Mapping vulnerability to dengue in Mekong Delta region, Vietnam from 2002 to 2014 using a water-associated disease index approach and geospatial data

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1. Why we need to map vulnerability to dengue under climate change?
2. How to create the vulnerability map to dengue?
3. How research’s results apply or use in support public health management?
Introduction

Analysis of vulnerability has been applied popularly to assess health hazards related to climate change (Patz, 1996, Dickin et al., 2014). Patz (1996) offers a framework of assessment health vulnerability due to climate change and emphasized a requirement of geographic integration using GIS and remote sensing data.

The research’s objective is to utilize geospatial data and technique and the WADI index approach, which developed by Dickin et al. (2013) in order to map change of vulnerability to dengue for provinces in Mekong delta region (MDR) from 2002 to 2014.

Vulnerability is the degree to which a population, individual or organization is unable to anticipate, cope with, resist and recover from the impacts of disasters. *Environmental health in emergencies and disasters: a practical guide.* (WHO, 2002)

From a climate change perspective, according to the IPCC, vulnerability is “the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes”

Vulnerability of Human Health to Climate Change

Dickin (2013 & 2014), Fullerton (2015) developed the a water associated disease index (WADI) approach to provide a “practical tool” and vulnerability map in support dengue prevention and control in South East Asia, South America and global scale.

Select the WADI index approach because of following reasons:
• The index approach that is likely simpler than statistical and mathematical approach, however, it describes clearly the geographic integration of factors associating with dengue transmission. The flexibility framework adapts multi-dimensional data at different scales and geographic places, such as at global (Fullerton, 2015), and local level in Malaysia and in Brazil as well as to both urban and rural area (Dickin et al., 2013, 2014, Louis, 2014).
• Moreover, its validated result was applied in Malaysia, a nation in South East Asia has climate conditions similar to Southern Vietnam. The index approach is completely built on geospatial technology that process, assess and visualize rapidly the vulnerability index to dengue with available data, adaptable factors and thresholds (Dickin et al., 2014).


http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0063584
**Study area**

The Mekong Delta region or Lower Mekong Basin situates in the Southern of Vietnam and includes 13 provinces. Geographic features are plain and a complex network of streams. The region has the largest agricultural area and the biggest rice crops per acre in the Vietnam.

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**Dengue cases of Mekong Delta and Viet Nam**

Dengue transmission occurs throughout the year and increases toward a peak between July and September which coincides with the rainy season in the Southern of Vietnam (Cuong, 2013, Thuy 2015, Toan 2015). Aedes aegypti is principal vector responsible to dengue transmission in Mekong delta provinces (Yukiko et al., 2010, Thuy, 2015), especially during wet season in rural and transition areas of the Southern region of Vietnam the number of aedes aegypti was higher than that in urban as well as other regions of Vietnam (Yukiko et al., 2010). Thi et al. (2001), Toan (2015) recognized that the majority of dengue cases and deaths came from rural areas of the Mekong Delta.

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### References

- Thuy NTT, Peter Horby et. al., The Atlas of Communicable Diseases In Vietnam From 2000 To 2011, National Institute of Hygiene and Epidemiology & Oxford University Clinical Research Unit, 2015
Dengue cases per 100,000 persons in provinces of Viet Nam from 2000 to 2015
Methodology

Vulnerability index = 3*Exposure Indicator + Susceptibility Indicator
<table>
<thead>
<tr>
<th>Component</th>
<th>Data sources</th>
<th>Threshold</th>
<th>Value</th>
<th>Threshold source</th>
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<td>Landcover</td>
<td>MODIS Land Cover Type Yearly L3 Global 500m (MCD12Q1) using classification type 3</td>
<td>Forest</td>
<td>0</td>
<td>Cheong (2014), Dickin (2014)</td>
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<td></td>
<td></td>
<td>Bare soil</td>
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<td></td>
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<td>Shrubs</td>
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<td></td>
<td></td>
<td>Mixed horticulture</td>
<td>0.25</td>
<td></td>
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<td></td>
<td></td>
<td>Water</td>
<td>0.3</td>
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<tr>
<td></td>
<td></td>
<td>Cereal agriculture/ paddy field</td>
<td>0.45</td>
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<tr>
<td></td>
<td></td>
<td>Urban</td>
<td>1</td>
<td></td>
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<tr>
<td>Population density</td>
<td>General statistic office</td>
<td>&lt;0.1</td>
<td>0</td>
<td>Dickin, 2014</td>
</tr>
<tr>
<td>(thousand per square km)</td>
<td></td>
<td>&gt;0.1-&lt;0.25</td>
<td>0.25</td>
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<td>&gt;0.25-&lt;0.5</td>
<td>0.5</td>
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<td></td>
<td></td>
<td>&gt;0.5-&lt;1</td>
<td>0.75</td>
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<td></td>
<td></td>
<td>&gt;1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>Hydro-meteorology stations</td>
<td>Maximum monthly temperature, lag of 1 months</td>
<td>&gt;20°C and &lt;34°C : linear increase in exposure up to 1; &lt;20°C or &gt;34°C : 0 exposure</td>
<td>Dickin, 2014</td>
</tr>
<tr>
<td>Rainfall</td>
<td>GSMaP data</td>
<td>Monthly cumulative precipitation, lag of 1 months</td>
<td>&lt;300 mm precipitation: linear increase in exposure up to 1; &gt;300 mm monthly precipitation: 0 exposure</td>
<td>Dickin, 2014</td>
</tr>
</tbody>
</table>

## Susceptibility indicator

<table>
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<tr>
<th>Component</th>
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<th>Threshold</th>
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</thead>
<tbody>
<tr>
<td>Age under 15 years</td>
<td>The General Statistic Office of Vietnam (2009 census dataset)</td>
<td>% population under 15 years by state</td>
<td>Dickin, 2013</td>
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<tr>
<td>Health care access</td>
<td>Annual report from the General Statistic Office of Vietnam</td>
<td>Density health facilities per square km area</td>
<td>Hagenlocher, 2013</td>
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<tr>
<td>Poverty</td>
<td>Annual report from the General Statistic Office of Vietnam</td>
<td>% poverty household</td>
<td>Hagenlocher, 2013</td>
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</table>

\[
\text{Susceptibility component}_x = \frac{(x - x_{\text{min}})}{(x_{\text{max}} - x_{\text{min}})}
\]

Results

The map series illustrate spatial-temporal dynamic patterns of vulnerability to dengue in the region. From 2002 to 2012, vulnerability value increases and get a peak in 2008 when high and very high values are observed at all provinces.

- **Temporal:**
  Except in 2014, high vulnerability dominates over the delta. In 2008, high and very high vulnerability are observed at all provinces.

- **Spatial:**
  Although river is not breeding site for dengue mosquitoes, provinces adjacent to rivers have vulnerability at high or very high level.
## Validation

The vulnerability outputs were validated using monthly dengue rate obtained from database of the Vietnamese Ministry of Health. Correlation coefficients were used to evaluate the associations between dengue rates and vulnerability values that aggregated at the province level. The Pearson correlation coefficient, which represents the linear relationship, between dengue rate and vulnerability within each year since 2002 to 2014 are calculated for each province.

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<td>0.92</td>
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<td>0.51</td>
<td>0.92</td>
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<td>0.72</td>
<td>0.72</td>
<td>0.72</td>
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<td>*0.14</td>
<td>0.89</td>
<td>0.82</td>
<td>*0.10</td>
<td>*0.18</td>
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<td>0.72</td>
<td>*0.13</td>
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<tr>
<td>No. of provinces &gt;0.5</td>
<td>11</td>
<td>8</td>
<td>10</td>
<td>11</td>
<td>8</td>
<td>10</td>
<td>13</td>
<td>6</td>
<td>13</td>
<td>13</td>
<td>9</td>
<td>4</td>
<td>8</td>
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<tr>
<td>No. of provinces &gt;0.7</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>10</td>
<td>4</td>
<td>6</td>
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<td>7</td>
<td>11</td>
<td>4</td>
<td>1</td>
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</table>

(*) $\rho > 0.05$

Pearson correlation coefficient between dengue rate and vulnerability index for each year ($\rho \leq 0.05$)
Dengue Rate in Mekong Delta

Dengue rate (per 100,000 population)

- 0
- 1 - 10
- 11 - 20
- 21 - 30
- 31 - 50
- >50

Vulnerability to Dengue in Mekong Delta

Vulnerability
- Low
- Medium
- High
- Very high
Spatially localized Correlation between Vulnerability and Dengue Rate using a 3x3 window sliding.
Spatially localized correlation between Vulnerability and Dengue rate from 2002 to 2014
Vulnerability average index

Dengue case

Dengue rate

Pearson correlation

P value

Dengue case and Vulnerability index

0.35

<0.05

Dengue rate and Vulnerability index

0.34

<0.05
Correlation coefficient

- < 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- > 0.5

Correlation was calculated using the time series of Vulnerability and Dengue rate from 2002 to 2014 (the whole study period).

Different lags were taken into account in order to see role of climate variables in different areas which were then divided into groups.
Correlation between Vulnerability and Dengue rate in different lag of Rain and Temperature

Group A: Correlation is NOT AFFECTED by climate variables
Correlation between Vulnerability and Dengue rate in different lag of Rain and Temperature

Correlation coefficient
- < 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- > 0.5

**Group A:** Correlation is **NOT AFFECTED** by climate variables

**Group B:** Correlation is **AFFECTED** by climate variables
Correlation between Vulnerability and Dengue rate in different lag of Rain and Temperature

Correlation coefficient

- Yellow: < 0.3
- Orange: 0.3 - 0.4
- Brown: 0.4 - 0.5
- Dark Brown: > 0.5

**Group A:** Correlation is **NOT AFFECTED** by climate variables

**Group B:** Correlation is **AFFECTED** by climate variables

**Group C:** Correlation is **PARTLY AFFECTED** by climate variables
Correlation between Vulnerability and Dengue rate in different lag of Rain and Temperature

Correlation coefficient
- < 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- > 0.5

Generally, in the provinces bordering the sea, climate variables play less important roles than in other ones.

Again, the provinces, except Vinh Long where the Tien river through shows stronger correlation.
Summary

• The maps of vulnerability to dengue for MDR seem to be effective evidence to utilize geospatial technology to support public health authorizes in disease control and intervention.
• Under climate change impacts the provinces along the Tien river are more vulnerable to dengue that others in Mekong delta.
• Mapping vulnerability to dengue with 1 months lag of rainfall and temperature contributes to warn early and to identify areas where a population is high vulnerable if dengue fever outbreaks.
• The most essential challenge of existing approaches in mapping dengue risk is to improve accuracy in describing spatially localized dengue distribution.

INTERNATIONAL WORKSHOP
VIETNAM & JAPAN & PHILIPPINES
APN FUNDED PROJECT
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Hanoi, 15 September 2017