Simulation Model for Predicting Dengue Fever Outbreak

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Abstract—Dengue fever is prevalent in Malaysia with numerous cases including mortality recorded over the years. Public education on the prevention of the desease through various means has been carried out besides the enforcement of legal means to eradicate Aedes mosquitoes, the dengue vector breeding ground. Hence, other means need to be explored, such as predicting the seasonal peak period of the dengue outbreak and identifying related climate factors contributing to the increase in the number of mosquitoes. Simulation model can be employed for this purpose. In this study, we created a simulation of system dynamic to predict the spread of dengue outbreak in Hulu Langat, Selangor Malaysia. The prototype was developed using STELLA 9.1.2 software. The main data input are rainfall, temperature and denggue cases. Data analysis from the graph showed that denggue cases can be predicted accurately using these two main variables- rainfall and temperature. However, the model will be further tested over a longer time period to ensure its accuracy, reliability and efficiency as a prediction tool for dengue outbreak.

Keywords—dengue fever, prediction, system dynamic, simulation

I. INTRODUCTION

DENGUE cases have doubled over the past 10 years, with the situation turning significantly worse this year compared with the previous year. The disease has in fact become the fastest-growing mosquito born disease in the world, [5].While the reason for the deteriorating situation was yet undetermined, it can be attributed to the increase temperatures, rainfall amount and urbanization. According to the Malaysian Health Ministry, a total of 37,419 dengue cases were reported in the country from January to October. 2010, an increase of 17 percent or 5,411 cases compared with 32,008 cases recorded in the same period in 2009. During this period, 117 death cases were reported, a surge of 65 percent or an increase of 46 cases compared with the same period the previous year.

According to the WHO, many dengue cases were reported in Southeast Asian and South Asian countries during the first eight months of 2010, with 60,000 cases recorded in Indonesia, 58,000 in Thailand and 27,000 in Sri Lanka. According to [3], Malaysia has a good laboratory based surveillance system, however, it is basically a passive system and has a little predictive capability. Problem may occur if one waits for laboratory test confirmation of the case before giving out notification. Delay in notification may lead to delay in control measure, which will further lead to occurrence of outbreaks, since dengue needs optimum time of management as the transformation of Dengue Fever (DF) into severe form

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of dengue takes a very short period [5]. One of the solutions is to implement a simulation of dengue spread in Malaysia, with emphasizes on an early prediction of dengue outbreak [2]. It may improve public health problem since the accurate and well-validated simulation to predict dengue outbreak will enable timely action by public health officials to control such epidemics and mitigate their impact on human health [4].

Therefore, simulation of dengue outbreak prediction that incorporates location, time and intensity DF are needed to help identify specific location, temporal and intensity of dengue outbreak accurately and rapidly. Currently there is, no such study has being carried out to predict the dengue outbreak in Malaysia and there is insufficient discussion about the suitable model to predict the future dengue outbreak. Hence, reviewed several prediction models, specifically those that incorporated the requisite parameters such as rainfall and temperatures, as the basis for this study. These two parameters are important determinants of the Aedes mosquitoes breeding cycle.

System dynamics (SD) is a computer aided approach to policy analysis and design. With origins in servomechanisms engineering and management, the approach uses a perspective based on information feedback and mutual or recursive causality to understand the dynamics of complex physical, biological, and social systems. What SD attempts to do is understand the basic structure of a system, and thus understand the behavior it can produce. Many of these systems and problems which are analyzed can be built as models on a computer. The SD fans claim that SD takes advantage of the fact that a computer model can be of much greater complexity and carry out more simultaneous calculations than can the mental model of the human mind. I do not agree with this, obviously exaggerated and false opinion. However, the SD models can be useful to rapidly show how the real system could behave and to check what can happen if something in the model is changed.

The system dynamics approach involves:

- Defining problems dynamically, in terms of graphs over time.
- Striving for an endogenous, behavioral view of the significant dynamics of a system, a focus inward on the characteristics of a system that themselves generate or exacerbate the perceived problem.
- Thinking of all concepts in the real system as continuous quantities interconnected in loops of information feedback and circular causality.
- Identifying independent stocks or accumulations (levels) in the system and their inflows and outflows (rates).
- Formulating a behavioral model capable of reproducing, by itself, the dynamic problem of

concern. The model is usually a computer simulation model expressed in nonlinear equations, but is occasionally left unquantified as a diagram capturing the stock-and-flow/causal feedback structure of the system.

- Deriving understandings and applicable policy insights from the resulting model.
- Implementing changes resulting from model-based understandings and insights

II. RESEARCH METHODS

A. Data Collection and Analysis

Data concerned in this study are dengue cases from the year 2007 to 2011 for Hulu Langat district, in Selangor, Malaysia. Data were acquired from Selangor State Health Department. These data then segmented into weeks (a year consists of 52 weeks). A total of two hundred and twenty one data sets were collected in this study. The data included weekly values of total rainfall, mean temperature and the total number of dengue cases. The considered data sets cover a five-year period, from the first week of January 2007 to the 20th week of 2011. Fig. 1 shows the number of dengue cases for this period and Fig. 2 shows the number of cases for 2009. The graph in Fig. 2 shows a dengue outbreak in the early 2009 at week two. The number of weekly cases declined afterwards, and the outbreak of this disease was under control by week twenty nine. Data set shows a total of 21436 dengue fever cases as indicated in, Fig. 1.
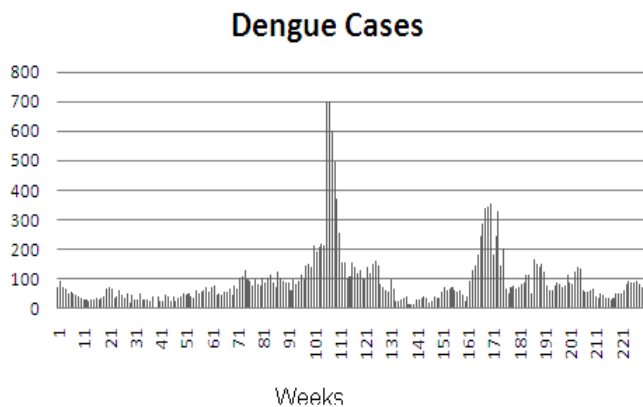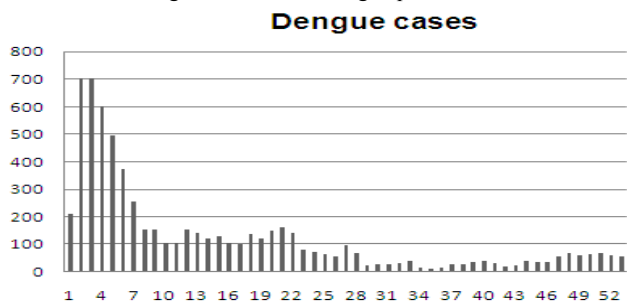

Fig. 1 Data set for dengue prediction

Fig. 2 Outbreak of dengue in 2009

B. System Dynamic Modelling for Prediction Dengue Fever Cases

The system dynamic was used in this study. The data set consists of 221 weekly measurement of total rainfall, mean temperature and dengue cases. The SD model developed in this study consists of two modules: development module and weather module. The initial development module comprised of four parameters related to the mosquitoes life cycle stages: egg, larvae, pupae and adult. The weather module compromise of two parameters: rainfall and temperature.
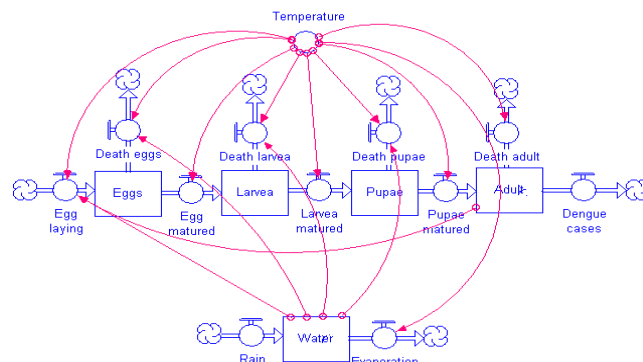

Fig. 3 Dynamic dengue simulation model

III. RESULT AND DISCUSSION

The completed SD model for predicting Dengue fever cases is as shown in Fig. 3. The System Dynamic run in just a few seconds. Fig. 4 shows the actual dengue cases simulation. Fig. 5 shows the predicted result for the dengue cases.
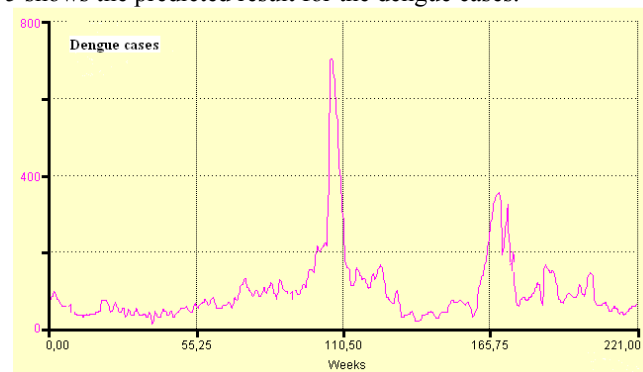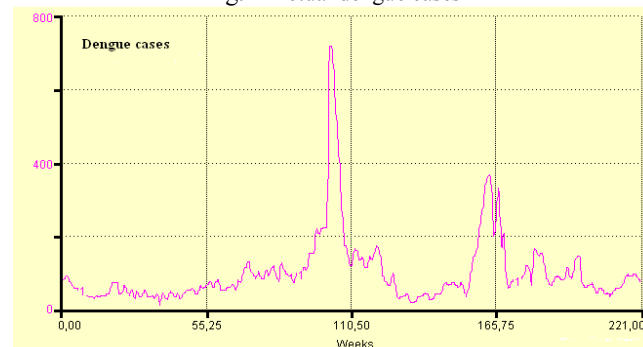

Fig. 4 Actual dengue cases

Fig. 5 Dengue cases prediction

IV. CONCLUSION

The purpose of this research was to predict dengue fever outbreak based using System Dynamic bases on a five years actual data. Result showed that the three important entity namely total rainfall, mean temperature and the total number of dengue cases were very efficient in predicting the number of dengue fever outbreak. The study gave very encouraging result. The prototype of prediction model can be used in other countries for any period of time since our model does not use time information.

However, for future studies, additional parameters should be included to produce better prediction. Indices used to monitor the vector population for dengue virus transmission such as House Index (HI), Container Index (CI), Breteau Index (BI) and Aburas Index to measure the adult mosquito population [1]. In addition, future research can also explore using longer time period to predict dengue fever outbreak.

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