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# Spatial analysis of malaria distribution in the Union of Comoros

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## Introduction

Malaria remains endemic in Comoros. In 2006, malaria was the leading cause of mortality, morbidity and consultation in hospitals. The Government of the Union of the Comoros is committed in the fight against malaria through the establishment of a National Strategic Plan in 2007 that was later updated for the period 2012-2016. The results of these efforts show that the disease is in a pre-elimination phase. Despite a clear decline of malaria several aspects of its epidemiology should be clarified including the identification of endemic areas.

The occurrence of malaria shows spatial variations between and within islands. Several factors determine its transmission, including environmental and climatic factors, social conditions, individual behaviors, physiological conditions, control actions. This has shown the importance of a spatial and multidisciplinary study of malaria.

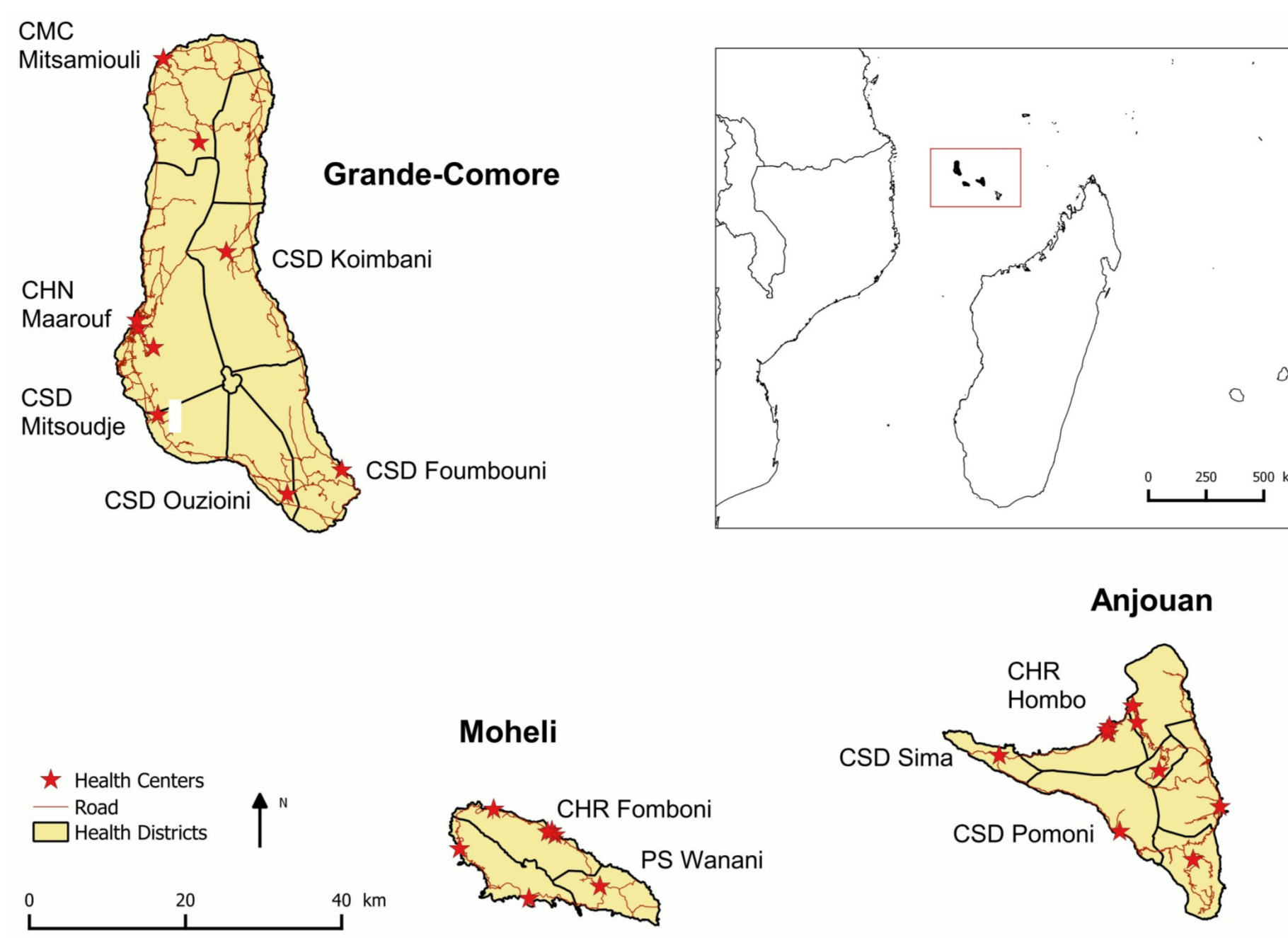
Therefore, the purpose of this study is to:

- characterize the spatial and temporal dynamics of malaria,
- describe its ecological and social patterns,
- assess the impact of control actions,
- statistically model its distribution.

## Material and methods

### Study area

Located at the northern of the Mozambique Channel between the east coast of Africa and Madagascar, Union of Comoros is composed of three islands: Grande Comore (1,147 km<sup>2</sup>), Anjouan (424 km<sup>2</sup>) and Moheli (360 km<sup>2</sup>).



### Epidemiological information

The monitoring and evaluation service of the "Programme National de Lutte contre le Paludisme" (PNLDP) is regularly tracking notification of identified cases of malaria at public health centers, private hospitals and medical and biological laboratories. The diagnosis of malaria is made with a thick blood smear and a rapid diagnostic tests. Monthly cases, as reported by the PNLDP from 2010 to 2014, were geo-referenced in each island at the sanitary district level (7 in Grande Comore, 7 in Anjouan, 3 in Moheli). The incidence of malaria by district was calculated using population data from the National Census.

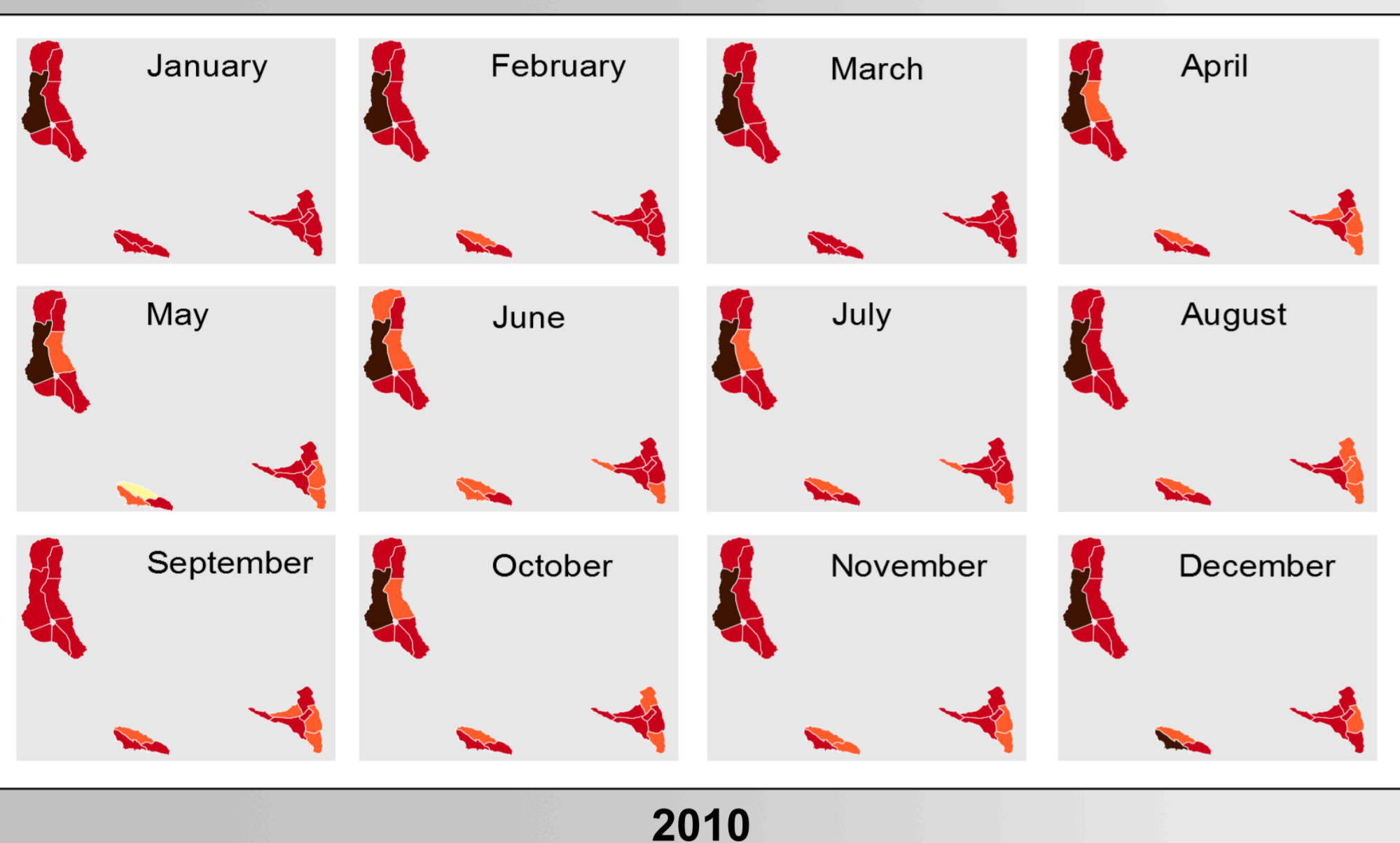
### Land cover mapping

A land cover map was realized for each island by remote sensing analysis (Object-Based Image Analysis) of SPOT 5 images (2.5m in panchromatic mode), provided by SEAS-OI station (<http://www.seas-oi.org/>).

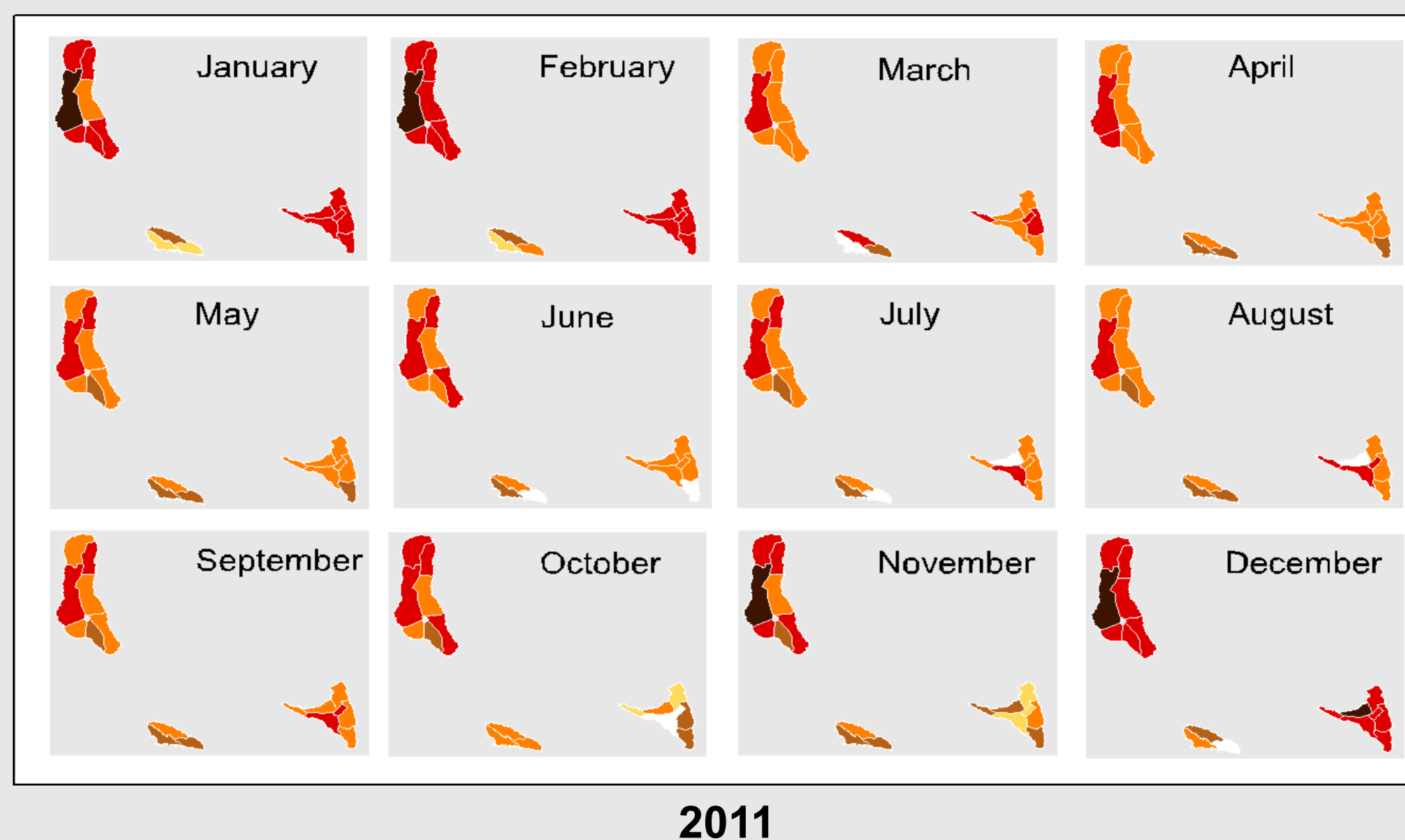
### Spatial database

We completed the spatial database with data on environmental and social factors including meteorology, physical geography, population characteristics, and health care facilities.

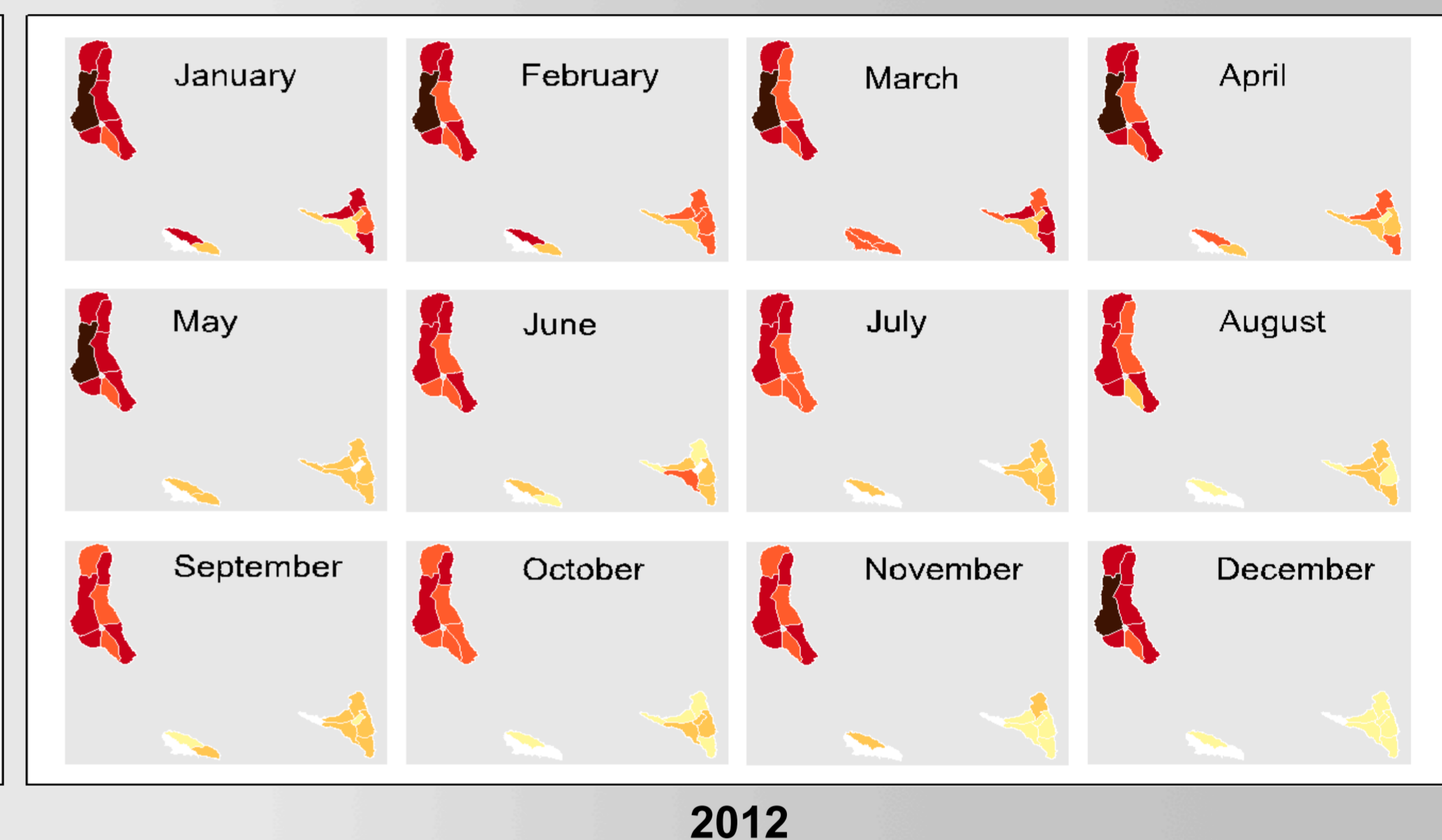
## Results



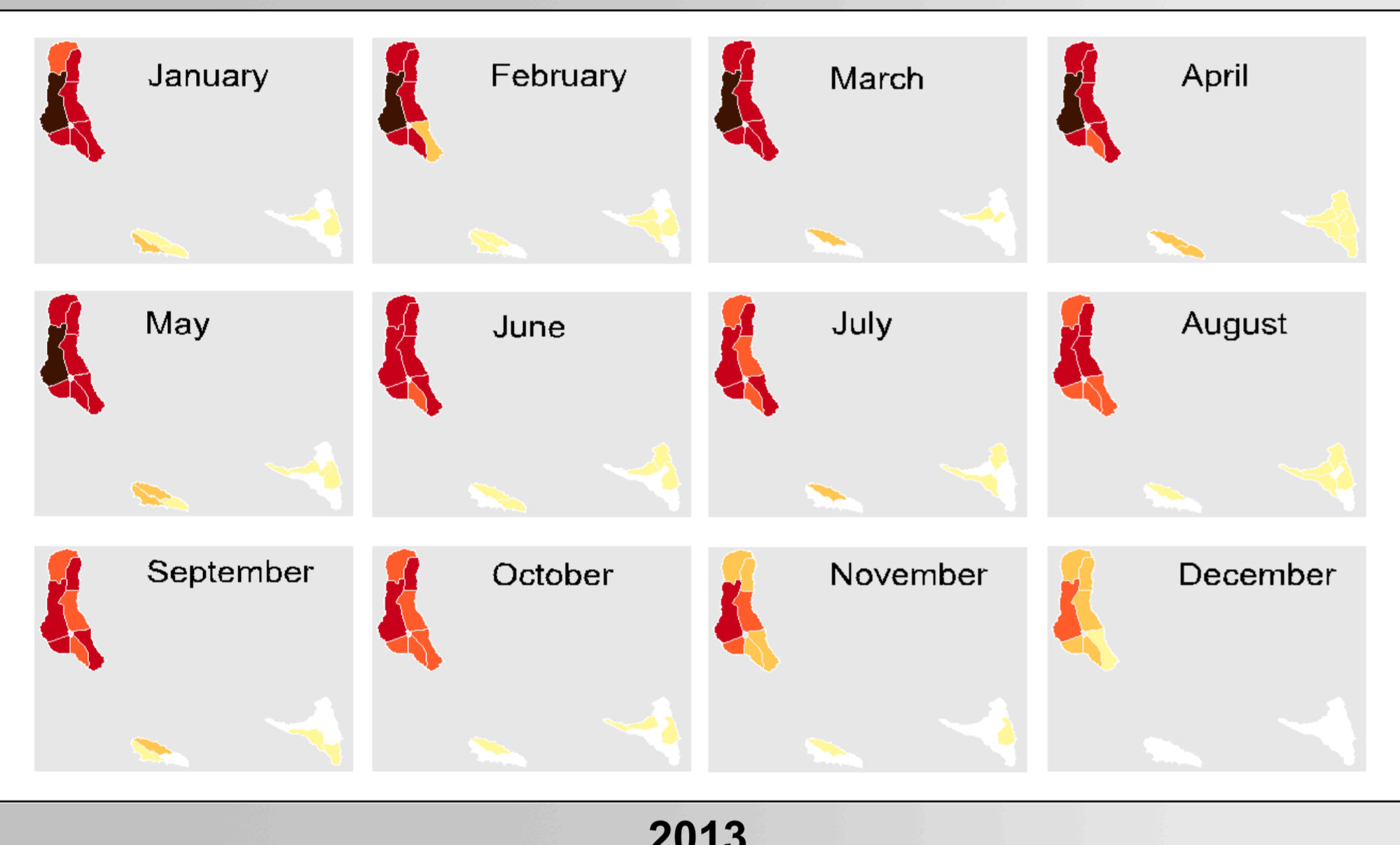
2010



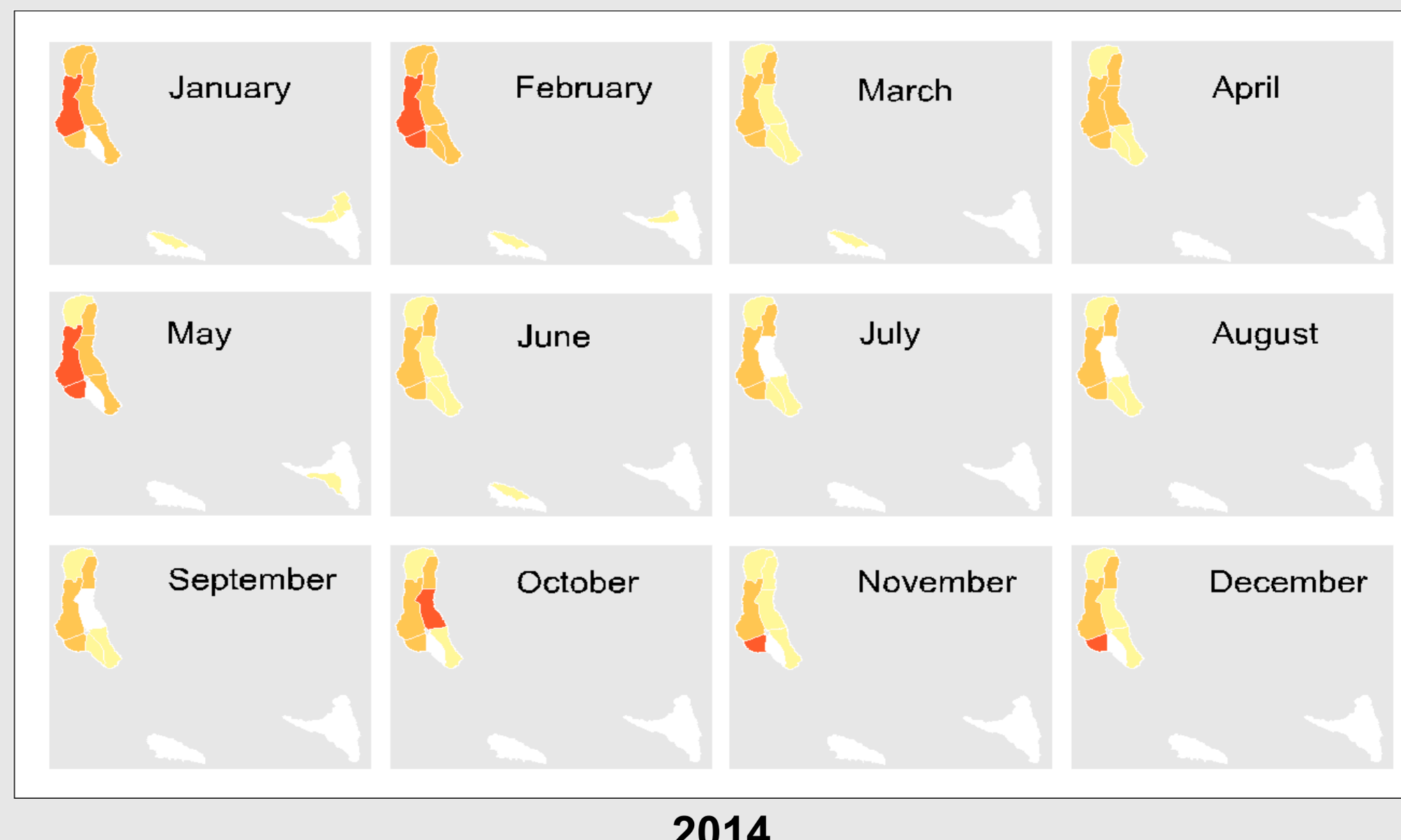
2011



2012

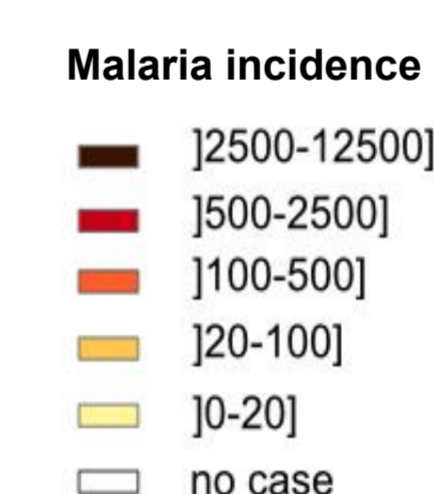


2013



2014

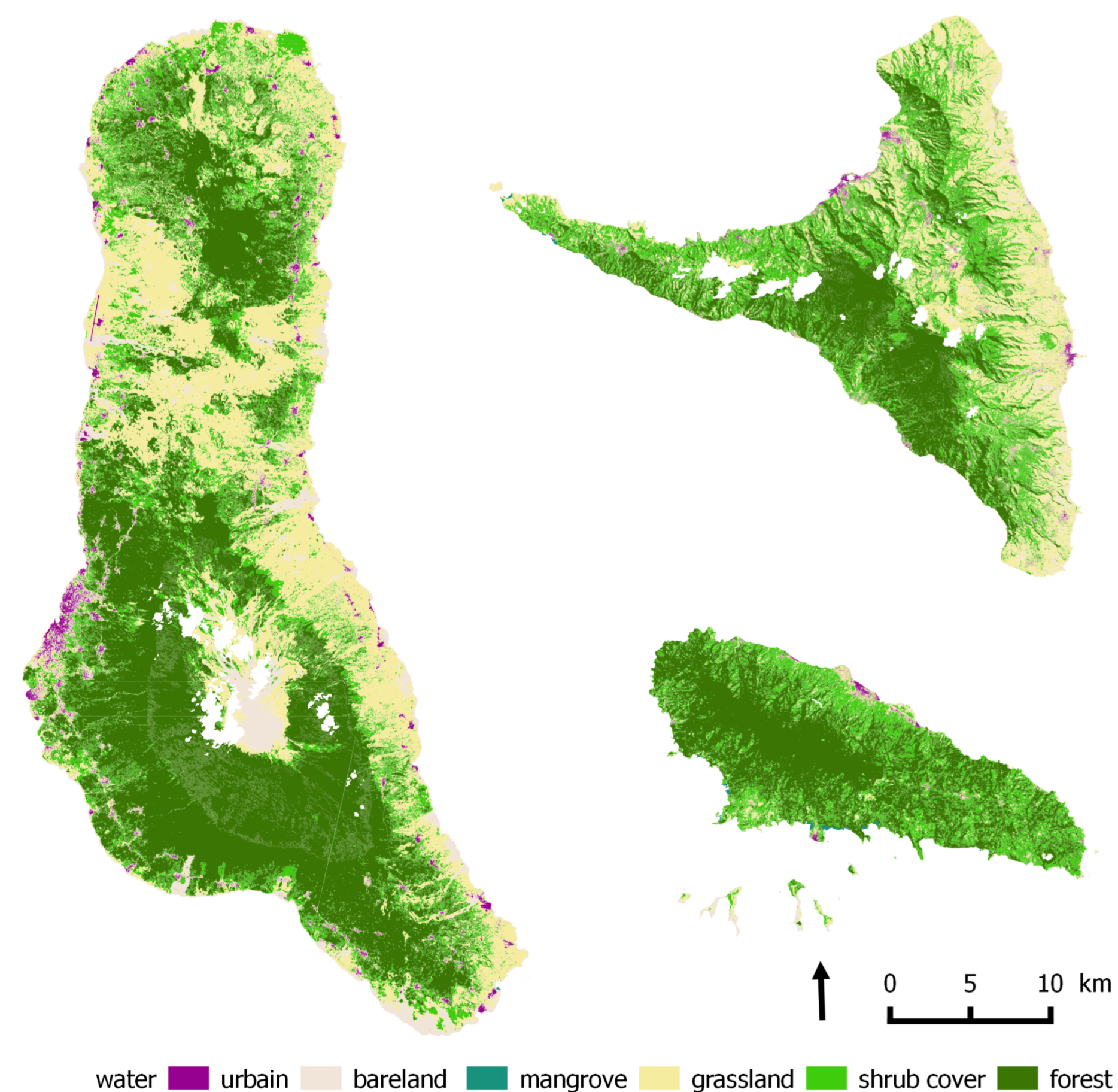
### Monthly incidence of malaria (per 100 000 habitants) by health district between 2010 and 2014



From 2010 to 2014, 356,318 cases of malaria were reported with 300,457 cases in Grande Comore, 21,968 in Moheli and 47,170 cases in Anjouan. Grande Comore presented the highest average monthly incidence (596.14 per 100,000 inhabitants), followed by Anjouan (225.57) and Moheli (43.58).

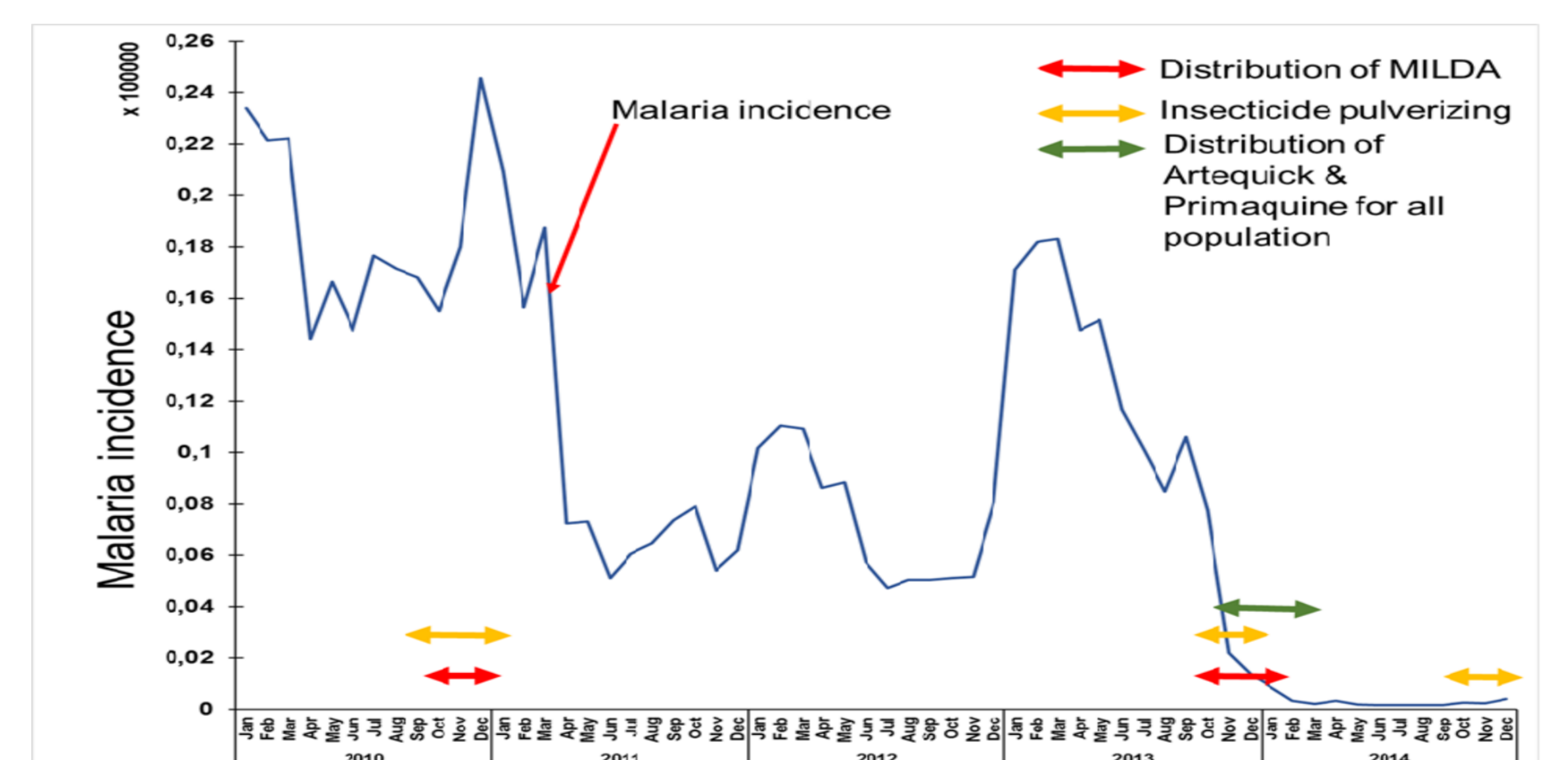
Malaria incidence has decreased severely in 2014 with an average monthly incidence of 293.64.

### Remote sensing analysis and landscape metrics

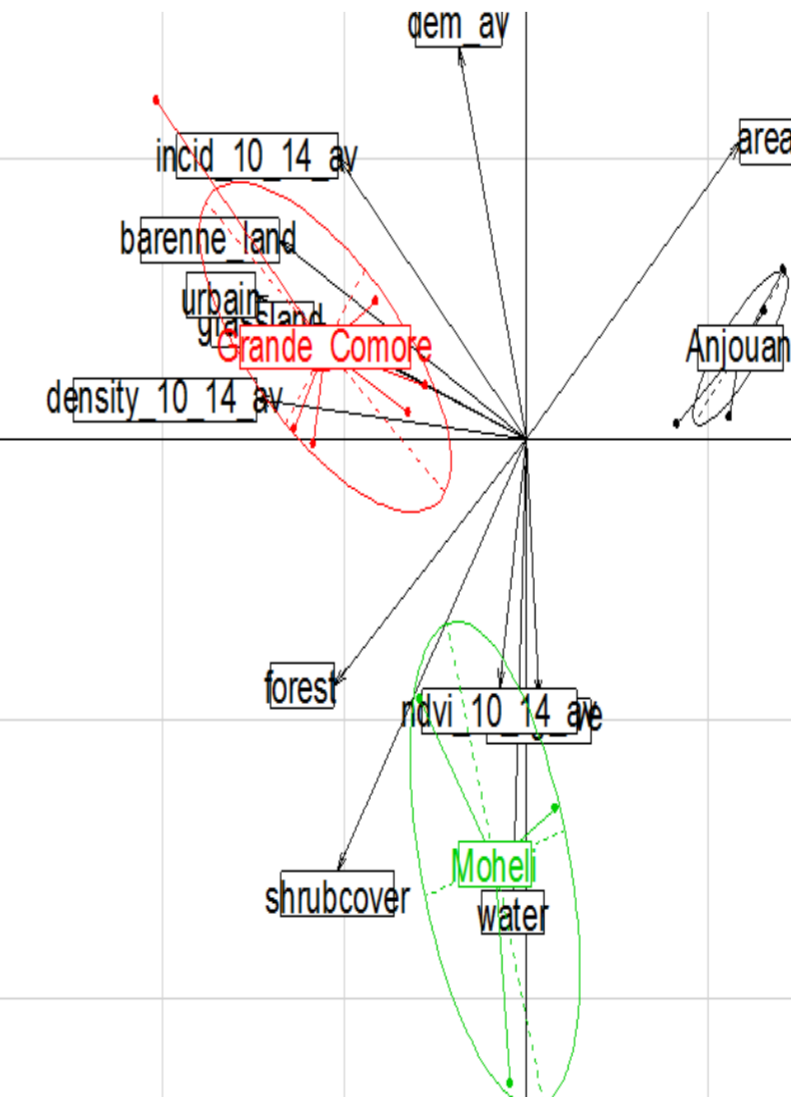


An homogeneous high resolution land cover was realized for the three islands with 7 classes. Based on these maps, landscape metrics (such as the percentage of each class and edge densities per sanitary district) were calculated in order to search for environmental indicators that describe the epidemiology of malaria.

The decrease of malaria incidence has been driven by different control actions organized since 2010, based on spraying campaigns and the distribution of Long Lasting Insecticidal treated Nets (LLINs). Starting in 2013, the Government conducted a massive distribution campaign of Artequick and Primaquine for all Comorian population.



A PCA can discriminate the islands by using the environmental variables. Because Grande Comore reported the highest malaria incidences, the environmental variables that characterize Grande Comore present also a strong positive correlation with the average incidence of malaria: the proportion of urban land ( $r = 0.79$ ;  $p < 0.0001$ ), bare land ( $r = 0.59$ ,  $p < 0.01$ ) and the population density ( $r = 0.64$   $p < 0.001$ ).



## Conclusion

The fight against malaria action of the Comorian government has achieved its goals. Moheli and Anjouan are in pre-elimination phase, while Grand Comore is in control phase.

The landscape metrics built from the land cover map can describe the environmental characteristics of each island. We can use them to have a better knowledge of ecological conditions for malaria. At this step, the ecological analysis shows some environmental indicators that are characteristics of Grande Comore (more urbanized, with more barelands and grasslands).

The perspectives for this study are:

- to assess locally the environmental patterns and the vulnerability of the populations to the disease (case-control study with interviews);
- to integrate in a statistical model other indicators related to climate, sociological data and control actions.

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