GIS FOR DENGUE EPIDEMIC MANAGEMENT FOR IPOH/BATU GAJAH/TBD

By

ABD MUHAIMIN SYAHMAN B. MOHD NGAH

FINAL YEAR PROJECT REPORT

Submitted to the Civil Engineering Programme
in Partial Fulfillment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Civil Engineering)

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CERTIFICATION OF APPROVAL

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2806

A project dissertation submitted to the
Civil Engineering Programme
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Approved:

Dr. Abd Nasir Matori,
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

June 2006

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

Abd Muhaimin Syahman b. Mohd Ngah

ABSTRACT

Geographic Information Systems (GIS) has proven to be one of the most useful tools in public health research. It has been widely used in disease surveillance and monitoring, research hypotheses generation, identification of high-risk area and population at-risk, targeting resources and the monitoring of interventions. GIS provides an effective tool for visualization and spatial analysis of epidemiology data and environmental exposure. Recent studies have shown the increasing use of GIS as an important component in public health and epidemiology. This research will utilize the spatial analytical tools in GIS to establish the relationship between dengue fever cases, road/railway and drainage system distribution, and usage of septic tank factors that contribute to dengue fever transmission. This undertaking of building a GIS-based dengue fever investigation and surveillance system will aid in better health mapping and analysis compared to conventional methods. It will provide the epidemiologist with an effective tool to identify the environmental factors and mosquito breeding sites at risk related to the dengue outbreak. With detailed mapping and modeling of localized outbreaks, prevention and control activities can be implemented for instance. The successful implementation of GIS technology in disease investigation and surveillance will help to increase the awareness of GIS technology in the public health sector.

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CHAPTER 1
INTRODUCTION

1.1 Project Background

Geographic Information Systems (GIS) is a computer system capable of capturing, storing, analyzing, and displaying geographically referenced information; that is, data identified according to location. Practitioners also define a GIS as including the procedures, operating personnel, and spatial data that go into the system. GIS has proven to be one of the most useful tools in public health research. It has been widely used in disease surveillance and monitoring, research hypotheses generation, identification of high-risk area and population at-risk, targeting resources and the monitoring of interventions (Gupta *et al.,* 2003). GIS provides an effective tool for visualization and spatial analysis of epidemiology data and environmental exposure. Recent studies have shown the increasing use of GIS as an important component in public health and epidemiology (Gupta *et al.,* 2003; Gatrell and Löytönen, 1998; Pearce, 1996). Dengue fever (DF) is a mosquito-borne acute febrile viral disease characterized by sudden onset, fever, intense headache, myalgia, loss of appetite, rash and some non-specific signs and syndromes (WHO-SEARO, 1999). The female mosquito *"Aedes aegypti"* was found to be the most efficient vector. The *Aedes* female becomes infected when she takes the blood meal from an infected person within the viraemic phase of illness. The extrinsic incubation time of the *Aedes* female is about 8-12 days. After the extrinsic incubation period, the *Aedes* female is able to transmit the dengue virus to a human through her bite. The incubation within a human takes about three to 14 days (average 4-7 days). DF remains an important public health issue in Malaysia due to its tropical climate, which is suitable for vector (mosquito) breeding sites. The dengue virus cannot be transmitted directly from human to human. Effective vector control is the only solution for dengue control and prevention in situations where vaccines are unavailable. With its powerful analysis, modeling and mapping capabilities, GIS systems may serve as a decision-support tool for epidemic investigation, monitoring, simulation, prediction, prevention and resource allocation (Davenhall, 2002). The overall aim of this research is to analyze the spatial pattern and diffusion of dengue fever cases by incorporating epidemiological and statistical techniques into a GIS system. This research will utilize the spatial analytical tools in GIS to establish the relationship between dengue fever cases, road/railway and drainage system distribution, and usage of septic tank factors that contribute to dengue fever transmission. This undertaking of building a GIS-based dengue fever investigation and surveillance system will aid in better health mapping and analysis compared to conventional methods. It will provide the epidemiologist with an effective tool to identify the environmental factors and mosquito breeding sites at risk related to the dengue outbreak. With detailed mapping and modeling of localized outbreaks, prevention and control activities can be implemented for instance. The successful implementation of GIS technology in disease investigation and surveillance will help to increase the awareness of GIS technology in the public health sector.

1.2 Problem Statement

Dengue cases have been on the rise and could become a serious public health problem if the epidemic is not managed properly. It seems there is a correlation between the dengue's case increase and the urbanization activities, where more than 80% of the cases are reported in the urban area. This in due to the fact that some of human activities during urbanization provide the breeding environment to the Aedes mosquito, which is the causes of dengue.

To control and manage of dengue epidemic is one of the most important missions to health department. When dengue epidemic happened, traditionally, we mark patient's location on the paper map, and create patient's base data by computer. But this method cannot build the link between patient's base data and spatial data, so this paper will offers new method. We used a GIS to build dengue epidemic management system that provided management and analyze functions

GIS, Geographic Information Systems, is a system that data is saved by computer identically bases on all kinds of geographic data on the paper map, and the data mining, saving, processing, analyzing and displaying quickly and easily. GIS data is constituted by spatial data and attribute data. As soon as GIS is used of dengue epidemic management system, patients' location will be displayed on the map. It will solve the problem of data visualization; moreover, we can query patient's spatial data from attribute data or query patients attribute data from spatial data.

After GIS is leaded to dengue epidemic management system, the functions of system will be improved in data mining, saving, processing and analyzing. And we can combine each kind of dengue epidemic spread model with spatial analysis of GIS to analyze the high dangerous area of dengue epidemic, and the display the analysis on the map. After that, we select the countermeasure to prevent the spread of dengue epidemic.

This paper attempts to discuss some of the usage of GIS technology in Dengue Epidemics Management for Batu Gajah area.

1.3 Objectives and Scope of Study

The objective of the project is:

1. To map and perform spatial data could be contributory to dengue cases.
2. Analysis such as to observes the pattern of dengue cases in relation to factor road/railway and drainage distribution usage of septic tank.
3. To assess the effectiveness of GIS for the dengue epidemic management.

1.3.2 Feasibility of the Project within the Scope and Time Frame

The feasibility study of the project within the scope is to get the best way to manage the dengue epidemic in Malaysia now days. The author must get the resources from Ipoh and Batu Gajah Hospital about dengue cases and their location in order to know the flow of the epidemic.

Besides that, the author must get the location for all dengue cases, map of water retention structure, pattern of movement of people and then input all of this information into GIS software. After that, using GIS the spatial correlation between dengue cases and it cause will be investigate.

The project will take 28 weeks of project duration to complete this task.

CHAPTER 2

LITERATURE REVIEW

Dengue fever (DF) was first reported in Malaysia in 1902 and is now one of the major public health problems in Malaysia, especially with the emergence of dengue hemorrhagic fever (DHF) in 1962. Notification of DF and DHF was instituted in 1971, requiring all medical practitioners to report any case of confirmed or suspected dengue or dengue hemorrhagic fever to the nearest health office. Prevention and control of DF and DHF was further strengthened with the enactment of the Destruction of Disease-Bearing Insects Act 1975 which was amended in 2001 for heavier penalties.

Dengue infection is predominant in urban areas where 61.8% of the country's population lives, as compared to only 34% in 1980. Rapid industrial and economic development over the last two decades has brought about massive infrastructure development and a very active construction sector for housing and commercial development, creating many manmade opportunities for *Aedes* mosquito breeding. This, coupled with rural-urban migration and pockets of illegal settlements, indiscriminate solid-waste disposal and a tropical rainfall, provide fertile grounds for *Aedes* breeding and the rise of dengue transmission in the country.

Dengue continues to be a public health problem in Malaysia showing an upward trend from 27.5 cases/100,000 population in 1990 to a high of 123.4 cases/100,000 population in 1998 during the global pandemic, declining to 31.99 cases /100,000 population in the year 2000 based on notification of clinically-diagnosed cases. There is a predominance of dengue fever (DF) over dengue hemorrhagic fever (DHF), with the highest incidence among the working and school-going age groups. Major sources of *Aedes* breeding are at construction sites, solid-waste dumps, open spaces and in factories. Several initiatives have been taken to strengthen dengue control. Some of the initiatives include reprioritizing *Aedes* surveillance aimed at new breeding sites; strengthening information system for effective disease surveillance and response; legislative changes for heavier penalties;

strengthening community participation and intersectoral collaboration; changing insecticide fogging formulation, mass abating and, lastly, reducing case fatality.

In this ever increasingly complex world, it is no surprise that the dengue problems are becoming more and more intricate to solve. A cross-disciplinary approach may be one of the ways to discover new methods.

Recently, GIS has emerged as an important component of many projects in public health and epidemiology. GIS is particularly well suited for studying these associations because of its spatial analysis and display capabilities. Medical geography is relatively a new concept in the world. GIS has been used in the surveillance and monitoring of vector-borne diseases, water-borne diseases, in environmental health, analysis of disease policy and planning, health situation in an area, generation and analysis of research hypotheses, identification of high-risk health groups, planning and programming of activities, and monitoring and evaluation of interventions. GIS enabled researchers to locate high prevalence areas and populations at risk, identify areas in need of resources, and make decisions on resource allocation. Good epidemiology science and good geographic information science go hand in hand.

The sheer size of our country, varied life styles, climatic zones and environmental conditions (all of which have a direct impact on dengue) make it all the more important for Malaysia to have a systematic record as GIS. Manual process lacks the ability to do spatial analysis and to display database. Using GIS the spatial correlation between dengue cases and its causes will be investigated in order to manage/control the diseases.

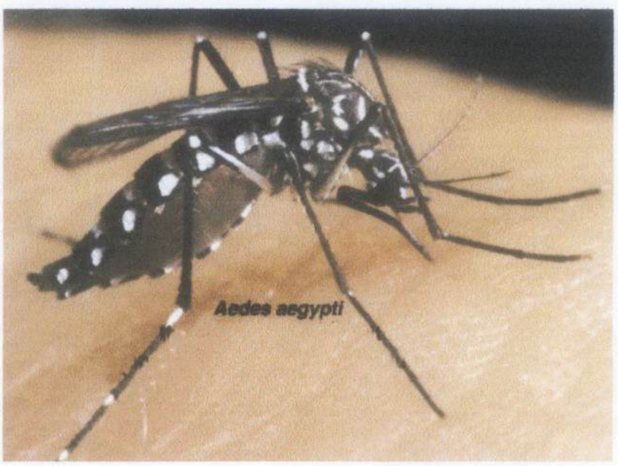


Figure 1: Aedes aegypti

CHAPTER 3

METHODOLOGY / PROJECT WORK

3.1 Tools / Equipment Used

1. MapInfo Professional v7.0 software
2. Google Earth software
3. Relevant software and computing facilities

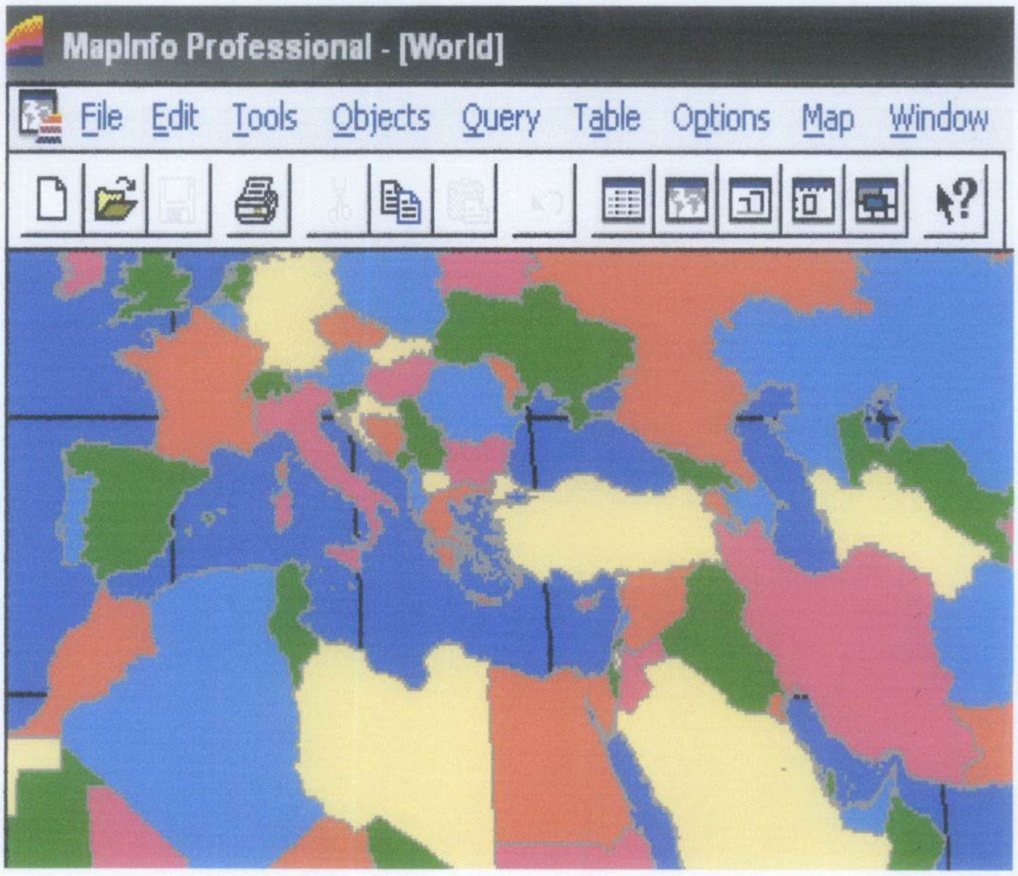


Figure 2: MapInfo 7.0 software

3.2 Description of study area

Kinta is one of the districts of Perak State and is situated in the north-western of Malaysia. It lies between 4° 27'and 4° 30' north latitude and 101° 01' and 101° 04' east longitude. The climate is characterized as tropical; annual southwest (April to October) and northeast (October to February).

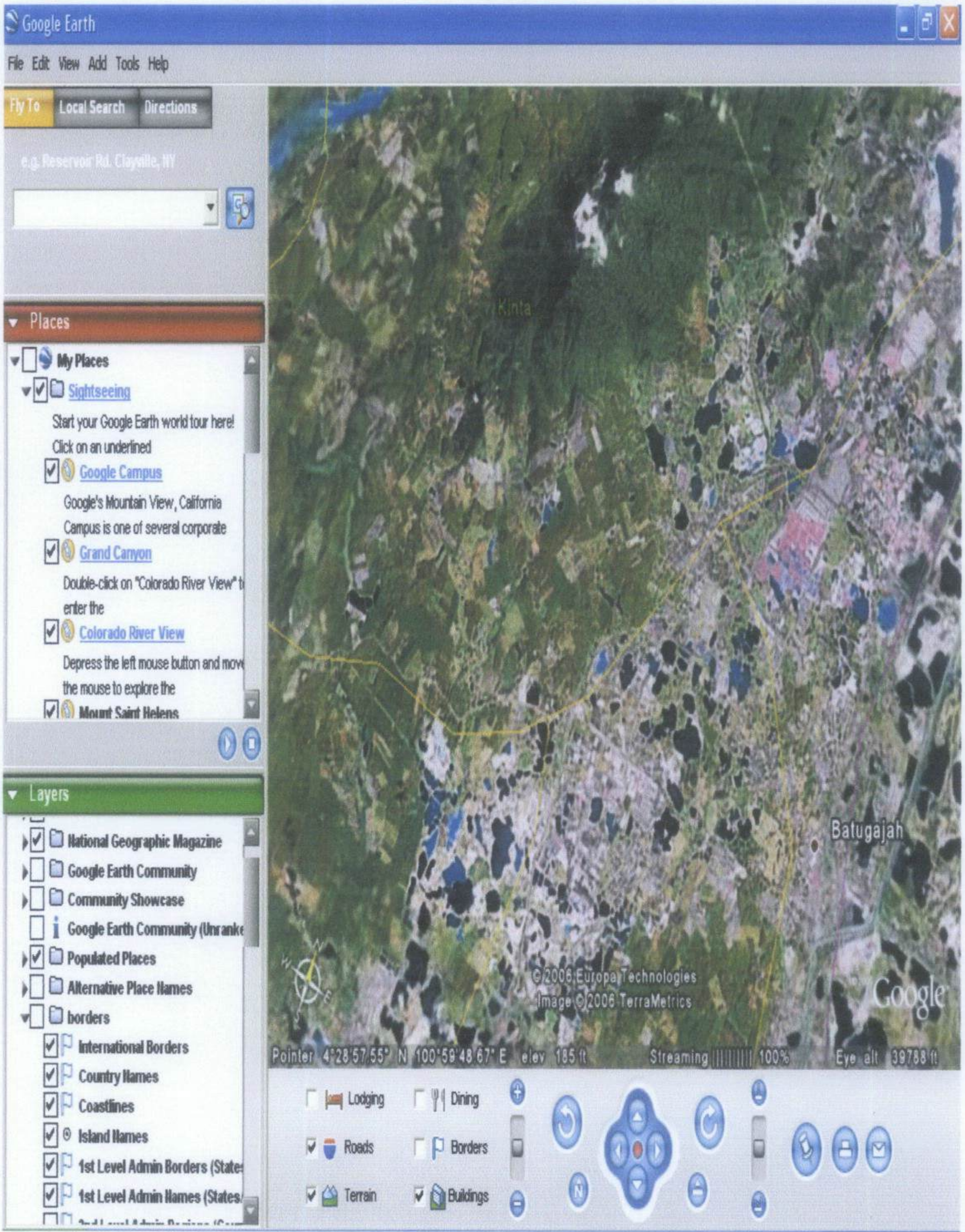


Figure 3: Kinta area from Google Earth software

3.3 Data Collection, Integration and Management

MapInfo Map turns applications such as word processors and spreadsheets into "mini–MapInfo" programs where we can create display and edit a map for presentation, reporting or publishing. This is possible through a process called Object Linking and Embedding (OLE), whereby a server application (such as MapInfo) provides information that is stored in a client application that can accept OLE information (such as a word processor). MapInfo Map allows us to embed a Map window in any application that accepts OLE objects and to use some of MapInfo's features to create, display and edit the map directly.

Data from Batu Gajah Hospital were collected, manipulated and integrated into the GIS system. Generally, spatial data consists of administrative boundaries of Kinta, case event data, and hardcopy topographic maps. Dengue fever patient records and population data were a spatial data utilized in this study. All suspected and indeterminate cases of dengue fever reported in the Kinta for 2005 were used in this study. It should be noted that these cases were suspected cases only and could include other vector-borne diseases that are clinically similar to dengue fever infection. A reason for using suspect cases is because the antibody profiles differ at different stages of infection and the virus can only be isolated from serum drawn within the first few days of illness. Furthermore, dengue fever is endemic in Malaysia, and thus the possibility of suspected cases becoming confirmed cases is very high. The total number of cases was 92.

Figure 4: Data are collected layer by layer

3.3.1 Hypothesis 1: dengue fever and road/railway distribution (population density)

Hypothesis 1 is about the relationship between road or railway distribution and dengue fever cases in Kinta area. Most of the reported cases were from the young and middle-age groups who were active outdoors, whether working, schooling or playing outside their homes. So, the only way to move out is the road or railway, and this is the main consideration in this study. The author wants to know whether the dengue case is occur beside the road/railway or not.

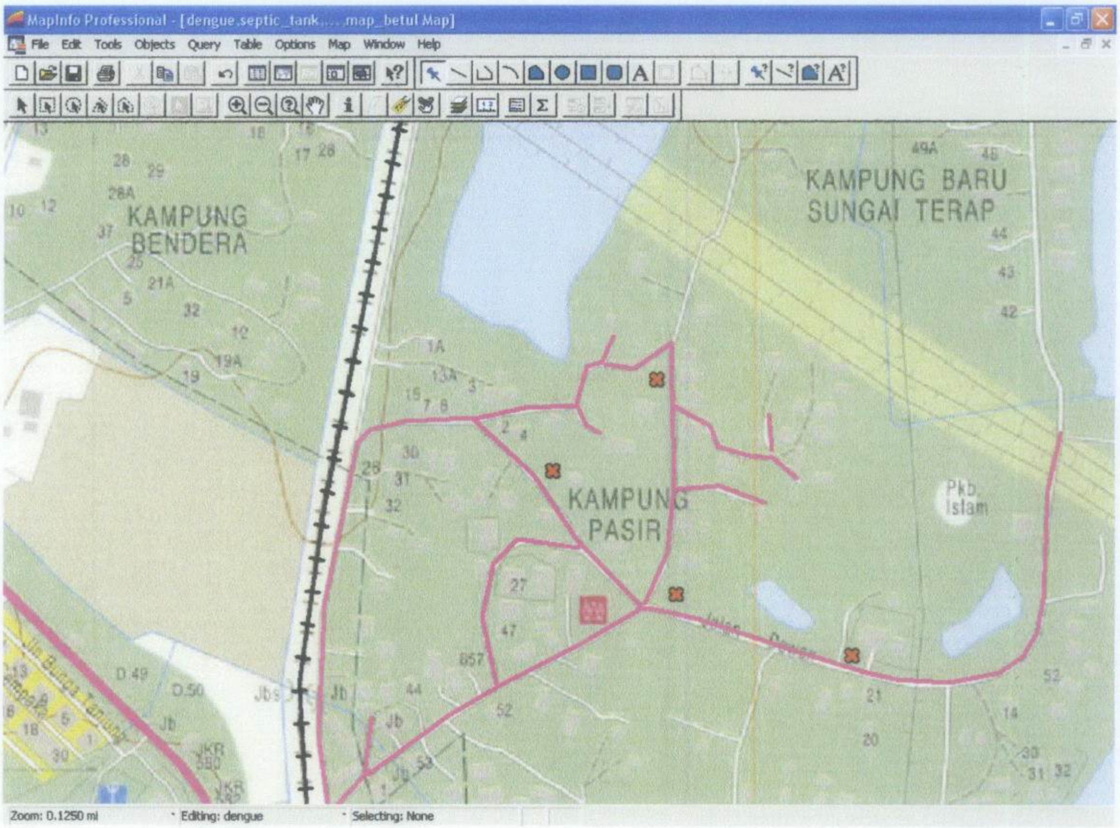


Figure 5: Dengue cases at Kampung Pasir is beside the road

3.3.2 Hypothesis 2: dengue fever and drainage system

Housing pattern: A review of the available literature indicated that in a crowded area, many people living within the short flight range of the vector from its breeding source could be exposed to transmission. Therefore, higher population density and interconnection of drainage system lead to more efficient transmission of the virus and thus increased exposure to infection. The transmission of the disease is normally limited by the flight distance of *Aedes aegypti* during its lifetime. The flight distance of *Aedes aegypti* could range from a few meters to more than 50 meters in a closed urban environment.

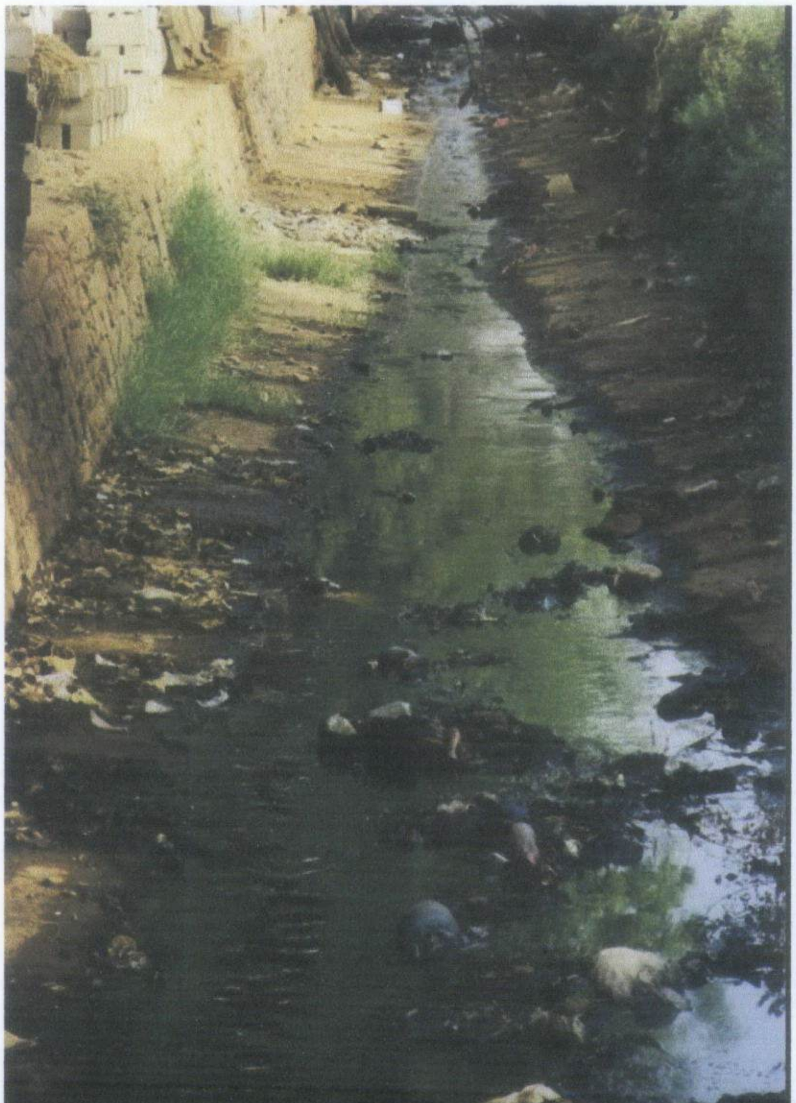


Figure 6: Poor drainage system

Hypothesis 3: dengue fever and septic tank

The *Aedes aegypti* mosquito is a domestic breeder and breeding can occur in toilet bowl (for septic tank), which are not cleaned for sufficiently long periods. Event though the *Aedes aegypti* eggs need clear and stagnant water, they can survive for a long period under extreme conditions and will hatch when they find a well condition water to enable the larvae to swim out. The *Aedes aegypti* eggs are normally laid on the damp walls of both artificial and natural containers and they could resist desiccation for several weeks to several months. The eggs hatch when submerged in water. Since water is essential during the first 8 days in the life of mosquitoes, therefore if the frequency of cleaning is more than 8 days, this could contribute to an increase in the abundance of adult mosquitoes and the risk of dengue virus transmission. Whereas, cleaning the toilet bowl once or twice a week will greatly reduce the risk of dengue fever.

Figure 7: Toilet bowl

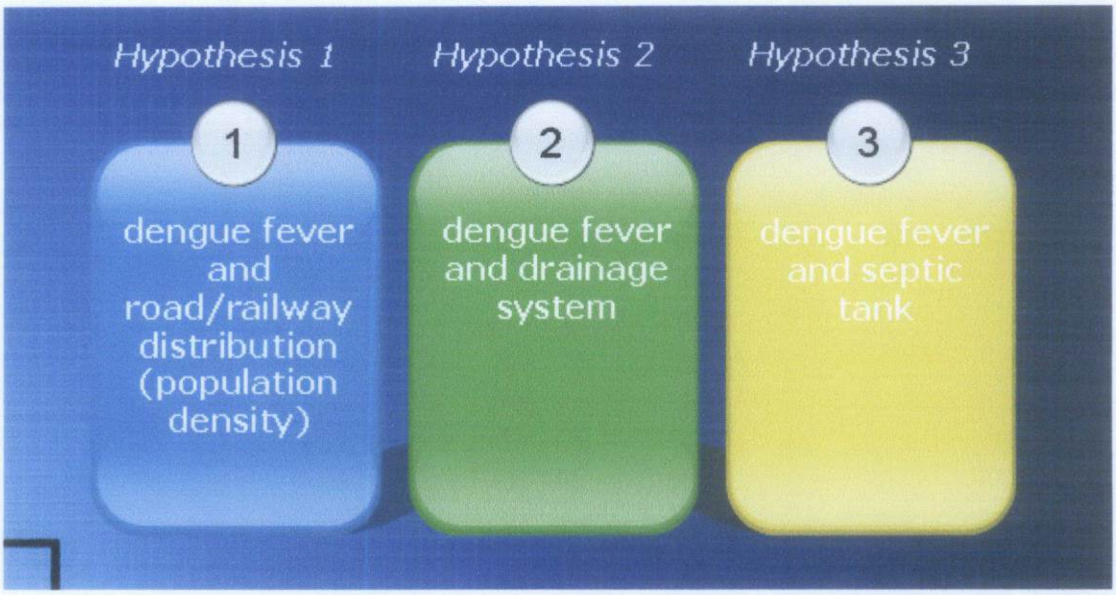


Figure 8: Diagram for hypothesis

3.4 Project Work

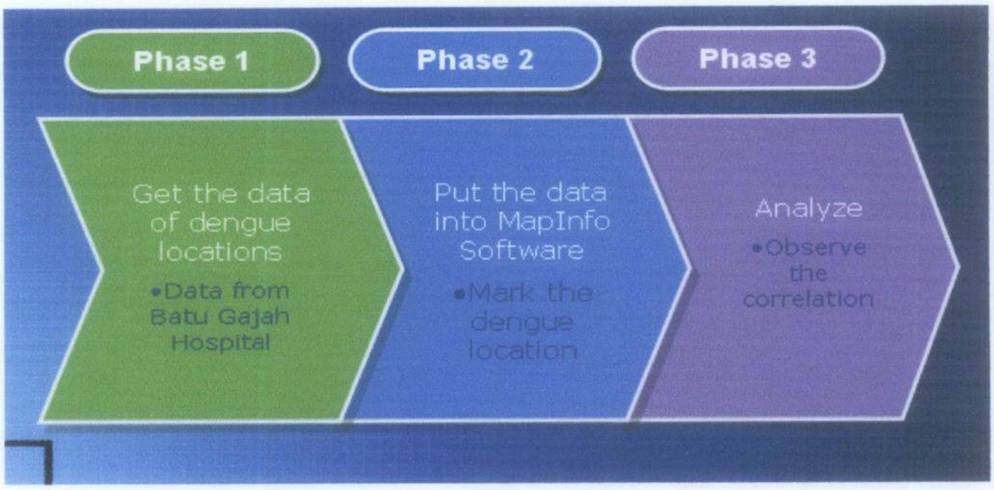


Figure 9: Diagram for project work

3.4.1 Detailed project work steps

1) Register for raster image in MapInfo software.

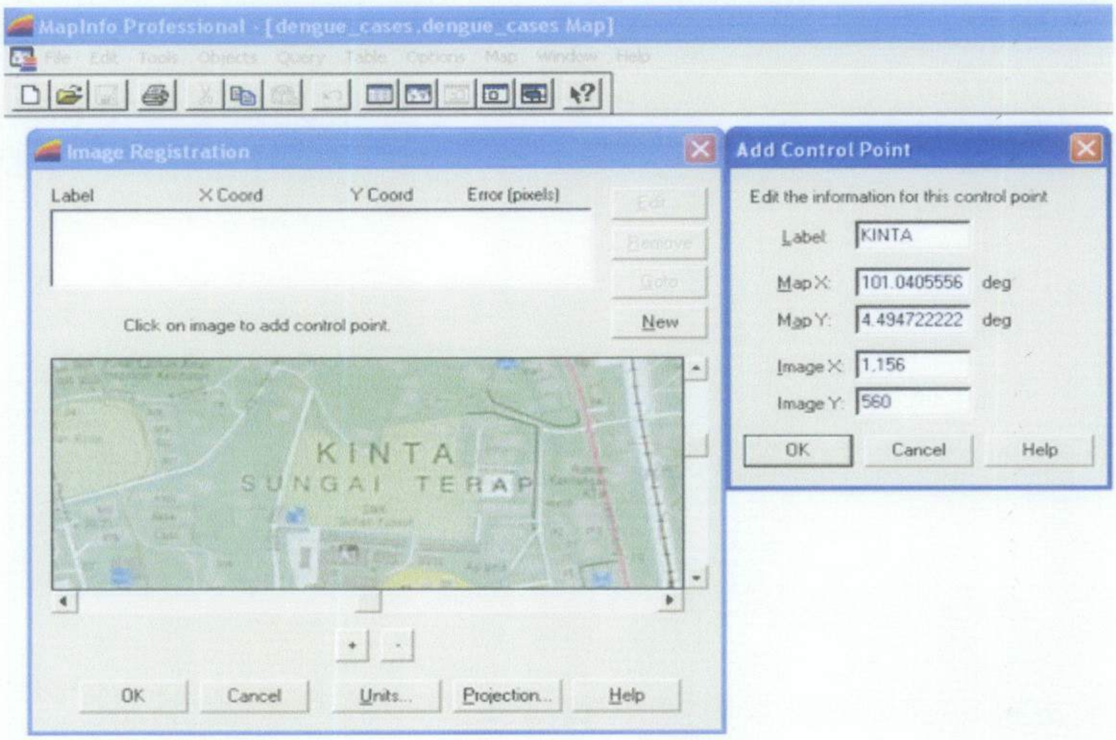


Figure 10: Register for raster image

2) View the map

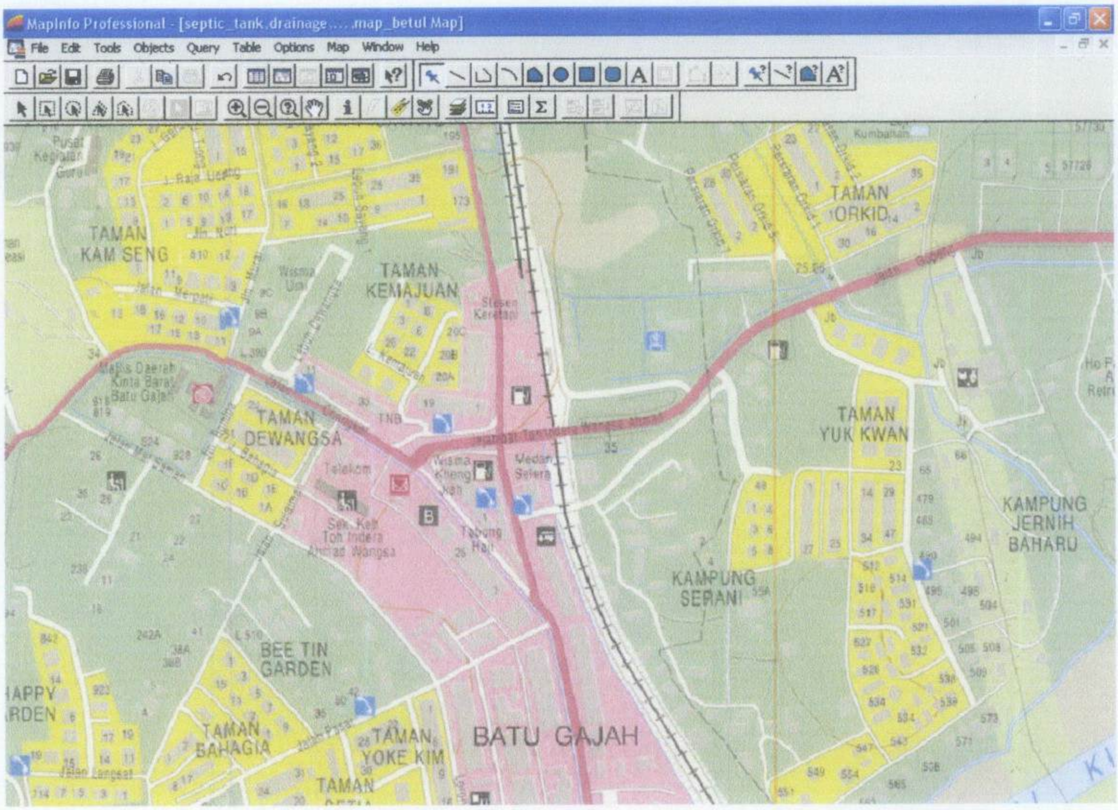


Figure 11: View the map

3) Digitalize the map for road

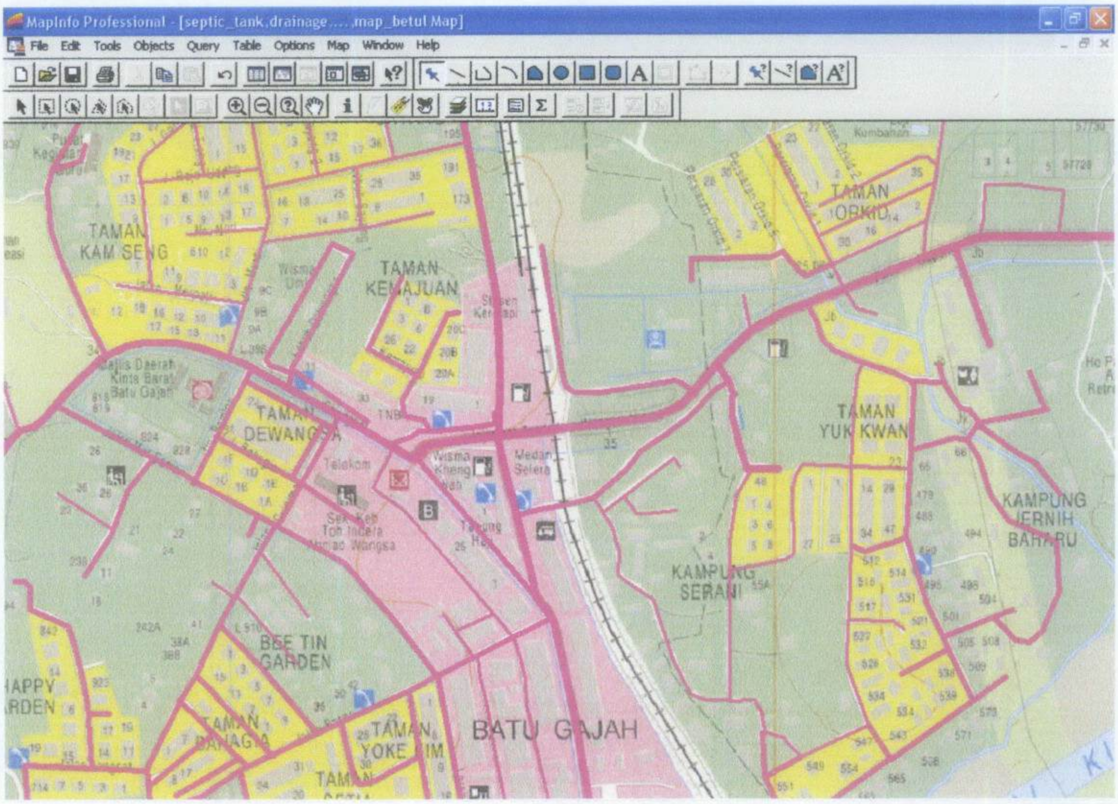


Figure 12: Digitalize the map. Road is pink color

4) Digitalize the map for drainage

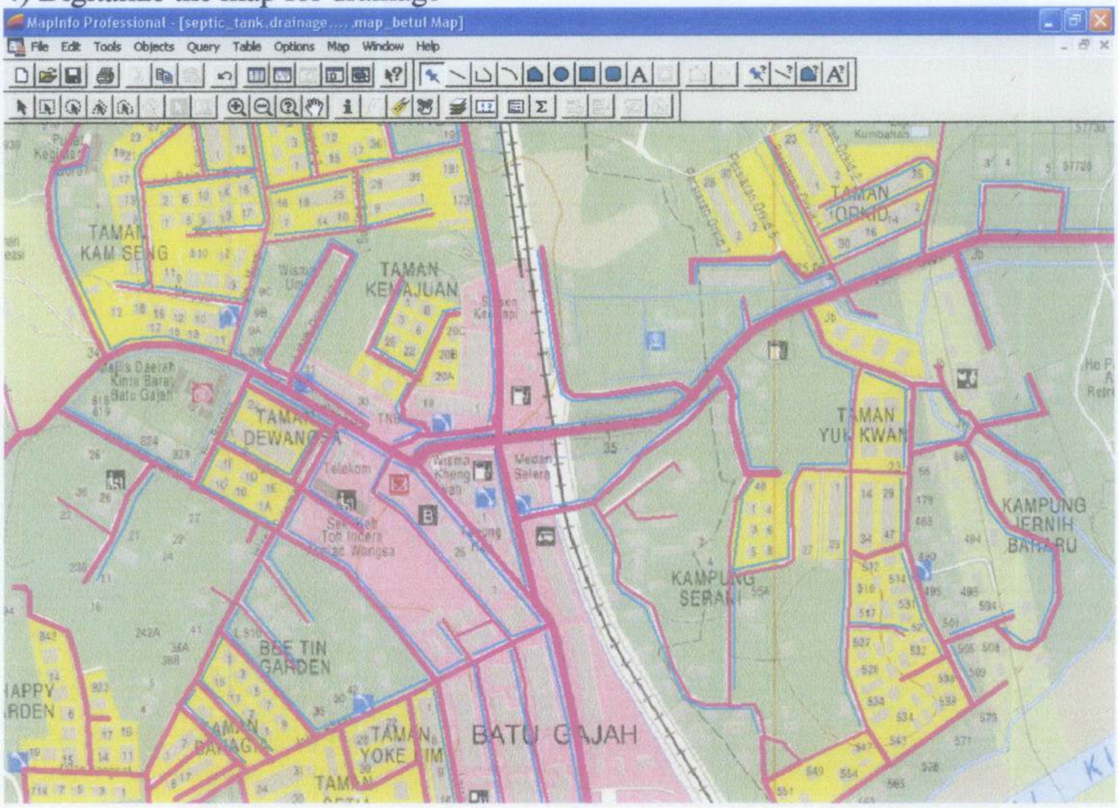


Figure 13: Digitalize the map. Drainage is turquoise color

5) Use layer control to view or hide the layer

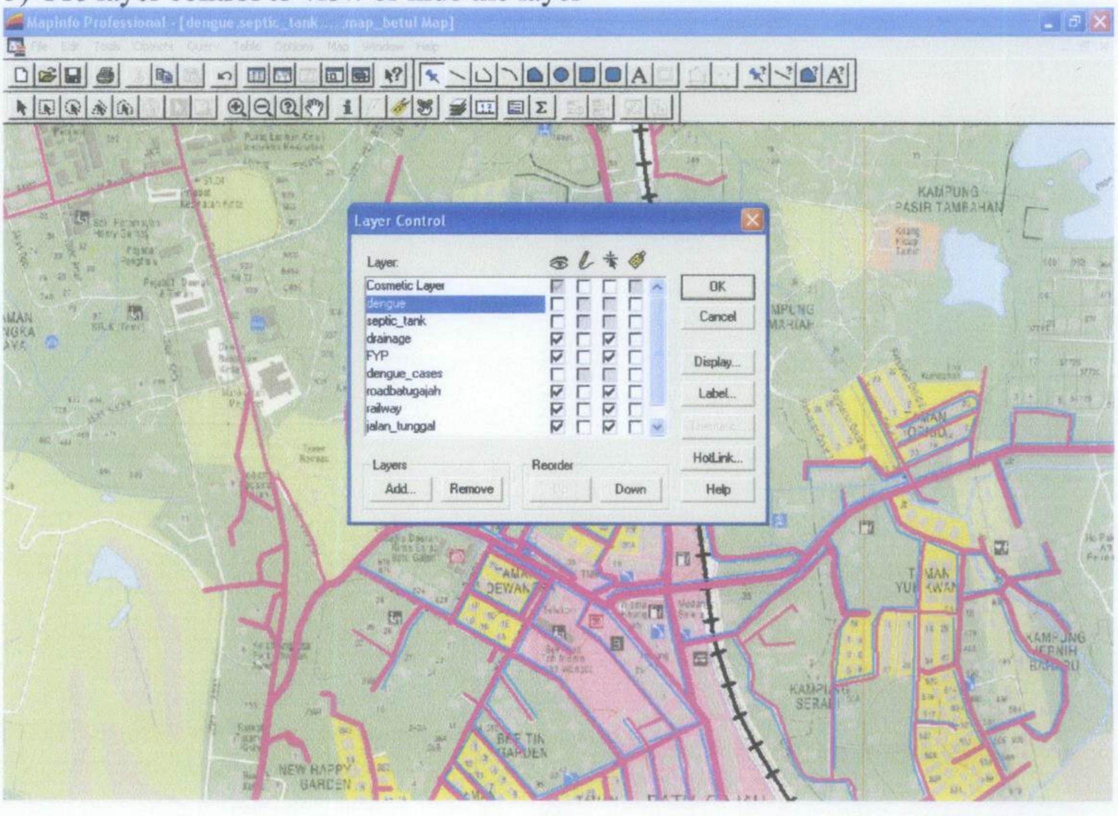


Figure 14: Layer control option to view the layer

6) Mark the dengue case locations

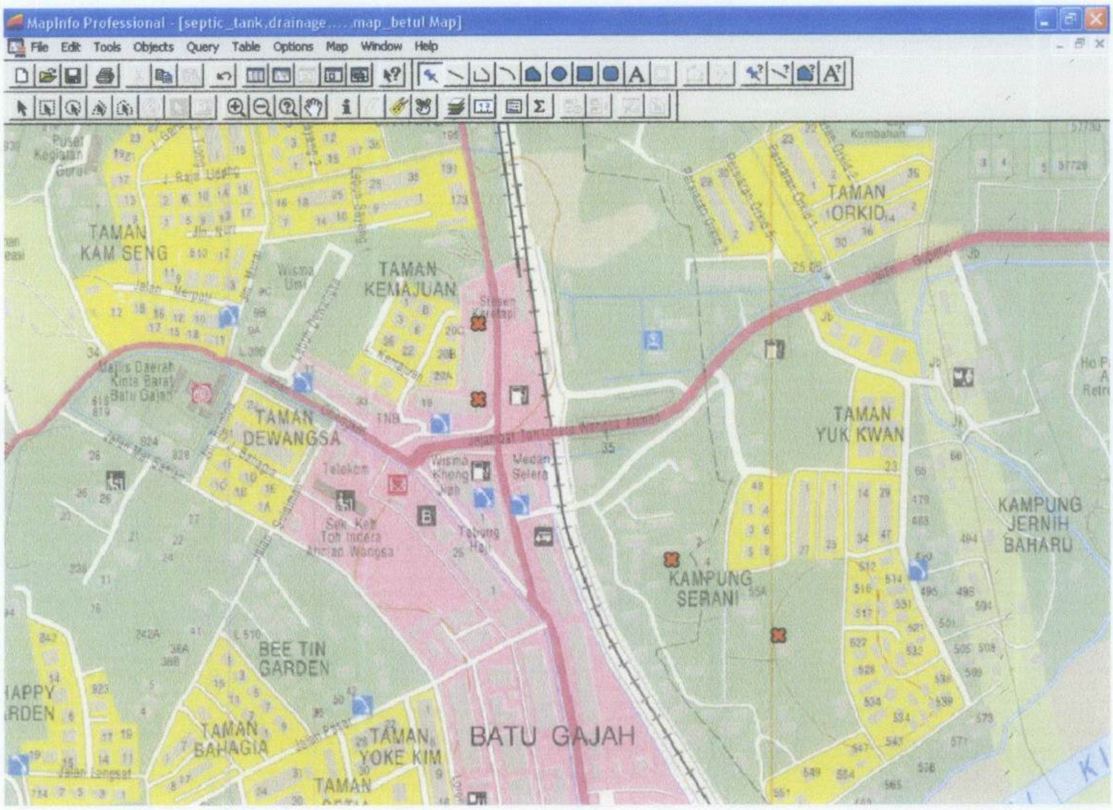


Figure 15: Dengue case locations in red cross

7) Analyze the dengue locations with road and drainage distribution

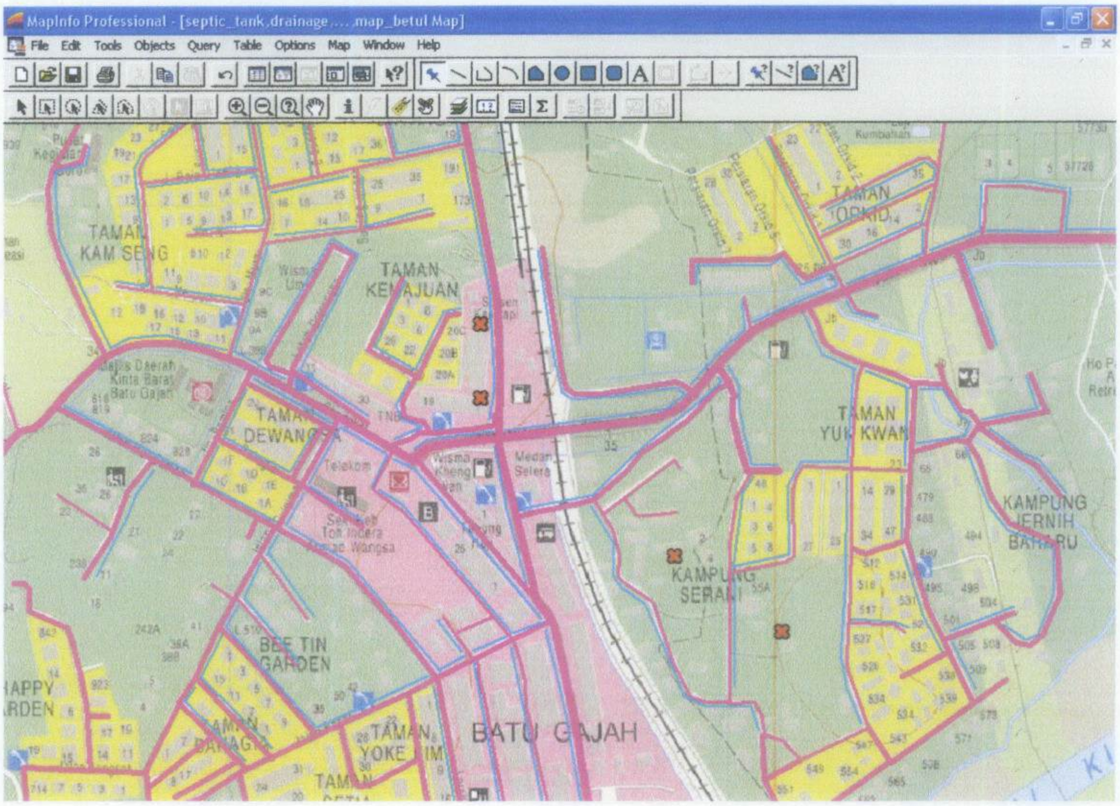


Figure 16: Railway Quarters, Batu Gajah is beside the road

8) Identify the location either using the septic tank or not.

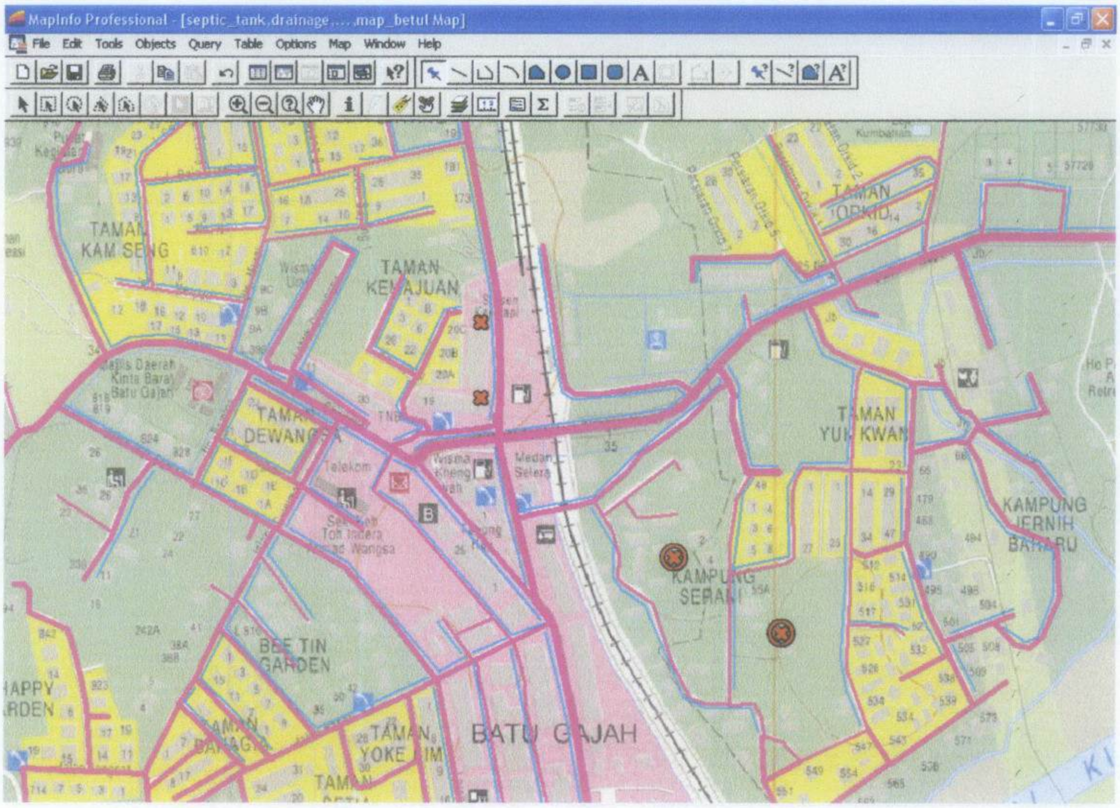


Figure 17: Septic tank in red circle

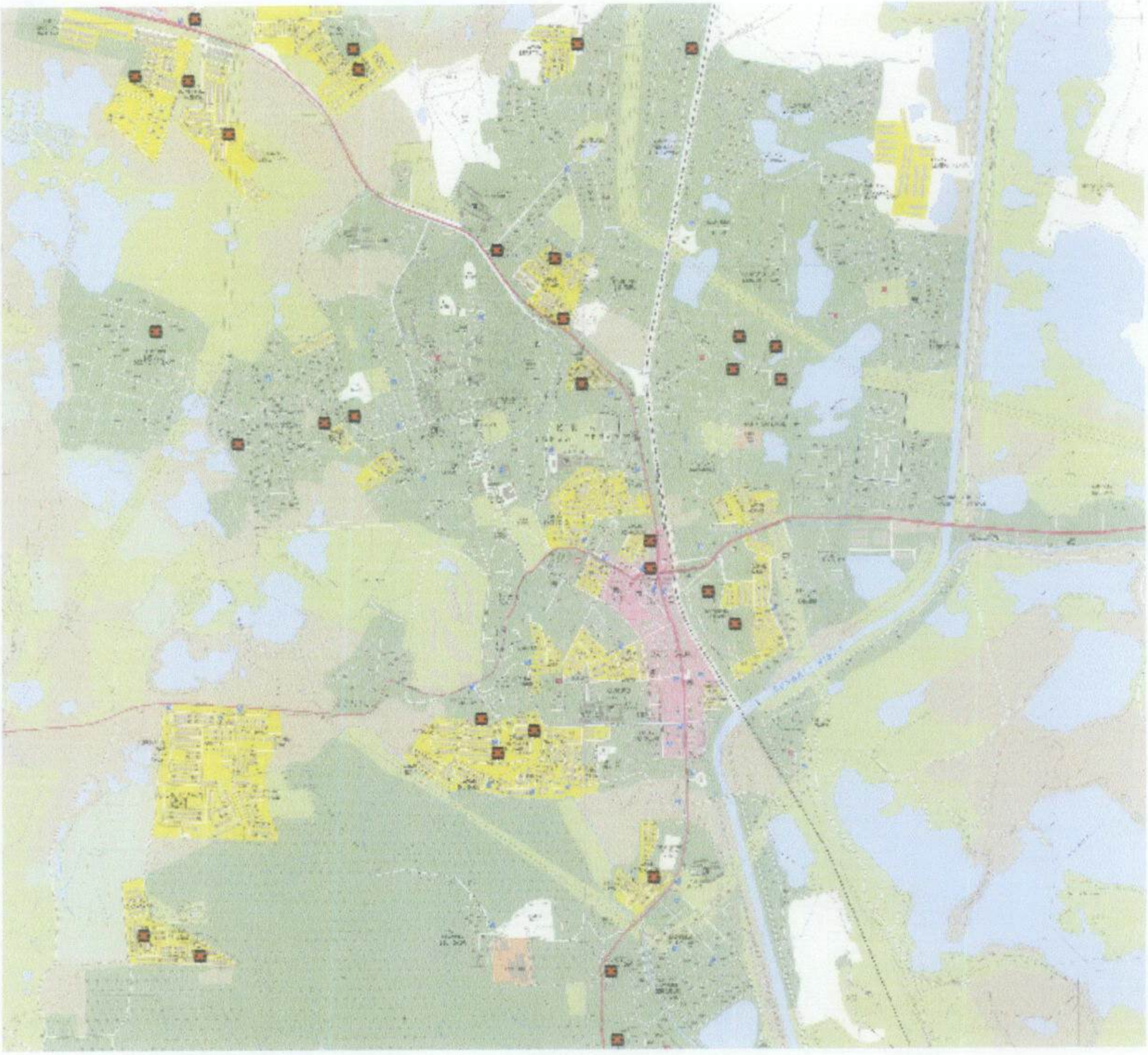


Figure 18: Dengue case locations in Kinta area

CHAPTER 4
RESULTS

4.1 Result

Table 1: Location of Dengue Epidemic in Kinta 2005

No.	Location	No. of Dengue Cases
1	K/B Kopisan	11
2	Jln Muhibah, Kg Tgku Hussein, Ipoh	3
3	Jln Bunga Tanjung, Kg Sg Tapah, Ipoh	2
4	K/B Jeram, Kampar	11
5	Tmn Tualang Tjg Tualang, Batu Gajah	2
6	RPT Pengkalan Pegoh, Ipoh	3
7	Hosp. Bahagia Ulu Kinta	2
8	RPt Bt 5, Tambun, Ipoh	5
9	Tmn Kinta Gopeng	3
10	Kg Lawan Kuda, Gopeng	3
11	Kg Seri Kulim, B. Gajah	3
12	Jln Merak Kg Das Tamb, Ipoh	2
13	Lrg Mat Saman, B. Gajah	3
14	SM Raja Permaisuri, DAS 2, Ipoh	6
15	Jln Tok Ketua, Kg Tgku Hussein, Ipoh	4
16	Kopisan Baru Gopeng	2
17	Changkat Desa, B. Gajah	2
18	Kg DAS Tambh 2	8
19	Kg DAS Tambh	2
20	Jln Meranti Tmn Pelangi, Batu Gajah	2
21	Kg, Sg Tapah, Ipoh	2
22	Railway Querters, B. Gajah	2
23	Kg. Serani, B. Gajah	2
24	Kg. Pasir Sg. Terap, B. Gajah	4
25	New Wah Loong, Kampar	3
	Total	**92**

4.2 Correlation of Dengue Fever and Road/Railway (Hypothesis 1)

Table 2: Result for Hypothesis 1

No.	Location	Beside the road
1	K/B Kopisan	Yes
2	Jln Muhibah, Kg Tgku Hussein, Ipoh	Yes
3	Jln Bunga Tanjung, Kg Sg Tapah, Ipoh	Yes
4	K/B Jeram, Kampar	Yes
5	Tmn Tualang Tjg Tualang, Batu Gajah	Yes
6	RPT Pengkalan Pegoh, Ipoh	Yes
7	Hosp. Bahagia Ulu Kinta	Yes
8	RPt Bt 5, Tambun, Ipoh	Yes
9	Tmn Kinta Gopeng	Yes
10	Kg Lawan Kuda, Gopeng	Yes
11	Kg Seri Kulim, B. Gajah	Yes
12	Jln Merak Kg Das Tamb, Ipoh	Yes
13	Lrg Mat Saman, B. Gajah	Yes
14	SM Raja Permaisuri, DAS 2, Ipoh	Yes
15	Jln Tok Ketua, Kg Tgku Hussein, Ipoh	Yes
16	Kopisan Baru Gopeng	Yes
17	Changkat Desa, B. Gajah	No
18	Kg DAS Tambh 2	Yes
19	Kg DAS Tambh	Yes
20	Jln Meranti Tmn Pelangi, Batu Gajah	Yes
21	Kg, Sg Tapah, Ipoh	Yes
22	Railway Querters, B. Gajah	Yes
23	Kg. Serani, B. Gajah	No
24	Kg. Pasir Sg. Terap, B. Gajah	Yes
25	New Wah Loong, Kampar	Yes

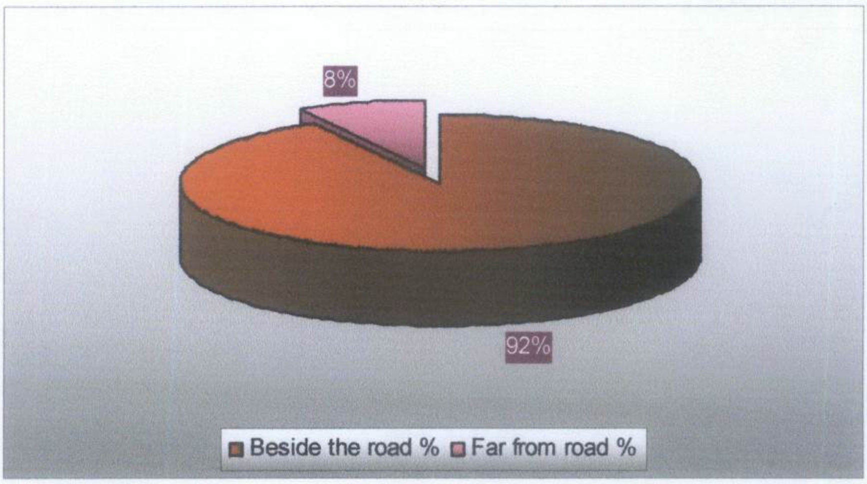


Figure 19: Percentage of road factor to dengue fever

4.3 Correlation of Dengue Fever and Drainage System (Hypothesis 2)

Table 3: Result for Hypothesis 2

No.	Location	Beside the drainage
1	K/B Kopisan	No
2	Jln Muhibah, Kg Tgku Hussein, Ipoh	Yes
3	Jln Bunga Tanjung, Kg Sg Tapah, Ipoh	No
4	K/B Jeram, Kampar	No
5	Tmn Tualang Tjg Tualang, Batu Gajah	Yes
6	RPT Pengkalan Pegoh, Ipoh	Yes
7	Hosp. Bahagia Ulu Kinta	Yes
8	RPt Bt 5, Tambun, Ipoh	Yes
9	Tmn Kinta Gopeng	Yes
10	Kg Lawan Kuda, Gopeng	No
11	Kg Seri Kulim, B. Gajah	Yes
12	Jln Merak Kg Das Tamb, Ipoh	Yes
13	Lrg Mat Saman, B. Gajah	Yes
14	SM Raja Permaisuri, DAS 2, Ipoh	Yes
15	Jln Tok Ketua, Kg Tgku Hussein, Ipoh	Yes
16	Kopisan Baru Gopeng	Yes
17	Changkat Desa, B. Gajah	No
18	Kg DAS Tambh 2	Yes
19	Kg DAS Tambh	Yes
20	Jln Meranti Tmn Pelangi, Batu Gajah	Yes
21	Kg, Sg Tapah, Ipoh	Yes
22	Railway Querters, B. Gajah	Yes
23	Kg. Serani, B. Gajah	No
24	Kg. Pasir Sg. Terap, B. Gajah	No
25	New Wah Loong, Kampar	Yes

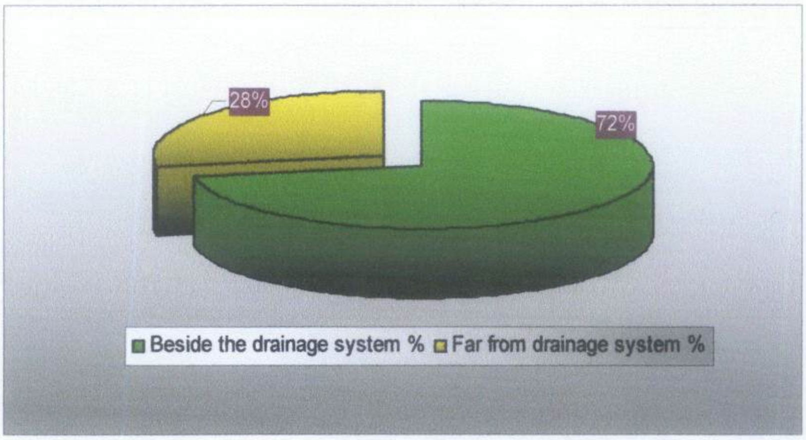


Figure 20: Percentage of drainage system factor to dengue fever

4.4 Correlation of Dengue Fever and Septic Tank (Hypothesis 3)

Table 4: Result for Hypothesis 3

No.	Location	Septic tank
1	K/B Kopisan	Yes
2	Jln Muhibah, Kg Tgku Hussein, Ipoh	Yes
3	Jln Bunga Tanjung, Kg Sg Tapah, Ipoh	Yes
4	K/B Jeram, Kampar	Yes
5	Tmn Tualang Tjg Tualang, Batu Gajah	No
6	RPT Pengkalan Pegoh, Ipoh	No
7	Hosp. Bahagia Ulu Kinta	No
8	RPt Bt 5, Tambun, Ipoh	No
9	Tmn Kinta Gopeng	No
10	Kg Lawan Kuda, Gopeng	Yes
11	Kg Seri Kulim, B. Gajah	Yes
12	Jln Merak Kg Das Tamb, Ipoh	Yes
13	Lrg Mat Saman, B. Gajah	Yes
14	SM Raja Permaisuri, DAS 2, Ipoh	No
15	Jln Tok Ketua, Kg Tgku Hussein, Ipoh	Yes
16	Kopisan Baru Gopeng	Yes
17	Changkat Desa, B. Gajah	Yes
18	Kg DAS Tambh 2	Yes
19	Kg DAS Tambh	Yes
20	Jln Meranti Tmn Pelangi, Batu Gajah	No
21	Kg, Sg Tapah, Ipoh	Yes
22	Railway Querters, B. Gajah	No
23	Kg. Serani, B. Gajah	Yes
24	Kg. Pasir Sg. Terap, B. Gajah	Yes
25	New Wah Loong, Kampar	Yes

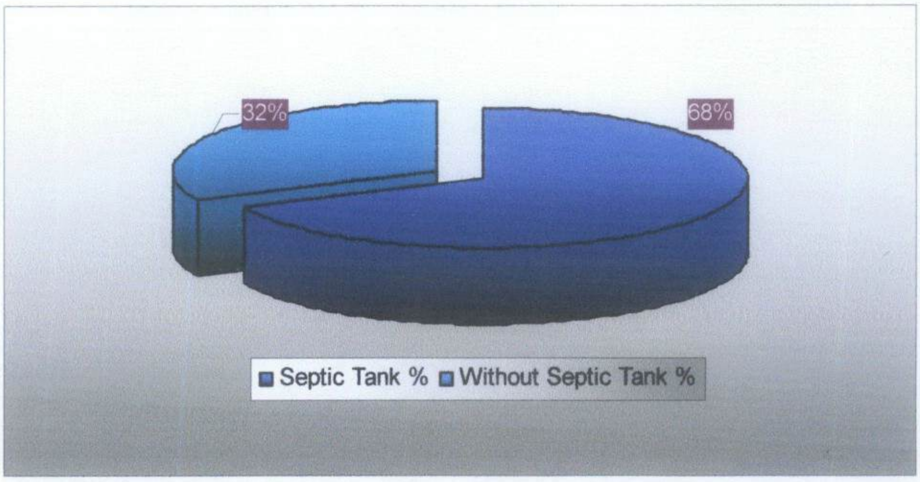


Figure 21: Percentage of septic tank factor to dengue fever

Table 5: Summary of the result

No.	Location	No. of Dengue Cases	Beside the road	Beside the drainage	Septic tank
1	K/B Kopisan	11	Yes	No	Yes
2	Jln Muhibah, Kg Tgku Hussein, Ipoh	3	Yes	Yes	Yes
3	Jln Bunga Tanjung, Kg Sg Tapah, Ipoh	2	Yes	No	Yes
4	K/B Jeram, Kampar	11	Yes	No	Yes
5	Tmn Tualang Tjg Tualang, Batu Gajah	2	Yes	Yes	No
6	RPT Pengkalan Pegoh, Ipoh	3	Yes	Yes	No
7	Hosp. Bahagia Ulu Kinta	2	Yes	Yes	No
8	RPt Bt 5, Tambun, Ipoh	5	Yes	Yes	No
9	Tmn Kinta Gopeng	3	Yes	Yes	No
10	Kg Lawan Kuda, Gopeng	3	Yes	No	Yes
11	Kg Seri Kulim, B. Gajah	3	Yes	Yes	Yes
12	Jln Merak Kg Das Tamb, Ipoh	2	Yes	Yes	Yes
13	Lrg Mat Saman, B. Gajah	3	Yes	Yes	Yes
14	SM Raja Permaisuri, DAS 2, Ipoh	6	Yes	Yes	No
15	Jln Tok Ketua, Kg Tgku Hussein, Ipoh	4	Yes	Yes	Yes
16	Kopisan Baru Gopeng	2	Yes	Yes	Yes
17	Changkat Desa, B. Gajah	2	No	No	Yes
18	Kg DAS Tambh 2	8	Yes	Yes	Yes
19	Kg DAS Tambh	2	Yes	Yes	Yes
20	Jln Meranti Tmn Pelangi, Batu Gajah	2	Yes	Yes	No
21	Kg, Sg Tapah, Ipoh	2	Yes	Yes	Yes
22	Railway Querters, B. Gajah	2	Yes	Yes	No
23	Kg. Serani, B. Gajah	2	No	No	Yes
24	Kg. Pasir Sg. Terap, B. Gajah	4	Yes	No	Yes
25	New Wah Loong, Kampar	3	Yes	Yes	Yes
	Total	**92**			

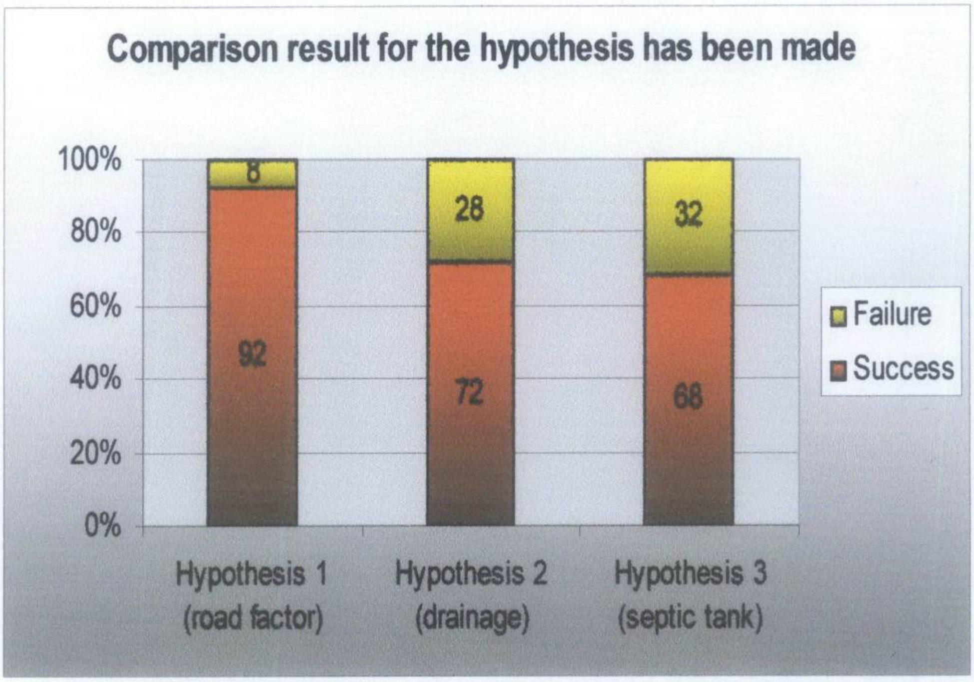


Figure 22: Comparison result for the hypothesis has been made

From the graph showed we know that Hypothesis 1 (road factor) give the highest result, 92% compare to the Hypothesis 2 (drainage factor) 72% and Hypothesis 3 (septic tank factor) 68% that contribute to dengue cases.

CHAPTER 5
DISCUSSION

In general, the population parameter estimate can be divided in three zones, namely, low, medium and high. When the population is higher, that's mean the road distribution is higher (**Hypothesis 1**). Dengue fever cases in the Center of Kinta district have a high correlation with the road distribution parameter whereas the Northern-East area of Kinta district has a low correlation. The correlation of the population parameter slowly increases from the Centre district towards the East of Kinta. The parameter estimates surface show that the populations in the Center of Kinta district have a higher risk to get infected by the dengue virus compared to the East area. The West area can be compared to the Center of Kinta district with regard to topography, road network, and agricultural aspects. This may explain the similar trend of dengue fever transmission. It is speculated that accessibility to a road network, and thus a close proximity to towns, encourages people to travel around as part of their daily activities and facilitating the passive vector transmission by different types of transportation. Rural conditions, such as substandard housing and improper waste management as well as agricultural activities have fostered the dengue fever transmission, thus generating a high association with the population parameter estimates. The forest reserves and the less developed area towards the edge of the Northern-East of Kinta districts have become a natural barrier to stop the disease from spreading through the North districts. West area has a lot of plantation and a few small recreation forests. South area on the other side has a limited road connection with only one principal road from Tanjung Tualang. West area is a forest area with the lowest population in Kinta district. As a result, only 7 cases were reported in West area due to its topography and population constraint. Overall, the high population density as well as an easy accessibility to the road network in the Centre district has increases the transmission causing a high incidence rate in dengue cases, which also means that the road/railway factor has a maximum impact on the transmission. The graph (***Figure 19***) shows that the correlation between dengue fever and road/railway is 98%. So, the hypothesis is acceptable and road/railway distribution is the main factor for the dengue transmission. By understanding the quantitative association of the population factor, prevention activity should be focused on areas with a high population parameter estimate (high risk) and close proximity to each other because dengue fever is able to spread across a sub-district in a short span of time.

Urbanization and population growth in areas such as the Kinta district has fostered the dengue fever transmission especially in residential areas where inappropriate waste management at household level has created an abundance of artificial containers in surrounding premises which eventually become mosquitoes breeding sites. Poor drainage systems make the situation become worst. During the survey it was observed some drainage is not maintained properly and full with garbage. Some of them are the filled with container that provide ideal breeding places for *Aedes Aegypti* mosquitoes. The result from **Hypothesis 2** indicates that drainage system makes a positive contribution to dengue incidence with 72% of the dengue cases occurred beside the drainage. That's mean the drainage system is a second factor that contribute to dengue fever. Furthermore, information from epidemiological data shows that 83% of the dengue fever cases in Kinta district are reported within residential areas followed by 9% from squatter areas and 8% from traditional areas. This information has reaffirmed the association of dengue transmission with common breeding grounds associated with humans especially in developing and domestics environment such as the Kinta district.

The *Aedes aegypti* mosquito is a domestic breeder and breeding can occur in toilet bowl for septic tank (**Hypothesis 3**), which are not cleaned for sufficiently long periods. Event though the *Aedes aegypti* eggs need clear and stagnant water, they can survive for a long period under extreme conditions and will hatch when they find a well condition water to enable the larvae to swim out. And they are able to survive in these conditions for up to six months. However, the eggs would need to be laid in water first. Lab tests have shown that the eggs can survive for four months and they can even last up to six months without a drop of water. For example we have had a very long dry spell and in the last month we had rain. With the onset of rain, the eggs will hatch and the larvae will find their way into waterlogged areas. The same episode happens when the toilet bowl (for septic tank) is not flush for along period, *Aedes aegypti* eggs are laid on it. After we flush it the egg will survive until the water out flow from the septic tank. Then with the aid of rain, the egg will find the proper place to hatch. This is prove by result from **Hypothesis 3** that indicates the usage of septic tank makes a positive contribution to dengue incidence with 68%. That's mean all the hypothesis is acceptable. But further investigation such as aerial photos of high risk areas should be obtained to explore population related factors such as housing distribution, vegetation and living environment for dengue prevention and control measure.

Beside that for prevention and control, fogging would only kill the adult mosquitoes but would not affect the eggs that had been laid. The eggs are laid in tree crevices, drains and containers when water collects there. It is impossible to destroy the eggs totally. Efforts should be to drastically reduce the number of adult mosquitoes. Difference study found these astonishing and unexpected characteristics of the aedes mosquito; The eggs have a very strong shell that cannot dry or crack for as long as they are incubating in mud, soil, damp leaves or wet sand. The eggs can survive for a long period under such conditions and will hatch when the next round of rain comes, forming a small pool of water to enable the larvae to swim out. Continuous fogging with the same chemical will, in a short time, result in a change in the immune system of the aedes mosquito, enabling the insect to adapt to the chemical and shield itself from poisonous effects. The mosquitoes can breed in all types of water, even in clean water in bath tanks or any storage tank. Perhaps new formula of fogging components will be created to kill the adult mosquitoes.

CHAPTER 6
CONCLUSION

As a conclusion, the Project of GIS for dengue epidemic management for Kinta area is successful. The result revealed that road/railway distribution, drainage system and usage of septic tank significantly affected incidence of dengue transmission. Control of dengue and dengue hemorrhagic fever is a multi-sectoral effort which requires strong community participation. With this GIS system, it is hope that better planning and decision modeling can be done. This is to ensure that problems related to dengue case, will be reduced and finally overcame albeit slowly. Hopefully, The Ministry of Health in Malaysia will continue to provide the leadership in getting all parties to work together while enhancing its own capacity and technical capability to face the many challenges in the control of dengue in the country. Several initiatives have been taken to strengthen dengue control in the country but certainly, more could be done. With proper focus, new initiatives and continual effort, careful prevention planning and evaluation need to be done to develop an ultimate plan to control the dengue epidemics.

APPENDICES

1. Ministry of Health, Malaysia (1990-2000). Annual Reports of Vector-Borne Disease Control Programme.
2. www.gis.com
3. www.mma.org.my
4. www.sun2surf.com
5. www.ipoh-online.com.my
6. www.map.com.my
7. www.thestar.com.my

Figure 1. ***Distribution of clinically-diagnosed and serologically-confirmed cases per 100 000 population, 1991-2000***

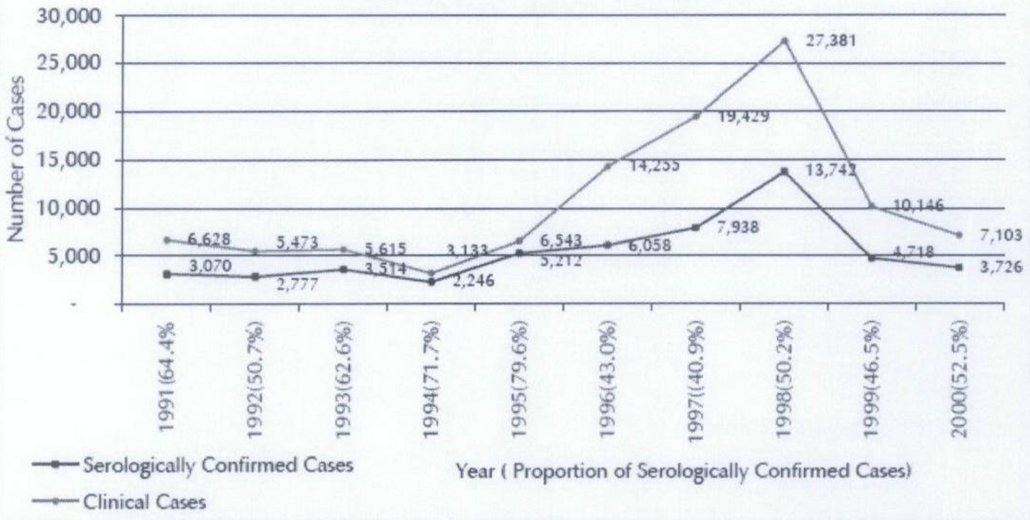


Table 1. *Ratio of DF and DHF reported cases, 1996-2001 (August)*

Year	DF	DHF	DF:DHF Ratio
1996	13,723	532	25.8:1
1997	18,642	787	23.7:1
1998	26,240	1133	23.1:1
1999	9,602	544	17.6:1
2000	6,692	411	16.28:1
2001 (August)	9,375	524	17.9:1

Figure 2. ***Distribution of dengue cases by age-specific morbidity rate per 100,000 population, 1991-2000***

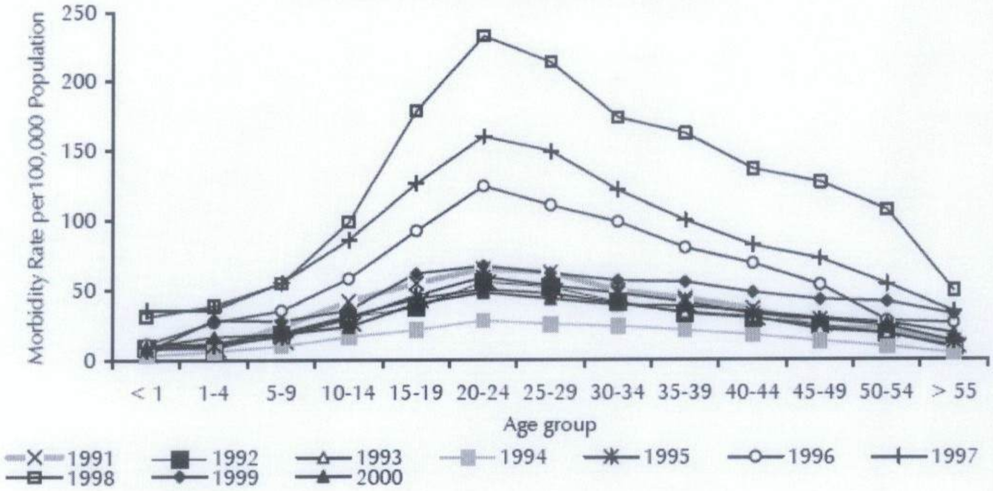
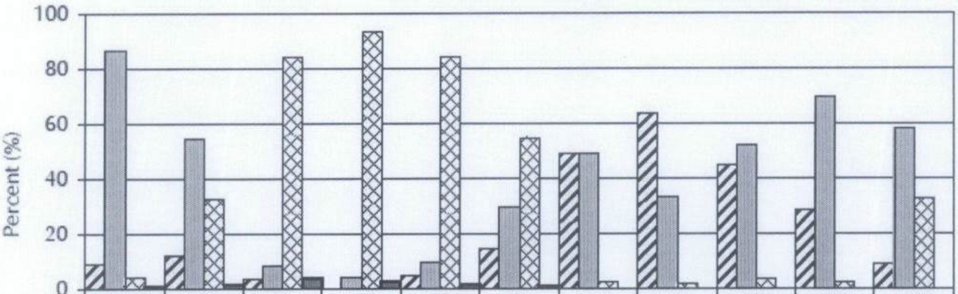


Figure 3. ***Circulating DEN serotypes 1990-2000***



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
DEN-1	8.9	11.9	3.7	0	4.8	14.7	48.7	63.5	44.4	28.2	9.3
DEN-2	86.2	54.2	8.6	4.1	9.5	29.5	48.7	33.4	51.9	69.2	58.1
DEN-3	4.1	32.5	83.7	93.1	84.1	54.6	2.6	2.1	3.7	2.7	32.6
DEN-4	0.8	1.4	4	2.8	1.6	1.2	0	0	0	0	0

Figure 4. ***Dengue case-fatality rate according to DF/DHF and DHF in Malaysia 1984-2000 (August)***

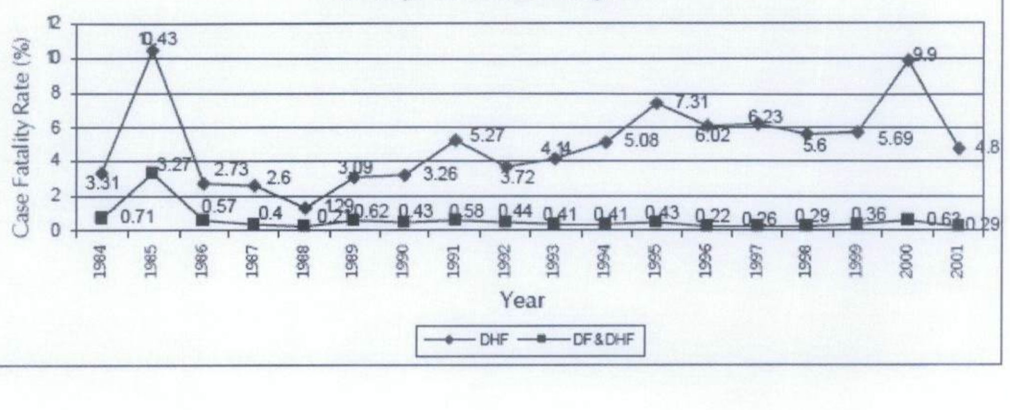


Table 2. *Aedes breeding by type of premises in 2000*

Type of premises	No. examined	*Aedes* breeding	
		No. positive	%
Factories	8,064	651	8.10
Abandoned housing projects	828	56	6.80
Construction sites	6,335	398	6.30
Vacant land	5,789	212	3.70
Garbage dump sites	3,439	110	3.20
Offices	3,199	94	2.90
Schools	22,464	576	2.60
Houses / Shops	1,916,604	11,187	0.60