Mapping spatio-temporal spread of dengue in Delhi

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Associate researcher: Center for policy research

Dengue

4 serotypes

Aedes aegypti & Ae. albopictus
(Ae. polynesiensis -South Pacific)

Flaviviridae

Virus	Serocomplex	Clade	Cluster
West Nile	Japanese encephalitis	XIV	Mosquito-borne
Kunjin			
Japanese encephalitis			
Murray Valley encephalitis			
St Louis encephalitis		XI	
Dengue-1	Dengue	IX	
Dengue-3			
Dengue-2			
Dengue-4			
Yellow fever	None	VII	
Central European encephalitis	Tick-borne encephalitis	IV	Tick-borne
Far Eastern encephalitis			
Powassan			
Dakar bat	None	III	No vector

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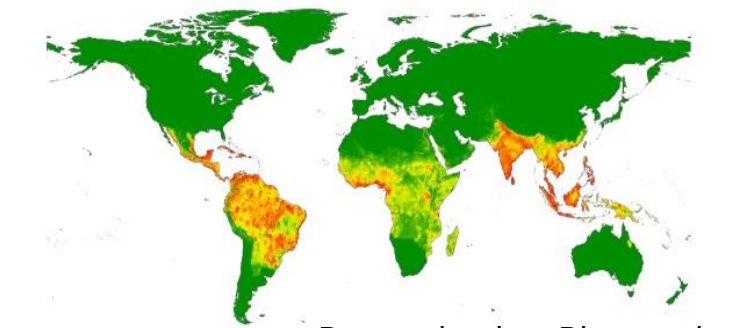
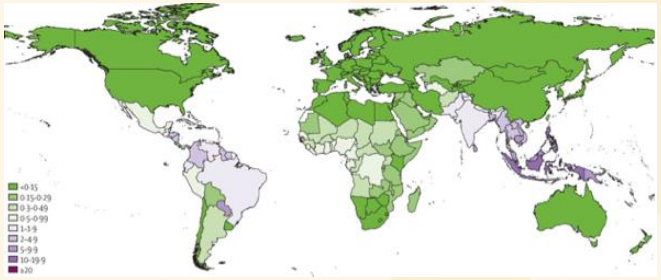
Dengue burden

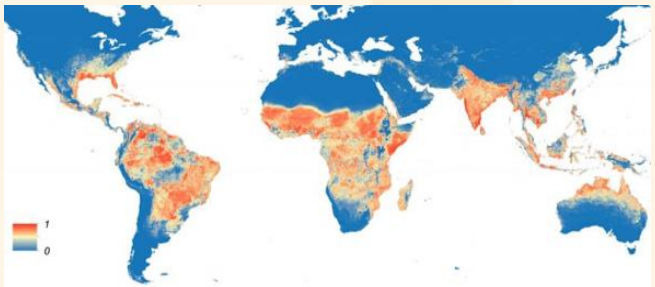
- 2013 Bhatt *et al*
  - 390 million infections
  - 98 million clinical
- 2014 Stanaway *et al*
  - 58 million clinical
- 2015 Kraemer *et al*
  - *Aedes* spp. on all continents
- 2016 Sheppard *et al*
  - Average cost US$ 8.9 billion



Dengue burden, *Bhatt et al*



Dengue burden, *Stanaway et al*



Aedes distribution, *Kraemer et al*

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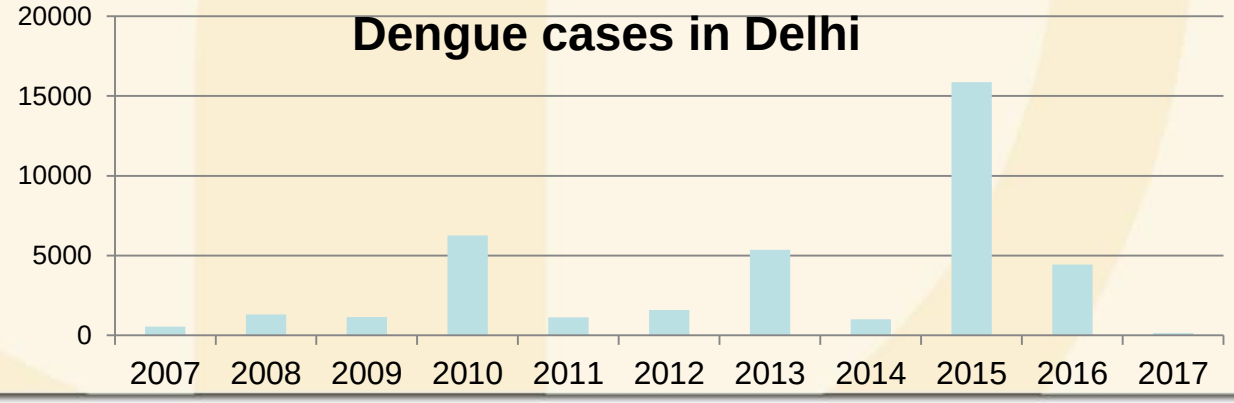
Dengue in India

- Dengue in India
  - Spread since the 60's
  - Important diffusion since the 90's
  - Important inequalities in dengue surveillance

- Dengue in Delhi:
  - Identified during the 60's (Balaya and al., 1967)
  - Increased number of cases since 1996
  - 38 sentinel hospitals



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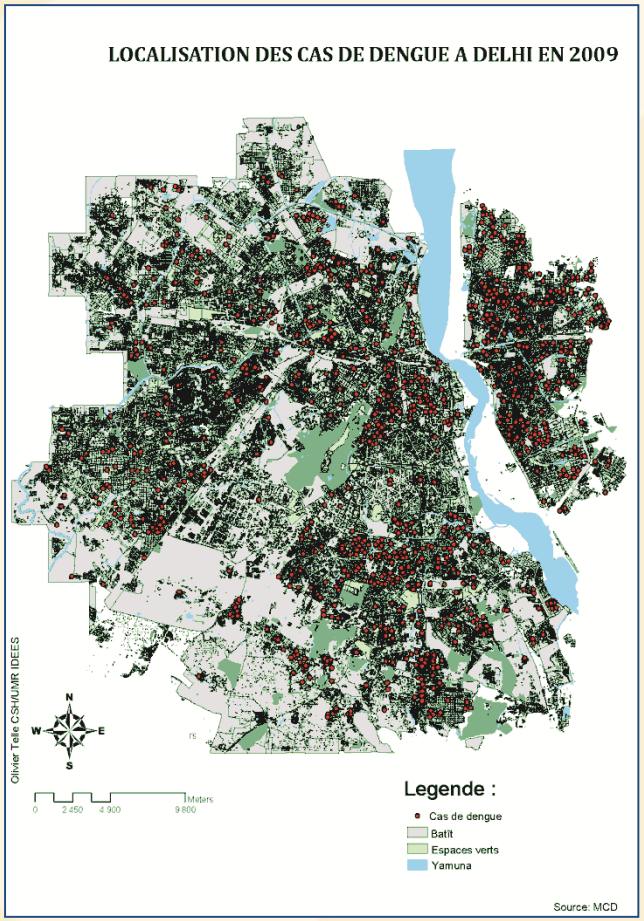

Aims of the study

- 1) Understand how dengue spread in the urban area of Delhi:
- 2) Relation between environment (socioeconomical factors) and dengue incidence
- **Method:** Spatial epidemiology, GIS study
- **Data:** Surveillance system and fieldwork study (detection of antibodies in population)

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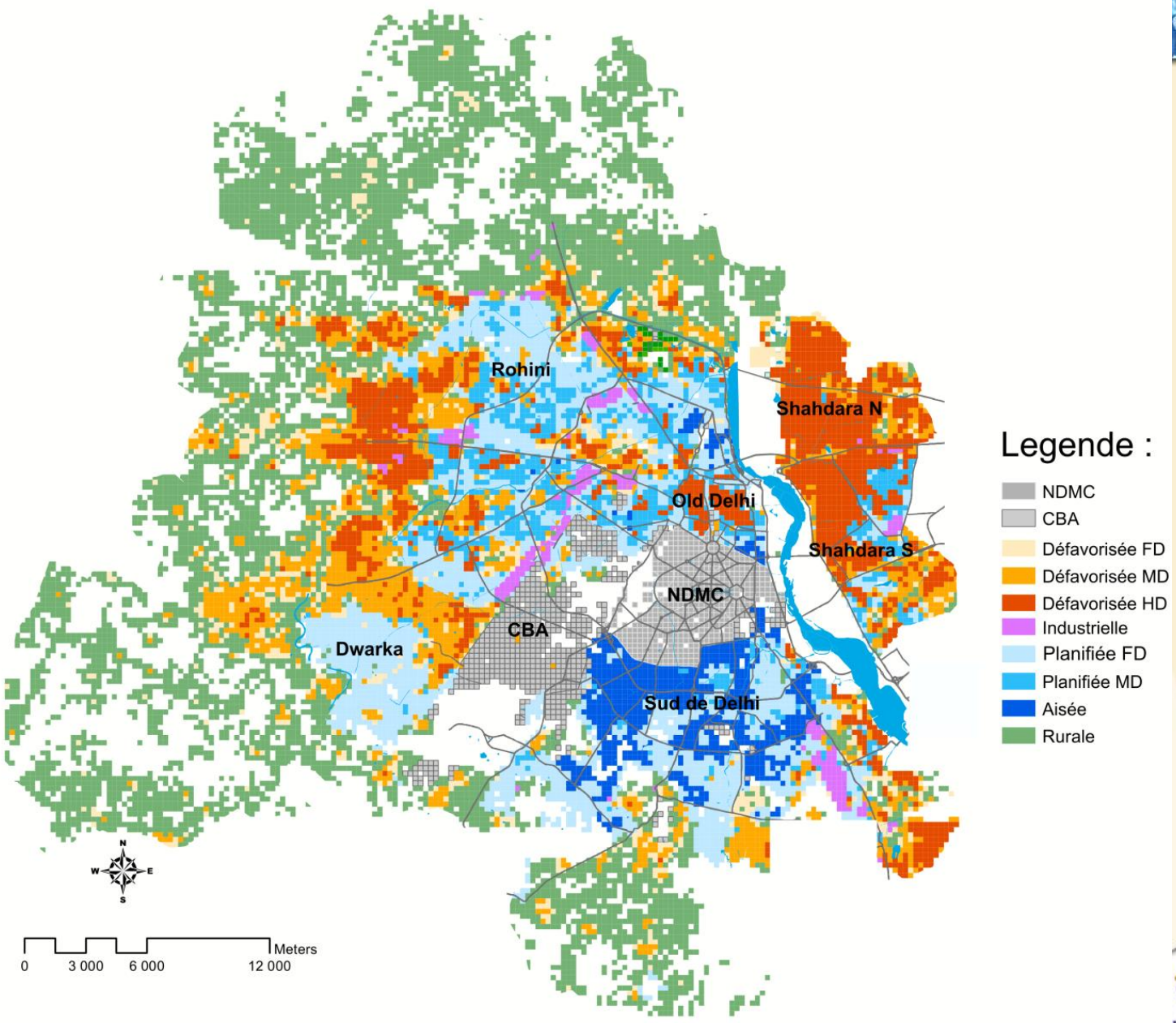
Rohini
Shahdara N
Old Delhi
Shahdara S
NDMC
CBA
Dwarka
Sud de Delhi
Legende :
NDMC
CBA
Défavorisée FD
Défavorisée MD
Défavorisée HD
Industrielle
Planifiée FD
Planifiée MD
Aisée
Rurale
N
W
E
S
0
3 000
6 000
12 000
Meters

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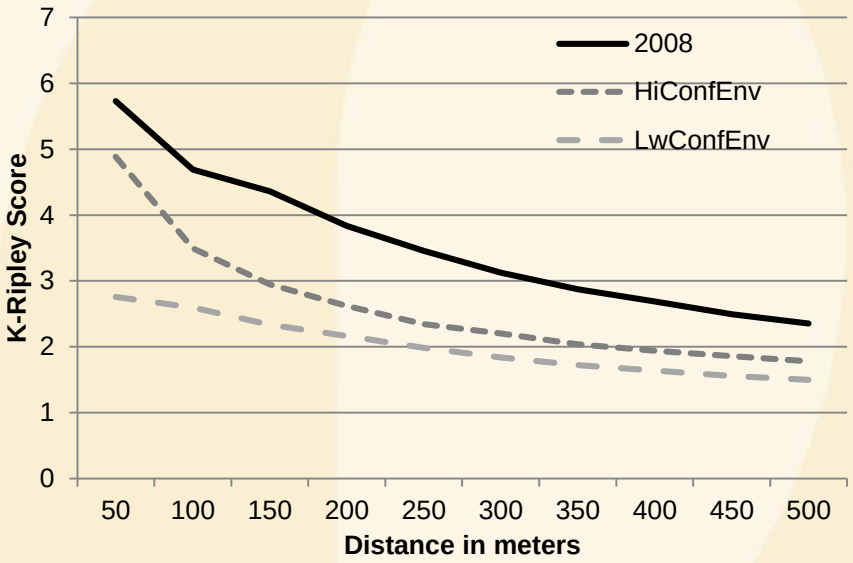
Study spatial pattern



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Risk factor of dengue in Delhi. Odd ratio. IN Plos One, 2016

Year	2010				2009				2008			
	Ora	Lower	Upper	p	Ora	Lower	Upper	P	Ora	Lower	Upper	p
Continuous Predictors					Continuous Predictors				Continuous Predictors			
Population	**1.0001**	**1.0000**	**1.0001**	**0.0000**	**1.0000**	**1.0001**	**1.0002**	**0.0000**	**1.0002**	**1.0002**	**1.0002**	**0.0000**
Distance to forests	**0.9999**	**0.9999**	**0.9999**	**0.0000**	**1.0000**	**0.9999**	**0.9969**	**0.0018**	**0.9999**	**0.9999**	**0.9999**	**0.0000**
Distance to sentinel hospitals	**0.9999**	**0.9999**	**0.9999**	**0.0000**	1.0000	1.0000	1.0000	0.1439	1.0000	1.0000	1.0000	0.2255
Unit typology					Unit typology				Unit typology			
Rich	**2.87**	**2.31**	**3.57**	**0.00**	**1.61**	**1.17**	**2.20**	**0.00**	**1.89**	**1.32**	**2.72**	**0.00**
Planned	**3.02**	**2.45**	**3.71**	**0.00**	1.28	1.16	1.71	0.09	**1.82**	**1.30**	**2.55**	**0.00**
Deprived LD	**3.08**	**2.50**	**3.80**	**0.00**	1.17	1.16	1.57	0.29	**1.43**	**1.00**	**2.03**	**0.05**
Deprived MD	**8.04**	**6.57**	**9.85**	**0.00**	**1.66**	**1.16**	**2.21**	**0.00**	**2.50**	**1.79**	**3.49**	**0.00**
Deprived HD	**10.03**	**7.95**	**12.67**	**0.00**	1.50	1.24	2.29	0.06	**2.19**	**1.41**	**3.40**	**0.00**
Indus	0.95	0.59	1.55	0.85	1.13	1.35	2.04	0.67	0.53	0.19	1.49	0.23
Cantonment	**2.37**	**1.81**	**3.09**	**0.00**	1.34	1.22	1.99	0.15	1.00	0.56	1.79	1.00
Periph (rural)	REF				REF				REF			
Distance to Index cases					Distance to Index cases				Distance to index cases			
]0m -] 100m	**3.14**	**2.75**	**3.58**	**0.00**	**3.57**	**1.16**	**4.78**	**0.00**	**4.55**	**3.40**	**6.10**	**0.00**
]100m -] 250m	**2.23**	**1.95**	**2.56**	**0.00**	**4.49**	**1.12**	**5.63**	**0.00**	**3.52**	**2.68**	**4.62**	**0.00**
]250m -] 500m	**1.39**	**1.23**	**1.56**	**0.00**	**1.69**	**1.13**	**2.16**	**0.00**	**2.48**	**1.97**	**3.11**	**0.00**
]500m -] 750m	**1.50**	**1.35**	**1.66**	**0.00**	**1.60**	**1.12**	**2.00**	**0.00**	**1.94**	**1.55**	**2.43**	**0.00**
]750m -] 1000m	**1.27**	**1.14**	**1.41**	**0.00**	**1.58**	**1.12**	**1.96**	**0.00**	**2.15**	**1.75**	**2.64**	**0.00**
]1000m -] 1500m	**1.17**	**1.08**	**1.27**	**0.00**	**1.45**	**1.09**	**1.71**	**0.00**	**1.05**	**0.80**	**1.36**	**0.73**
]1500m and more	REF				REF				REF			

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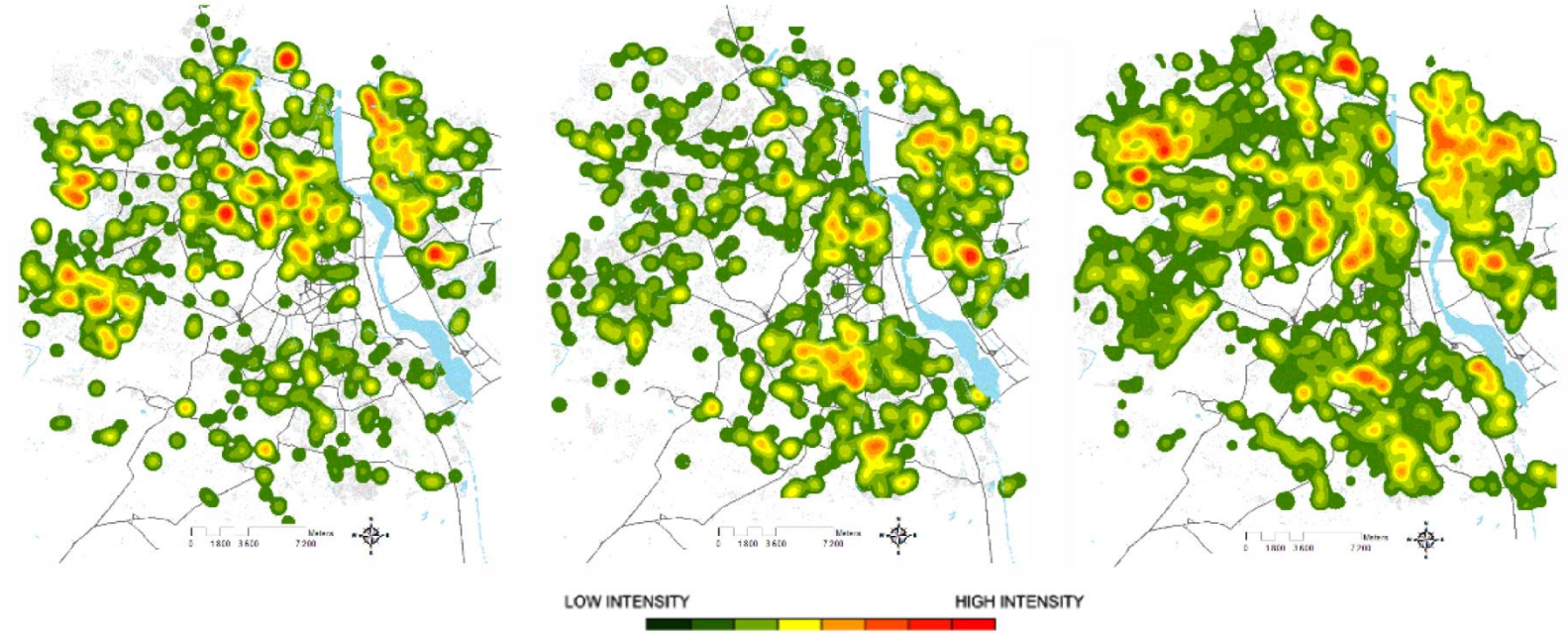
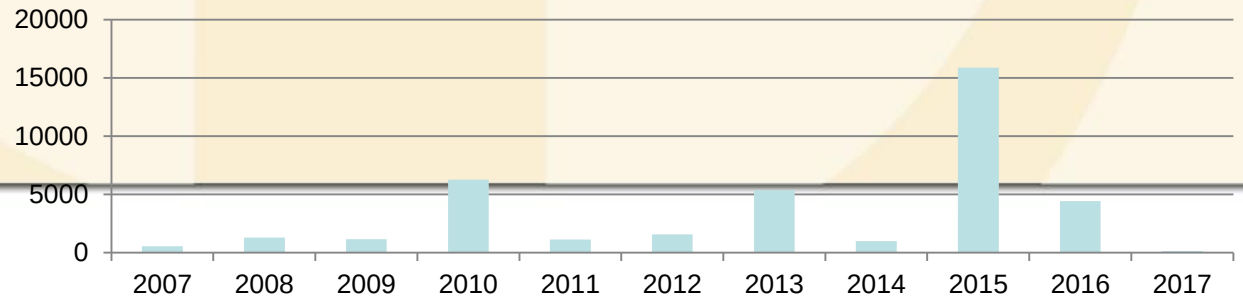
Surveillance system: Density of dengue cases in 2008; 2009 and 2010 (source: Telle O. et al., Plos one, 2016).



Dengue cases in Delhi



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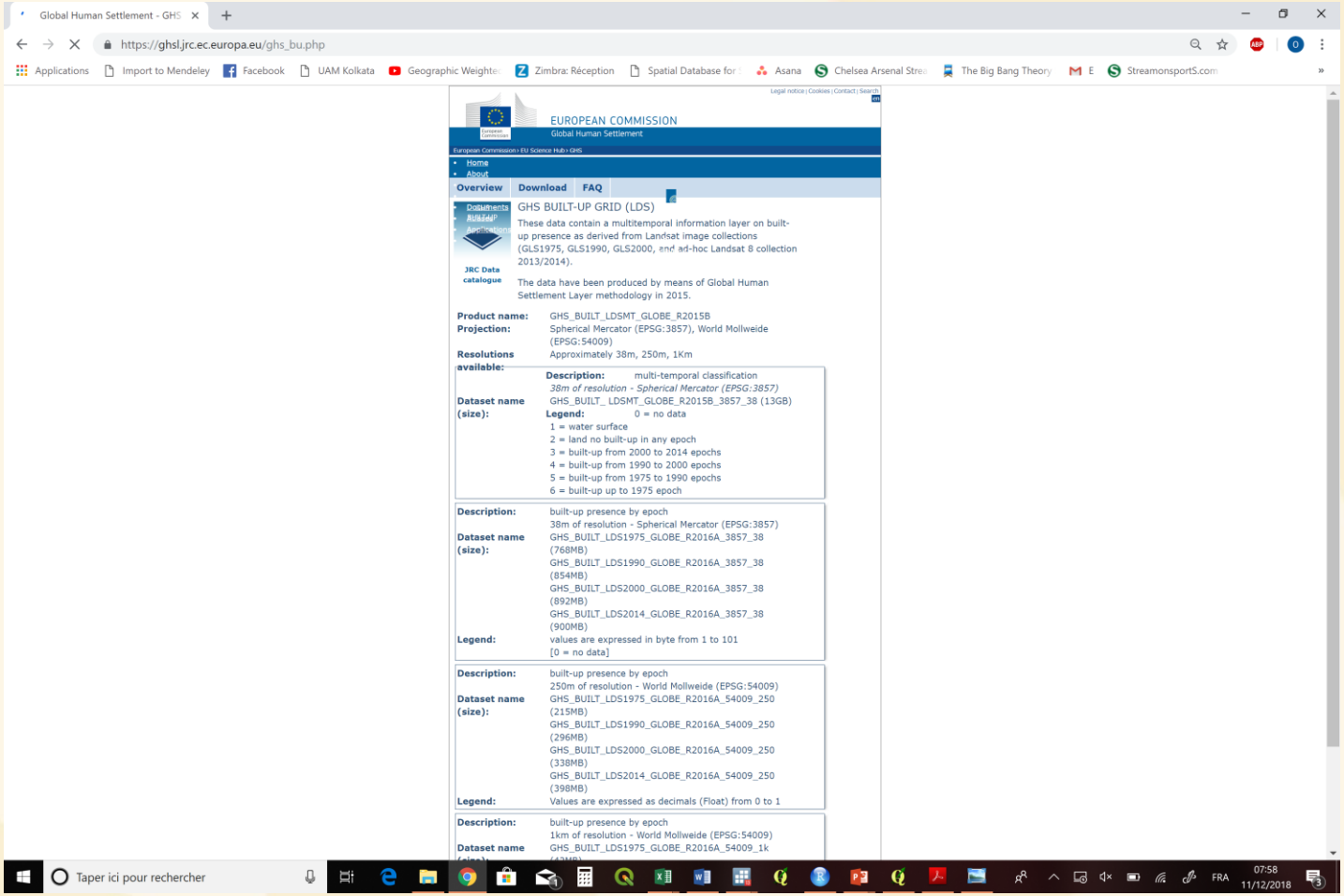

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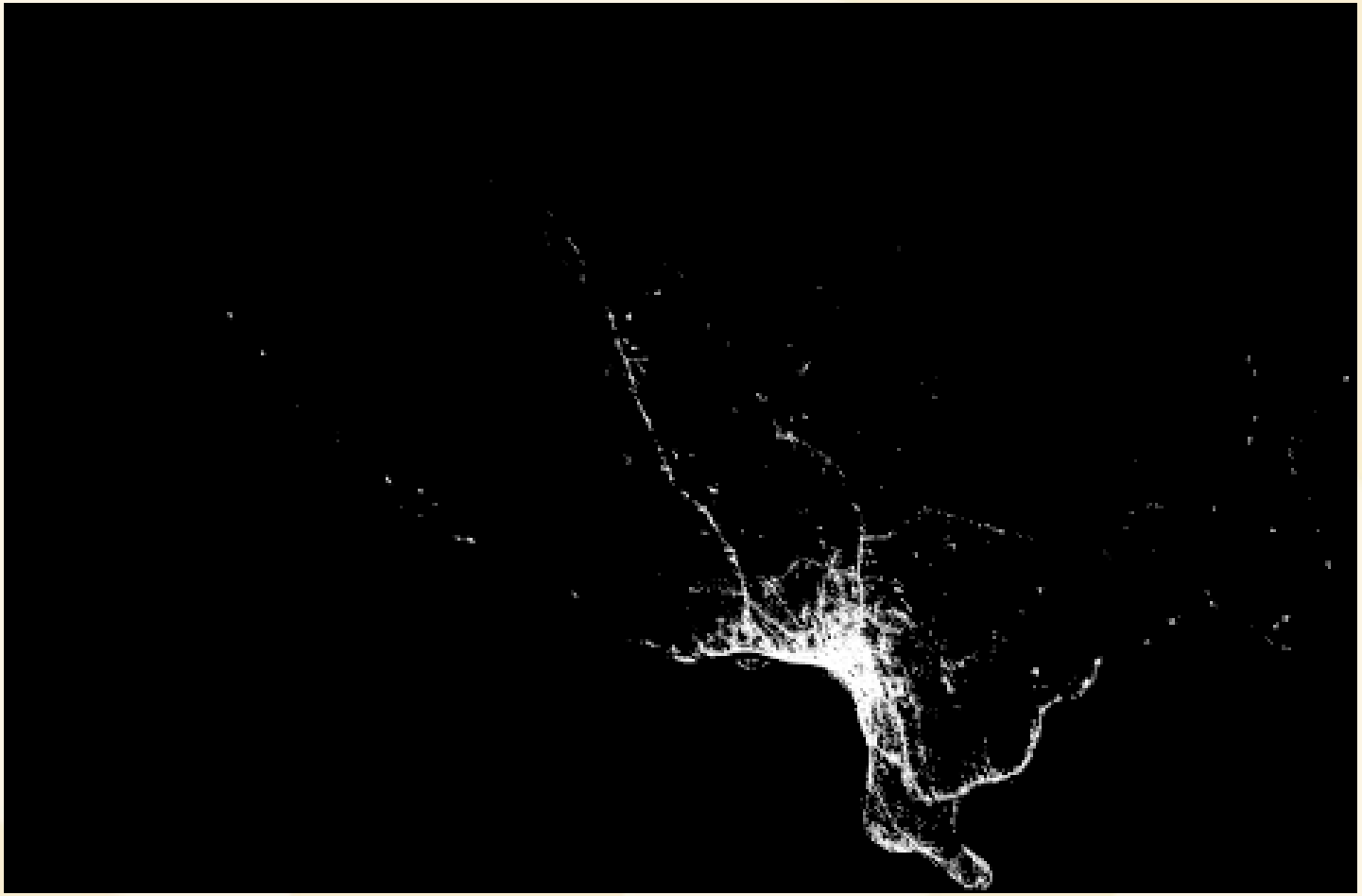
Vientiane, Lao PDR



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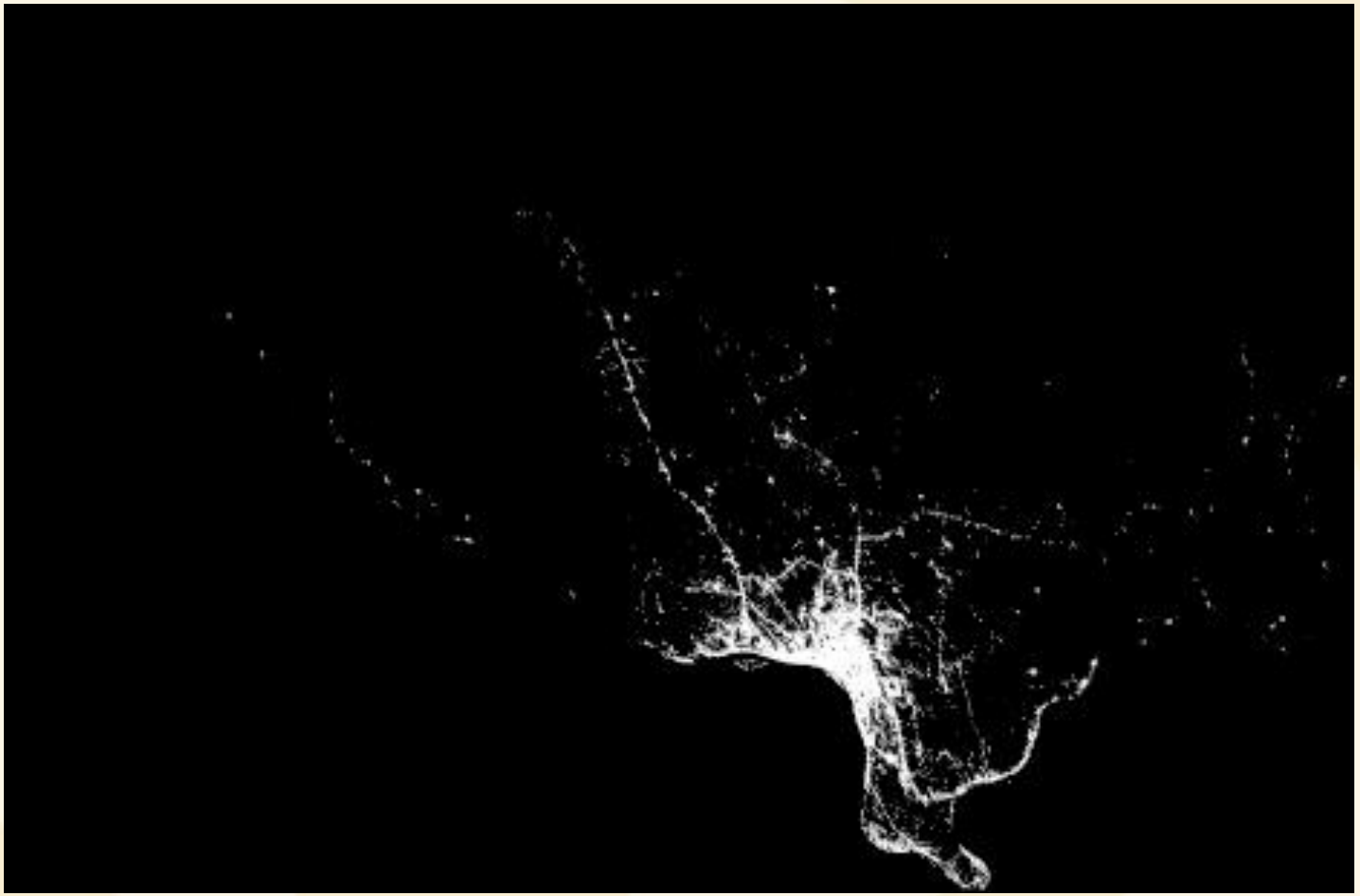

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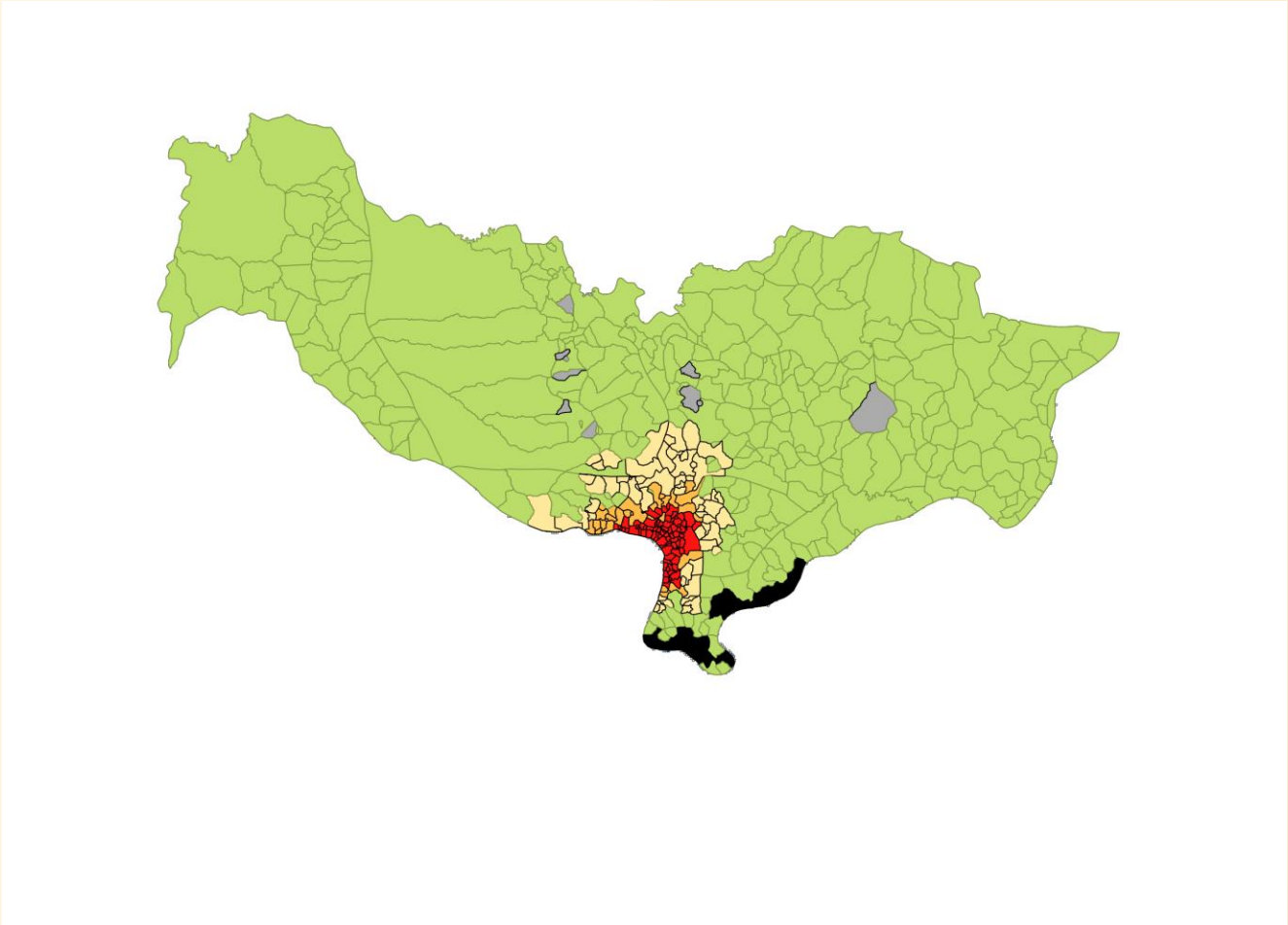
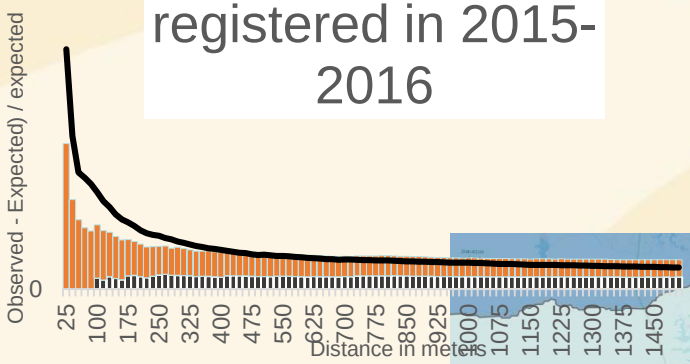
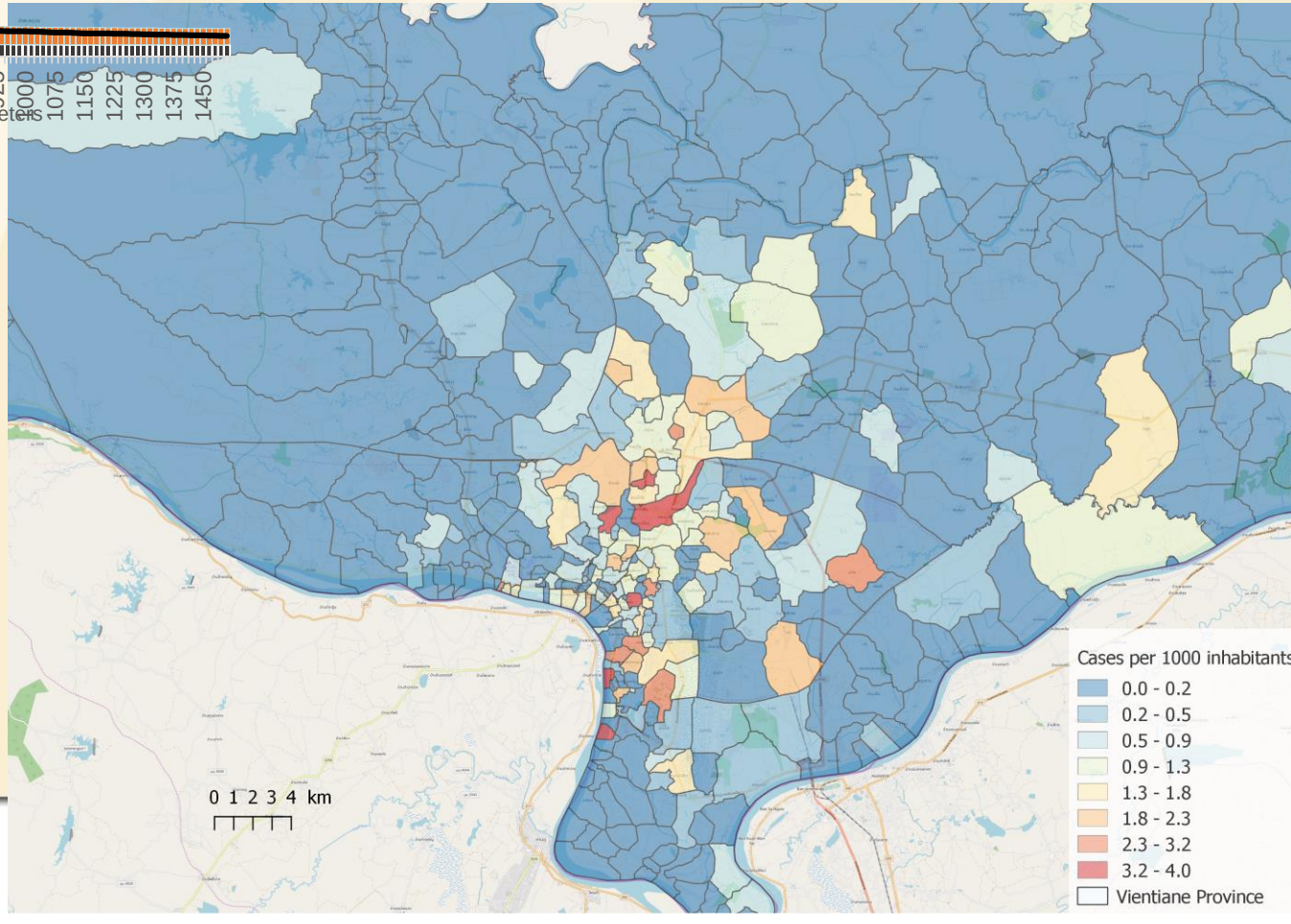
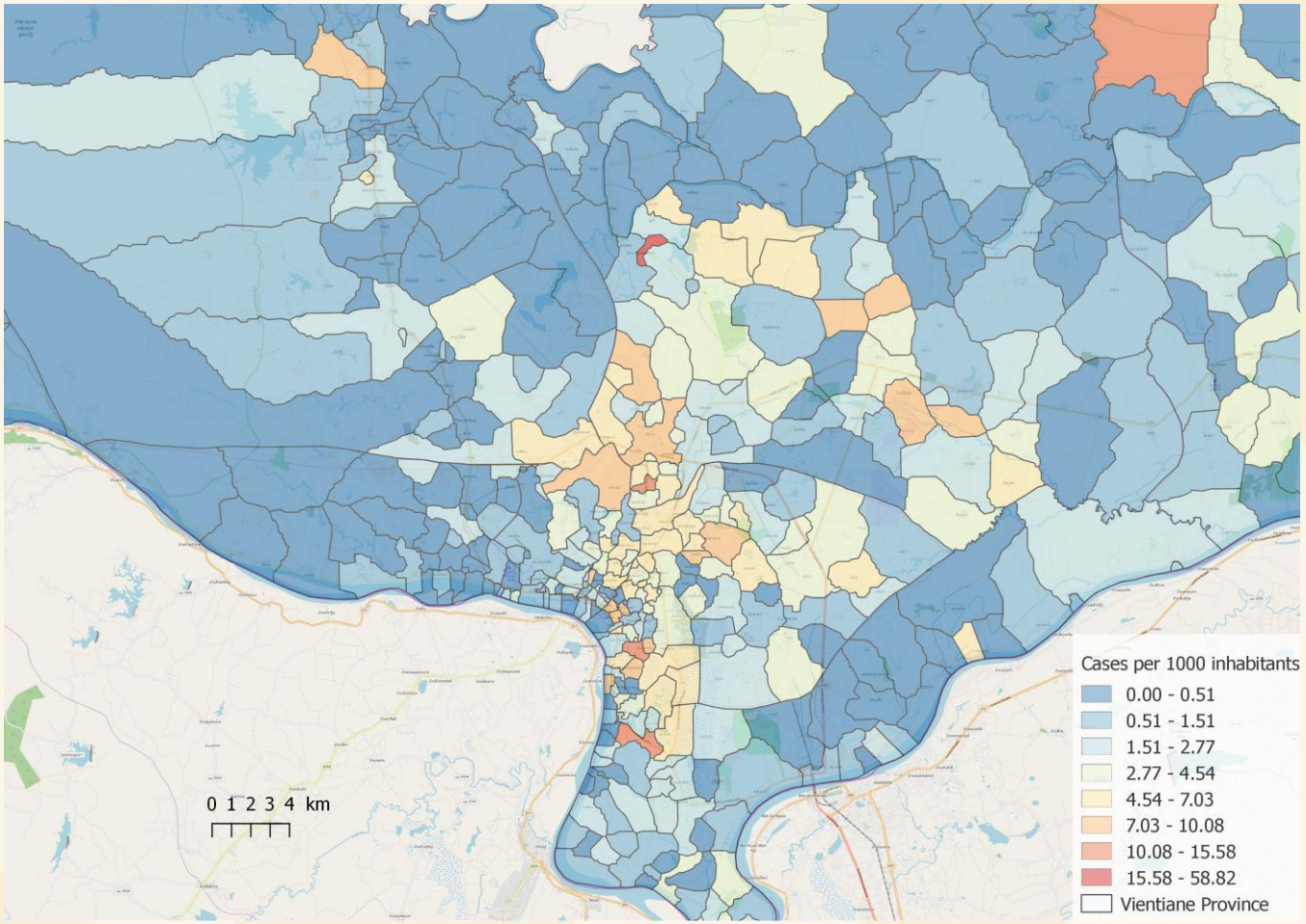
Risk factor in Vientiane



K-Ripley Score of dengue cases registered in 2015-2016







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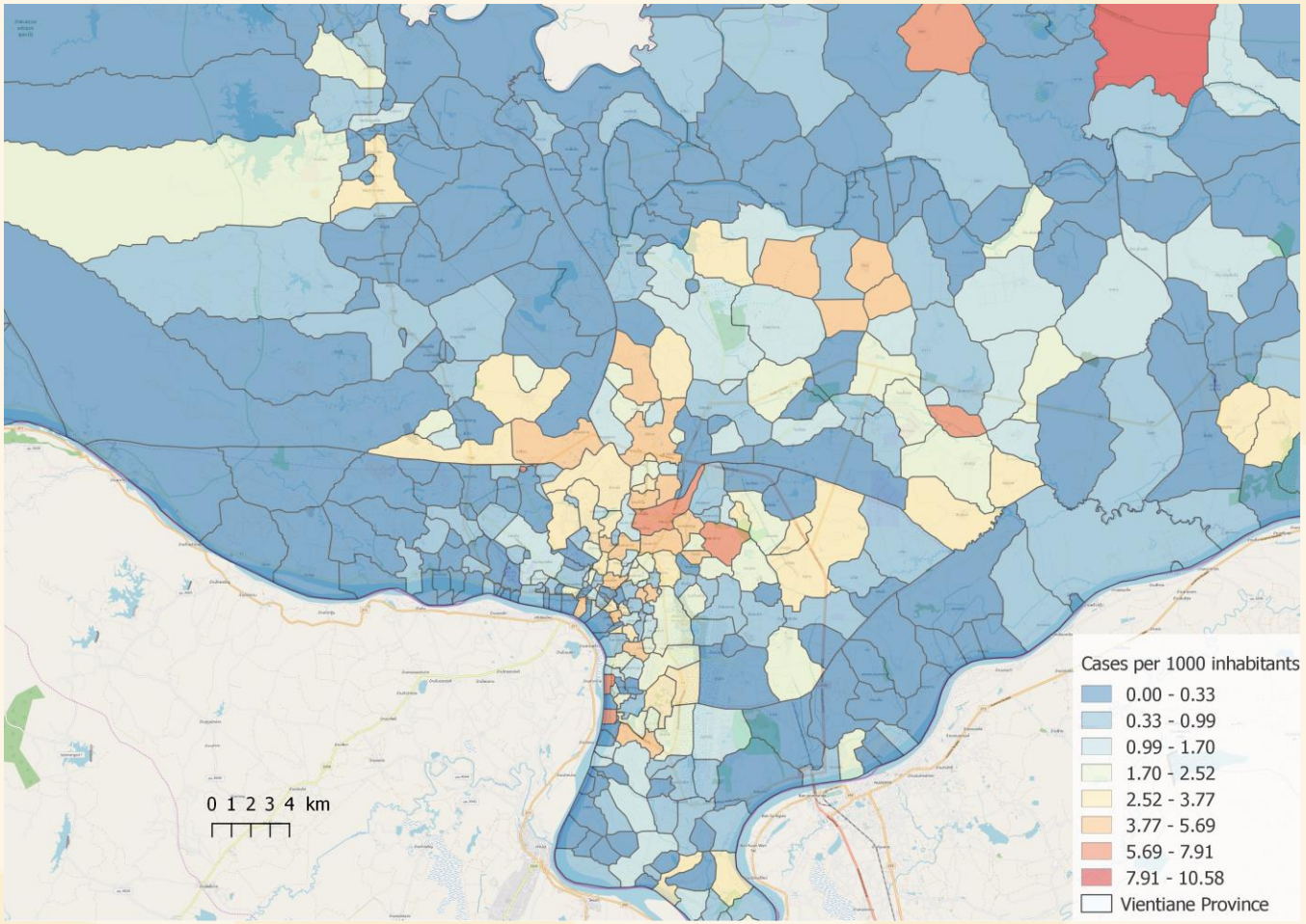

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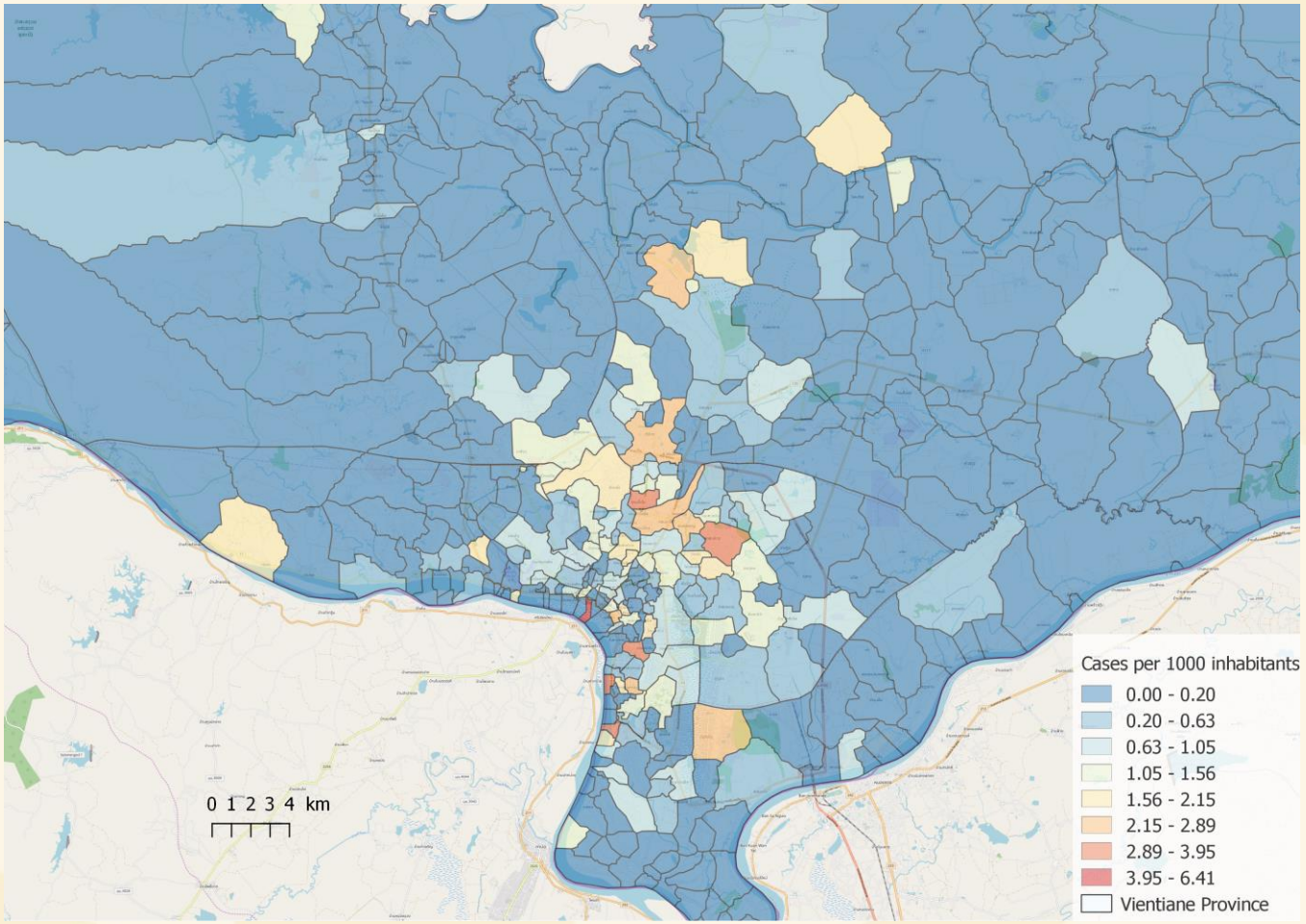

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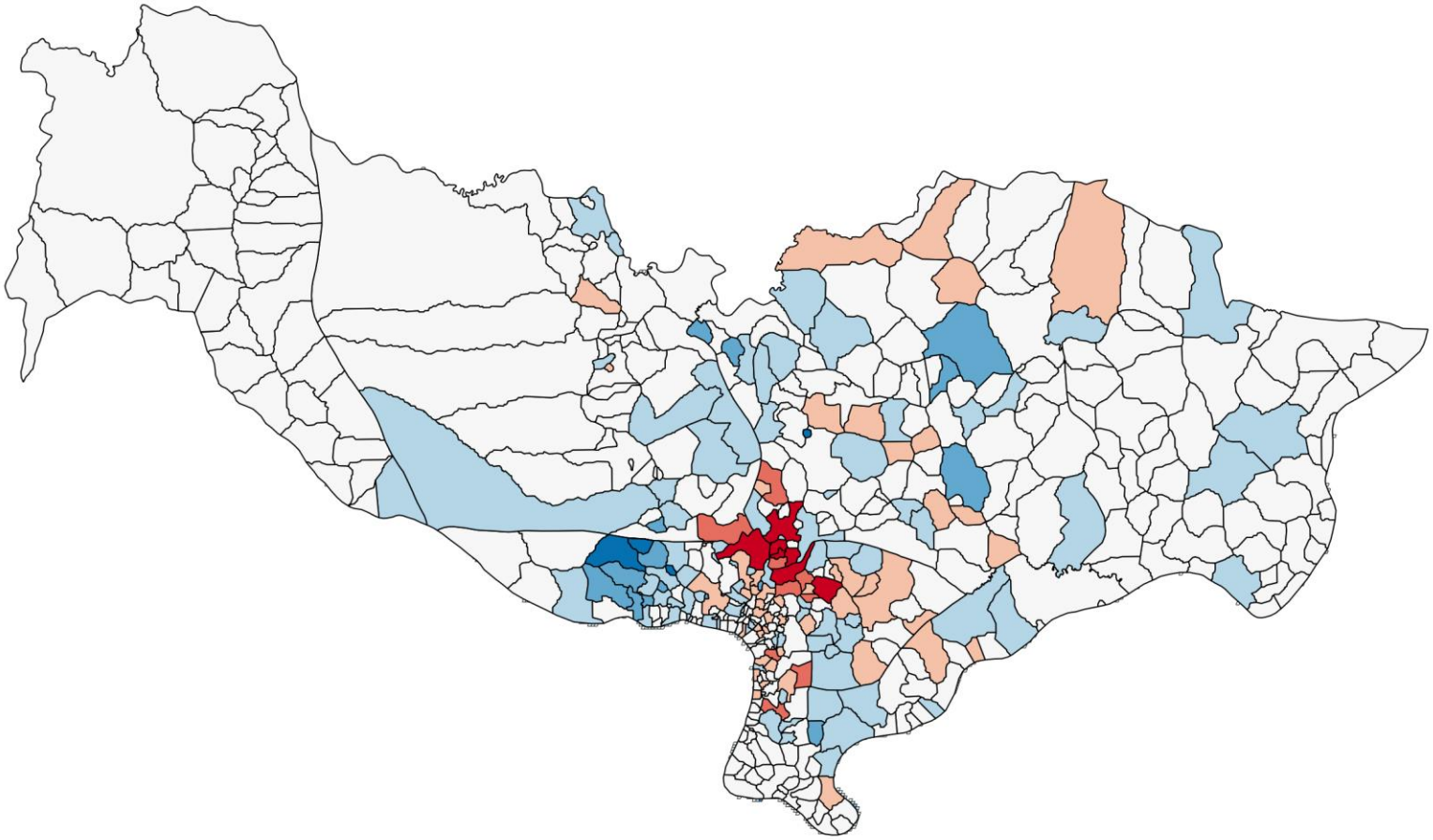
R^2=0.567

All	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]	
nb_person	0.0003794	7.18E-06	52.83	0	0.0003654	0.0003935	
RURAL	**REF**						
Urban Core	0.740536	0.0462841	21.05	0	0.8833385	1.064769	**1.90**
1st periphery	1.030568	0.0536731	19.2	0	0.9253702	1.135765	**2.80**
2nd	1.009465	0.0479951	21.03	0	0.9153963	1.103534	**2.74**
Old settlement	0.2984308	0.1142641	2.61	0.009	0.0744773	0.5223843	**1.35**
New Settlement	0.2446658	0.113497	2.16	0.031	0.0222157	0.4671158	**1.28**
Rural	**REF**						

Mapping autocorrelation of residual



Objectives

1) Better control dengue virus at short term

- during epidemics (locate central places with mobile data)
- between epidemics (locate dengue niches in relation with temperature and demographic data)

2) Long term perspective of dengue control:

- governance of diseases
- development of cities

- Collaboration between Indian institutes

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Autodissemination of pyriproxyfen 10% dust

Control of DF/DHF Vector, *Aedes* Mosquito, with Insecticides

Takaaki ITOH

Takarazuka Research Center of Sumitomo Chemical Co. Ltd.
4-2-1, Takatsukasa, Takarazuka, Hyogo 665, Japan

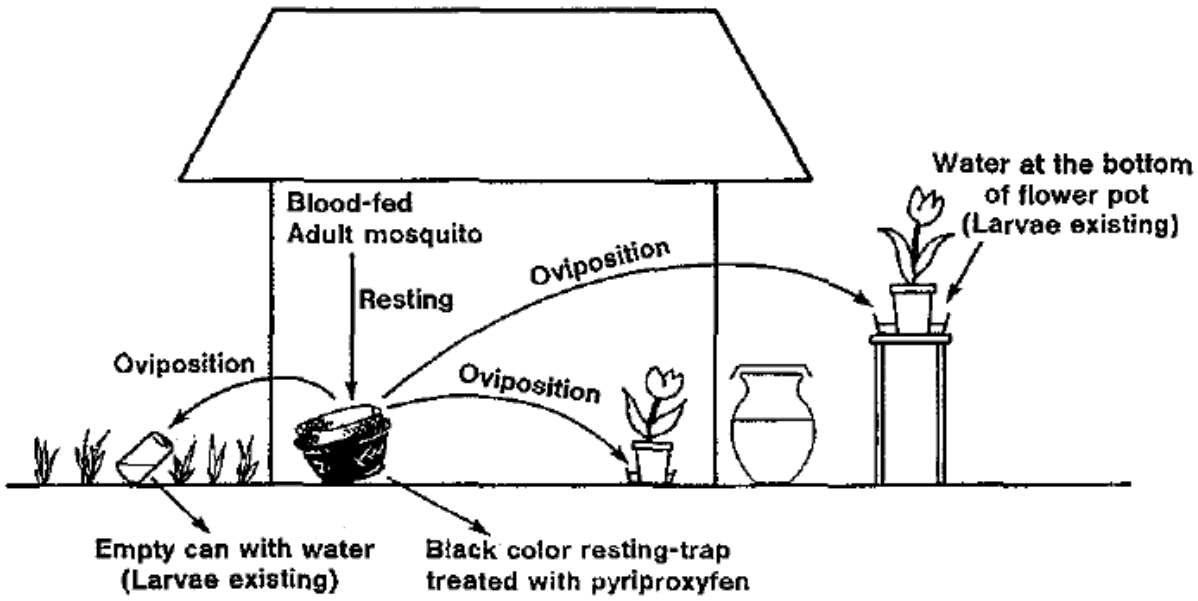


Fig. 4. Utilization of adults of *Aedes aegypti* as a vehicle of pyriproxyfen for small and inconspicuous larval habitats

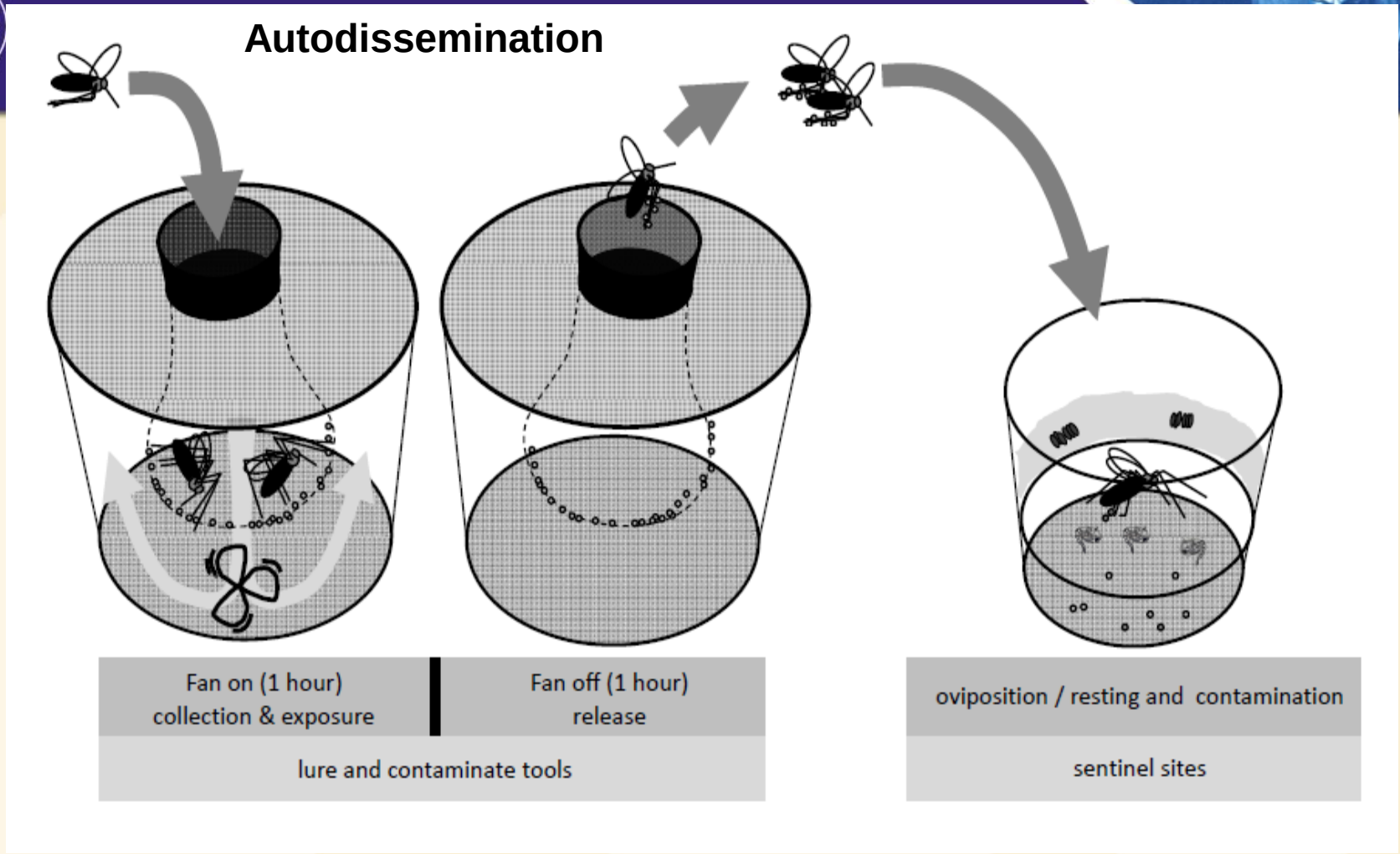


Figure 1. Adapted BG traps for pyriproxyfen dissemination. Trialled in Peru 2010 and Madeira 2014.

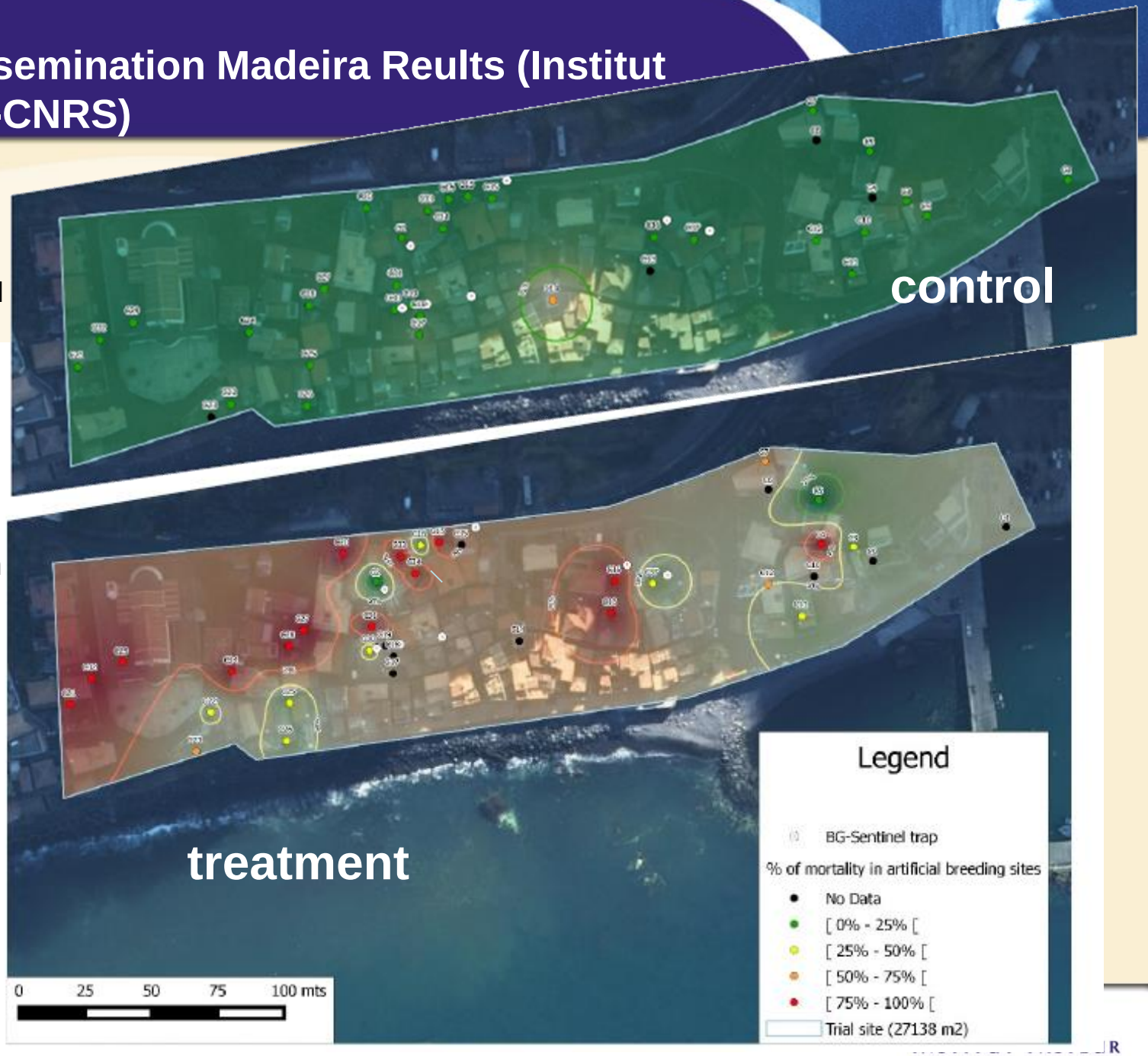
Autodissemination Madeira Reults (Institut Pasteur-CNRS)

White spots are adapted BG traps (6).

Other spots are sentinel sites (27) suitable for oviposition by contaminated adult females emerging from adapted BGs.

Sentinels are colour coded for impact (green = no impact, red = maximum impact; see legend)

Each sentinel site originally seeded with 20 *Ae aegypti* larvae.



Conventional fumigation and larviciding are hard to implement in modern urban cities

Sao Paulo 1940s (Aedes eradication era) and now

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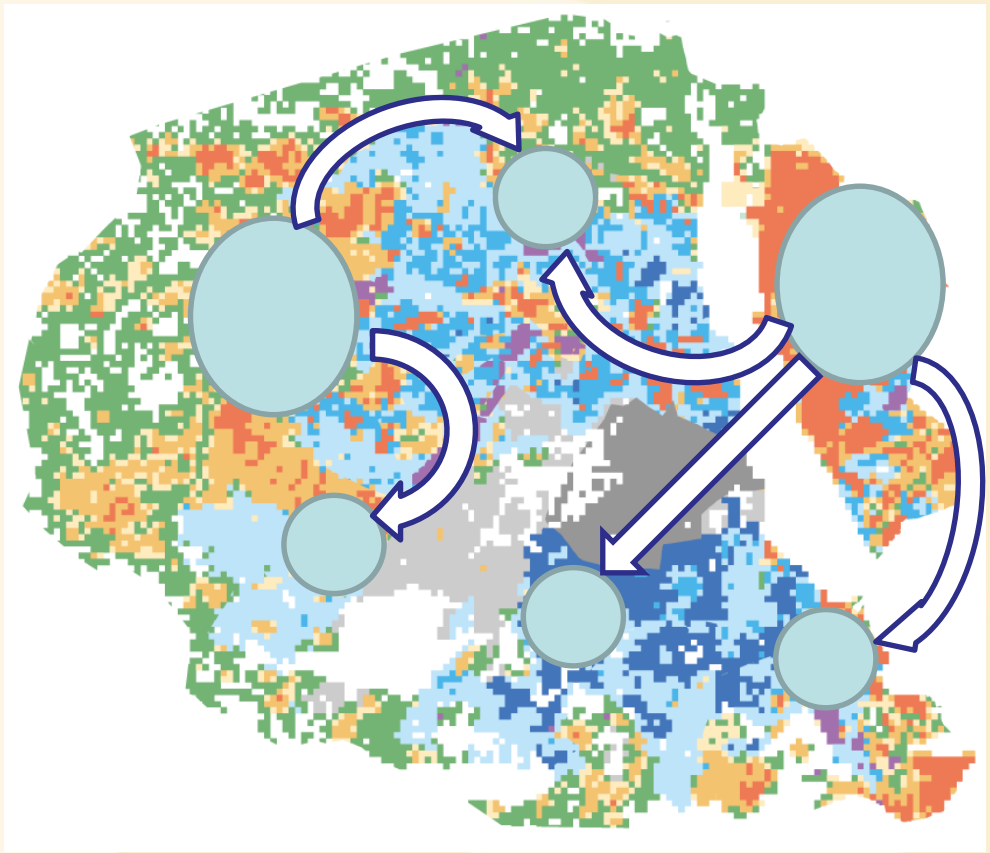
Are there identifiable migration patterns that go beyond physical distance?

Source-sink structure to Delhi ?



Viral genetics more informative than mobile phones/twitter etc

Genome 11000 bases and mutation rate 10^{-3} per generation (man mosquito man)

Thus 1-10 mutations per generation

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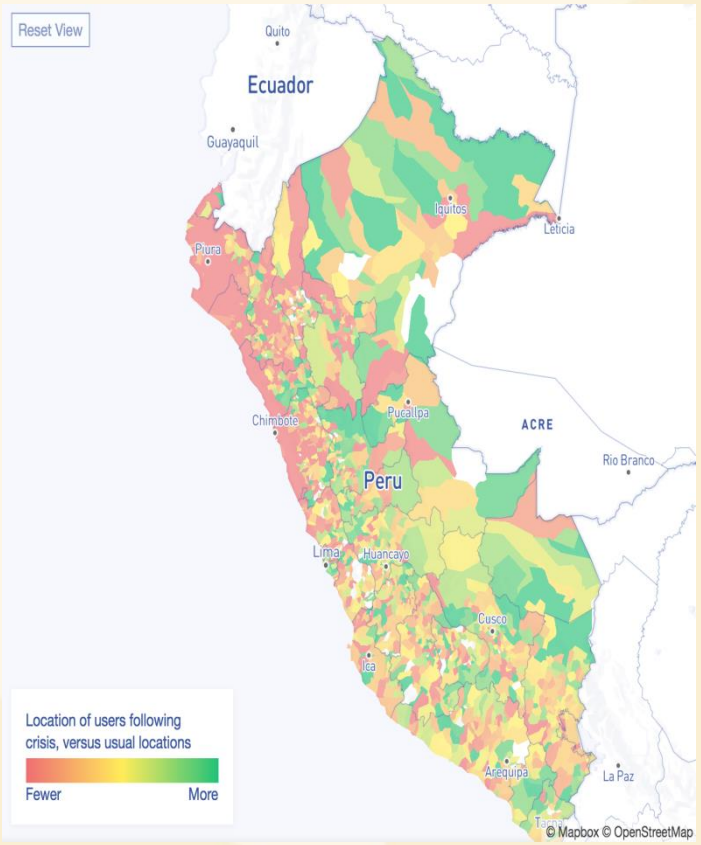
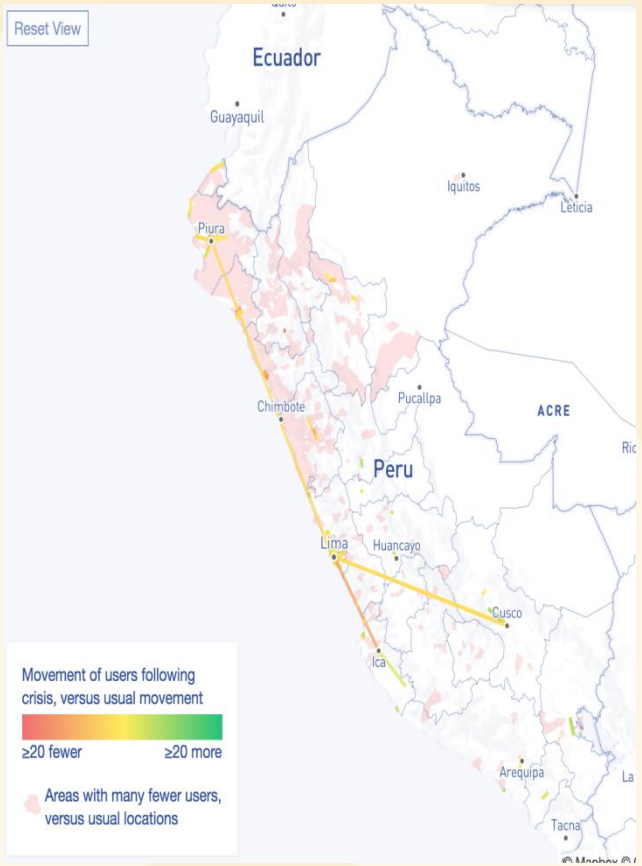
Disaster Maps – Peru Flooding – March 2017

1 Population/Location



2 Movement



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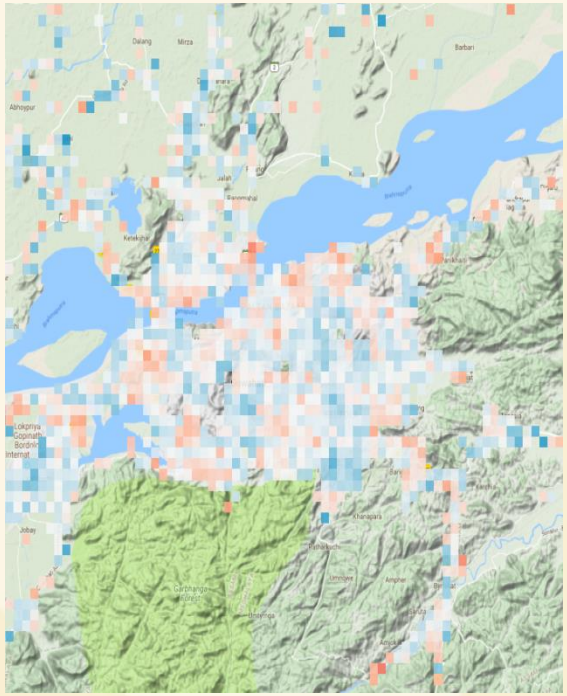
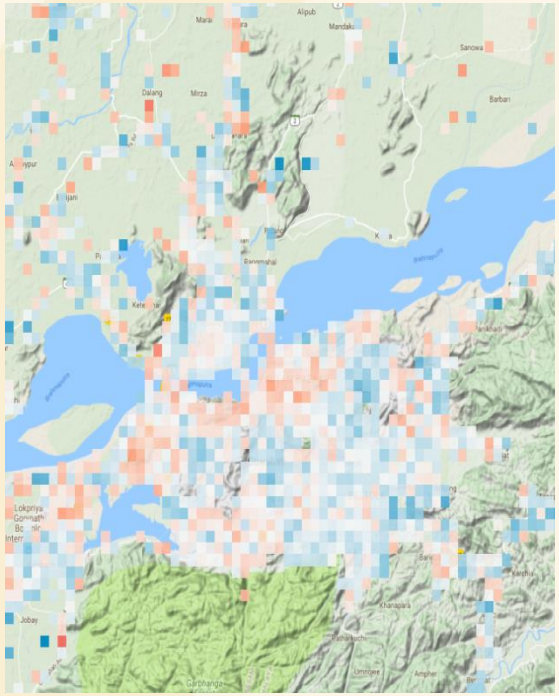
Kamrup Metropolitan Area (Guwahati)

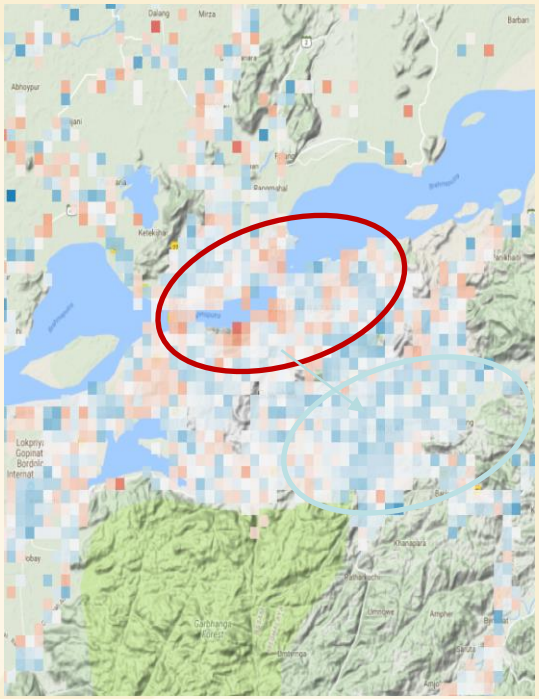
July 6th



July 8th



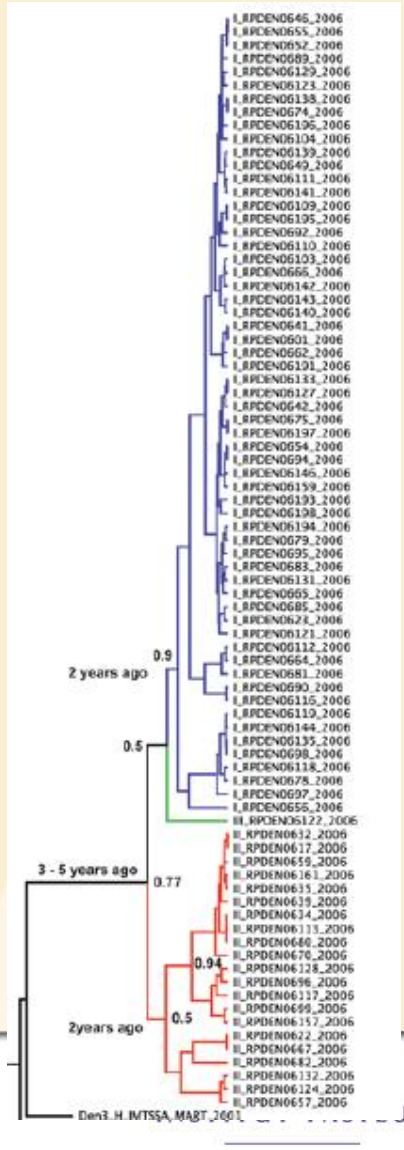
July 10th



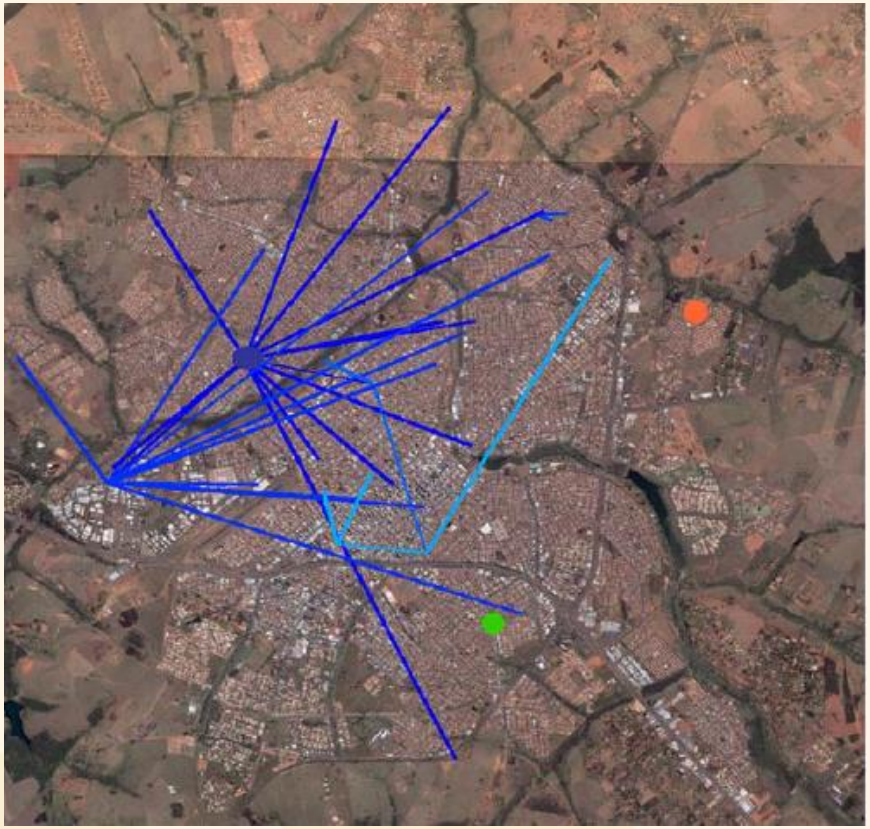
Population Decrease — Population Increase

Inferring micro-epidemiology through viral sequencing

Phylogenetic distance tree



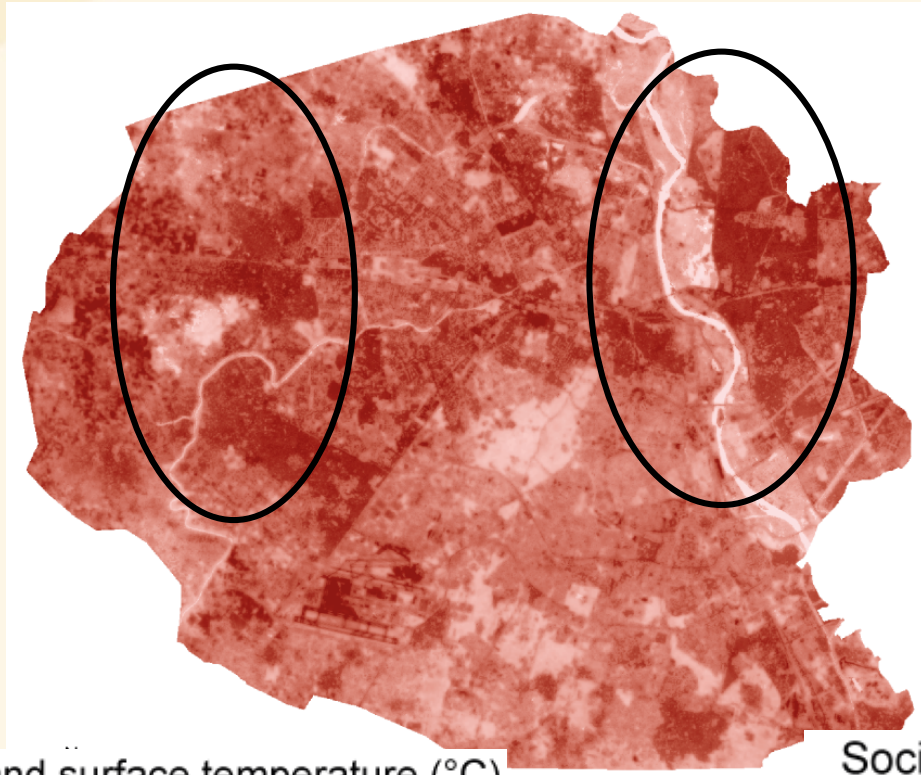
Route of viral dispersal inferred through viral phylogenetics

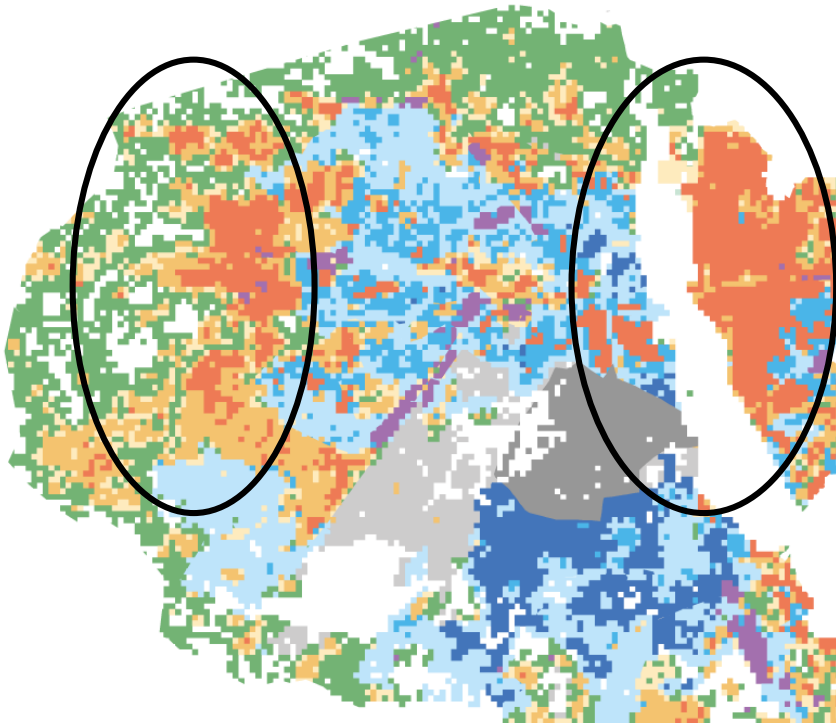


San José de Rio Preto, Brazil. Mondini et al. 2009

Winter Hotspots and Urban Heat Islands

Poor densely populated areas 5-10°C hotter in winter at night





Land surface temperature (°C)

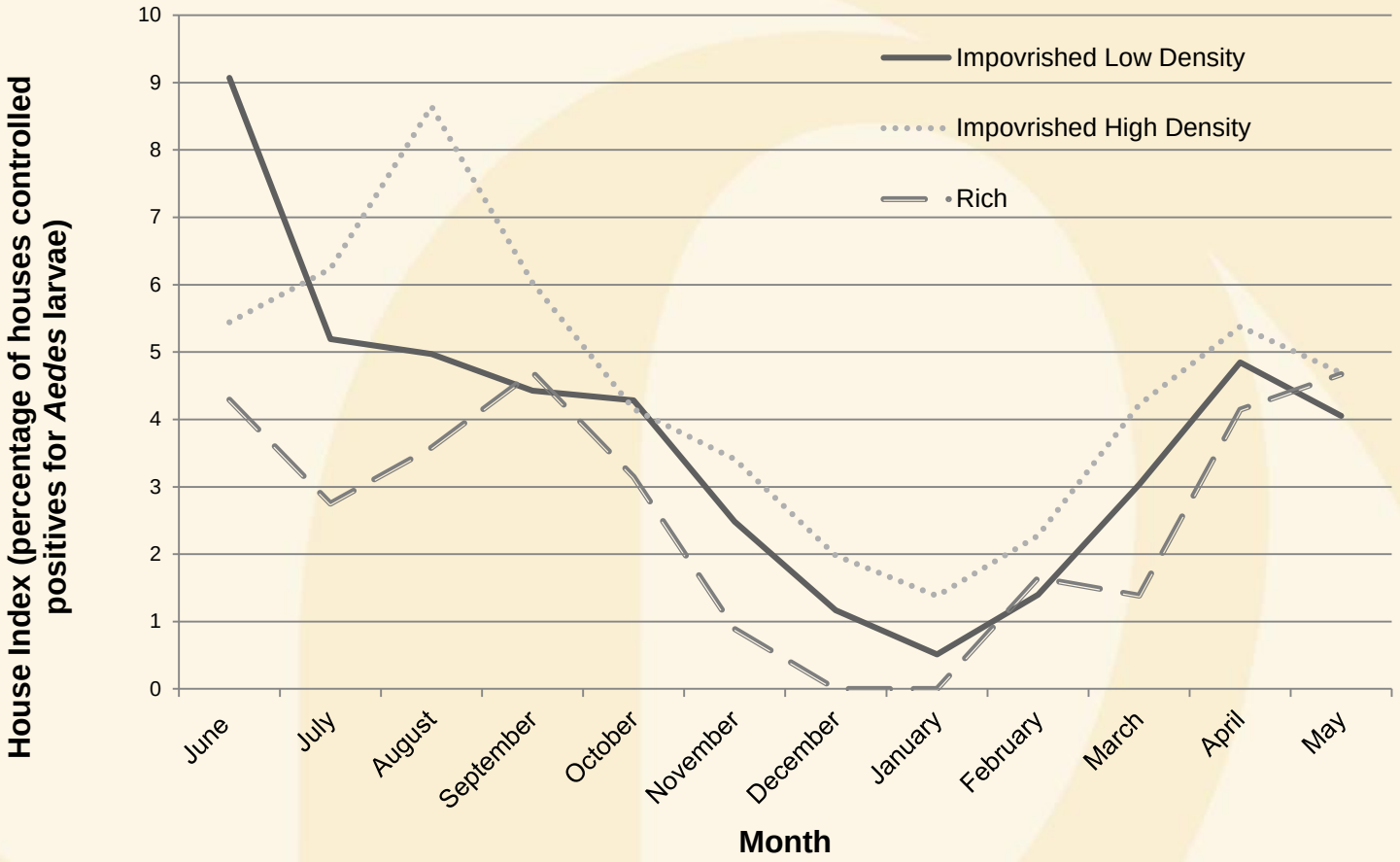
34 39 44

Socio-economic characteristics typology

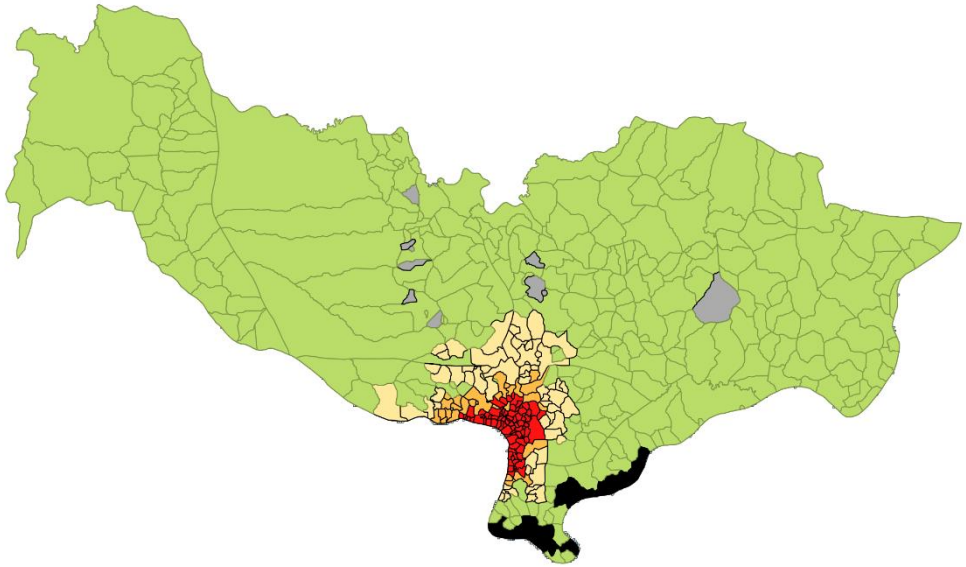
- Impoverished, low densities
- Impoverished, medium densities
- Impoverished, high densities
- Planned, low densities
- Planned medium densities
- High incomes
- New Delhi (NDMC)
- Cantonment (CBA)
- Industrial
- Rural
- Uninhabited

Virus found in mosquitoes in winter – urban hotspots

Presence of mosquito larvae vs socio-economic typology



- Mapping dengue require tremendous effort for health authorities and researchers:
  - Trying to developp a better way to locate individuals this from distance (what app, line…).
  - It required as well several spatialised data: location of individuals, surface/air temperature, water access….
  - Use of Open data !! (Global human settlement)



Thank you

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