Building the Prototype of Vector-Control Strategy Interoperability in Dengue Fever: Case Surabaya, Kuala Lumpur, Bangkok

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Abstract. Dengue fever is a communicable disease that attacks more than 120 countries in the world during 50 years. Therefore, it is make a sense to say that collaboration among the countries, especially neighborhood countries, is one important key to combat the dengue. Currently, except a serological collaboration, the collaboration in dengue are sporadic and temporal. This paper addresses the initiative to build vector-control strategy interoperability among Surabaya (Indonesia),Kuala Lumpur (Malaysia) and Bangkok (Thailand). Deriving the global policy from World Health Organization (WHO), we build the system that (1) extracting global feature from the local feature, (2) selecting the significant features, to determine ranking of importance of a feature, by weighting a feature, and (3) matching the pattern of data to the suitable strategy by measuring the similarity. We built the system from the real data of the Surabaya, Kuala Lumpur and Bangkok in 2012. We verified reliability of the system by comparing the data with the real action in January 2012 The result shows that the system is system feasible to be implemented, however we still need more preparation to implement the system.

Keywords. *Interoperability, vector-control strategy, similarity, global policy, Surabaya, Kuala Lumpur, Bangkok.*

1. Introduction

Dengue fever is a painful, debilitating mosquito-borne disease caused by one of four closely related dengue viruses [1]. The process of dengue spreading in the world depends on two vehicles (known as a vector): Aedes Aegepty mosquito as a local vector and human as a global vector. Mosquito transmits dengue from an infected people to a health people in its flying range (around 40 m) [2]. The dengue virus can spread in another country because the infected people fly away to another country. Since the mosquito is available almost in every countries, the local transmission is took place in another country.

Given such a fact, WHO published global strategy for controlling the dengue. This strategy is emphasized in dengue transcends international borders [3]. Therefore, the collaboration among countries, especially among neighborhood countries is imperative [4]. There are several kind of research collaboration is offered from different view: international travel [5], world risk map [6], or practical work to reduce mosquito susceptibility [7]. However, all collaborations are temporary and sporadic. The result shows that the collaboration has no big impact in long-term surveillance. To overcome, we need to find the long-term collaboration strategy for surveillance [8]. The keys of success in long-term surveillance collaboration are monitoring and evaluation [9]. Consequently, interoperability in strategy for monitoring and evaluation is important. In health care domain, interoperability architecture in the data management [e.g.10], the platform [e.g. 11], and the data interpretation [e.g. 12] are known-well. However, strategy and policy implementation is rarely discussed [13].

This study deals with awareness strategy interoperability among neighborhood countries. The model consist of : (1) extracting the global feature from the local one, (2) determining a ranking of importance of the global features by weighting, and (3) mapping the data to suitable-action subspace in the vector-control context by measuring the similarity. As the study area, Surabaya (Indonesia), Kuala Lumpur (Malaysia) and Bangkok (Thailand) were chosen.

2. Research Approach

One of interoperability challenges in neighborhoods-countries collaboration is how to express an action to combat the dengue in the same measurement system. WHO have the global guidance, and every country translates it in their local governance differently. In this study, we developed the common-risk strategy to provide the system for sharing the information. Our approach is projecting the dengue-related data to the "suitable action" by similarity. The suitable action is break downed from the objective of WHO strategy for South-East Asian [14].

2.1 Preliminary Data Observation

In this paper, our area study is Surabaya (Indonesia), Kuala Lumpur (Malaysia) and Bangkok (Thailand). We described our area study at glace as follows:

- Surabaya [15], the second big city in Indonesia. Famous as a commerce and business city since it is a port city on the Indonesian island of Java. With the area 350 km^2, the population density is $8500/km^2$. Surabaya consists of 31 districts . The seasons in Surabaya are rainy season (October - March) and dry season (March-October).
- Kuala Lumpur [16] is the cultural, financial and economic center of Malaysia. It covers an area of 243 km^2 while the population density is $6,891/km^2$. Kuala Lumpur is divided by 11 district and. The season area rainy season (October - March) and dry season (March-October).
- Bangkok [17] is the capital of Thailand where business and tourism growth rapidly. It encompasses area 1,568 km^2 with population density $5300/km^2$. Bangkok comprises 50 districts. The seasons are hot season (March -June, rainy season (July-October), and cool season (November – February).

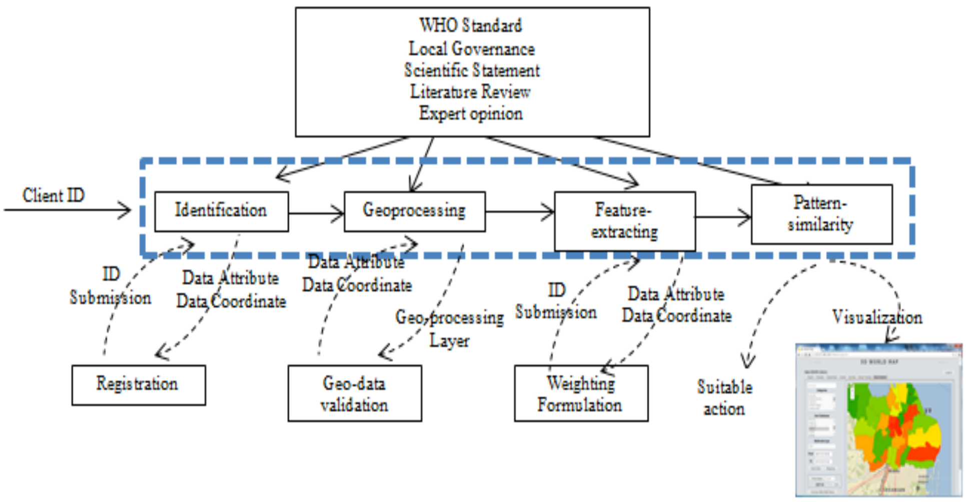
Due to the differences in vision, every city interpreted global guidance of WHO in different governance. The differences in governance brought to the differences in research approach. Table 1 shows governance in preventing dengue and the research approaches of every city.

Table1. Governance in dengue in the implementation

Place	Governance	Implementation (in Research)
Indonesia	Empowering the people to prevent dengue [18]	Spatial-transmission of vector-borne(e.g[20]) Impulse-event analysis (e.g [21]) Social-ecological Awareness (e.g [22]) Spatio-temporal dengue-event history (e.g [23]) Weather prediction (e.g [24]) Event-based monitoring (e.g [25])
Malaysia	Vector-borne surveillance [19]	Community-Wealth based forecasting (e.g[26]) Spatial Vector-borne Dimension (e.g [27]) Community-based surveillance (e.g [28]) Urban risk factor (e.g [29]) Vector-breeding site classification (e.g [30])
Thailand	Case-based Risk assessment [20]	Community-based assessment (e.g [31]) Event-history risk prediction (e.g [32]) Demographic transition Analysis (e.g [33]) Environmental-fluctuation pattern (e.g [34]) Case-sustainable factor (e.g [35])

2.1 Architecture of The System

Architecture of the system is shown in figure 1.



All process in operational agent (identification, etc) refers to semantic strategy (WHO standard, etc) from different resources. The agent translated the process into module (registration) as a representation of business service. The business rule is illustrated as thin-dash between operational agent and the module. The result is suggestion and visualization. In our research, we utilized 5D World Map [50] as a platform for visualization.

2.2 The Feature Selection

The Feature selection is a process to select a global features Y from a local features X. We utilized WOE (Weight of Evidence) as the spatial association analysis [36] between a given features and a real case of dengue. The weighting result are (1) W^+ is weights of the feature which has evidence (in this case: infected people) (D^P), and (2) W_- is weights of the feature which has no evidence (D^N) and $T = D^P + D^A$; T is a total study area. Weight positive and negative is written as :

$$W^+ = ln\left(\frac{P(B_i|s)}{P(B_i^+)}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

$$W^- = ln\left(\frac{P(B_i|s)}{P(B_i^-)}\right)$$

$W^+ > 0$ implies positive association; and $W_- > 0$ implies negative association; while $W^+ = W_- = 0$ implies no association.

The differences between W^+ and W_- indicates the contrast relation in both spatial association parameters, it is written as

$$C = W_i^+ - W_i^- \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3)}$$

If $C > 0$ association is positive, $C < 0$ is negative, if $C = 0$ no spatial association.

Each cell's weighting is determined by comparing stud of several classes.

$$stud(C) = \frac{C}{s(C)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(4)}$$

The outcome of WOE is ranking of local system features that reflecting the most significant features in the local system. To characterize the global system, we calculated average of every feature from 3 cities, and then make a ranking of them.

$$y_m = \frac{\sum_{n=1}^{k} x_{(n,m)}}{k} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(5)}$$

Where : y_m denotes the global feature m

$x_{(n,m)}$ denotes the local feature m of the city n

k denotes number of city

2.3 The Spatial Matching

Purpose of a pattern matching is projecting a set of local data matrix to the projection semantic space: in this case is the action standard. Note that we only choose data matrix of global feature. In our study, we focused on vector-control context: environmental management, chemical control, biological control, and non-insecticidal control, as a subspace [37]. Every action is strongly influenced by some features. Table 2 shows the subspace and the combination feature that perform it [38][39][40][41].

Table 2. Relation between the subspace and the feature

	Feature									
Action-Strategy	House (H)	Rainfall (R)	Commerce area (CA)	House Index(HI)	Population Density(PD)	Temperature (T)	Traditional Market (TMA	Garden (G)	Primary school (PS	Bussiness Area(BA)
Environmental Management (EM)	X	X		X	X	X		X		
Chemical Control (CC)	X	X	X	X				X	X	X
Biological Control (BC)		X				X	X	X		
Non-insecticidal Control (NC)	X	X		X	X	X	X	X		

The next process is measuring similarity between the data and all sub spaces. We utilized vector similarity to calculate the similarity from data set with subspace that reflects vector-control context by following step:

- Create set of data matrix of global features for every sub city. The data should be normalized in between -1 to 1.
- A set of invariant subspaces as the projections semantic space is performed by composition of data standard.
- Find the similarity pattern by similarity in MMM [42]. We projected all data to all subspace and calculate distance between data and subspace. Similarity can be expressed by nearest distance by a following equation

$$min(b\_i\ (k) \in B)\ \|P(S(i)(b - \overline{b_{\ i}(k)}\|,1 < i < m \qquad \ldots\ldots\ldots(6)$$

3. Application of The Prototype

We built the application to realize common-risk policy for practice action and provided the system for sharing the information by the empirical data of 3 cities: Surabaya, Kuala Lumpur and Bangkok.

3.1 The Data

We collected secondary data provided by government of Surabaya, Kuala Lumpur and Bangkok. Also, we gathered data of victim in district from those cities. Figure 4 shows the example of data (scale 1:500000)

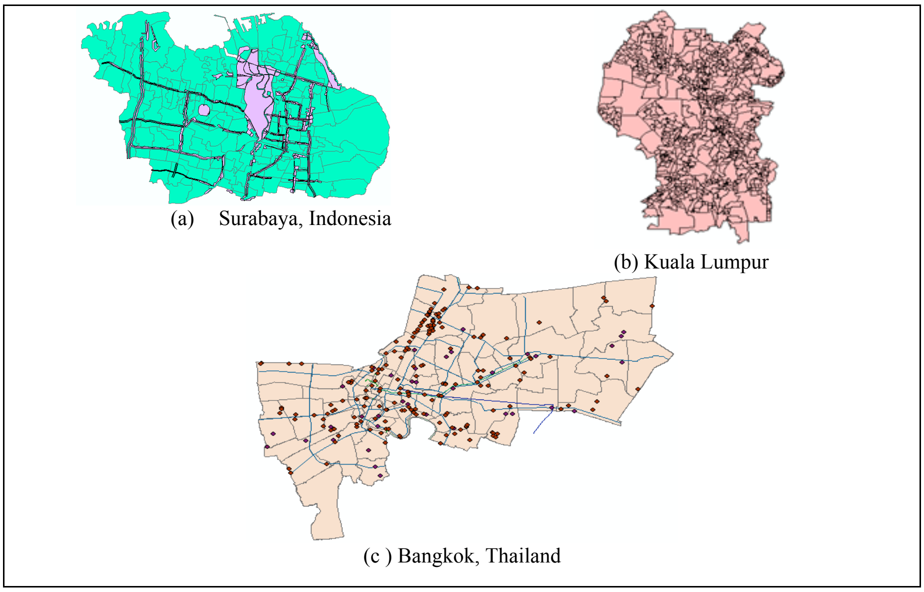


Figure 2. The spatial data : Surabaya, Kuala Lumpur, and Bangkok

3.2 The Feature

We conducted literature review of 53 papers concerning with the awareness strategy in Indonesia, Malaysia, and Thailand. It is consist of: 31 research papers, 10 collaboration-work papers and 12 official papers from the government. The similar group represents the feature which has similarity in: type of data, measurement, and definition; it is called the global features. The specific data represents the feature that is specific in: type of data, measurement, and definition; it is called local feature. Table 3 shows the global and local features in our study.

Table 3. The Features: the Global Features and the Local Features

The Global Feature of Surabaya, Kuala Lumpur and Bangkok		**The Local Feature**		
		Surabaya	**Kuala Lumpur**	**Bangkok**
Rumah /Teres/Housing area	Rainfall	Apartment	Cemetery	Canal Station
Commerce area	Temperature	Ruko	Apartment	Condominium
Business area	Population density	Humidity	Religion facility	Public Facilities
Traditional market	House Index	Industrial area	Hospital	Youth Facility
Supermarket	Primary school	River	Banglow house	River
Mall	Secondary school			
Garden	High school			
Apartment	University			
Open area	Solid waste			

Note that rumah, teres and residential area pointed out the similar meaning. Apartment has different definition in every country. Among them, we selected the most important common feature. By this, we performed a thematic subspace.

3.3. The Result

3.3. 1. The Result of Feature Selection

Feature selection is the process to determine ranking of importance of a feature in the global strategy. We applied equation (2)-(4) to get the ranking of importance of every city (local), and equation (5) to get the ranking of importance for common-strategy. The result is shown in table 4.

Table 4. Ranking of Importance of the attribute in local and global strategy

Local Feature			**Global Feature**
Surabaya	**Kuala Lumpur**	**Bangkok**	**Common features**
Rumah sederhana	Rainfall	Housing area	Rumah/ Teres/Housing area
Rainfall	Rumah Teres	Rainfall	Rainfall
Commerce area	House index	Traditional market	Commerce area
Population density	Temperature	House Index	House Index

Primary school	Forest/Garden	Solid waste	Population density
Solid waste	Business Area	Commerce area	Solid Waste
Temperature	Solid Waste	Forest/Garden	Temperature
Traditional Market	Commerce Area	Population density	Traditional Market
Garden	Population density	Primary school	Garden
Business area	Traditional Market	Temperature	Primary school
House Index	Primary School	Open area	Business area
Secondary school	Open area	Business area	Open area
High school	University	Secondary School	Secondary school
Open area	High School	High School	High school
University	Secondary school	University	University
Supermarket	Mall	Mall	Supermarket
Mall	Supermarket	Supermarket	Mall

3.2. Result of Spatial Matching

In this research, the degree of similarity is utilized to detect matching between a data of district/sub district with the strategy. Table 5 shows the example of data.

Table 5. Example of the data

Name of District	House	Rainfall	Commerce area	House Index	Population density	Temperature	Solid Waste	Garden	Primary school	Bussiness area
Tegalsari, Surabaya	0.7196078	0.6196078	0.147541	0.7081967	0.917647059	-0.8666667	0.637284	-0.535294118	0.4117647	0.239215686
Cheras, Kuala Lump	0.6885246	0.7568627	0.1901639	0.7081967	0.890196078	-0.7081967	0.3514374	-0.275409836	0.2131148	0.498039216
Prawet, Bangkok	0.6980392	0.8803922	0.2754098	0.7176471	0.787843137	-0.8803922	0.4235343	0.28627451	0.3941176	0.666666667

To projecting the data, we composed a set of matrix data for projections semantic space: Environmental Management, Chemical Control, Biological Control, and Non-insecticidal Control. WHO does not mention specifically about the data but the guidance said that we can refer to the standard from the countries in the same region [38]-[41]. Table 6 shows the semantic projection space.

Table 6. The Semantic Projection Standard

Action	House[43]	Rainfall [44]	Commerce area [45]	House Index[41]	Population density[43]	Temperature [44]	Solid Waste [41]	Garden / City-Forrest[43]	Primary school [45]	Bussiness area[45]
EM	0.392	0.84	0	0.87	0.8	0.58	0.613253	0.063	0.46	0
CC	0.392	0.84	0.19	0.87	0	0	0.417534	0.063	0.79	0.19
BC	0	0.84	0	0	0	0	0.51832	0.063	0	0
NC	0.392	0.84	0	0.87	0.8	0.58	0.41754	0.063	0	0

To find the similarity, we calculated the minimum distance of projection result by equation. The result is shown in table 6.

Table 6. The Example of Calculation Result

Place		Action				
District	City	Environment Management	Chemical Control	Biological Control	Non Insecticidal Control	Suitable Action
Tegalsari	Surabaya	0.654	0.536	-0.114	0.215	Environment Management
Cheras	Kuala Lumpur	0.324	0.213	0.119	0.413	Non Insecticidal Control
Prawet	Bangkok	0.486	0.526	-0.231	0.237	Chemical Control

4. Discussion

In order to establish long-term collaboration in dengue awareness, we proposed strategy interoperability in "Integrated surveillance and outbreak preparedness" [38]. By this interoperability, the planning, especially in the near future, can be realized quickly [47]. Moreover, the system provides same measurement that is useful for strengthen the collaboration in awareness, evaluating, and planning [48] the cost of dengue disease among 3 cities.

We evaluated the system based on accuracy and degree of implementation. To measure the accuracy of system, we transcribe the scenario:

(1) We applied our strategy in the same time with action in Dengue Day 2012.
(2) We evaluated effectivity of the strategy by comparing with the real data one month after the Dengue Day 2012.
(3) For every district:
   - if the real action is same with our strategy and number of case increase in the next month, the score is 0
   - else, the score =1
   - $\text{the accuracy} = \frac{\text{total score}}{\text{total district}} \text{x} 100\%$

Here is fact of Dengue Day activity in 3 cities during " Dengue Day ASEAN 2012"

(1) Surabaya: Campaign "Awas DB" the actions are Environmental Management [44] and self- protecting using chemical spray and chemical lotion [45].
(2) Kuala Lumpur: Campaign "Jom Ganyang Aedes", the action is environmental management [46].
(3) Bangkok : Campaign "Big Cleaning Day" the action is environmental management [46].

Figure 3 shows the example of action result from our prototype

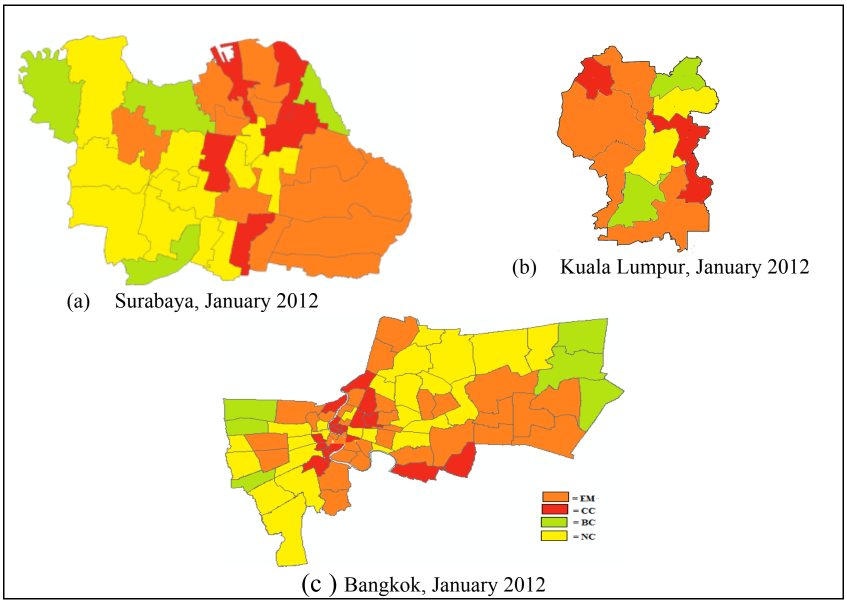


Figure 3. The Result of Distribution of Action in Vector-Strategy Interoperability

We applied this action in all district. And then, we compared the result of real action February 2012-Mei with data January 2012-April 2012.

City	Surabaya	Kuala Lumpur	Bangkok	Average
Accuracy (%)	79	86	82	82.3

From table 5, we can see that in the point of view of accuracy, performance of the system is quite good. However, to increase the accuracy, several parameters should be considered. Recently, we faced difficulties to get standard data for action. For example, the standard of using chemical spray in Surabaya is different with Kuala Lumpur. Also, preference to choose the decision of action is depend on the authority holder, it affected differences in strategy for the same situation. Another problem is size of the district is vary; it bring about difficulties to compare the successful of action in every area. In the next research, we should analyze the area in grid, involving knowledge of beholder, and establish standard of awareness in every country.

5. Conclusion and Future Work

We proposed the new system for collaboration to combat the dengue spreading among 3 big cities in neighborhoods countries: Surabaya (Indonesia), Kuala Lumpur (Malaysia) and Bangkok (Thailand). Our system is interoperability system in policy regarding with vector control. We explored similarity in features and implement the real data among the 3 cities to build the common strategy. Our result shows that this strategy is possible to be the good candidate system in an action practice in the future

However, in order to convey the prototype to the real implementation, we need to collaborate with the health authority in this country. There are many aspect that we have to consider regarding with technical implementation. Our next future work is deal with preparation in the real implementation in the small scope.

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