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# REMOTE SENSING AND URBAN MALARIA: RADAR ENVISAT CONTRIBUTION FOR THE DETERMINATION OF POTENTIAL ANOPHELES BREEDING SITE IN ANTANANARIVO (MADAGASCAR)

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## Abstract

Most studies of anopheline mosquito larval ecology have been done in rural settings. However, latest data based on two cross-sectional surveys in Antananarivo, the capital of Madagascar, shown low rate of malaria cases among febrile episodes but autochthonous malaria cases exist. *Anopheles funestus* constitutes the main vector of malaria in the highlands of Madagascar. This paper described the determination of their potential breeding site using remotely sensed data. A supervised classification by the classical method of maximum likelihood was used for enhanced thematic mapper image of Landsat 7. Overall accuracy of the classification was 86% and kappa index was 0.835. Determination of landscape change by subtraction of images acquired on January and July was carried out for the Advanced Synthetic Aperture Image Precision images of Envisat. Increased backscatter coefficient between the two periods made possible to raise ambiguity between rice fields and other vegetation. That may improve the determination of potential anopheles breeding sites.

## BACKGROUND

In most of sub-Saharan Africa countries, malaria transmission is generally intense in rural settings. In contrast, malaria transmission occurs at significantly lower level in urban areas where population density is high, and where the number of mosquito breeding sites is reduced [1]. Central Highlands of Madagascar are known as a malaria epidemic-prone area. Several malaria cases have been reported during the last epidemic of the 80's. In addition to a policy of early drug therapy, a vector control programme was launched by the "Ministère de la Santé, du Planning Familial et de la Protection Sociale". It was based on indoor insecticide spraying. *Anopheles funestus* constitutes the main vector of malaria in the Central Highlands of Madagascar. Rice fields are known as their potential breeding sites [2-4].

The latest data based on two cross-sectional surveys in 43 health centres in Antananarivo showed low rate of malaria cases. In February 2003 (rainy season) and July 2003 (dry season), 1.9% positive cases and 1.5% positive cases were respectively detected. Only two cases of 15, both *P. falciparum*, were likely to have been autochthonous (0.26%). In July, three cases were considered to be of local origin (0.4%) [5].

Antananarivo, like most of urban areas was considered as a malaria transmission free zone. However, the latest cross-sectional surveys had shown that autochthonous malaria cases exist. The

issue is to know if these cases could induce an epidemic. Antananarivo landscape is characterized by both urban and agricultural area with vast rice field plains. Rapid change of urban area involved updating the map of potential mosquito breeding sites using remotely sensed data. It constitutes a relevant parameter to assess the malaria epidemic risk. This study aimed to determine the contribution of radar remote sensing to detect these mosquito-breeding sites.

## MATERIALS AND METHODS

The study area includes the urban area of Antananarivo and the immediate neighbourhoods, 18°48'S and 47°24'E in the North West 19°00'S and 47°42'E in the South East. The landscape is characterized by both urban and agricultural area with vast rice field plains in the north and west.

An Enhanced Thematic Mapper Plus (ETM+) image of Landsat 7, acquired on May 2000 and two Advanced Synthetic Aperture Image Mode Precision (ASA\_IMP\_1P) images of Envisat, acquired on January and July 2004, were used for the determination of the mosquito potential breeding sites (Tab. 1).

A supervised classification of the ETM+ image by the classical method of maximum likelihood was used to map rice fields. The classification accuracy was estimated by calculating the Kappa coefficient. Adaptive filters were applied to improve the quality of ASA\_IMP\_1P images. Landscape change between January and July was compared by the

way of visual interpretation and backscatter coefficient analysis.



Figure 1. Location of study zone

Table 1. Data specification

<b>ETM + Landsat 7</b>	
Date	2000/05/12
Preprocessing level	1G
Band	1-7, P
<b>ASAR Envisat</b>	
Date	2004/01/19 2004/07/12
Product type	ASAR_IMP_1P
Polarisation	VV
Band	C
<b>Digital Elevation Model (EO Epidemio Project)</b>	
Date	2004
Product type	ASAR_IM4 ASAR_IM5
<b>Topographic maps</b>	
Date	1970
Scale	1:10 000 1:50 000

Topographic maps and GPS location were used to complete visual interpretation of the images and for supervised classification of the image ETM+ Landsat7. There were used especially for identifying the training sites, the test sites location and for the ground truth validation. Geographical coordinates of these sites were positioned using handheld Global Positioning System (GPS).

Digital Elevation Model (DEM) was acquired by the way of Epidemio project). It was used to assert from their location the rice fields in the plain and the vegetation located on the crests.

## RESULTS

Composite image, with near infrared (band 4) in red channel the mid-infrared (band 5) in the

channel of green and red (band 3) in the channel of blue, shows vegetation type and condition characterized by colour hues (Fig 2).

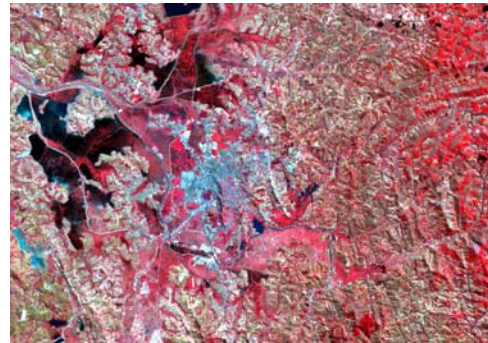


Figure 2. Infrared false colour composite of the image ETM+ Landsat7

The supervised classification by the method of maximum likelihood showed confusion between rice fields and chlorophyllous trees. Similar confusion was observed between lakes and flooded rice fields. Overall accuracy of the classification was 86%. Kappa coefficient was 0.835. Determination of landscape change was carried out by subtraction images of Envisat after normalization (Fig 3 and 4).

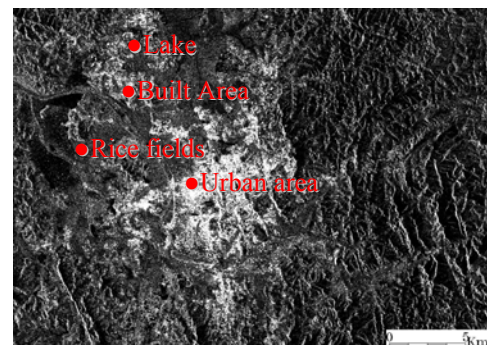


Figure3. Image of January 2004 (ASA\_IMP\_1P Envisat)

Rice fields present higher response in July than in January. Low backscatter coefficients characterized the flooded rice field in January. Young rice shoot in the seedbeds, cut plants after the harvest and rough ground of rice fields in ploughing were characterized by high backscatter coefficient in July. Turbid water body in January, rainy season, present higher backscatter coefficient. Change between the two periods made possible to raise ambiguity between rice fields and other vegetation (Fig 5).

It allowed removing commission error observed with optical data. However, the results cannot map rice fields only from other potential breeding sites like marsh and other wetland.

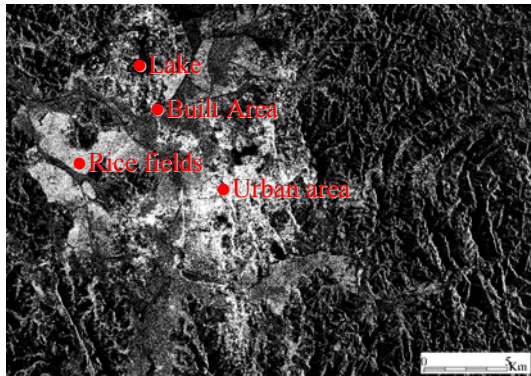


Figure 4. Image of July 2004  
(ASA\_IMP\_1P Envisat)

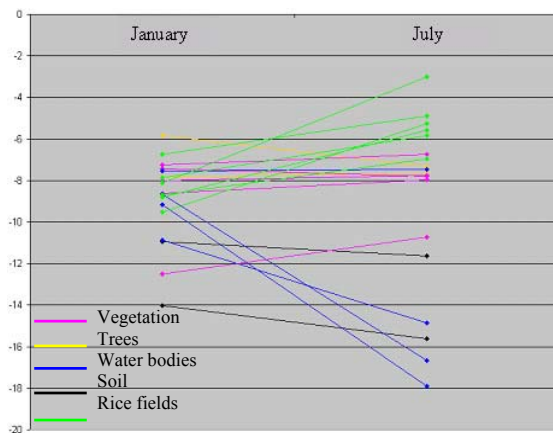


Figure 5. Backscatter coefficient change  
between January and July 2004

## CONCLUSION

In health application, remote sensing is commonly used to identify vector habitats e.g. vector borne diseases. Kaya et al. reported that the combined use of remote sensing and GIS provides a strong tool for monitoring environmental conditions that are conducive to malaria, and for mapping the disease risk to human population [6]. Results shows that supervised classification of optical data by the method of maximum likelihood may present confusion between rice fields and other vegetation so such study showed interest in using high spatial resolution combining passive and active data acquisition [7, 8]. Uneven aspect of the highlands of Madagascar constitutes the limitation of using radar remotely sensed data. In so far as rice fields located at the bottom of small valleys or in terrace, following hill round, using radar data is not really suitable for reliable extraction of rice fields. That was not the case of the plain of Antananarivo where the signal change of rice fields was easily detectable even if their intensity varied, due to the lag of cultivation calendar and the problem of water management. The contribution of radar imagery allows (i) data acquisition during wet season which

eases the comparison of different periods [9, 10] and (ii) erasing confusion between larval habitats and other vegetation such as reeds, trees. Hence radar remote sensing is the obvious choice as the most appropriate data source for multirate acquisition. This work showed the interest of using high spatial resolution image combining passive and active data acquisition. The results contribute to the malaria vector control in epidemiological application.

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