60TH SESSION OF THE STSC OF THE UN-COPUOS

Health-related Applications of Remote Sensing and GIS in the Philippines

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Outline

- Introduction
  - Health and epidemiological problems in the Philippines
  - PhilSA and activities related to GeoHealth
- GeoHealth Applications
  - Urban heat islands
  - Dengue incidence analysis, modelling, and prediction
- Challenges and Opportunities
  - Data gaps
  - Computational resources
  - Citizen science

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Introduction

THE LEADING CAUSES OF MORTALITY IN THE PHILIPPINES

- Diseases of the heart
- Diseases of the vascular system
- Pneumonias
- Malignant neoplasms/cancers
- All forms of tuberculosis, accidents, COPD and allied conditions, diabetes mellitus, nephritis/nephritic syndrome and other diseases of respiratory system

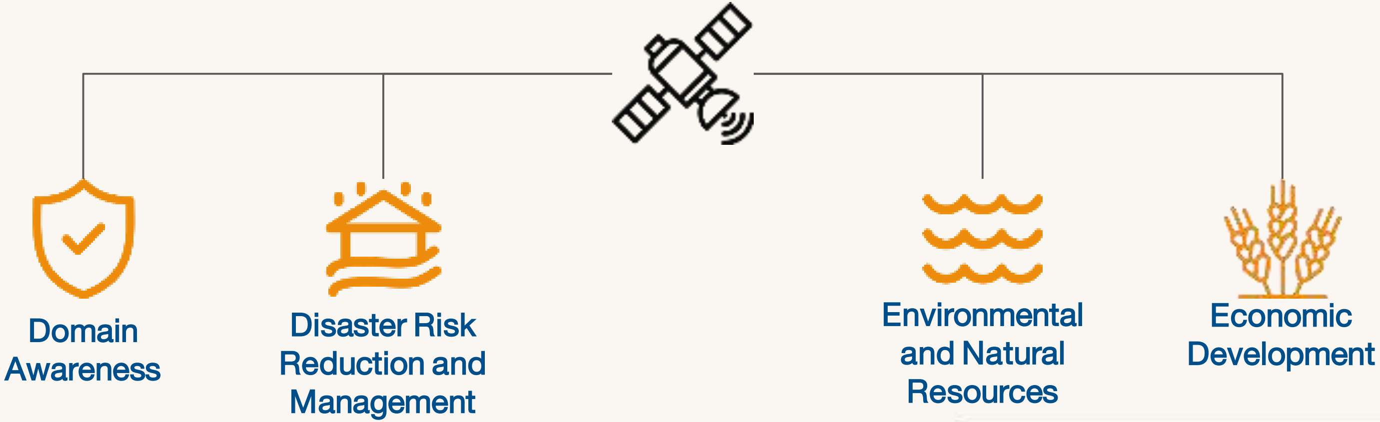
Data from the Department of Health (DOH)’s Disease Surveillance Report showed there were 220,705 dengue cases recorded from Jan. 1 to Dec. 17, 2022. The figure is 182 percent higher than the 78,223 cases reported during the same period in 2021.

Introduction

Mobilizing Space Data

For Economic Development, Disaster Risk Reduction, & Maritime Domain Awareness

The PhilSA aims to further the **development and application of remote sensing (RS), artificial intelligence (AI), machine learning (ML), data science and other methodologies** in producing space-enabled information to support the operations of various government agencies and other end users.



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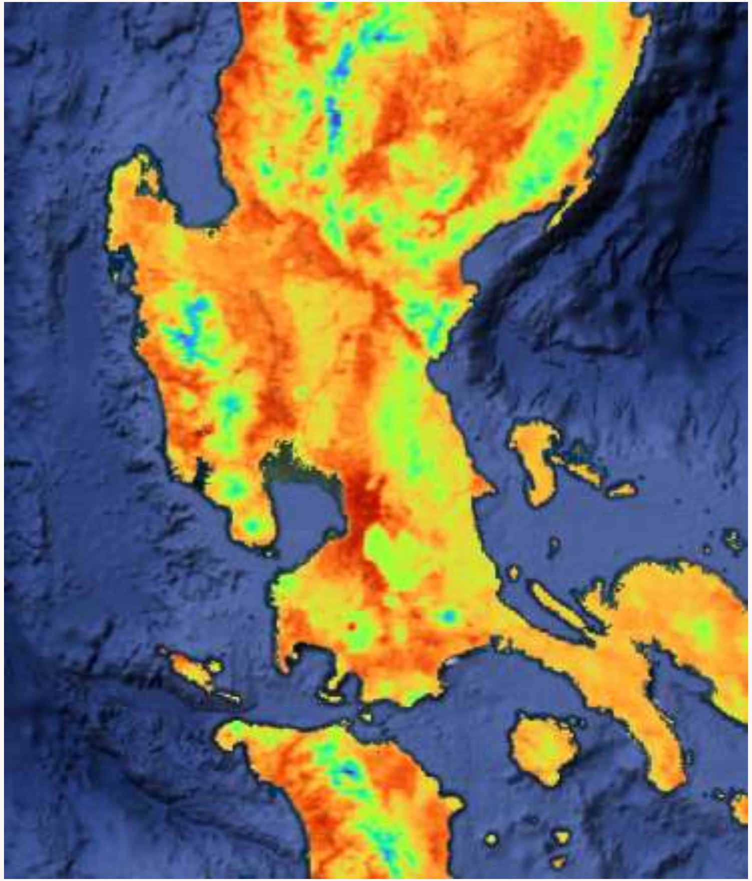
GeoHealth Applications: Urban Heat Islands



Surface UHI Index based on 50-km Neighborhood

UHI Health Implications

Exacerbation of minor existing conditions

Increased risk of hospitalization and death

Heat stroke

Heat is often a contributory factor to deaths and morbidity from other causes, such as respiratory illness

The enhancement of temperatures due to the UHI effect therefore increases heat-related mortality risk in urban areas, and this is likely to further increase in future, due to climate change

Source: Heaviside et al., 2017

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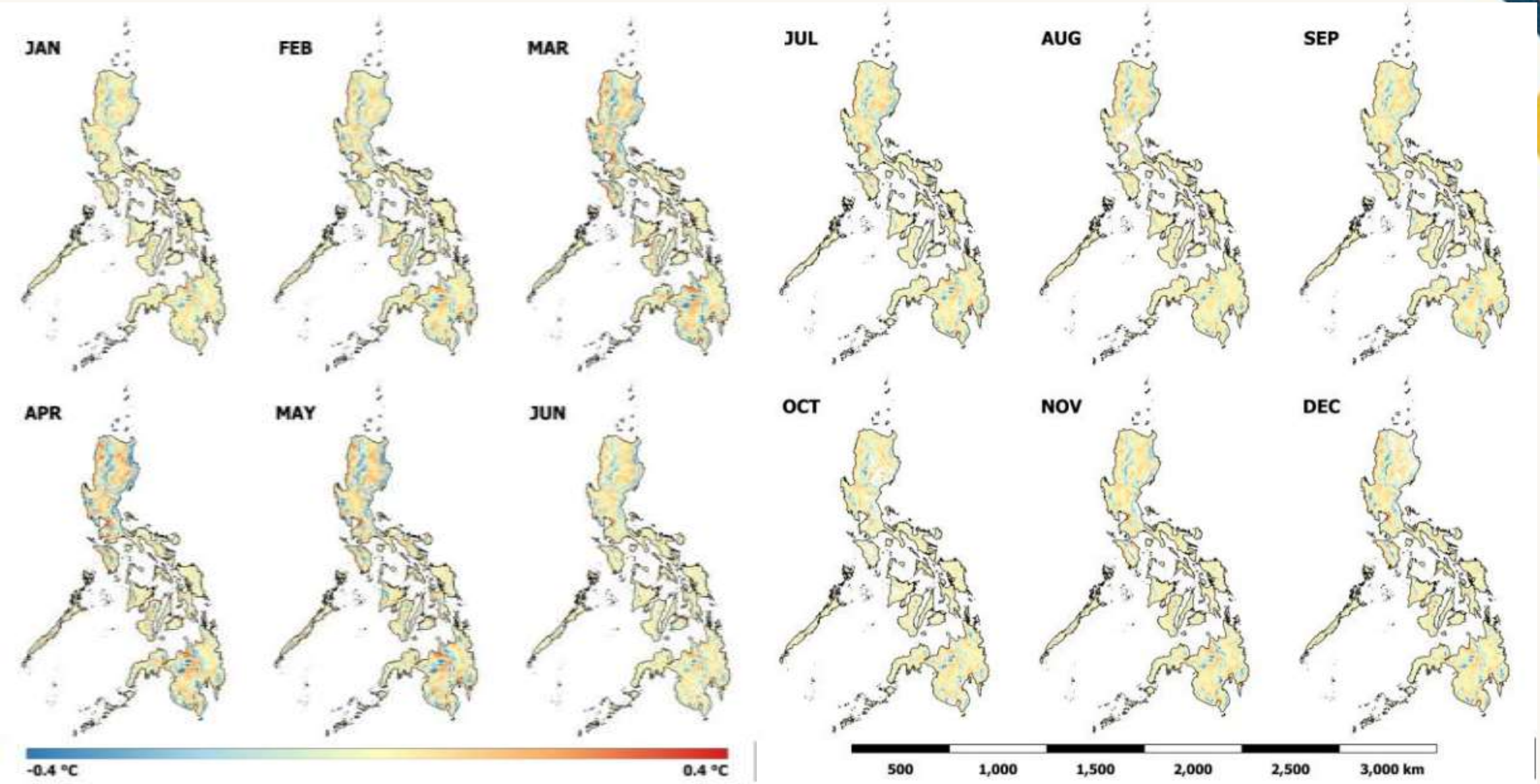
GeoHealth Applications: Urban Heat Islands
UHI as Hazard Layer



Spatio-temporal distribution of UHI in the Philippines in 2020

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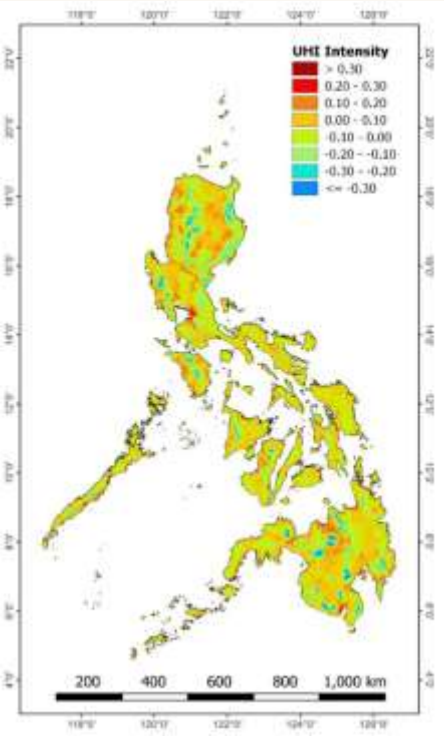
GeoHealth Applications: Urban Heat Islands
UHI Health Risk



Hazard

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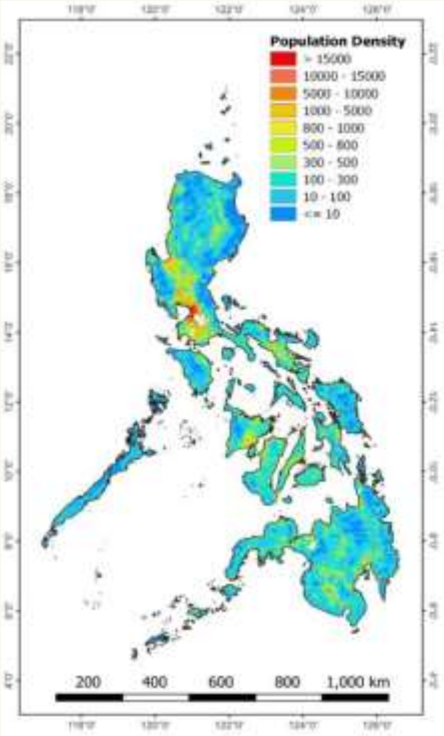

Exposure
2020 Population density data

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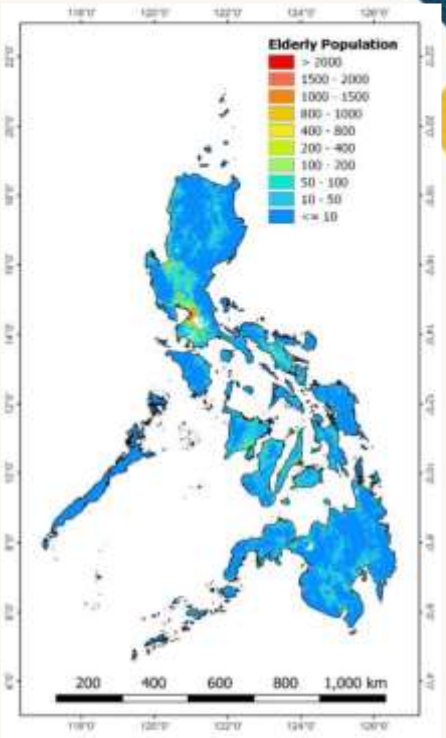

Vulnerability
2020 Elderly Population data

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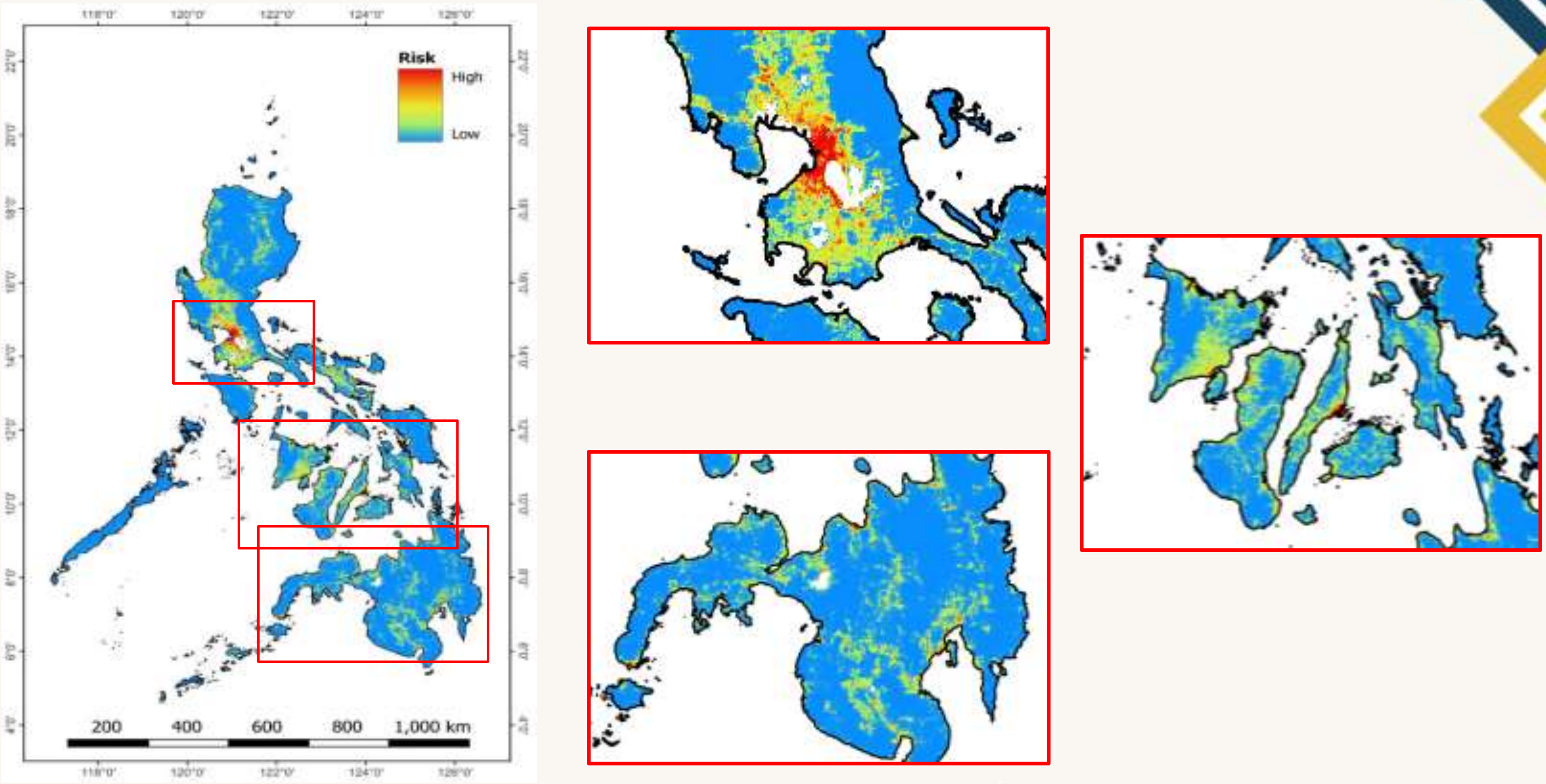
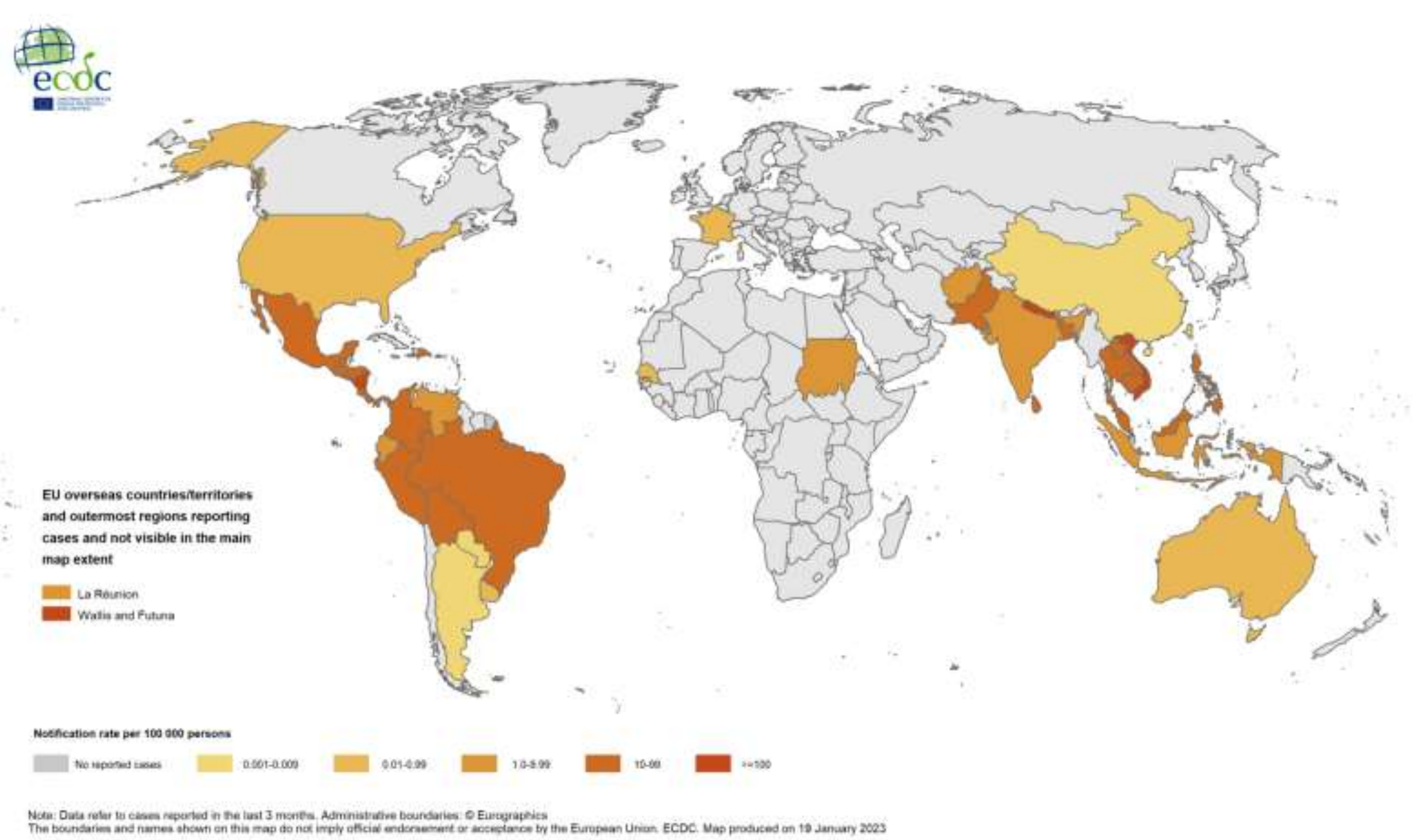
GeoHealth Applications: Urban Heat Islands
UHI Health Risk



GeoHealth Applications: Dengue



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GeoHealth Applications: Dengue

- The *Aedes aegypti* mosquito is the main vector that transmits the viruses that cause dengue.
  - The viruses are passed on to humans through the bites of an infective female *Aedes* mosquito, which mainly acquires the virus while feeding on the blood of an infected person.

- Flight range studies suggest that most female *Ae. aegypti* may **spend their lifetime in or around the houses** where they emerge as adults, and they usually fly an average of **400 meters**.
- This means that people, rather than mosquitoes, rapidly move the virus within and between communities and places.

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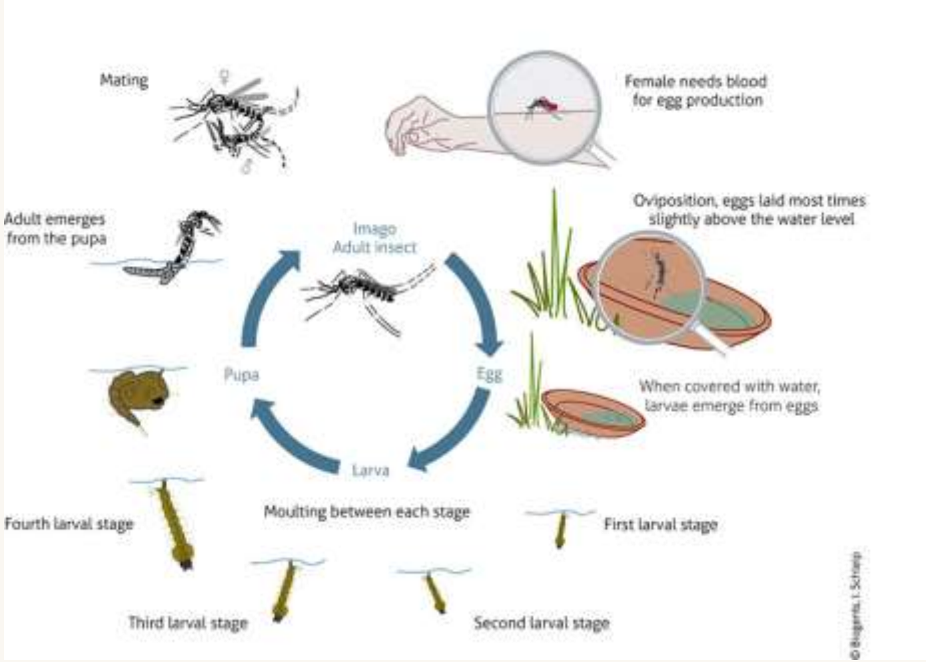
GeoHealth Applications: Dengue

- *Aedes aegypti* is abundant in neotropical regions, where environmental factors (e.g., rainfall, temperature, and relative humidity) favor its life cycle (Eisen et al. 2014).
- **Optimal temperatures** for development, longevity, and fecundity are between **22°C and 32°C** (Beserra et al. 2009).
- With higher temperatures in the favorable survival range of Ae. aegypti, **egg-laying time decreases, causing an increase in egg number** (Costa et al. 2010).
- Moreover, the **extrinsic incubation period of the dengue virus is reduced, resulting in higher rates of viral transmission** (Focks et al. 2000, Hopp and Foley 2001).



Four (4) life stages: egg, larva, pupa and adult. Mosquitoes can live and reproduce inside and outside the home.
The entire life cycle, from an egg to an adult, takes approximately 8-10 days.

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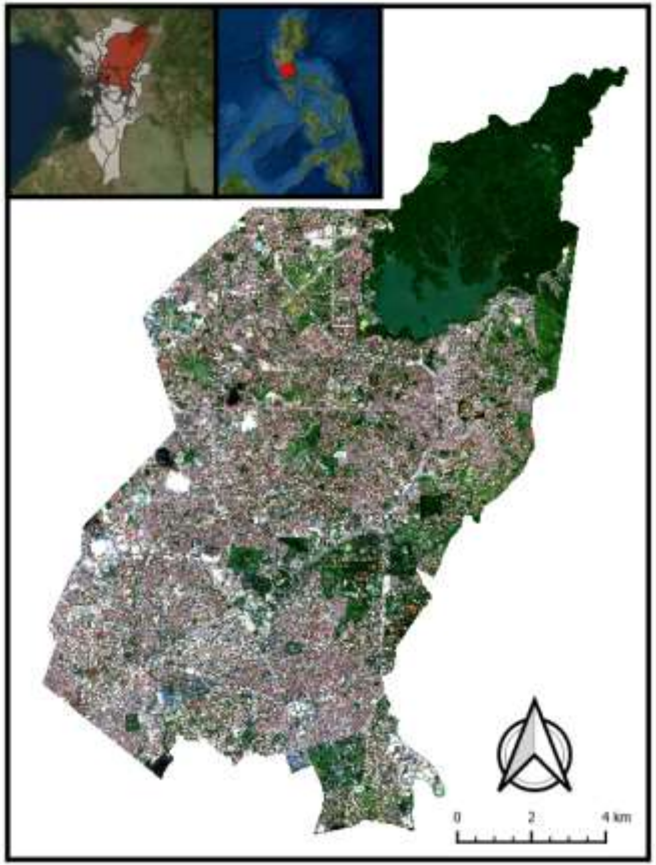
Geospatial Analysis of Dengue Incidences



- The main objective of the study is to identify factors (e.g., land use land cover, meteorological) influencing the spatio-temporal prevalence of dengue cases in Quezon City, Metro Manila.

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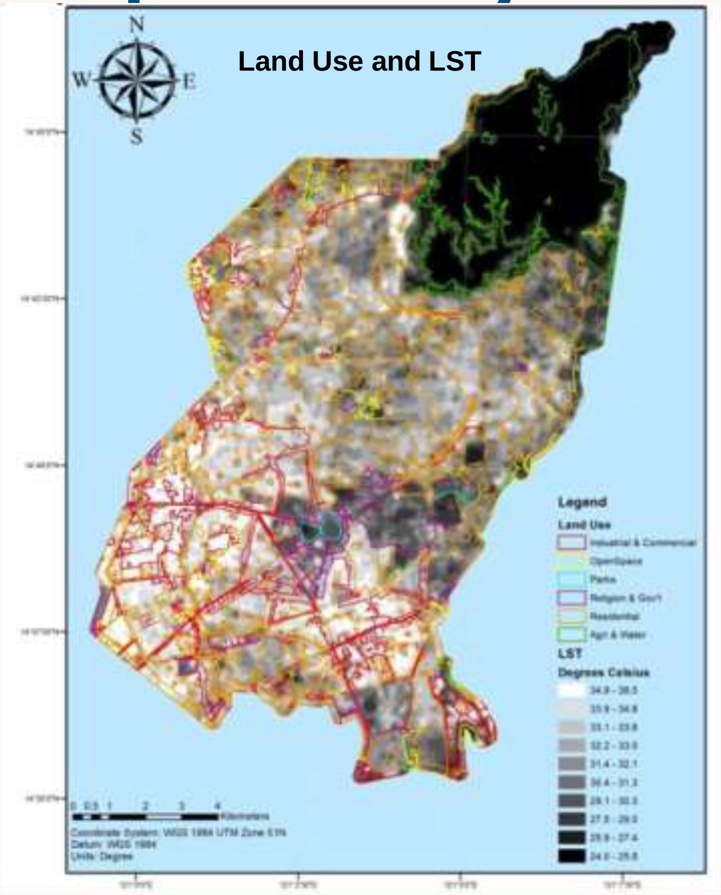
GeoHealth Applications: Dengue

Geospatial Analysis of Dengue Incidences



Number of **dengue cases** in each barangay of Quezon City in 2015 (including monthly)

Land Use Classes: Informal Settlements, Very Low Density Residential, Open Spaces, Medium Density Residential, Commercial Areas,

Barangay **population** in 2015 (including normalized)

Rainfall (Mean, Monthly)

Air Temperature (Mean, Monthly)

Land Surface Temperature (Mean, Max)

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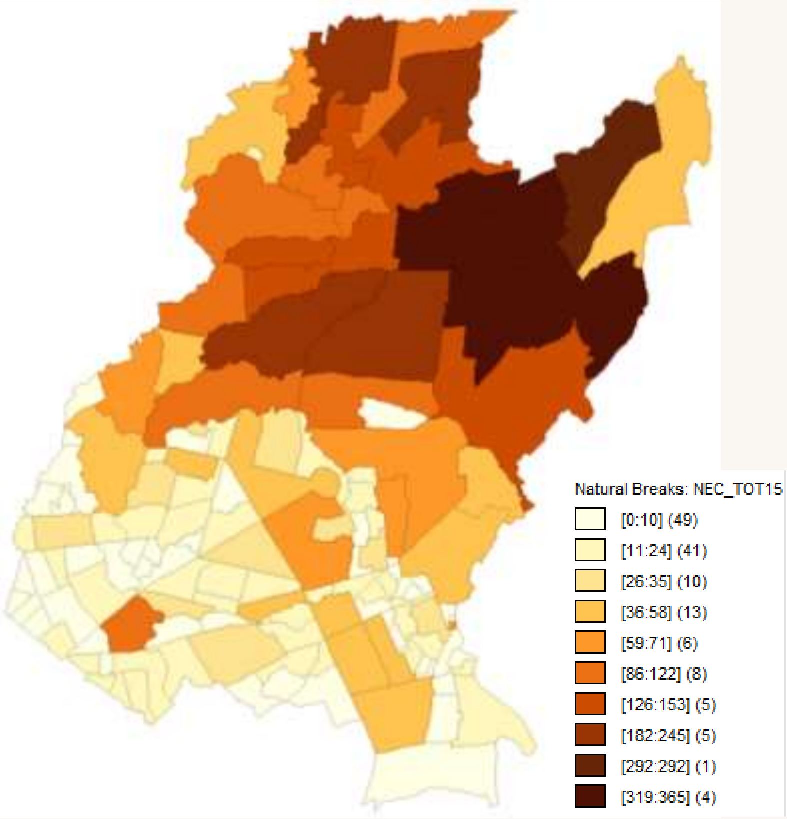
GeoHealth Applications: Dengue
Geospatial Analysis of Dengue Incidences



Dengue Cases in Quezon City (2015)

- The spatial distribution of dengue cases in 2015 indicate very high values in areas with large informal settlers.

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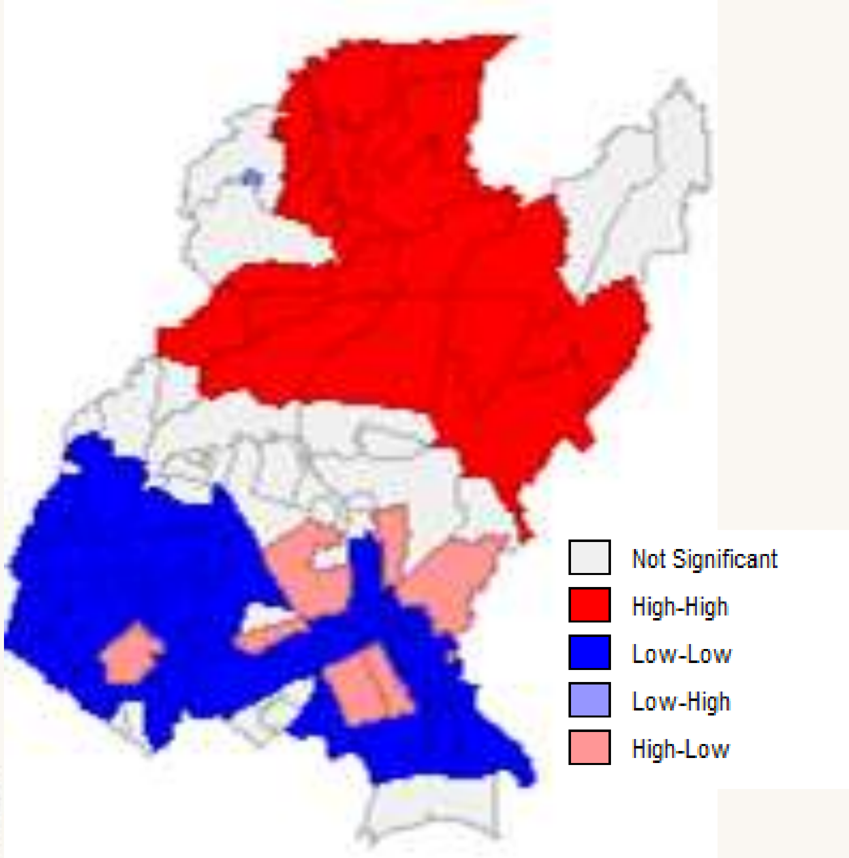
Geospatial Analysis of Dengue Incidences



2015 LISA Clusters

- Persistent clustering of high-high values in the northern part of Quezon City while low-low clusters are in the southern part of the city, whether yearly or monthly.

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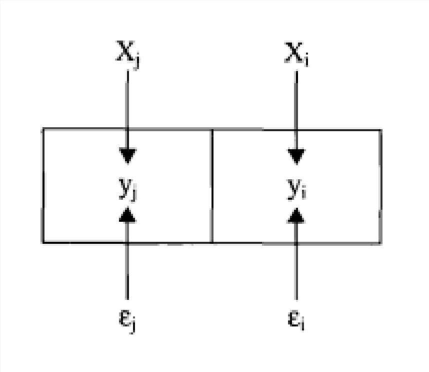
GeoHealth Applications: Dengue

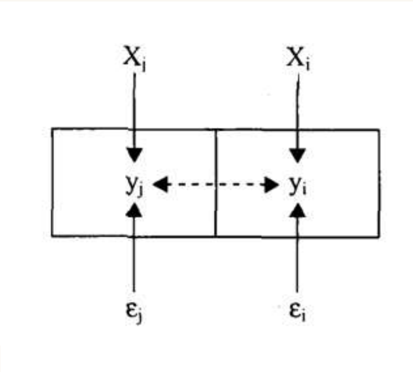
Geospatial Analysis of Dengue Incidences

OLS



No influence from neighbors

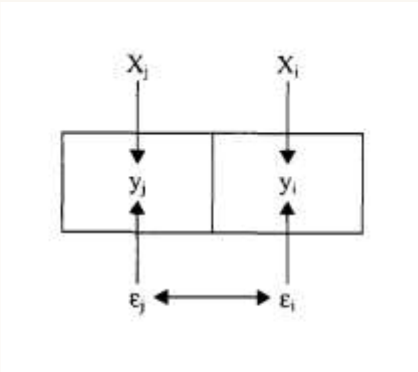
SPATIAL LAG



Dependent variable influenced by neighbors

$$Y = \beta_0 + \lambda WY + X\beta + \varepsilon$$

SPATIAL ERROR



Residuals influenced by neighbors

$$Y = \beta_0 + X\beta + \rho W\varepsilon + \xi$$

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GeoHealth Applications: Dengue

Geospatial Analysis of Dengue Incidences

OLS Model for 2015 Using Land Use Variables Only

NEC2_TOT15 = 18.2545 + 3.40894**OPNSPCS* + 5.52552**INF_SET* + 3.28358**VL_RESD*

- **Open Spaces, Informal Settlements, and Very Low-Density Residential Areas**, account for 65.9% (R-squared) of the variability of dengue cases in 2015. However, standard error (S.E.) is 41.8.

- Spatial dependence is significant. Spatial Lag regression (SL) is preferred based on spatial dependence diagnostics (i.e., Langrange Multiplier).

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Geospatial Analysis of Dengue Incidences

Spatial lag Model for 2015 Using Land Use Variables Only

$$NEC2\_TOT15 = 4.25566 + 0.503008*W\_NEC2\_TOT15 + 2.26656*OPNSPCS + 4.54279*INF\_SET + 1.81258*VL\_RESD$$

- Same variables as in the OLS model.
- **Spatial lag regression improved the R-square to 0.71. S.E. is 38.6.**

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GeoHealth Applications: Dengue
Geospatial Analysis of Dengue Incidences

OLS Model for May 2015 (Low Dengue Case)

$$NEC2\_0515 = -2.48342 + 0.064177 * INF\_SET + 0.352647 * NEC2\_0415 + 0.276018 * APR\_RF - 0.0340807 * MAY\_RF$$

- Indicates **significant contribution of the previous month's dengue cases (NEC2_0415) and rainfall (APR_RF)**.
- R-squared is 0.65. S.E. is significantly lower at 1.02.
- Based on diagnostics for spatial dependency, analysis should proceed to spatial error (SE) regression. This yielded an R-squared of 0.771 and S.E. of 0.812 at around 2-km lag.

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GeoHealth Applications: Dengue

Geospatial Analysis of Dengue Incidences

OLS Model for September 2015 (High Dengue Case) Using All Variable Types

	OLS_S1	OLS_S2	OLS_S3
CONSTANT	430.649	571.315	-11.608
NEC2_0815	1.2378	1.28206	1.30283
INF_SET	0.517221	0.512069	0.479771
AUG_AT	-1.37287	---	---
AUG_RF	-0.118146	---	---
SEP_AT	---	-1.81117	---
SEP_RF	---	-0.216222	
LST_AUG	---	---	3.01199
LST_SEP	---	---	-2.29511
R-squared	0.891201	0.894165	**0.898082**
S.E.	6.53452	6.44489	**6.32449**
AIC	940.984	937.062	**931.707**

- The models indicate **significant contribution of the previous month's dengue cases, meteorological condition, and even land surface temperature (LST)**.
- Among the land uses, **Informal Settlement** is the only type included in the models, indicating that such areas may be breeding grounds of mosquitos.
- Based on diagnostics for spatial dependency, analysis should proceed to spatial lag (SE) regression.

GeoHealth Applications: Dengue

Geospatial Analysis of Dengue Incidences

SL Model for September 2015 (High Dengue Case) Using All Variable Types

	SL_RF	SL_LST	SL_Combi
CONSTANT	-58.3262	-6.79409	-113.872
W_NEC2_0915	-0.524919	-0.187042	-0.317454
NEC2_0815	1.28829	1.35122	1.25994
INF_SET	0.514707	0.51866	0.518478
AUG_RF	-0.404695	---	0.109881
SEP_RF	0.706446	---	
LST_AUG	---	1.82658	2.89623
LST_SEP	---	-1.33582	
R-squared	0.902351	0.901424	0.902154
S.E.	6.08064	6.10946	6.08678
AIC	928.08	929.037	928.093

- For the high dengue case month, spatial lags model using **6-km threshold** distance provided the **best models, incorporating the rainfall and LST of the previous month**.

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Geospatial Analysis of Dengue Incidences

- **Informal Settlement** variable was found significant in all regression models and even in factor analysis. This indicates that such areas **being breeding grounds** is **highly probable**.
- The inclusion of **rainfall and temperature** variables, *including temporally lagged*, **can improve the modelling** of dengue cases.
- Modelling of dengue cases was enhanced with the used of **spatial lags (spatial dependence) and temporal lag**.
- Seasonal Autoregressive Integrated Moving Average (**SARIMA**) modelling is ongoing.

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Challenges

- Data availability and quality
  - Health and epidemiological data may not be available in desired spatial and temporal scales; incomplete at times
  - Mobility studies are also needed.
- Realization of the value chain
  - Are insights and information used and acted upon?
  - Are the methods and systems developed put in place?

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Opportunities

- SST for health applications is recognized → funding
- Networking and collaboration through the PhilSA Integrated Network for Space-enabled Actions towards Sustainability
- Citizen science

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Thank you!

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