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RISK EVALUATION, SURVEILLANCE AND FORECAST OF VECTOR-BORNE TROPICAL DISEASES BY EARTH OBSERVATION DATA MINING
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RISK EVALUATION, SURVEILLANCE AND FORECAST OF VECTOR-BORNE TROPICAL DISEASES BY EARTH OBSERVATION DATA MINING

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Università degli Studi di Napoli Federico II

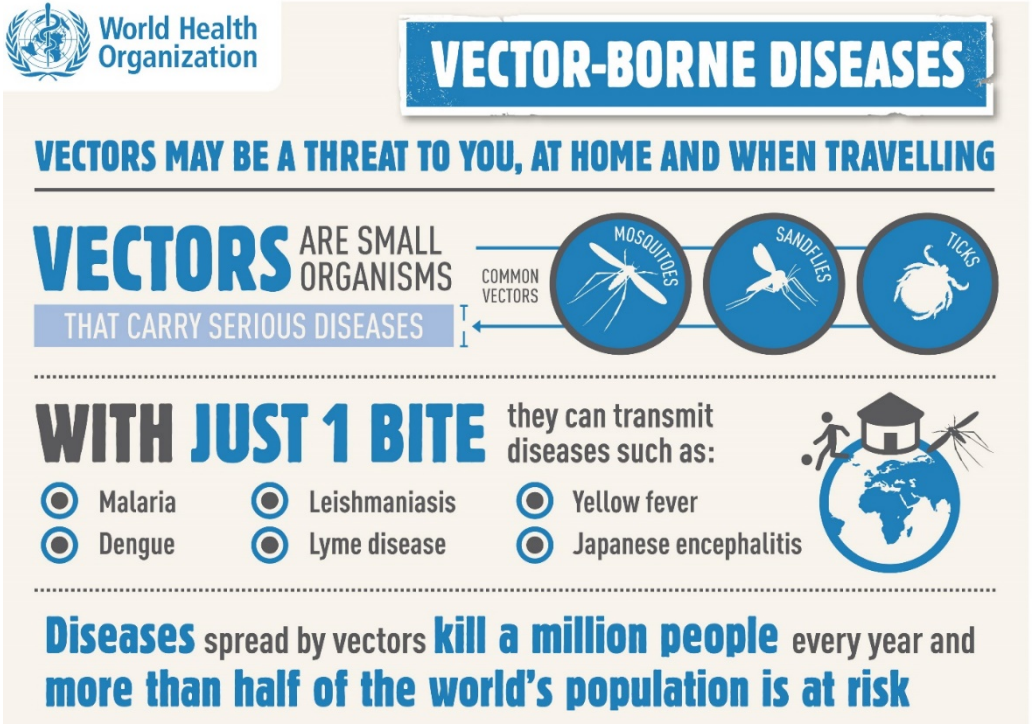
Università degli Studi di Perugia

Project Introduction

ID. 32260 Risk Evaluation, Surveillance and Forecast of Vector-Borne Tropical Disease by Earth Observation Data Mining

	EU Principal Investigator	Chinese Principal Investigator	Project Titles
32260_1	Prof. Alfredo Milani University of Perugia, Italy	Prof. Jiming Liu Hong Kong Baptist University, Hong Kong	Mosquito-borne diseases
32260_2	Prof. Juerg Utzinger Swiss Tropical and Public Health Institute, Switzerland	Prof. Lingli Tang Academy of Opto-Electronics (AOE), Chinese Academy of Science, Beijing	Snail-transmitted diseases
32260_3	Prof. Laura Rinaldi, University of Naples Federico II, Napoli, Italy	Prof. Xiao-Nong Zhou National Institute of Parasitic Diseases, China CDC, Shanghai	Tick-borne diseases

Vector-Borne Tropical Diseases



Vectors are organisms that transmit *pathogens* and *parasites* from one infected person (or animal) to another.

These diseases are commonly found in *tropical* and *sub-tropical* regions and places

Worldwide Major Vector-Borne Tropical Diseases

Mosquitoes

- *Aedes*
  - Chikungunya
  - Dengue fever
  - Rift Valley fever
  - Yellow fever
  - Zika
- *Anopheles*
  - Malaria
- *Culex*
  - Japanese encephalitis
  - Lymphatic filariasis
  - West Nile fever

Black flies

- Onchocerciasis (river blindness)

Aquatic snails

- Schistosomiasis (bilharziasis)

Ticks

- Crimean-Congo haemorrhagic fever
- Lyme disease
- Relapsing fever (borreliosis)
- Rickettsial diseases
- Tick-borne encephalitis
- Tularaemia

Triatomine bugs

- Chagas disease (American trypanosomiasis)

Tsetse flies

- Sleeping sickness (African trypanosomiasis)

Fleas

- Plague (transmitted by fleas from rats to humans)
- Rickettsiosis

Major Vector-Borne Tropical Diseases in China

Mosquito-transmitted diseases

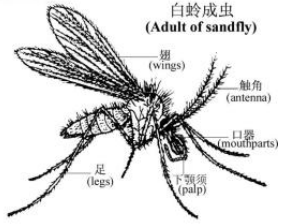
- Malaria (疟疾) → Anopheles Mosquitoes
- Dengue (登革热) → Aedes Aegypti Mosquitoes

Snail-transmitted diseases

- Schistosomiasis (血吸虫病) → Oncomelania Snails
- Fascioliasis (肝片吸虫病) → Lymnaea Snails

Tick-transmitted diseases

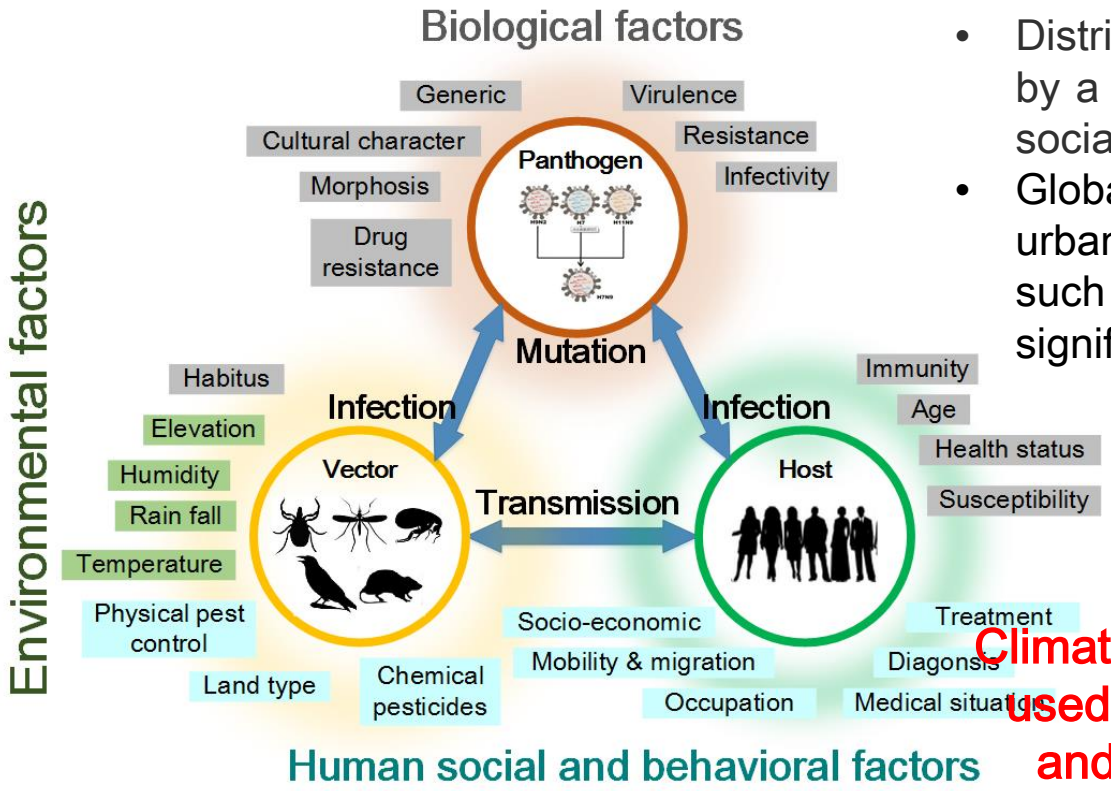
- Babesiasis (巴贝西虫病) → Ticks
- Theileiosis (泰勒虫病) → Ticks



Others

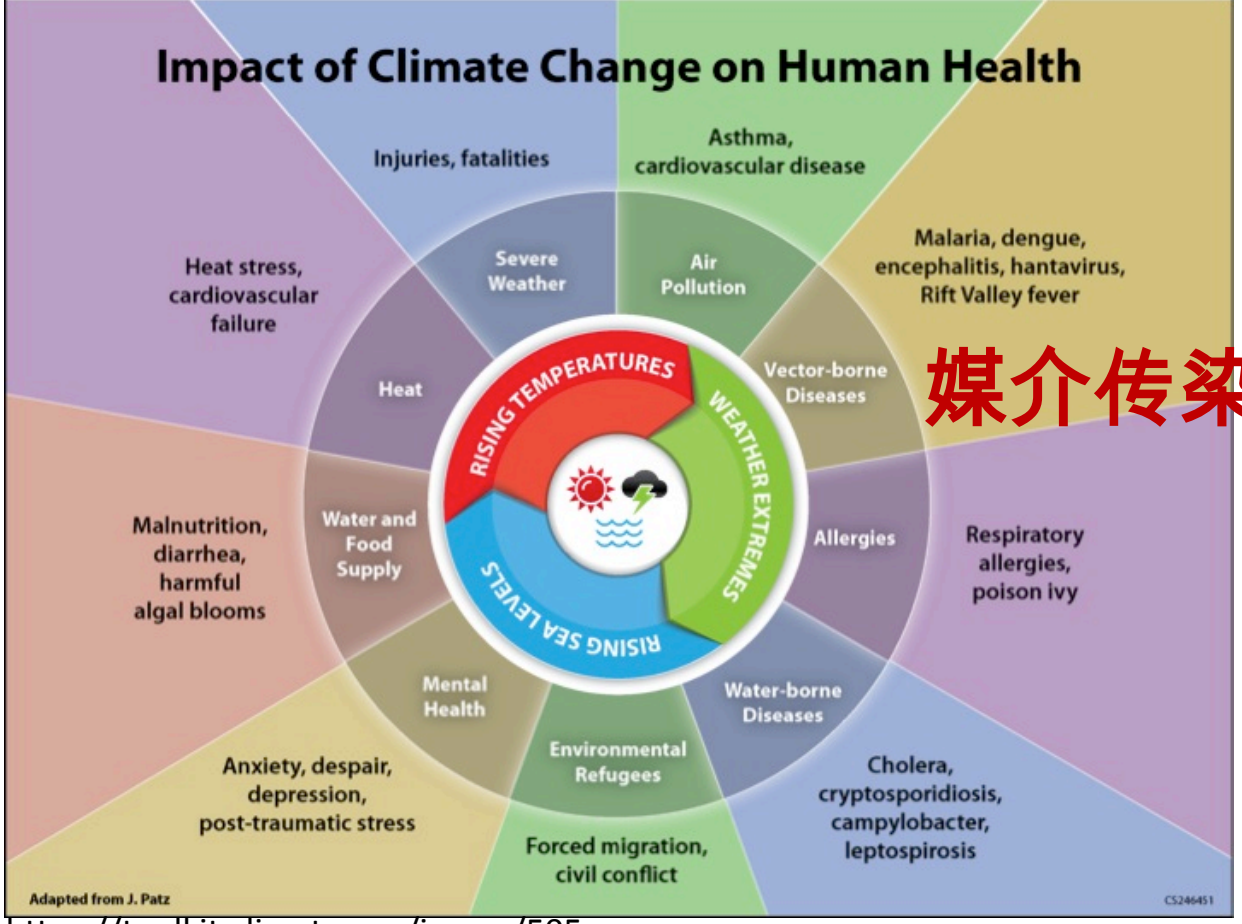
- Leishmaniasis (利什曼病-黑热病) → Sandfly

Impact Factors



- Distribution of these diseases is determined by a complex dynamic of environmental and social factors.
- Globalization of travel and trade, unplanned urbanization and environmental challenges such as climate change are having a significant impact
- Changes in agricultural practices due to variation in temperature and rainfall can affect the transmission of vector-borne diseases

Climate/Environmental information can be used to monitor and predict distribution and trends of vector-borne diseases

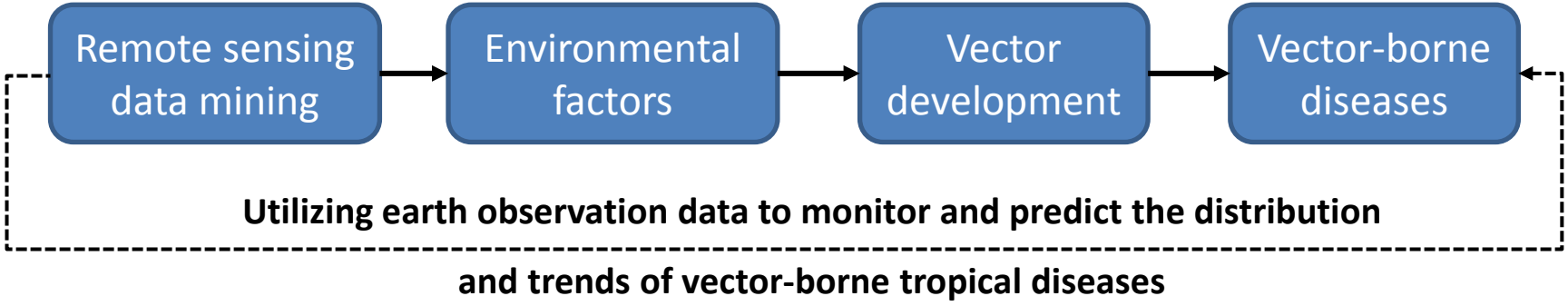


媒介传染病

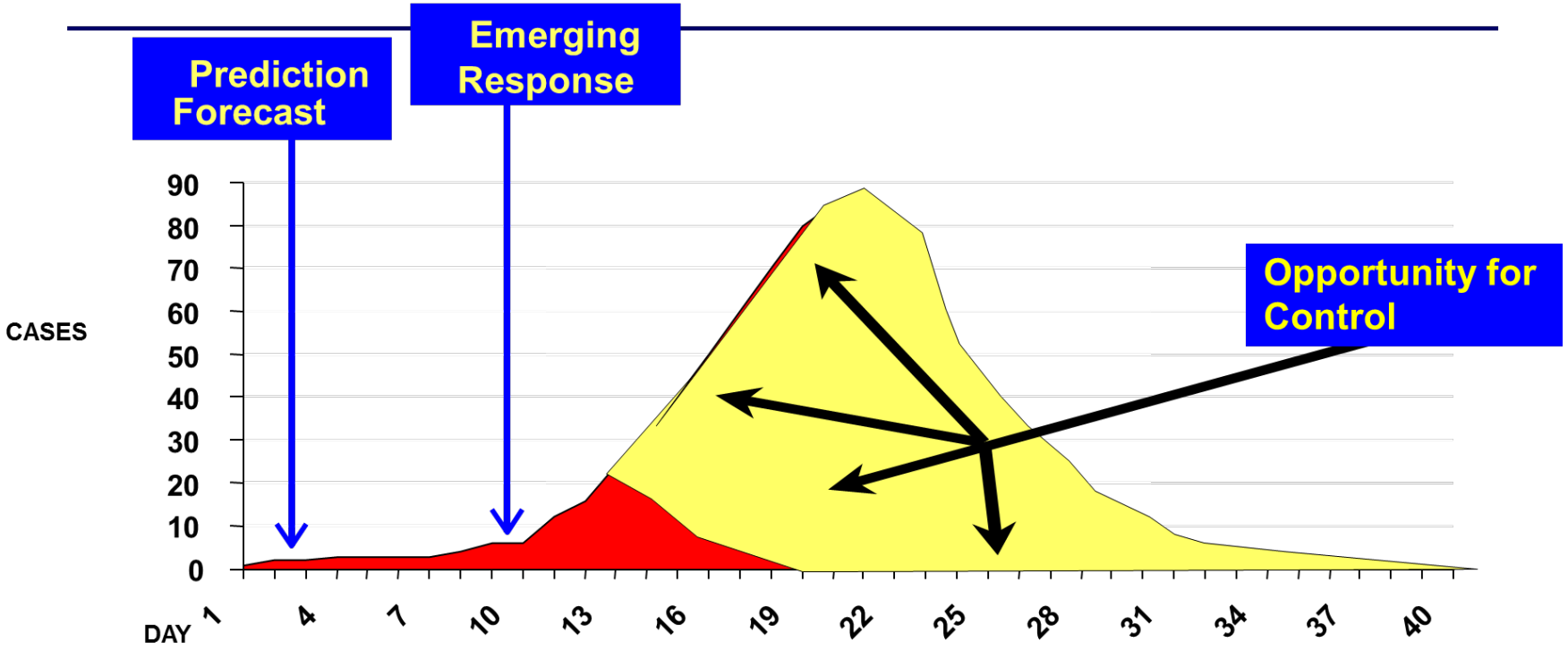
Original Image from https://toolkit.climate.gov/image/505

Diseases Monitoring and Early Warning By Earth Observation Data Mining

For all regions of interest (ROI), selecting the minimum number of targets that are ***prioritized*** to scan, which would sufficiently guarantee to cover a large percentage (or a threshold predefined according to the limitation of available resources) of all potential incidences within a period of time in the future.



Significance of Disease Monitoring and Early Warning



Risk Evaluation, Surveillance and Forecast

Schistosomiasis
Fascioliasis

Malaria
Dengue

Babesiasis
Theileiosis

Snails

Mosquito

Ticks

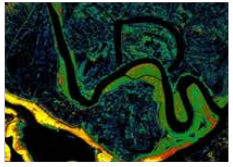
Water

Temperature

Humidity

Vegetation

.....



Monitoring
Early Warning

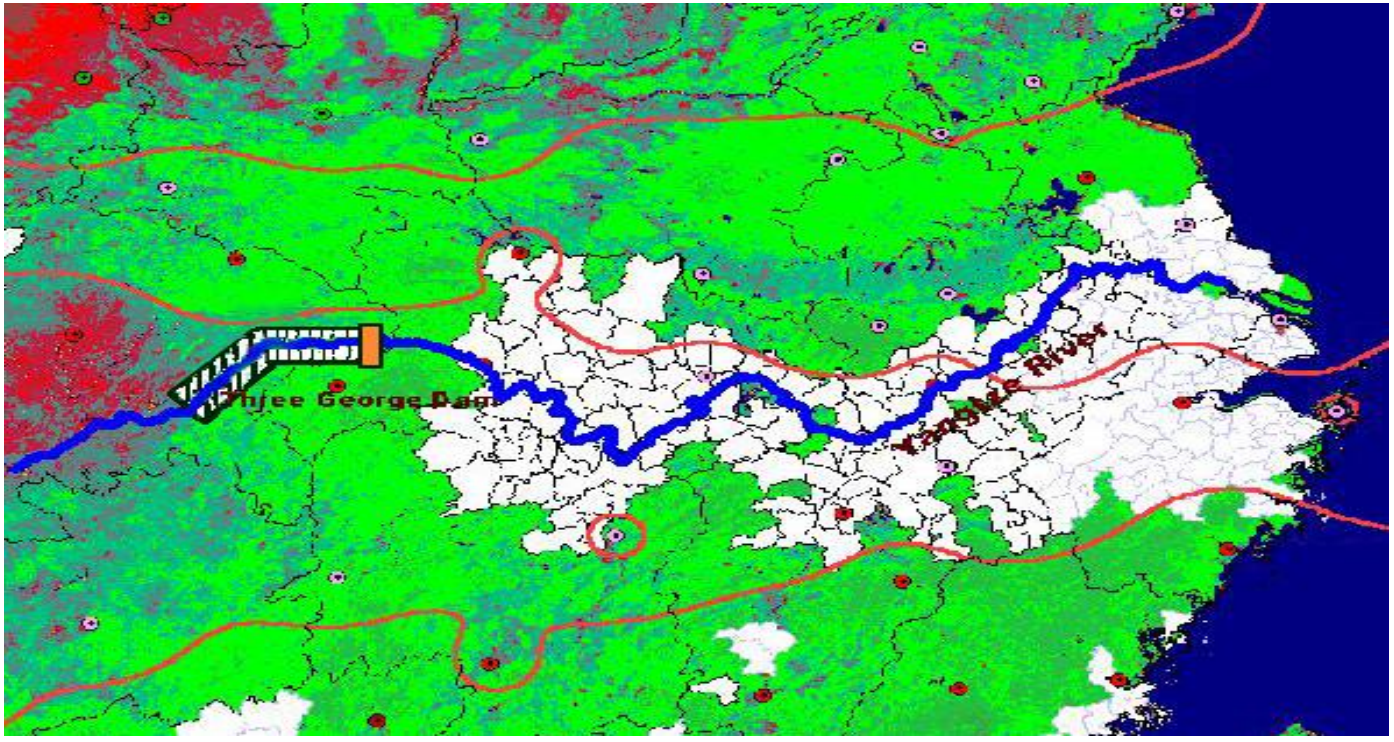
Vector-borne diseases

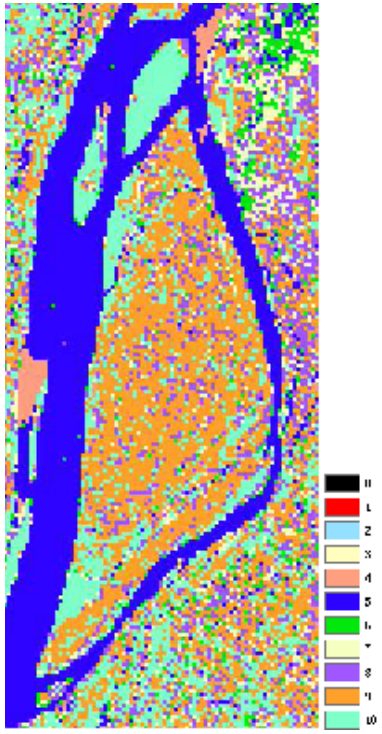
Vector

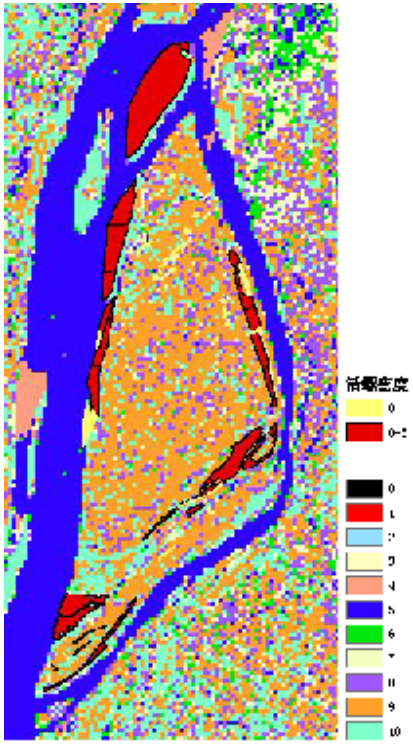
Environmental Factors

Remote sensing

Schistosomiasis Control in China (血吸虫病)

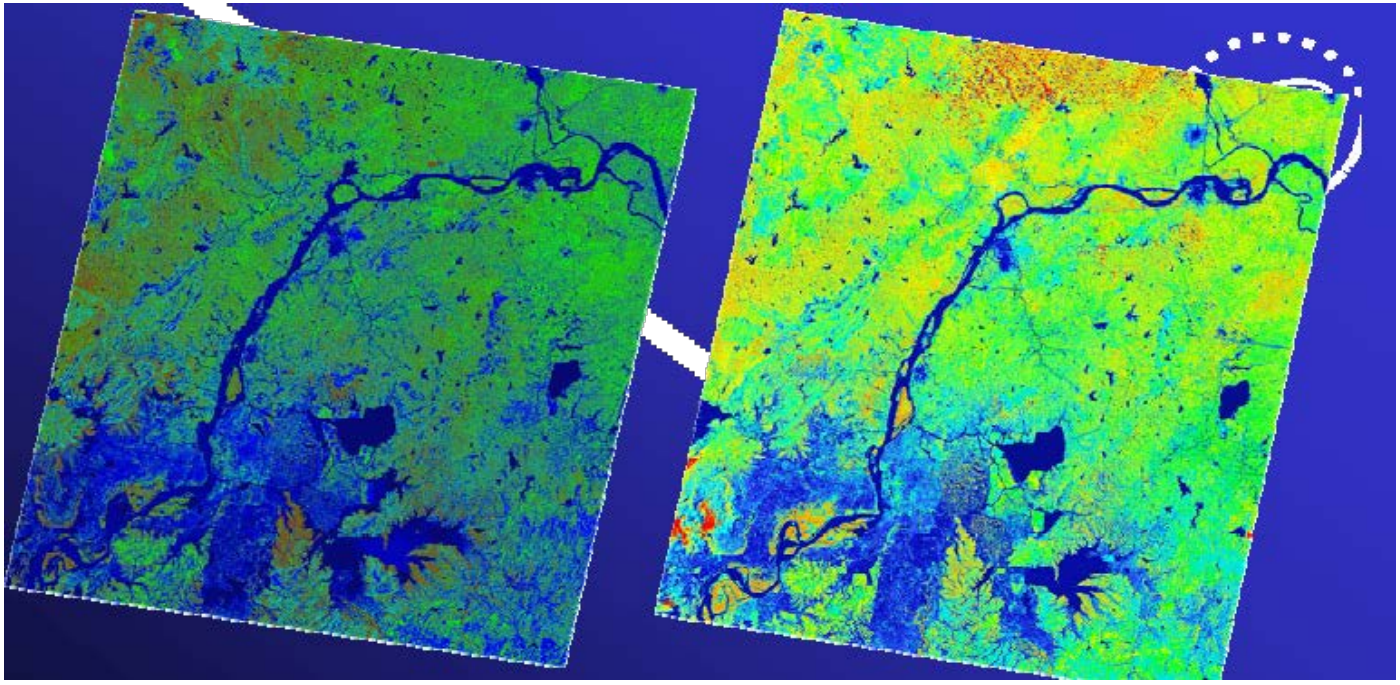






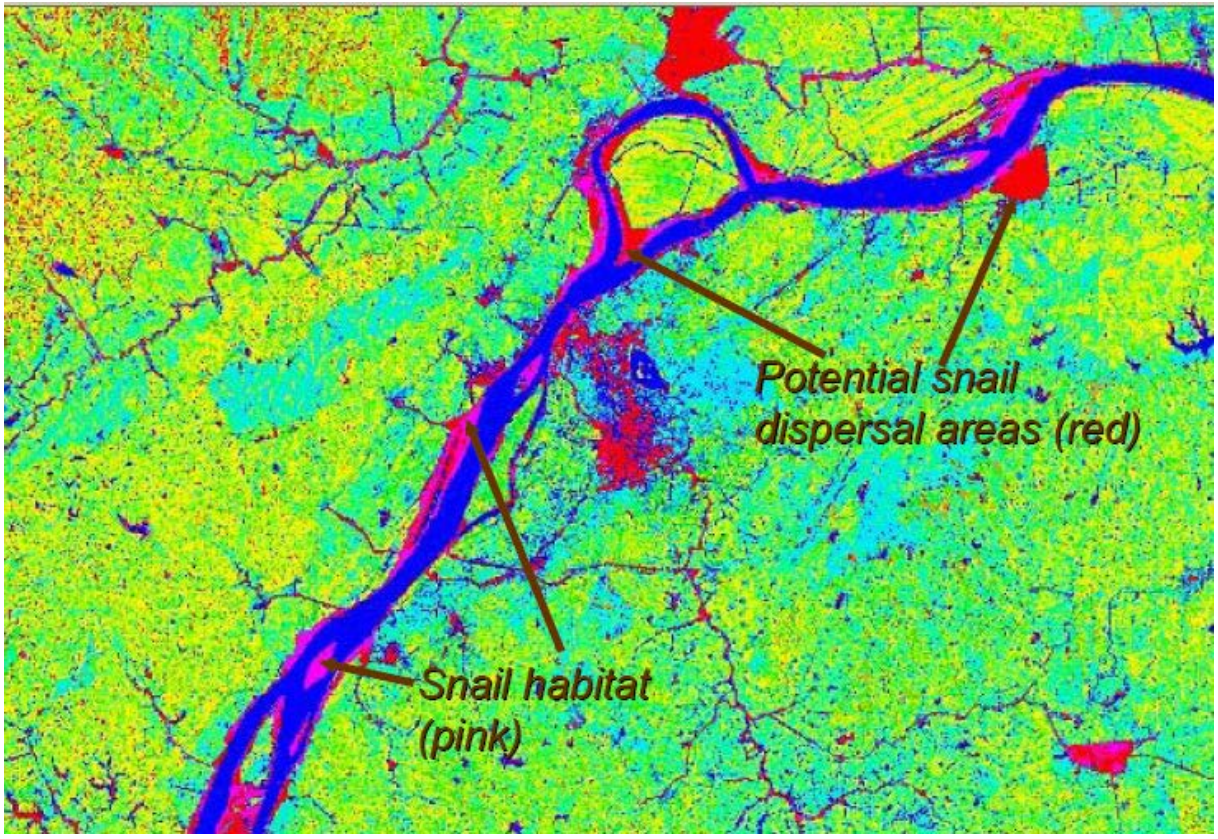
SPOT5 images covering the whole study area and acquired on March 16, 2006 were obtained from the China Remote Sensing Satellite Ground Station (Beijing, China). This imagery has a spatial resolution of 2.5m in panchromatic mode and 10 m in colored mode.

Snail Habitats Prediction (Middle Scale)



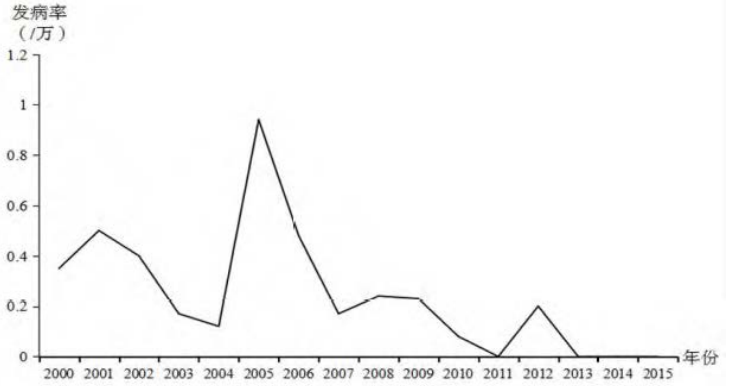
Flooding season in 1983 Normal water level in 1984

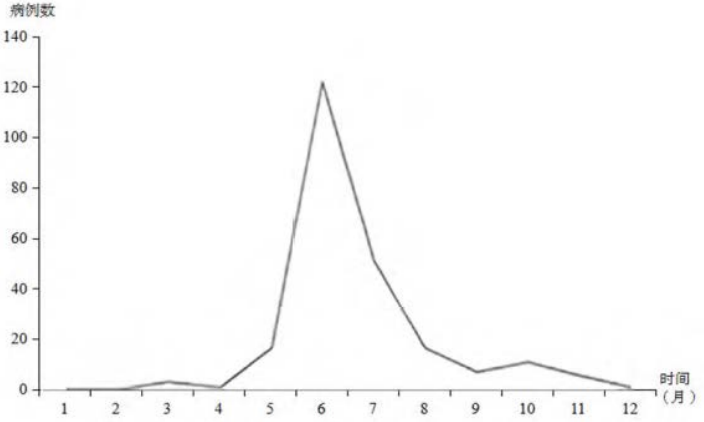
Three cloud-free Landsat-5 TM images of the study area with a spatial resolution of 30m



Three cloud-free Landsat-5 TM images of the study area with a spatial resolution of 30m.

Malaria in China-Myanmar Border

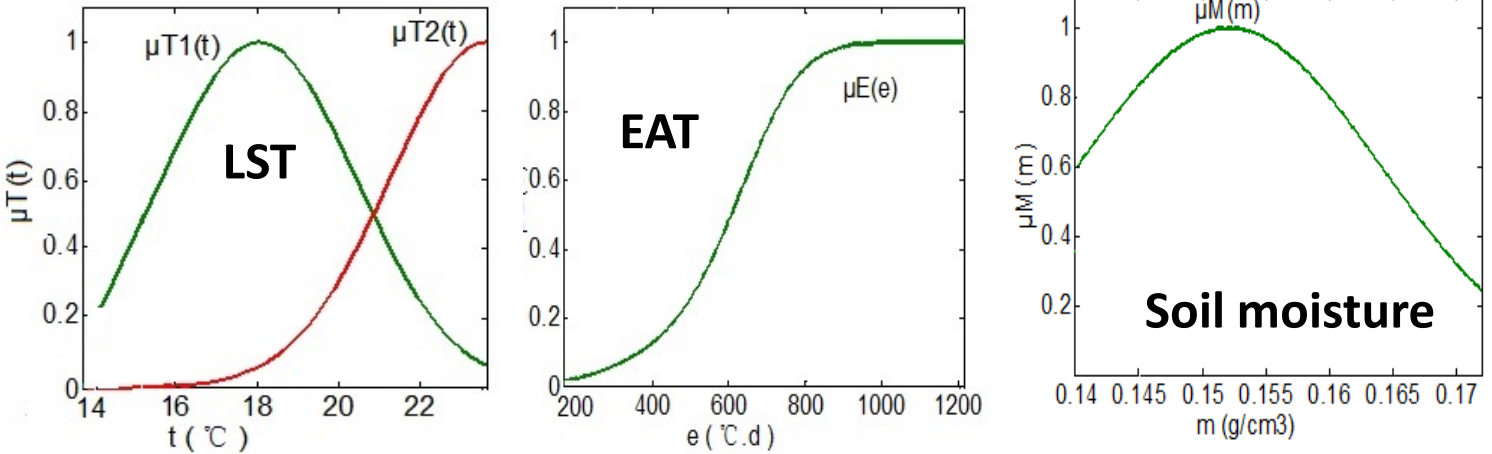




Malaria Risk Prediction

Quantitative suitability relationship between malaria and RS environmental parameters:

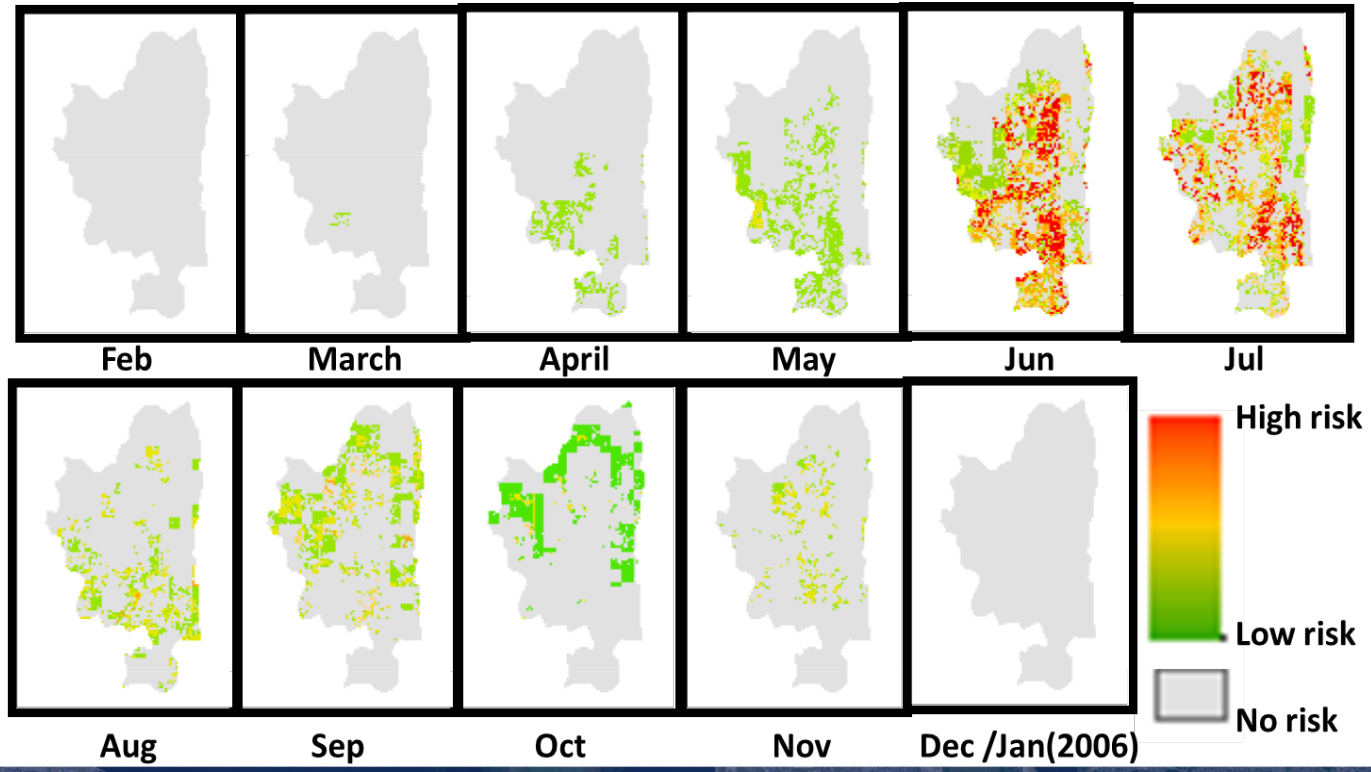
Suitability index for malaria

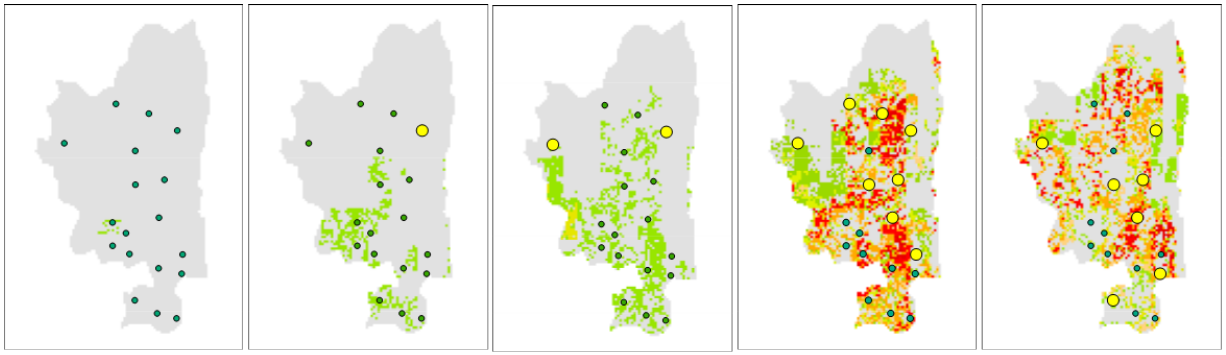


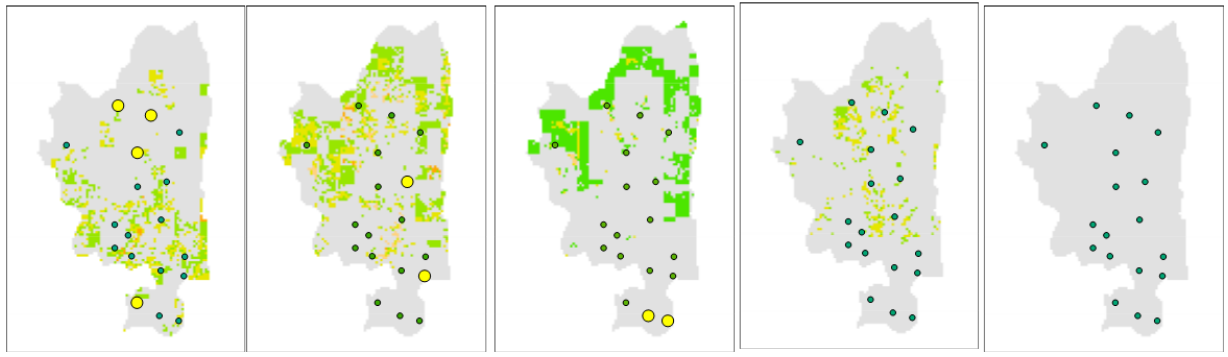
- Growth and breeding rate of mosquito and Malaria parasites are influenced by temperature:
  - Red line: below 16℃, the mosquito die, and suitability index increases with temperature between 16℃ to 23℃.
  - Green line: above 14℃, the malaria parasites can complete their growth cycle, and the peak is between 17℃ to 20℃.
- When it reaches the threshold of Effective Accumulated Temperature(EAT)-about 200℃ •day to grow up to adult mosquito, percentage of survival increases with ETA, and the peak is at 800 ℃•day.

Malaria Risk Prediction in China-Myanmar Border

12 months' dynamic monitoring results of Tengchong







No indigenous malaria case

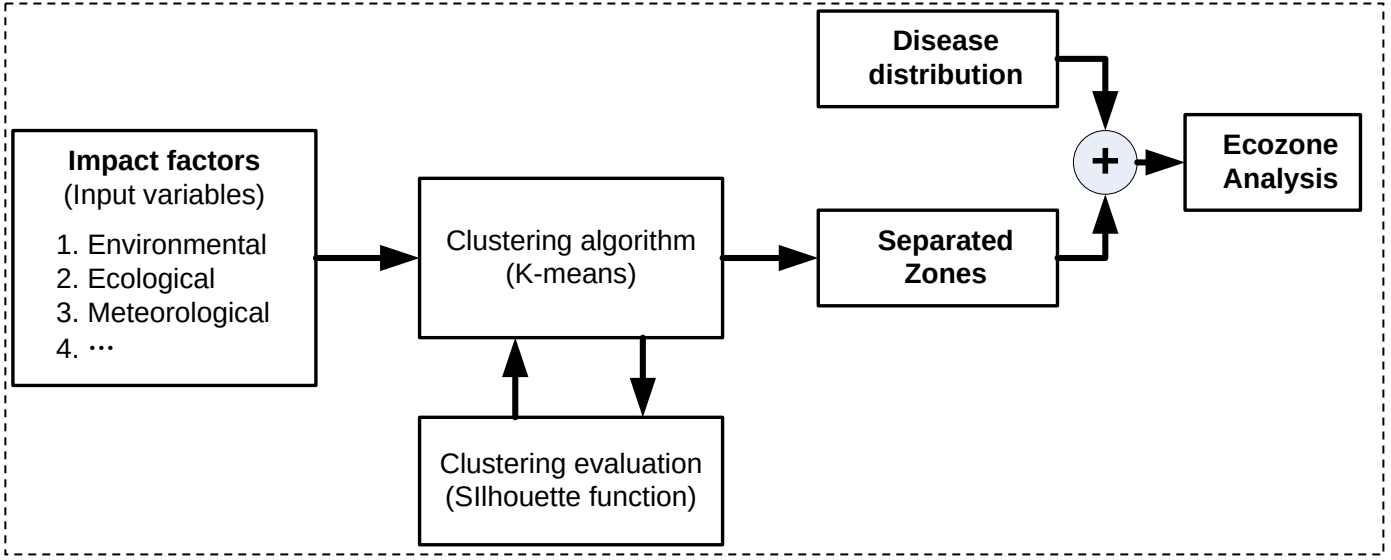
Indigenous malaria case

Accuracy of predicted malaria incident location is 74% .

Higher spatial resolution should improve the results.

Clustering high-dimensional data

Let $X = \{x_i\}_{i=1}^{n} \in \mathbf{R}^{d \times n}$ note the ***data set*** consisting of n samples (**points**) over n-dimensional space (**attributes**)



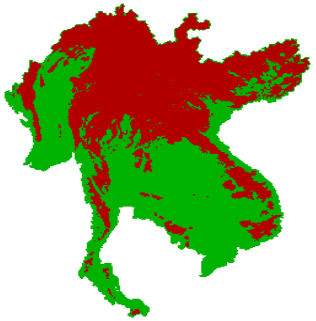
Ecozone in Lancang-Mekong SubRegion (LMS)

(a) DEM

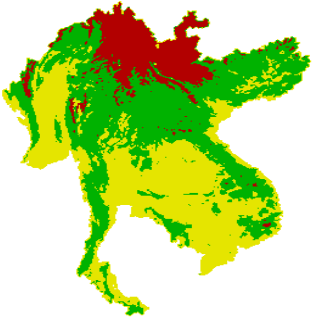
(b) NDVI

(c) LSTD

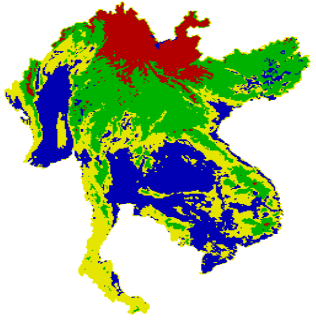
(d) LSTN



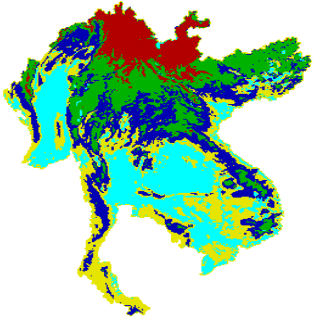
(a) K=2



(b) K=3

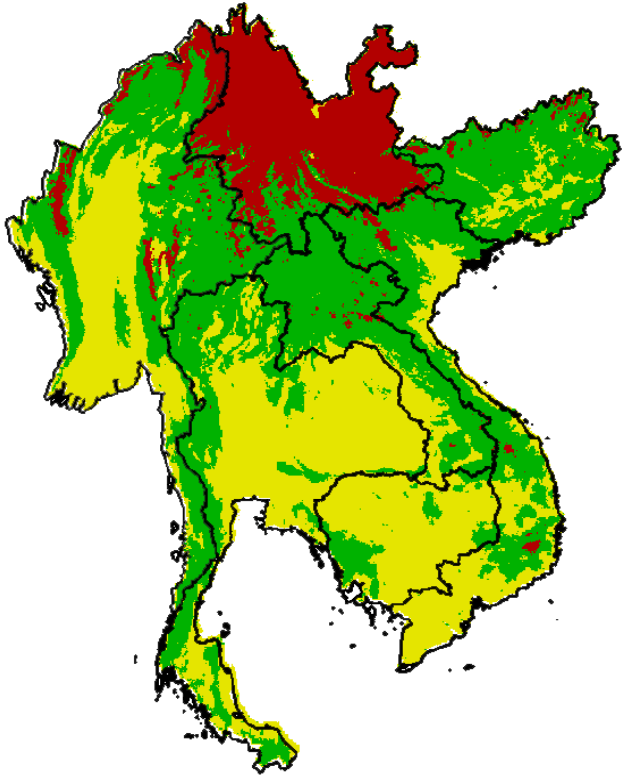


(c) K=4



(d) K=5

Mapping VBTDs in Ecozones of LMS

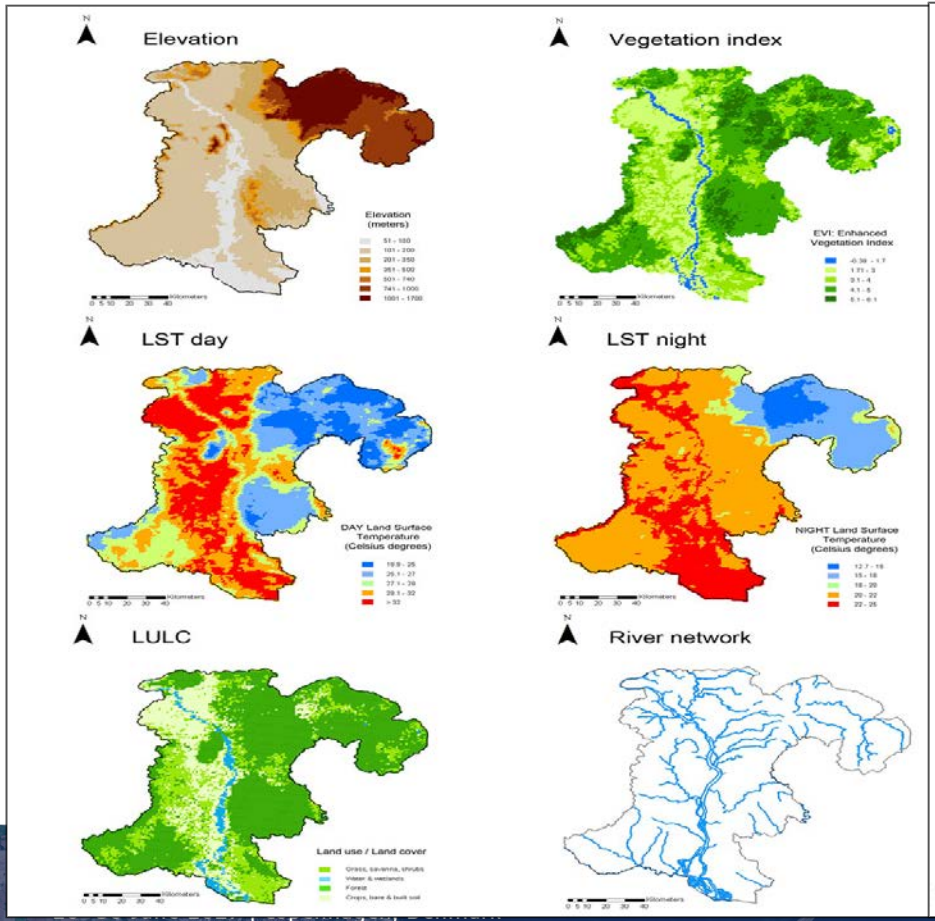


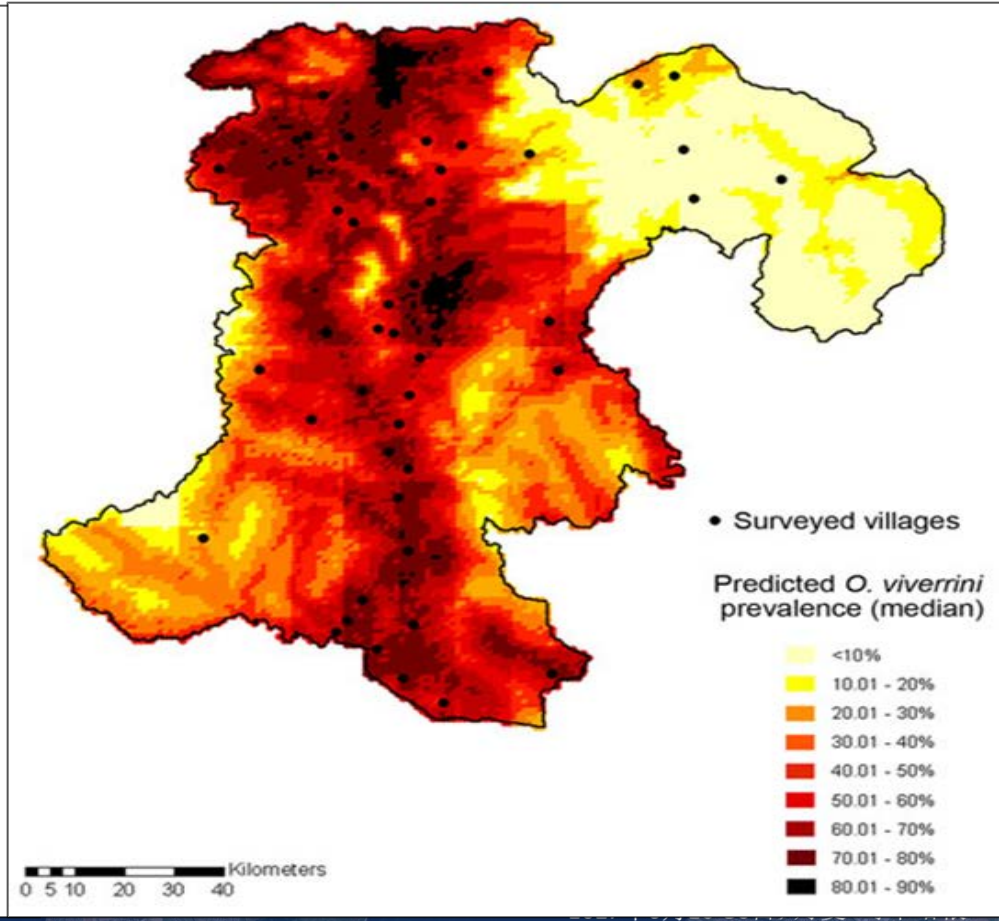
STH
Cysticercosis
Taeniasis
Echinococcosis
Schistosomiasis
Clonorchiasis
Fascioliasis
Paragonimiasis

STH,
Cysticercosis/Taeniasis
Fascioliasis
Opisthorchiasis
Paragonimiasis
Lymphatic filariasis
schistosomiasis

STH
Cysticercosis
Taeniasis
Lymphatic filariasis
Fascioliasis
Opisthorchiasis
Paragonimiasis

Ecozones based Disease Prediction





Conclusion

1. Diseases monitoring and early warning by earth observation data mining
2. Schistosomiasis and vector snail control in China
3. Malaria risk prediction in China-Myanmar border
4. Mapping vector-borne diseases by ecozone analysis