RESEARCH NOTE

Potential risk areas for dengue in the Jaffna Municipal Area in Northern Sri Lanka

S. Kannathasan[1*], K. Suthakar[2], P. J. Jude[3] and S.N. Surendran[3]
[1] *Department of Pathology, Faculty of Medicine, University of Jaffna, Jaffna.*
[2] *Department of Geography, Faculty of Arts, University of Jaffna, Jaffna.*
[3] *Department of Zoology, Faculty of Science, University of Jaffna, Jaffna.*

Dengue (DF) and dengue haemorrhagic (DHF) fever remain a major public health concern in Sri Lanka. An unprecedented DF/DHF cases have been reported in the country in recent time (Ramasamy & Surendran, 2012). The Northern Jaffna Peninsula is one of the regions badly affected by dengue (Table 1) and many DF/DHF cases have been reported in the Jaffna Municipal Area (JMA) (Regional Director of Health, Jaffna, 2011) (Figure 1a).

Table 1: Number of dengue/dengue haemorrhagic fever cases reported in Jaffna District during 2007 − 2011

DF/ DHF	2007		2008		2009		2010		2011	
	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths
	267	03	44	-	533	06	3007	30	400	04

(Source: Regional Directorate of Heath Services, Jaffna)

As there is no licensed vaccine for dengue, vector control is the major measure adopted to control disease transmission. *Aedes aegypti* and *Aedes albopictus* are the well established vectors of DF/DHF and chikungunya (Ramasamy & Surendran, 2012; Rezza, 2012). The control of dengue and chikungunya in tropical countries is mainly achieved through surveillance for *Ae. aegypti* and *Ae. albopictus* larvae and eliminating breeding sites with attendant use of insecticides and public education (Ramasamy *et al*., 2011). Larval control efforts invariably focus on freshwater breeding sites of the two mosquito species near human habitations (Ramasamy *et al*., 2011).

Identifying dengue risk areas is therefore expected to help health authorities to prioritize their resources to such areas and to prevent the spread of the disease further. Spatial factors such as built up areas, agricultural land, water bodies and land use pattern were previously considered as criteria to create dengue risk maps (Chang *et al*., 2009). Among the selected risk factors, built up area was considered as the factor with the highest influence and agricultural land as a moderate risk factor (Nakhapakon & Tripathi, 2005).

As dengue is a major public health problem in Jaffna, there is a need to have a risk map to prioritize the resources and to conduct public awareness programmes to control the disease. With this objective, the present study was initiated to create a dengue risk map for the Jaffna Municipal Area, since most of the identified cases are reported from this area.

Geographic information systems (GIS) coupled with remote sensing (RS) is a powerful and effective tool to combine many factors (Chang *et al*., 2009) that are

* Corresponding author (selvamkannathasan@gmail.com)

considered to be associated with dengue transmission, and to assess the cumulative impact of these factors to create risk maps. With the objective of creating a dengue risk map for JMA, land use/cover data collected from QuickBird (Pan and Ms) satellite images and other disease risk parameters were overlaid in a GIS environment to identify the spatial pattern of dengue.

The JMA is the major cosmopolitan location in the Jaffna District and is located in the extreme North of Sri Lanka (Figure 1). The total area of the JMA is 20.26 sq km. It is bound by the Jaffna lagoon on its Western and Southern sides and the Nallur divisional secretariat division on the North and West. The study site covers the entire Jaffna divisional secretariat division and part of the adjoining Nallur divisional secretariat division. The study area includes 28 Grama Niladhari divisions (GNDs) from the Jaffna divisional secretariat (DS), and 19 GN divisions from the Nallur DS. The area is composed of 27,895 families comprising 87,017 population (District Secretariat, 2010).

The risk factors and data, which are associated with vector prevalence and disease transmission, namely, land use/cover, population density, house type, economic status of the residents, and availability of public gathering places such as schools, hospitals and government offices were used as the criteria to create the risk map. The risk factors and criteria used to associate the risk factors with dengue transmission is given in Table 2.

The following maps were available for use as dengue transmission criteria: (i) land use/cover - a map whereby each pixel was classified as one of seven classes, namely, built up areas, water bodies, marshy land, agriculture land, scrubs, grassland and bare land; (ii) population density- a value map with population density ranging from 15 to 250 persons per hectare; (iii) house type - a value map representing the percentage of house types; (iv) economic status - a value map representing the percentage of 'Samurdhi' recipients; (v) public gathering - a map whereby for each pixel its distance in meters from the nearest public gathering places are stored as a numerical value.

As indicated in Table 2, the land use patterns like built up area and water bodies were considered as having a high risk for transmission of dengue fever, whereas marshy land and agriculture land were considered as moderate risk and the other land use patterns as low risk.

The population density above 151 persons per hectare (high population density) was considered highly
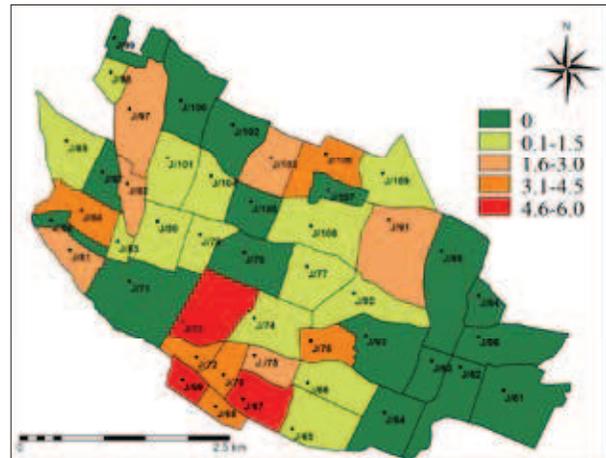

Figure 1: Study site

Figure 1a: Reported DF/DHF cases per 1000 population in Jaffna Municipal Area during October 2010 – March 2011
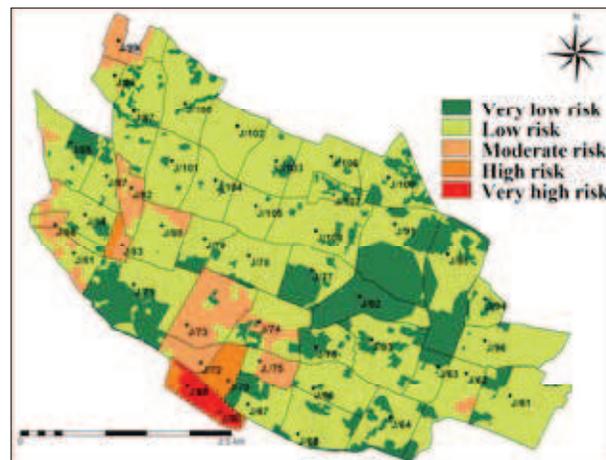

Figure 1b: Identified potential risk areas of DF/DHF in Jaffna Municipal Area

favouring the dengue transmission and the population densities 76 − 150 per hectare (moderate population density) and less than 75 per hectare (low population density) were considered as moderate and low risk, respectively for the transmission of dengue infection.

Improvised house type was considered as favouring mosquito bites and thus having a high risk for transmitting dengue fever, whereas semi-permanent and permenant house types were considered as moderate and low risk to transmit dengue fever, respectively.

Table 2:   The risk factors and criteria used to relate to dengue transmission

	Risk factors	*Criteria used to relate the risk of dengue transmission
1	Land use/cover	Built up areas > water bodies > marshy land >agriculture land > scrubs > grassland > bare land
2	Population density	High population density > moderate population density > low population density
3	House type	Improvised house type > semi-permanent house > permanent house
4	Economic status	Low economic status (Samurdhi recipients) > middle/high economic status (non Samurdhi recipients)
5	Public gathering	Public gathering places (school, market, theatre, hospital etc.) > non-public gathering places

* Factors in descending order in favour of dengue transmission

Since the socio-economic status is also associated with mosquito-borne diseases, the 'Samurdhi' recipients (monthly income < 2,500 LKR) who are having a poor socio-economic status were considered as high risk and the non 'Samurdhi' recipients were considered as at low risk to contact dengue fever.

Considering the flight range of vector mosquitoes, a distance less than 1000 m from public gatherings were considered as high risk, while 1001 − 2000 m and above 2000 m from the public gatherings were considered as moderate and low risk for transmission of dengue fever, respectively.

The required statistical data were obtained from the respective DS offices and QuickBird satellite images from the Department of Geography, University of Jaffna. Software ILWIS 3.7 was used in digital image processing, spatial analysis, multi-criteria analysis, and presentation of the results. Definiens Professional 5.0 (eCognition) was used in image segmentation and classification.

Spatial multi-criteria analysis (SMCA) was used to create the dengue risk map. SMCA comprises four main sub activities, which are structuring, standardizing, weighting and composition. Structuring in SMCA refers to the identification of criteria (risk factors) for mapping dengue risk. Five criteria identified as being relevant to dengue transmission were based on expert knowledge and literature. These are land use/cover, population density, house types, economic status, and distance from

public places. These criteria were mapped in the GIS environment using a Grama Niladhari division (GND) as a base unit. In order to compare the criteria with each other, all values were standardized (from 0 to 1). Standardization is a measure of appreciation of the experts (partial attractiveness) for dengue risk with respect to each criterion. Different standardization techniques were applied for different types of criteria maps. For value maps (house types, economic status, and public places), standardization by linear maximum standardization was made. For class maps, standardization was done by matching a value between 0 and 1 to each class in the map. This was carried out by ranking method with the assistance of expert knowledge and literature. Followed by standardization, a weight was assigned for each of the criterion using pair-wise comparisons developed by Saaty (Saaty, 2000) in the context of multi-criteria decision making process known as analytical hierarchy process (AHP).

The final step of the SMCA was to obtain the composite dengue risk map for the study area. Once the weights were assigned to each criterion, the spacial multi-criteria evaluation (SMCE) module of integrated land and water information system (ILWIS) was used to combine the weighted criteria. This combination was carried out by weighted linear combination (WLC) method. The composite dengue risk map has a value between 0 and 1. The values approaching 0 represents the least risk for dengue transmission and values approaching 1 stands for the high risk for prevalence of dengue vectors

in a particular place. The composite dengue risk map was reclassified into five categories using the 'SLICE' function of SMCE module in ILWIS: (i) very low risk, (ii) low risk, (iii) moderate risk, (iv) high risk and (v) very high risk.

The identified risk areas of the JMA are shown in Figure 1b. The GNDs, namely, Reclamation East (J/68) and Reclamation West (J/69) were identified as high risk areas whereas, Eachchamoddai (J/ 66), Gurunagar East (J/70), Gurunagar West (J/71), Jaffna Town West (J/73), Vannarpannai (J/82) and Vannarpannai North West (J/99) were of moderate risk. The identified risk areas showed close matching with the number of reported cases for dengue (Figure 1a).

The deviations may be due to various environmental factors and the nature of transmission (imported or local). The map created is expected to be useful for the health authorities to carry out their surveillance programmes and to implement vector control strategies on a priority basis to control disease transmission.

The identified risk areas may have environmental factors that are hitherto not recognized but, can contribute to vector breeding. Two of the high risk GS divisions (J/68 and J/69) were in the coastal areas. A recent study in the coastal areas of the Jaffna and Batticaloa Districts reported for the first time that the dengue vectors, *Ae. aegypti* and *Ae. albopictus*, can also breed in brackish waters (Ramasamy *et al*., 2011). Considering the adaptive radiation of the vector species and the danger of the disease transmission, public living in the risk areas should be educated through awareness programmes and to be actively involved in source reduction.

REFERENCES

1. Chang A.Y., Parrales M.E., Jimenez J., Sobieszcyk M.E., Hammer S.M., Copenhaver D.J. & Kulkarni R.P. (2009). Combining Google Earth and GIS mapping technologies in a dengue surveillance system for developing countries. *International Journal of Health Geographics* **8**: 49.

2. Nakhapakon K. & Tripathi N.K. (2005). An information value based analysis of physical and climatic factors affecting dengue fever and dengue haemorrhagic fever incidence. *International Journal of Health Geographics* **4**: 13.

3. Ramasamy R. & Surendran S.N. (2012). Global climate change and its potential impact on disease transmission by salinity-tolerant mosquito vectors in coastal zones. *Frontiers in Physiology (Systems Biology)* **3**: 198. doi: 10.3389/fphys.2012.00198.

4. Ramasamy R., Surendran S.N., Jude P.J., Dharshini S. & Vinobaba M. (2011). Larval development of *Aedes aegypti* and *Aedes albopictus* in peri-urban brackish water and its implications for transmission of arboviral diseases. *PLoS Neglected Tropical Diseases* **5**(11): e1369. doi:10.1371/ journal.pntd.0001369.

5. Rezza (2012). *Aedes albopictus* and the reemergence of Dengue. *BMC Public Health* **12**: 72.

6. Saaty T.L. (2000). *Fundamentals of Decision Making and Priority Theory with the Analytical Hierarchy Process*, pp. 1 − 14. R.W.S. Publications, Pittsburg, USA.