Role of GIS in Dengue Control Management Strategy at Jeddah Municipality

Abdulatif Alharthy
Jeddah Municipality, Jeddah, Saudi Arabia, [aalharthy@Jeddah.gov.sa]

ABSTRACT

Dengue Fever one the most dangerous vector borne disease having high fatality rate. In the past few years, there were an alarmingly increased number of confirmed cases of the disease in several locations including Jeddah, Saudi Arabia. The clinical symptoms of this disease range from mild fevers to severe and potentially life threatening hemorrhages. As Dengue fever is a vector borne disease, the best method to cope up with this threat is to eliminate the vector which in this case is Aedes Aegypti and Aedes Albopictus. To control the population of vector integrated, effective and collaborative management procedures are required which in turn requires DSS (Decision Support System) perform effectively and in a smartly. GIS plays a very important role in providing. This paper discusses the processes and procedures employed by GIS to support the DSS requirements of dengue control management Strategy.

Key words: Vector control, Decision support system, Dengue fever, Jeddah.

1. INTRODUCTION

The word dengue is claimed by some sources to be derived from a Swahili phrase "Ka-dinga pepo" which meant to be the disease caused by evil spirit. It could be a possibility that the Spanish word dengue originated from the Swahili word dinga meaning fastidious or careful, describing the gait of a person suffering dengue fever (Jose G., 1998). Dengue fever and Dengue Hemorrhagic Fever (DHF) is an acute febrile disease, found commonly in tropical regions and can spread similar to malaria (Teng, 1997). It is caused one out of four virus serotypes of genus Flavivirus. There is no cross-protection and each serotype is sufficiently different. Epidemics can occur by multiple serotypes of this virus (hyperendimicity). It is transmitted to humans by "Tiger" mosquitoes i.e. Aedes aegypti and sometimes by Aedes albopictus mosquitoes. In past couple of years (2005-2006) all over the world more than 232,724 people were infected by dengue fever virus out of which 1,673 people died. Early in 2007 over 16,000 cases were reported in Paraguay, from which 100 cases were detected as DHF (Ayyub at al., 2006).

Dengue fever begins to appear by sudden fever, with severe muscle and joint pain as well as headache and rashes. Dengue rashes are small red or purple spot on the body, caused by a minor hemorrhage due to broken capillary blood vessels. These rashes in some cases spread all over the body (Gubler, 1998). Some cases may develop milder symptoms which can be misdiagnosed as influenza or other viral infection. DHF also shows high fever, hemorrhagic phenomena, and low number of platelets in blood which results as increase in the proportion of red blood cells in blood. Some cases may lead to Dengue Shock Syndrome (DSS) which has a high mortality rate (Fakeeh and Zaki, 2001).

To control dengue fever many surveillance methods are used. Some of which are extremely impractical like, hand catching, or unethical like man-landing/biting or netting. Apart from these methods a better approach is to use CO_2 generating devices, commonly known as Black Hole devices. These devices are termed as best automatic methods for mosquito sampling as they partly operate as mosquito eliminating device too.

This paper describes the method for effective distribution of Black hole devices over spatial constraints all over Jeddah city in order to get meaningful and valid surveillance results.

2. BACKGROUND

2.1 Dengue In Jeddah, Saudi Arabia

In March 1994, two cases were notified in Jeddah characterizing one as grade 2 DHF where another was in a state of DSS. From week 13(end of March) to week 36(mid September), 315 confirmed cases fortunately without fatalities were recorded.

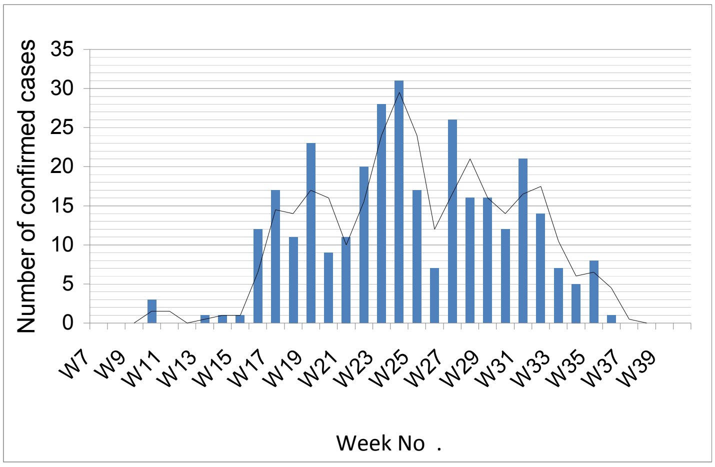

Figure- 1 Chart Displaying Number of Cases in Jeddah During Year 2006 (Courtesy WHO)

Since then dengue fever was confirmed no longer to be endemic. As Jeddah is a warm coastal city, this resulted in a humid weather, which along with scattered swamps made a very favorable condition for hosting mosquito breeding sites. Furthermore Jeddah is the gateway for millions pilgrims (approx. 6 mil. per year) all over the world destined towards Makkah, Holy city for pilgrimage or some other religious rituals. As of this massive passage of pilgrims, Jeddah in some cases also serves as a hub for such diseases. A suggested possibility is that some pilgrim bight be in incubation period of the disease and may infect the mosquitoes which in return infect nearby pilgrim or local residences.

In March 2006, as the number of dengue cases raised drastically, Saudi council of ministers allocated more than 1.42 Billion Saudi Riyals (more than US

$378,000,000) among Ministry of Municipality and Rural Affairs, Ministry of Health, Ministry of Agriculture and ministry of Water and electricity. As the funds were allocated to above mentioned ministries responsibilities and roles for each organization were also defined in the Dengue fever fighting program.

Since Jeddah was the center of this problem, therefore it was the main responsibility for Municipality for Jeddah to tackle the issue. Jeddah Municipality responded promptly to this situation and founded Crisis Management Department (CMD) a collection of highly professional epidemiologists, entomologist microbiologists, biochemists, GIS professionals and other professionals from interrelated disciplines. An Integrated Dengue Control Management Strategy (IDCMS) was formulated by above mentioned professionals. While implementing this strategy, vector surveillance methods as well as various chemical or biological methods were implemented, to reduce the rising number of cases in Jeddah.

2.2 Mosquito Surveillance Project

Since in any vector based disease, the most important process in controlling it is monitoring the vector population. Mosquito surveillance project (MSP) was implemented to serve this important factor of vector controlling and monitoring. This surveillance is important to prioritize the area for treatment and vector control measures.

As Aedes aegypti have a day biting habit and sometimes in early night (Suwonkerd at al., 2006). Black hole devices are supposed to be hanged at designated surveillance locations during these times for sampling. After the samples are acquired the specimens are returned to Jeddah Municipality laboratories. Here after the identification of species, male female population ratios are determined and recorded every week. Improper placement of black holes will cause inaccurate as well as inefficient sampling resulting in wrong conclusions.

To avoid such misinterpretation of results due to improper placement and distribution of black hole, MSP under the supervision of CMD GIS specialists begin to operate in monitoring the mosquito population. This paper discusses the spatial methods utilized by the CMD GIS Department to efficiently distribute these surveillance devices.

3. METHODS

3.1 Spatial Distribution Parameters

There are number of parameters that are considered during the process of placement of surveillance devices like population density, infection cases, population parameter estimate based on population density as well as infection cases and optimum distance between devices.

As for population, the census data was not available was not available for CMD at that time. Since then the population density was estimated using the number of electric meters, as in Saudi Arabia typically each residential or commercial unit should have its own electric meter.

The second parameter is the infection cases. As stated before, infected cases were weekly reported to the CMD by the Ministry of Health. Positions of infected persons and many other related information are included in those reports. The reports include termed as suspected infection cases. However, since the difference between the suspected and an actual case is very low, the information about the accuracy is negligible.

On the other hand, it is known that the optimum distance that black hole device placed between is from 200m-300m.

3.2 Procedure for distribution

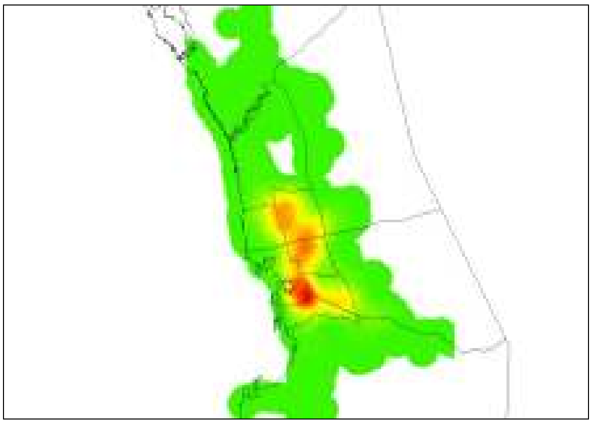

Figure- 2 Population Estimate Raster

In order to relate the impact of calculated population parameter to dengue fever cases, the local population parameter was loaded. The Point Density technique was performed to generate the raster from population parameter utilizing the electric meters (Figure-2), where the red represent high density. Furthermore it was superimposed with the dengue cases to check relationship with it, which turns out to be positive (Figure-3).

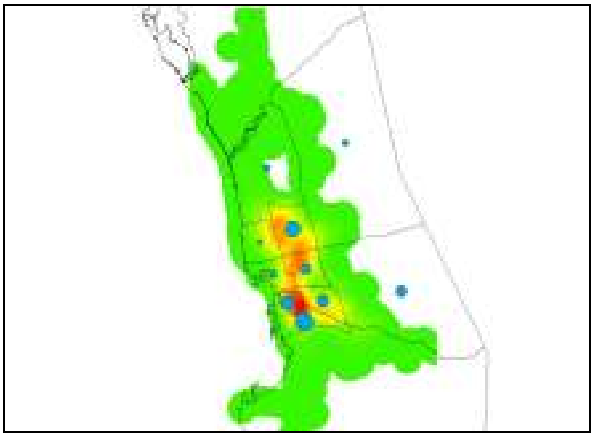

Figure- 3 Population pridection raster superimposed with Dengue fever cases

Similarly a raster was generated through residential locations of Dengue victims through Kernel density technique (Figure 4-5). Afterwards both raster surfaces were reclassified to be used in generating a weighted overlay (Figure-5). The weighted overlay was treated as suggested positions for surveillance points.

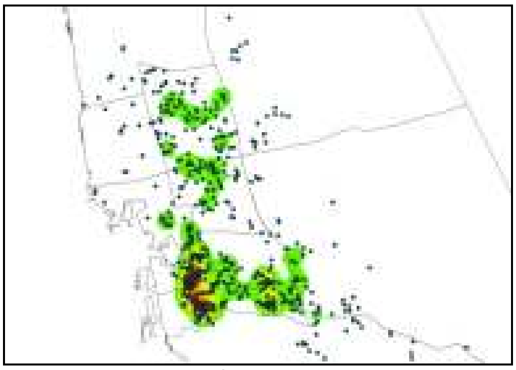

Figure- 4 Dengue fever raster with Dengue fever cases

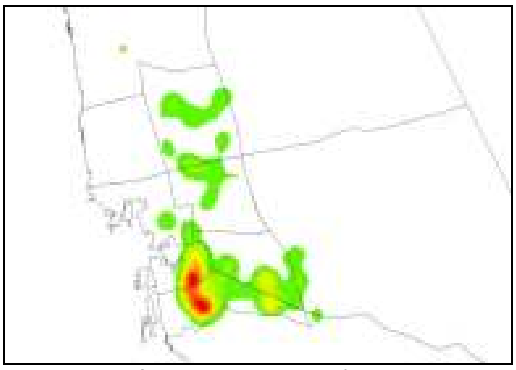

Figure- 5 Generated Raster from Dengue fever cases

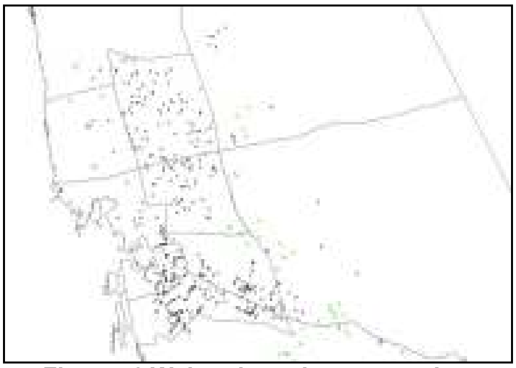

Figure- 6 Weigted overlay suggesting surveillance locaions

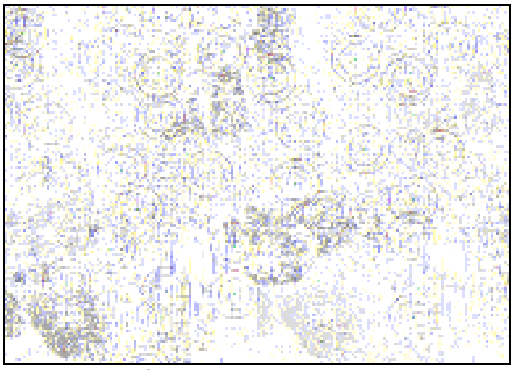

Figure- 7 Survelance points placed and checked 200-300m threshold

On this weighted overlay raster the point is placed on it manually as well as checking for the distance threshold by doing buffer analysis. These suggested positions are given to the black hole installation team to perform site survey and report back about the feasibility of location. If the location is not feasible i.e. the owner of private property may not allow the operation of such device or lack of electricity etc, the survey team suggests an alternate location. Upon these alternate locations along with the actual locations, proximity analysis is performed using the point distance tool in Arc Info.

4. Results

As a result of implementing surveillance at suggested positions by above mentioned process along with other factors in the dengue fever fighting program, a drastic decrease in the population of Aides Aegypti was observed. Some regions having high mosquito activity were reduced to zero mosquitoes. Further confirmation was done by the reduced activity of dengue fever confirmed cases and complains made by the citizens.

5. Discussion

Generated raster surface, through weighted overlay, confirms the fact that if a densely populated region has dengue fever cases it should be treated as high risk area and to be under constant surveillance. Another finding was observed that construction sites are one of the major breeding environment for Aides Aegypti. Consequently, construction sites should be under a continuous surveillance and treatment. As well as those areas that were dengue fever cases was detected but not relatively much populated can be occasionally monitored for mosquito density. This way the most resources can be allocated to high risk regions, hence efficient usage is obvious.

6. Conclusion

When considering the factors as population, dengue cases and mosquito population resulted in dynamic positioning of surveillance points. This positioning can be change at any time depending upon the factors. High risk areas can be used to enforce precautionary measures before the start of epidemic cycle.

Distributing surveillance points on spatial basis not only control the mosquito population but it also reduce the cost than in treating region haphazardly. Precautionary spraying and treatment can be concentrated on historically high risk for dengue fever regions.

Since the factors used in this spatial distribution are very common among any urban area, other factors might be included based on the characteristics of the region or surrounded environment.

7. Acknowledgements

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