

Modeling the Dengue Risk in Sri Lanka



Background

Dengue fever is a viral infection that spreads from infected mosquitoes to humans. This is a leading cause for most of the deaths in the tropical and subtropical areas around the globe. Dengue virus spread has risen largely in urban and semi-urban areas. This has become a main public health concern problem in the world. Dengue virus was discovered in early 1950s in Sri Lanka. Country experienced several outbreaks of dengue until the disease became endemic in 1989. In the early stages dengue was considered as a sporadic disease. Most of the dengue patients were found in Colombo. The human population was high in Colombo at that time. The number of infected patients exponentially increased in the year 1989. This happens in a severe form. The highest incident was informed in the year 2017. It was reported as 186,101 patients and 440 deaths [3]. The majority of reported from Colombo and Gampaha districts [3]. Gampaha is another district with a higher human population. Now, dengue is one of the noticeable among epidemic diseases in find in children and adults admitted to hospitals. Rapid urbanization is one of the key reasons that worsens dengue disease. Dengue has become significantly noticeable in other districts in Sri Lanka.

Scientists are still trying to find a suitable vaccine or antiviral treatment to fight against dengue virus. Health authorities recommend controlling mosquito birth as the most effective method to combat spreading of dengue. Therefore, it is helpful if the health authorities have a method of identifying and clustering dengue risk areas in time. Further, this kind of method will the health service authorities to implement necessary measures in similar transmission areas effectively. Funding agencies can make use of this model to distribute resources evenly. Therefore, the aim of our research is to implement a mathematical model to cluster the areas according to the dengue transmission.

Model Development

The following twenty-two areas were selected for the model construction: Ampara, Anuradhapura, Badulla, Batticaloa, Colombo, Galle, Gampaha,

Jaffna, Kalutara, Kandy, Kegalle, Kilinochchi, Kurunegala, Hambantota, Mannar, Matara, Mullaitivu, Nuwara Eliya, Puttalam, Ratnapura, Trincomalee, and Vavuniya. The selected predictive factors were temperature, rainfall, humidity, garbage disposal, number of rainy days, population density, population movements, and percentage of urbanization. These predictive factors were further divided into three risk levels considering their impact of dengue transmission. This is shown in Figure 1. Meteorology data were gathered from Department of Meteorology of Sri Lanka. Data on garbage collection, population density, population movements and urbanization were assessed from the reports of Central Bank of Sri Lanka and Department of Census and Statistics. Data on dengue patients were gathered from the Epidemiology Unit of Health Ministry of Sri Lanka considering the period between 2008 to 2022.

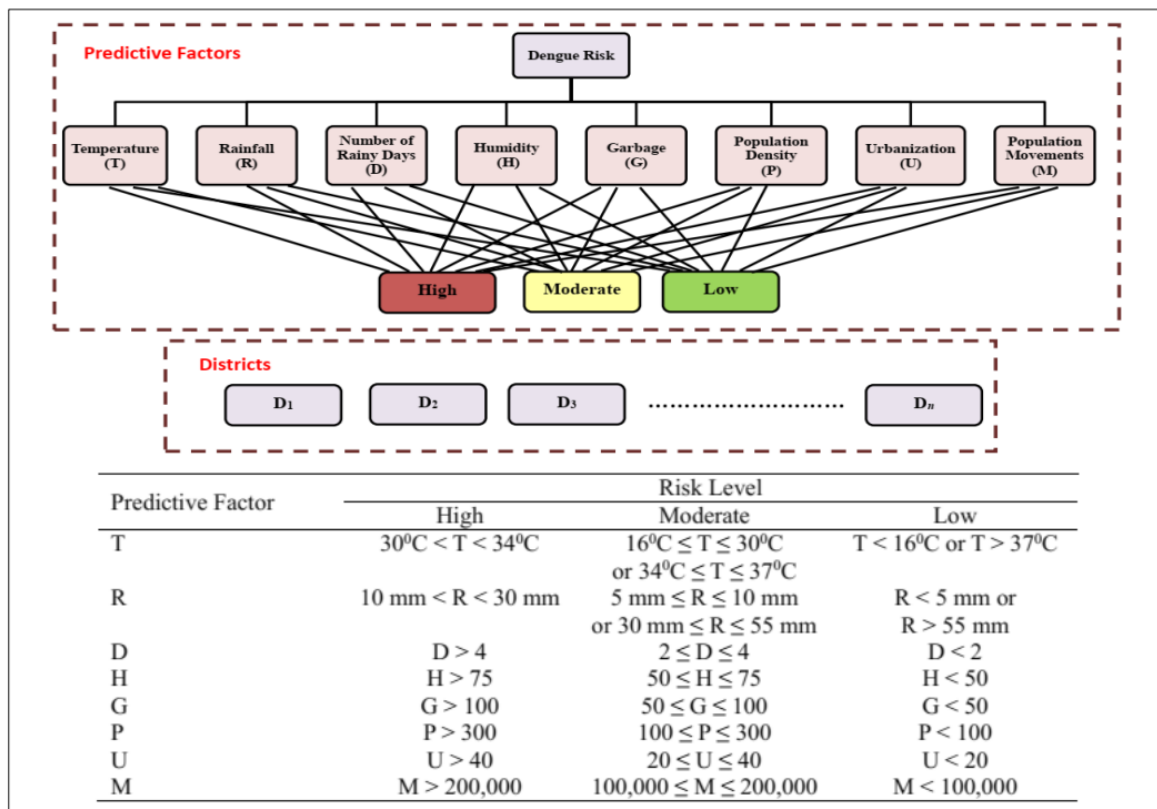


Figure 1: Predictive factors and their risk levels.

The steps shown in Figure 2 were used to identify the three dengue clusters [1, 2]. Due to the uncertainty nature of the selected predictive factors and their risk fuzzy mathematical concepts were used. Fuzzy analytic hierarchy technique was applied to rank the predictive variables. The proposed model sensitivity was assessed to identify the impact of uncertainty. The factor gained the highest rank was selected as the triggering variable. Then the relation between the triggering variable and other variables was generated. The results were stored in 3x3 matrices. These matrices were aggregated using the geometric mean. The concept of Haddon matrices was used to define the five dengue risk clusters. Random samples were generated to calibrate the risk clusters. Finally, the proposed model was applied to the selected districts. Generated results were compared with the number of dengue patients in each district to validate the model.

Results and Discussion

The results revealed that the population movement has the highest impact on dengue transmission. Three population movement clusters were identified, and they were named as high, moderate, and low. When the population movements were high then the dengue transmission risk could be seen as very high, high, and To capture the risk of dengue the heat maps shown in Figure 3 were generated. The Colombo district seems to be at a high-risk level. It is visible that the moderate-risk area is larger now. That means, more districts are being identified as dengue affected areas.

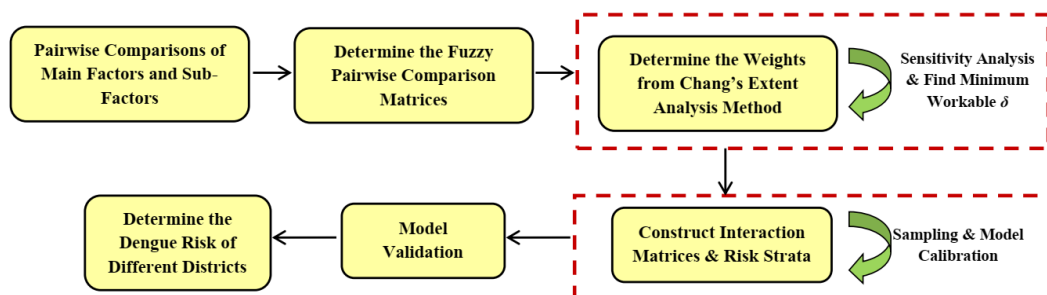


Figure 2: Model construction process.

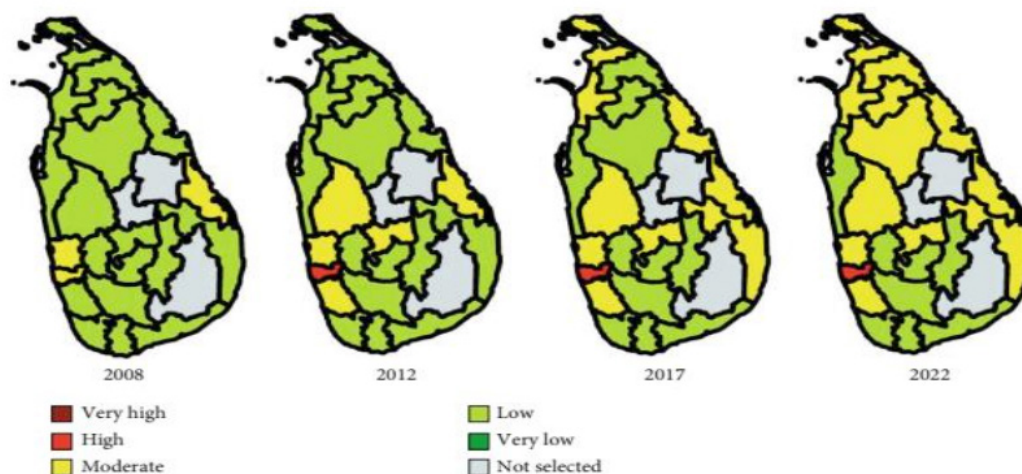


Figure 3: Heat maps showing the dengue risk in Sri Lankan districts.

References:

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- [2] Piyatilake I.T.S. and Perera S.S.N. (2020), Chapter 8: Developing a Multiparametric Risk Index for Dengue Transmission, Mathematical Modeling and Analysis of Infectious Diseases, Hattaf, Khalid and Dutta, Hemen (Eds.), Springer International Publishing. ISBN 978-3-030-49895-5. DOI: 10.1007/978-3-030-49896-2.
- [3] WHO, Dengue fever Sri Lanka, 2017, May 2019, <https://www.who.int/csr/don/19-july-2017-dengue-sri-lanka/en/>.

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