


Changes in land cover types between 2000 and 2003

Land cover type	2000	2003	Difference	
	km^2	km^2	km^2	%
Urban	331.7	397.9	66.2	19.96
Water	17.26	22.63	5.37	31.1
Vegetation	295.42	256.65	-38.77	-38.76
Mountain	94.43	61.62	-32.81	-34.74

Normal Difference Vegetation Index (NDVI) transformation was performed on the raw, mosaicked images using bands 4(NIR) and 3(Red). The range of NDVI varied from -1 to +1, using image exploration and also based on earlier studies from this region, density slicing was performed on the NDVI transformations and vegetation with NDVI more than 0.2 (representing dense thick vegetation) were highlighted and exported as separate classes for both the study years.

NDVI transformed, density sliced maps showing thick vegetation cover with NDVI>0.2

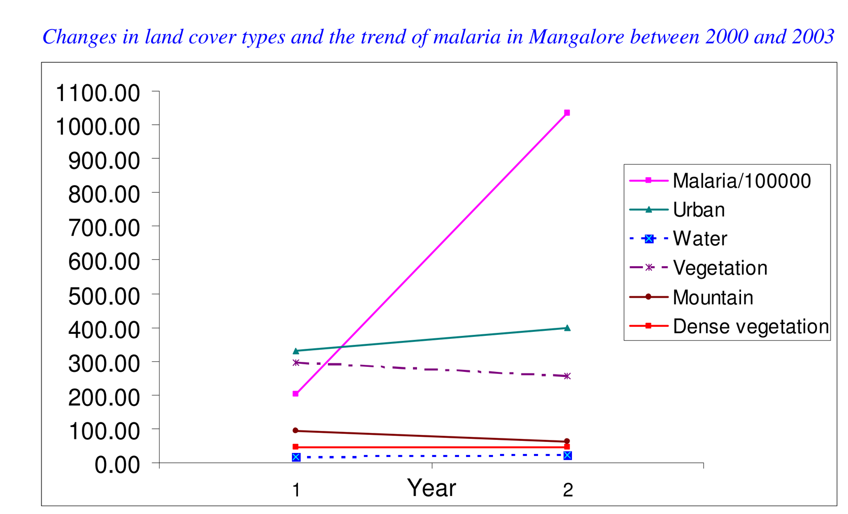


Thick vegetation cover in 2000 = 46.88km^2 ; in 2003 = 44.73km^2
A 4.5% reduction in thick vegetation cover (NDVI >0.2) between 2000 and 2003

Discussion and Conclusions

India with its unique geographic position (8^0 4' to 37^0 6' N latitude and 68^0 7' to 97^0 25' E longitude) has a diverse topography and climatic variations. India contributes greatly to the global malaria burden. The National Malaria Control program in India has been in action since 1960s, which has led to a great reduction in the burden of the disease in the country. Recent increases in malaria related morbidity and mortality has been noted in the coastal regions of India which is mainly due to urban malaria. Mangalore taluk, located on the western coastal region of South India has experienced an increase in the urbanization over the last two decades and a corresponding increase in malaria related morbidity and morbidity. Recent studies show that a rise in malaria among construction workers in this region.

This study looking at the changes in important land cover types in this region between the years 2000 and 2003 shows that there was an increase in the urban land cover by 20%, with a reduction in the mountainous terrain by 34.7% and vegetation by 38.7% correspondingly. A 4.5% reduction in the level of thick vegetation (NDVI>0.2) was noted in the region, which could be as a result of increased urbanization. The fresh water and stagnant water collections increased by 31% in 3 years and are essential for mosquito breeding and transmission of the disease. Some of these artificial water collections are due to construction related activities and collections after rainfall in places like disused vehicle tires, tree holes, used coconut shells, open water tanks, open wells etc. which are associated with human activities.



The absolute numbers of malaria cases in the region had also increased between the study period and the incidence of malaria increased five-fold from 203/100000 population in 2000 to 1035/100000 population in 2003.

An increase in the urban land cover, water collection and a rise in malaria burden are noted in Mangalore between 2000 and 2003.

Limitations

The breeding habits of the mosquitoes vary between species are dependent on other environmental factors like amount of rainfall, temperature, humidity, elevation of the terrain etc. Studies looking at malaria and RS data elsewhere have also looked at the mosquito larval densities by conducting field studies and other environmental parameters. This study has used the rates of the malaria disease in the region as an outcome measure due to the lack of data on mosquito larval densities in the region.

The information on the other essential parameters like rainfall, humidity etc. was not available for the study region for the period studied and hence could not be studied.

Further information

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Acknowledgements

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Data sources

- US Geological Survey data repository,
- NVBDCP, India.

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Dr. Venkata Raghava Mohan
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Tufts University School of Medicine