Where are the mosquitoes: How can remote sensing provide evidences in urban areas?

The case of *Aedes aegypti* (dengue vector) in Delhi, India

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India highly affected: Why?

96 million apparent dengue infections (Bhatt, 2013)

2.5 billion people at risk (Gupta, 2012)

Significant socio-economic impacts (Sheppard, 2013)
ENVIRONMENT & HEALTH: particularities of dengue

• Infectious diseases → often correlated to poverty

Poverty → Vulnerability → Risk

• Dengue particularities:
  - Weakly correlated to poverty (Khormi, 2011; Mondini, 2008)
  - Urban vectorial disease with multiple factors (Gubler, 1998)
  - No vaccine available: vector control strategies (Stoddard, 2012)

Dengue pathogenic system = complex system
DIVERSITY OF HOUSING IN DELHI

Old Delhi

+ High population density
- No vegetation

Visant Vihar

+ Significant vegetation cover
- Low population density

(Landsat 8, 30m, 2013)
THE COMPLEX SYSTEM OF DENGUE

DATA COLLECTION

Epidemiological Data

Entomological Data

Environmental Data

Social Data

Survey, Census, Retrospective Data, Satellite images

REMOTE SENSING

CENSUS, RESEARCH, RETROSPECTIVE DATA, SATELLITE IMAGES

SPATIAL ANALYSIS

Parameters / Input Data

Agent-Based Models

vector

host

evironment

virus

Monitoring System

Territorial Diagnosis

Spatial analysis

Simulation

Decision Support Tool

SPATIAL INTEGRATION (GIS)

Spatial Integration

Calibration / validation

Integratio

SIMULATION

THE COMPLEX SYSTEM OF DENGUE

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SEEKING FOR MOSQUITOES: traditional methods

- Traditional methods
  - House surveys
  - Entomological indices

- Strength
  - Accurate information for a specific neighborhood

- Limitations
  - Expensive and time-consuming
  - Restricted to houses
  - Punctual census
  - Difficult to reproduce
SEEKING FOR MOSQUITOES: from needs to maps

(vezzani, 2005)

BEHAVIORS

Linked to

NEEDS

Linked to

Urban environment components
(ex: tree)

Linked to

Urban spatial scales
(ex: remote sensing)

FEEDING

Nectar

Human blood

MOVING

Freshness

Shade

Low speed wind

BREEDING

Small containers

Clear and calm water

RESTING

Freshness

Shade
DIFFERENT SCALES: same objects and different information

Landsat, 30m  
Ex: Forest

Quickbird, 0.6m  
Ex: Single trees

Spot, 2.5m  
Ex: Rows of trees in streets
SEEKING FOR MOSQUITOES: method

- Behavior
  - Feeding: 2 pt
  - Breeding: 2 pt
  - Resting: 1 pt
  - Moving: 1 pt

- Weighting
  - Feeding: 2 pt
  - Breeding: 2 pt
  - Resting: 2 pt
  - Moving: 2 pt

Vectorial risk index $\text{cell}_j = \sum_{i=1}^{N \text{ objects in cell}} \left( \frac{\text{Grade}_i \times \text{Area}_i}{\text{Area Cell}} \right)$

Object index: 10 pt

Low = 0 pt
Medium = 1 pt
High = 2 pt
SEEKING FOR MOSQUITOES: Mapping the potential risk

Limitations:
- No small objects detected
- Only based on satellite imagery
- Only 2D
- No temporal dynamics
Temporal dynamics: perspectives

- Daily changes

- Annual changes
Purpose and practical applications

• Mapping the vectorial risk at metropolitan level
• Comparing estimated data / measured data
• Better understanding of the mosquito/environment relationships
• Improving the efficiency of anti-vectorial measures
Thank you for your attention

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Grading the identified urban components according to the mosquito’s needs

**Examples:**

**Trees:**
- **Feeding:** Medium
- **Moving:** Medium
- **Breeding:** Medium
- **Resting:** High

**Slums:**
- **Feeding:** Medium
- **Moving:** High
- **Breeding:** Low
- **Resting:** High
Carte : Renaud Misslin, 2013

Projet AEDESS

Images : S. Maneerat et E. Daudé, 2013