ISSN: **2348-5906**
CODEN: **IJMRK2**
IJMR 2014; 1 (4): 72-80

Received: 18-09-2014
Accepted: 24-10-2014

M.Palaniyandi
Division of Environmental Health, Vector Control Research Centre, (ICMR), Indira Nagar, Medical Complex, Pondicherry-605006, India

PH Anand
PG & Research Department of Geography, Government Arts College, (Autonomous), Kumbakonam-612 001, Tamil Nadu, India

R. Maniyosai
PG & Research Department of Geography, Government Arts College, (Autonomous), Kumbakonam-612 001, Tamil Nadu, India

For Correspondence:
M.Palaniyandi
Division of Environmental Health, Vector Control Research Centre, (ICMR), Indira Nagar, Medical Complex, Pondicherry-605006, India

GIS based community survey and systematic grid sampling for dengue epidemic surveillance, control, and management: a case study of Pondicherry Municipality

M. Palaniyandi, PH Anand and R. Maniyosai

Abstract

Background of the study: The dengue epidemics have become major challenging problems in India, including Pondicherry Union Territories and have the national public health important for the recent years. The dengue epidemics were reported from 24 states/union territories of India with the total cumulative record of 206,142 cases and 872 deaths during the period of January 2008 to August 2014, especially it has been recorded high rate to 50,222 cases and 227 deaths, 75,454 cases and 167 deaths during 2012 and 2013 respectively. The both dengue and chikungunya have been transmitted by the *Aedes* genus mosquitoes (*Ae aegypti* or *Ae. Albopictus)*. Hundreds of cases with multiple numbers of deaths occurred in Pondicherry, since 2007, and the huge number of dengue epidemics was reported in Pondicherry with 1102 cases and 5 deaths, 2215 cases during 2012, and 2013 respectively. Consequently, it has become very serious threat to the public in Pondicherry. The manmade breeding source of environmental determinants of dengue epidemic risk factors have been creating conducing environment and are fueling for sporadic disease epidemics in the city for the recent years.

Methods and Materials: The MapInfo 4.5 professional and the Arc View 3.2 GIS platform was used for applying the systematic 0.5 km X 0.5 km grid sampling procedure is applied for sampling, and the virtual GPS 12 XL is used to conduct rapid reconnaissance housing and the community survey for mapping the dengue vector mosquitoes breeding habitats positives with geo-coordinates of house locations and to assess the people's perception against the dengue vector breeding habitats and the knowledge of protection measures against to the mosquitoes biting.

Result and Discussion: The present study is made for preventing the spread of dengue epidemic transmission, and to monitor its vector (*Aedes aegypti*) mosquito breeding environments, and a combination of environmental and socioeconomic variables to mapping areas at risk of epidemic transmission. These variables include mosquito counts, population density in inhabited areas, total populations in the blocks /wards, access to drinking water supply, Out of 12 wards, 4 wards (30%), found were identified as of high risk, namely, Villianur (Town), and followed by Villianur Pudu Nagar, Odiyampet, and Anna Nagar; 4 wards (30%), were identified as of medium risk, namely, Jaya Nagar and followed by Olugrate, Moolakulam, and Kamban Nagar, remaining 3 wards (30%) were identified as of low risk and 1 ward (10%), Anna Nagar extention, were identified as of no risk. The GIS based systematic grid sampling methods used can be implemented as routine procedures for control and prevention. A concerted intervention in the medium- and high-risk level blocks identified in this study could be highly effective in dengue vector habitats source reduction towards the control and management of epidemic transmission in the urban areas.

Conclusion: GIS has been used to visualize and identify spatial heterogeneity of dengue vector density in the urban area as a whole. Dengue vector mosquito *(Ae. aegypti*) data is used to assess current risk areas (Fig. 2), spatial agreements of correlating immature mosquito counts with environmental and socioeconomic parameters. The result provided that socioeconomic and environmental condition in the study region, estimates for identifying the socioeconomic and environmental key variables associated with dengue and chikungunya epidemics, visualising the risk of epidemic and vulnerable areas, estimates the population at risk of exposure to the epidemic, prioritization of areas/wards / blocks for vector control and management, GIS based spatial solution for vector control and management and a protective measures against dengue vector biting, and to be calling attention to the importance of dengue transmission at work, schools and other public spaces. The spatial component of transmission could be isolated, after controlling for variables of interest, thus contributing to future studies that consider new hypotheses and variables in the analysis. Consequently, GIS may perhaps, assisting to dengue epidemic surveillance and controlling the epidemic situation in the urban areas as whole.

Keywords: GIS mapping, systematic grid sampling, peoples' perception, dengue surveillance, dengue epidemic transmission, environmental determinants, *Aedes* genus vector mosquitoes, *Ae. aegypti, Ae. Albopictus.*

1. Introduction

The dengue and dengue hemorrhagic fever (DHF) have been endemic in the Southeast Asia, Western Pacific, Africa, Sri Lanka, South America and eastern Mediterranean for more than ten decades. But, the situation was not very serious in India till 1990 [4, 11]. The first case of dengue was clinically confirmed and it was reported in India during 1989. From 1991 onwards the epidemics of dengue has been steadily increased to become very serious threat to public and has become essentially public health important in India. Now, India has become host for all the four types of dengue virus [4, 6, 7, 13]. The dengue epidemics were reported from 24 states / union territories of India with the total cumulative record of 206,142 cases and 872 deaths during the period of January 2008 –August 2014, especially it has been increased to 50,222 cases and 227 deaths, 75,454 cases and 167 deaths during 2012 and 2013 respectively, 60 deaths in Tamil Nadu state alone was the highest number in the country and followed by 59 deaths in Maharashtra as second position in the country [4-6, 7, 15, 16]. There was 9,249 clinically confirmed epidemic cases reported from Tamil Nadu, and followed by 6225 cases in West Bengal, 3760 cases in Kerala, 3640 cases from Karnataka, 2196 cases from Odisha, 1980 cases from Delhi and 1102 cases from Pondicherry Union Territory [4-6, 7]. The hundreds of cases with multiple numbers of deaths occurred in Pondicherry urban areas, [6, 7] since 2007. It has become very serious problems to the public of Pondicherry. Therefore, a rapid survey method of dengue surveillance and control was carried out to mapping the problematic areas for control.

Gaining the spatial knowledge to better understand the distribution of epidemic cases in association with dengue vector breeding sources, vector density in reference to space and time, and it is important to develop spatial databases, and to analyze this information with climatic, geo-environmental, entomological and socioeconomic risk factors for a given area. Geographical information systems (GIS) based systematic housing and population survey with aid of virtual GPS is useful for collecting data for the study of factors affecting DF and its vector distribution. As on today, there is no drug or vaccination available to cure the dengue fever (DF), and thus, the most important option for prevention is to control epidemic transmission and monitor its vector mosquito (*Aedes aegypti*) and destruction of suitable breeding environments. The role GIS based method is an important datum of base line for formulating control activities, assessing changes in transmission in different environmental setup over time and determining resources to control prevalence, particularly in areas of high and moderate risk of epidemic transmission.

1.1 Background of the study and statement of the problems

Dengue fever is an infectious, epidemic disease, transmitted by the vector *Aedes aegypti*. It is an acute viral disease that causes fever, severe headache, bone and joint pains, nausea, vomiting, and prostration. In some cases, it may produce hemorrhagic manifestations, shock, and death. The principal vector is the mosquito *Aedes aegypti*, which has a worldwide distribution in tropical and many semitropical areas (Peter J. *et al*, 2002). The disease is becoming endemic mainly in tropical regions, where the expansion of urban populations, impoverished and crowded areas, and poor infrastructure create ideal habitats for vector proliferation and consequent spread of the virus. Dengue incidence is seasonal, increasing during months of highest temperature and precipitation (Ricardo Cordeiro., *et al*., 2011). The spatial analysis of dengue epidemic is carried out in relation to the socioeconomic variables context according to different geographical areas [1, 2]. The study described ecological aspects in the municipality urban areas; the occurrence of dengue was correlated with socioeconomic variables through Pearsons' correlation coefficient. Moran's global and local indexes were also used to assess the spatial auto-correlation between dengue and the variables that significantly correlated with the disease [3, 5, 11]. The multiple linear regression models and the conditional auto-regression spatial model were used to analyze the relationship between dengue and socioeconomic variables [1, 2]. Dengue and chikungunya epidemics are being reported from the coastal districts of Pondicherry and Tamil Nadu where the areas were marked for prone to tsunami and cyclone, since it is associated with the huge number of containers of damaged house hold things in the coastal areas suitable for Aedes aegypti mosquitoes breeding (M. Palaniyandi, 2014). The chikungunya in Kerala was most associated with massive number of coconut shells used for collection of rubber milk in the rubber plantation in Kerala, and the massive pineapple cultivation in the state also fueling for dengue and chikungunya vector profusion in the state Kerala, [5-10] which has been the most suitable climate condition (temperature and relative humidity) for year round enormous quantity of *Ae. albopictus*, mosquitoes breeding during the Southwest monsoon in south India [4-9]. Productivity of defective Rainwater harvesting structures (RWHS) was fuelled for dengue vector breeding and vector population profusion) huge number of breeding habitats in the domestic and peripheral domestic areas [4, 5, 14]. The defective rainwater harvesting structure accounted to 20 to 35%, and has been supporting profusion of dengue and chikungunya vector mosquitoes (*Aedes* sp.) breeding of 12 per cent of the total breeding habitats in the both urban and rural areas in Tamil Nadu state and Pondicherry union territory of India [5-10].

2. Rationale

Dengue and chikungunya epidemics were reported from the coastal districts of Pondicherry and Tamil Nadu where the areas were marked for prone to tsunami and cyclone, since it was associated with the huge number of containers of damaged house hold things in the coastal areas suitable for *Aedes aegypti* mosquitoes breeding [4-9, 13, 14]. Productivity of defective Rainwater harvesting structures (RWHS) was fuelled for dengue vector breeding and vector population profusion) huge number of breeding habitats in the domestic and peripheral domestic areas [8, 15]. The chikungunya in Kerala was most associated with massive number of coconut shells used for collection of rubber milk in the rubber plantation in Kerala, and the massive pineapple cultivation in the state also fuelling for dengue vector profusion in the state, [8] which has been the most suitable climate condition (temperature and relative humidity) for year round enormous quantity of *Ae. albopictus,* mosquitoes breeding in the Southwest monsoon. On the one side, dengue and chikungunya epidemic situation in the country has increased in recent years, on the other hand, vaccination or immunization or direct medicine is not available for treatment in the world. Dengue and chikungunya virus identification and isolation was carried out at the 311 government sentinel surveillance hospitals and 14 public referral hospitals working in the 37 states and the Union Territories of India as on 2014 [15-18]. India has now become a host for all the four types of dengue virus guidelines, [18] the physician and patient ratio is minimum of 1:1000, whereas, 0.4/1000 ratio is available in India, it is very below the normal ratio, and therefore, there is an urgent need for studying the socioeconomic and environment in the two different cultural regions of south India and for mapping dengue and chikungunya transmission segments in the study region, hence, develop a GIS based decision making tool for dengue vector control, dengue epidemic surveillance, control and management at the national level [4-9, 13].

3. Material and methods

The Arc View 3.2, Arc View Spatial analysis and Arc View image analyst GIS was used for systematic grid sampling methods for conducting the reconnaissance survey and mapping the mosquito breeding habitats positives. GARMIN 12XL GPS was used to collect the mosquito reconnaissance survey for mosquito breeding habitats in the Pondicherry urban areas. The GIS based (0.5 km X 0.5 km) grid map was overlaid on the Pondicherry town digital map. The density of mosquito breeding habitats of dengue and chikungunya was mapped with graduated colors, using the quantile method. Based on the ward wise population density and mosquito breeding density map, 4 wards are selected from each blocks, and 10 number houses was selected from each ward for a systematic grid sampling and ground truth study, which was conducted in different parts of the town limits for reexamining and rechecking the mosquitogenic condition in each ward of the Pondicherry urban settlements.

3.1 Study design and sampling survey methods

The virtual Global positioning Systems (GPS) was used under the GIS umbrella for conducting systematic reconnaissance survey with 0.5 km interval (grid sampling procedures) for assessing the mosquitogenic condition [4-9] and for mapping the grid sectors positives for dengue and chikungunya vector mosquitoes (*Aedes aegypti* or *Ae. albopictus*) [3] breeding habitats (water storage vessels, plastic and cement containers, tires, plastic cups, coconut cells, tree holes, flower vessels, fridge, stone grinder, etc.,) with accurate site specifications. The map overlay analysis was performed for spatial queries to identify the areas vulnerable to probability of dengue and chikungunya disease transmission, and thus, proficient to produce the map for grid sector wise priority for planning for appropriate control measures to barricade the Aedes species mosquitoes breeding and to prevent the disease transmission in the Pondicherry urban (Fig 1 and 2).

Spatial data are collected through home interviews and inspection of living conditions in and outside the home in both the case and different ecological groups in the Pondicherry, India. The study is designed with comparatively high, moderate and low income economic indicators and living conditions. Though, the regions are relatively developed and economically wealth and development, however, the municipality areas in the urban settlement are experienced with the highest incidence of dengue fever and suffer severely with epidemic problems every year, since 2006. A GIS based systematic grid sampling design with 0.5 km distance is applied to field survey and hose hold data collection. The study sites cover 10% of the villages from each district and 10% of the wards / blocks will be selected from each urban centre, and 10% of the hose hold population to be covered for socioeconomic survey both in the rural and the urban settlements from each district. A hand held GPS has to be used for house hold field data collection, the hose hold of clinical case data and the field data. The socioeconomic and the environmental variables field data are collected using the structured questionnaire. The data will be captured in to the MS excel or geo-database engine for geospatial analysis and for mapping the spatial relationship between the socioeconomic, environmental variables and of vector breeding habitats, and hence, achieving the GIS based solution for dengue and chikungunya epidemic control and management in the Pondicherry Urban limit areas.

A GIS based systematic grid sampling design with 0.5 km distance is applied to field survey and hose hold data collection. The study sites cover 10% of the villages from each district and 10% of the wards / blocks will be selected from each urban centre, and 10% of the hose hold population to be covered for perception and knowledge on dengue vector breeding habitats and personal protection measures among the common people in the urban areas. A hand held GPS has to be used for house hold field data collection, the hose hold of clinical case data and the field data. The socioeconomic and the environmental variables field data will be collected using the structured questionnaire (Table 2 and 3). The data is captured in to the MS excel or geo-database engine for geospatial analysis and for mapping the spatial relationship between the socioeconomic, environmental variables and of vector breeding habitats, and hence, achieving the GIS based solution for dengue and chikungunya epidemic control and management in different landscape environment and the cultural regions in south India.

3.2 Aims and objectives

1. To applying systematic grid sampling procedure for reconnaissance survey for assessing the percentage of positive for dengue and chikungunya vector mosquito breeding habitats in the Pondicherry urban area.
2. To utilizing GIS for mapping the density of *Aedes* species mosquitoes breeding surface habitats in the city limits.
3. To analyze the people perception on dengue vector breeding habitats and protection measures against dengue vector mosquitoes biting in the urban agglomerations
4. To give solution and recommendation for *Aedes* species mosquito control measures based on the grid sectors density map of Pondicherry urban areas.

3.3 Study area

The study site, Pondicherry is the capital of Pondicherry Union Territory, which is located in the East coast of South India about 160 Km south of Chennai (formerly Madras), it geographically extends between 11o 53’ 45” N and 11o 58’ 55” N, 79o 46’ 15” E and 79o 50’ 50” E. It has the geographical area measured to 48.06 Sq. Km. Monsoon is experienced from October to December in every year. Total urban population is 516,985, (Males 260,482 and Females 256,503) and the total number of households is 101,481 (Census of India 2001).

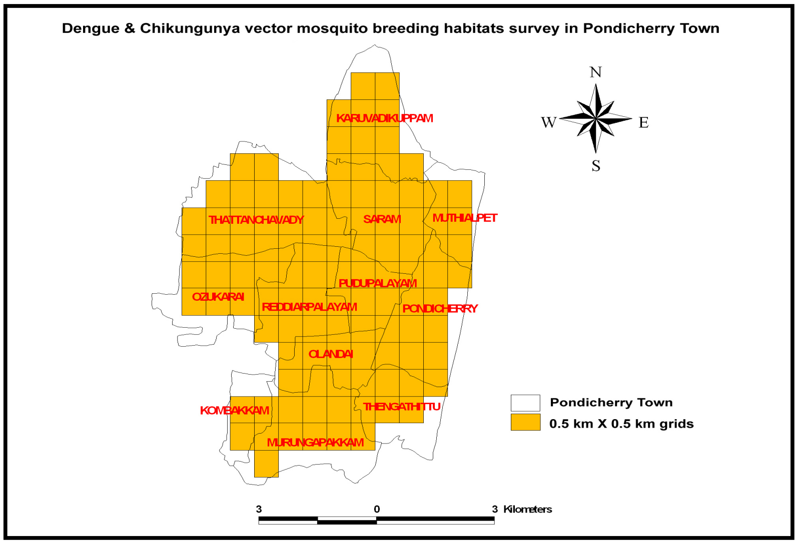

Fig 1: The GIS based grid map (0.5 km X 0.5 km) was overlaid on the block boundary of Pondicherry city map for housing survey for mapping Aedes species mosquitoes breeding habitats, using GPS

4. Result and Discussion

The dengue and Chikungunya vector mosquitoes (*Aedes aegypti* or *Ae. albopictus*) flight range between 200 meters – 400 meters, therefore, GIS was using for making (500 m X 500 m) 0.5 km grid map for the Pondicherry block boundary map. A systematic grid sampling was applied to conduct a rapid survey for mapping *Aedes* species mosquitogenic condition in the urban areas and the coordinates of sites of houses information with breeding habitats positive in the grid sectors was collected using GPS, and the mean value of positive habitats was analyzed by quintiles method for mapping the ground situation in Pondicherry town (Fig 2). The mosquito breeding habitats of dengue and chikungunya was mapped with graduated colors, using the quantile method. Based on the mosquito breeding density map, the 4 number of wards in each blocks was selected, and 10 number houses was selected from each ward for random sampling ground truth study, which was conducted in different parts of the town limits for reexamining and checking the mosquitogenic condition in each ward of the Pondicherry urban areas. The mean value of breeding habitats was calculated and it was assigned to the each grid cells for mapping the percentage of potential breeding habitats in Pondicherry town (Table 1, Fig. 2).

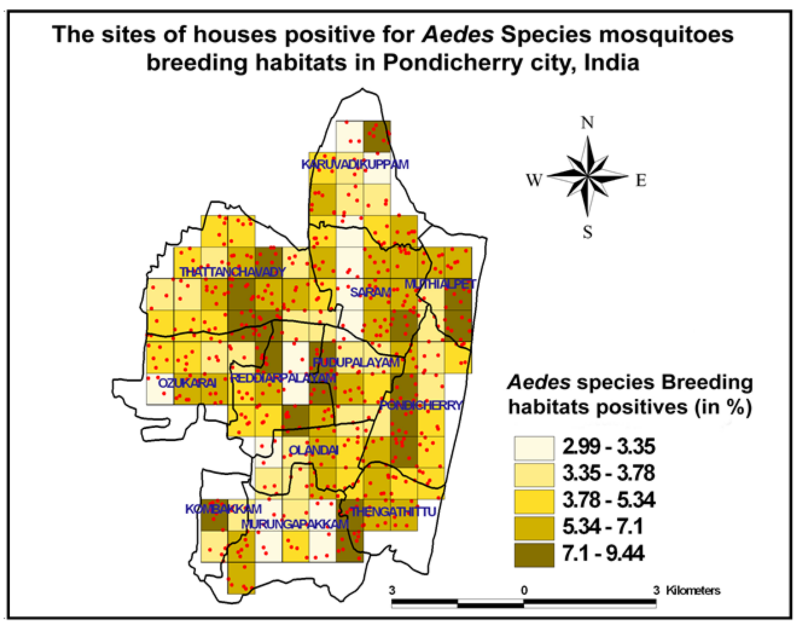

Fig 2: The density map of *Aedes* species mosquitoes breeding habitats (in %), based on the mean value of breeding habitats positives in the housing survey using GPS.

4.1 Study variables
All respondents in the research are included informed written consent after a full explanation of the study. During household visits, a trained team used a structured interview to obtain the following information about all participants: age (in years), gender, education level of head of household (years of schooling), whether or not they stay at home during the work day (yes/no), whether or not they spend any period of the day outside the neighbourhood (out of the District), working or studying (yes/no), previous report of dengue fever (self-reported yes/no), occupation, work and school addresses. Additional information about the household are obtained during the interview and referred to conditions within the preceding year (2006-2013): family income, household water delivery (centralized, well, water truck or "other"), experience with water shortages (yes/no/sometimes), whether household members practice water storage or not (yes/no), pronounced presence of garbage immediately surrounding the home (yes/no), garbage collection frequency (times per week), household experience with floods (yes/no), reports of mosquito bites during the day (yes/no), basic sanitation (indoor plumbing and centralized treatment/cesspool/open air), occurrence of mosquito breeding sites (yes/no), number of breeding sites, presence of larvae (yes/no) and home address (Table 2, and 3). During the visit, an entomological survey is carried out in the household and surroundings. Assessments of larvae densities (number of breeding sites for positive *Aedes aegypti* per 100 households) are analyzed (Table 1). This is the larva indicator that has been used as a parameter in most of the dengue fever control programs in the country. Household data quality is assured by randomly choosing 10% of the sample sites and repeating the entire survey, correcting any errors estimated.

4.2 Socioeconomic and environmental variables
The aim of this work is to estimate the spatial distribution of the risk of dengue fever in an area of continuous dengue occurrence. The environmental aspects of *Aedes* species vector mosquitoes breeding and the both dengue and chikungunya epidemics in Pondicherry town for the recent years. Many factors have been associated with circulation of the dengue fever virus and vector, although the dynamics of transmission are not yet fully understood. However, Dengue vector mosquito abundance is strongly associated with high human population density high building density, and low income neighbourhood community, low standard of living quality. . It is also well-known facts that high relative humidity with high temperatures and heavy rainfall has a positive impact on the breeding abundance, survival and longevity of living ecological conditions of vector mosquitoes [4-9]. A systematic housing and community survey was carried for the spatial assessment of density of immature dengue vector mosquitoes (*Ae. Aegypti*) in Pondicherry urban areas, 1317 containers were examined in the 400 houses of domestic and the peripheral domestic areas were surveyed, the immature stages of *Aedes* pupae were found in 70 containers (17.5%), and the total number of pupae is 929 is enough to high risk of epidemic transmission with 95% confidence CI (0.6042 to 0.7811) estimated error (< 5%), (Table 1). The results of socioeconomic, demographic, and environmental risk factors in association with dengue transmission considering people perception of the individual-level of awareness, the result shows that lack of knowledge of community people perception on dengue vectors breeding, epidemic transmission and protection or preventive measures and the number of unprotected containers in and around their houses (13%). Knowledge of development sites was positively associated with unprotected containers. No relationships existed between knowledge of dengue and adult mosquito reduction practices. A higher number of unprotected containers increased the likelihood of the house with one or more adult *Aedes aegypti*. Surprisingly, houses of respondents that used mosquito coils or had screening on doors and windows were significantly more likely infested with immature and adult dengue vector (*Ae. Aegypti*).
Perhaps, it is associated with socioeconomic and environmental variables which are responsible for risks of epidemic transmission are as follows: 1) Productivity of defective rainwater harvesting structures (RWHS) was fueled for dengue vector breeding and vector population profusion) and the huge number of breeding habitats in the domestic and peripheral domestic areas [14]. 2). The replacement of bottled cool drinks by consuming the tender coconut is welcome, but, a gigantic level of disposal of tender coconut cell found in the major cities of highways where the place of floating population was important for tourist attractions and, the vendors coffee bars, hotels and the petty shop business in the highways, serve them cool drinks and tea, coffee milk etc in the disposal cups. 3). There were a large number of domestic animals found (monkey, buffalo, donkey, dong, cat, rat, cow, goat, etc.) in the affected villages as known hidden host of dengue and chikungunya virus load [4-9, 13]. 4). The climate variables, temperature is experienced with a range of 22 ^{o}C to 31 ^{o}C, and relative humidity is 70% to 90%, and the rain fall providing most suitable environment for fueling the huge number of profusion of *Aedes* mosquito species breeding during the monsoon climate season of both southwest monsoon and the northeast monsoon from April to November and the vulnerability of epidemics reported during the months of mid July to Mid November period of the year, and the results obtained from the multivariate logistic regression model, the spatial association between the geo-climatic variables and the dengue and chikungunya epidemics has statistically significant [5-10]. 5). the dengue and chikungunya epidemics were reported from the coastal districts of Pondicherry was marked for prone to tsunami and cyclone, and hence, the abandon of houses and it was associated with the huge number of containers of damaged house hold things in the coastal areas suitable for *Aedes aegypti* mosquitoes breeding. 6). the lack of awareness of the common people about the vector mosquitoes, disease transmissions, vector breeding habitats and the source reduction of vector mosquitoes breeding habitats (13.89%) 7). Based on the newspaper source, moderate rain during the summer, a week interval of drinking water supply, absence / negligence of block wise periodical entomological survey of dengue vectors for source reduction of vector breeding and lack of awareness of the common people are causing the collective responsible for creating conducing environment for fuelling for propagation of dengue and chikungunya vectors and the disease epidemics since 2007. 9) It was observed that the larvae and pupae of both dengue and chikungunya vector species (*Aedes aegypti and Aedes Albopictus)* was found enormous numbers in the selected 12 wards of the 4 blocks (Table 1). The manmade environment in the urban / rural settlement areas (domestics and peripheral-domestics areas) was creating the conducing environment fuelling for propagation of chikungunya vector mosquitoes breeding [1, 2, 4-

[9, 13]. Considering socio-demographic, ecological, case severity, and household infestation variables, the relevant information are collected by in-home interviews and inspection of living conditions in and around the homes studied. The epidemic risk areas were classified as high risk, moderate, and low risk according to entomological survey data, and they were compared with controls through a quintile model for stratification of areas.

4.3 Dengue vector abundance

The present study is made for preventing the spread of dengue epidemic transmission, and to monitor its vector (*Aedes aegypti*) mosquito breeding environments, and a combination of environmental and socioeconomic variables to mapping areas at risk of epidemic transmission. These variables include mosquito counts, population density in inhabited areas, total populations in the blocks/wards, access to drinking water supply, Out of 12 wards, 4 wards (30%), found were identified as of high risk, namely, Villianur-Town, and followed by Villianur Pudu Nagar, Odiyampet, and Anna nagar; 4 wards (30%), were identified as of medium risk, namely, Jaya Nagarand followed by Olugrate, Moolakulam, and Kamban Nagar, remaining 3 wards (30%) were identified as of low risk and 1 ward (10%), Anna Nagar extention, were identified as of no risk. The GIS based systematic grid sampling methods used can be implemented as routine procedures for control and prevention. A concerted intervention in the medium- and high-risk level blocks identified in this study could be highly effective in dengue vector habitats source reduction towards the control and management of epidemic transmission in the urban areas.

5. Solution and recommendation

The virtual GPS under the GIS umbrella was used to conduct a rapid survey with 0.5 km distance interval (grid sampling procedures) for assessing the mosquito genic condition and for mapping the sectors positives for dengue and chikungunya vector mosquitoes (*Ae. aegypti* or *Ae. albopictus*) breeding habitats (water storage vessels, plastic and cement containers, tires, plastic cups, coconut cells, tree holes, flower vessels, fridge, stone grinder, etc.,) with accurate site specifications [3, 4, 13]. The adult mosquito trap has effective and efficient to collect the dengue and chikungunya vector adult mosquitoes. [9, 13] It is well known fact that the *Aedes* species (*Aedes aegypti or Ae. Albopictus*) adult mosquito's flight range from 200 meters to 400 meters, the sites were selected for setting up the adult mosquito trap with less than 1 km distance interval [4-9], so as enable it to collect the maximum of adult mosquitoes on all the four directions (i.e. the selection of alternative intersection points, based on the grids map with 0.5 km X 0.5 km distance, overlaid on the block boundary of Pondicherry urban map). The intensive and regular reconnaissance survey has to be conducted with the interval period of once in 10 to 15 days in the major cities for source reduction of dengue and chikungunya vector mosquito breeding habitats and keep away from aggressive day biting mosquitoes (*Aedes a*egypti and *Ae. Albopictus)* and making awareness among the people to prevention measures help to control the disease epidemics. The source reduction of mosquito breeding could be provided the safe environment and keep away from the dengue and chikungunya disease transmission in the Pondicherry urban areas. Thus, the utility of GIS technology for site selection of fixing the adult mosquito collection and the combined intensive vector control measures enable us to design a master plan for mosquito control in the city with low cost is achieved successfully [9, 13]. This information must be updated every 2 weeks/ fortnight of the every month and updating the field data in the web mapping GIS [3, 6-10, 13]. Web mapping GIS and dengue health information management systems for taking prevention measures to dengue epidemic control could be achieved [3-7].

Table 1: *Aedes* Species Mosquitoes Larval Indices

Sl. No	Area	No of houses searched	No of houses + ve for Larvae & pupae	No of containers searched	No of containers + ve for Larvae & Pupae	No of Pupae	House index (HI)	Container index (CI)	Breteu index (BI)	Pupal index (PI)
1	Moolakulam	10	5	17	5	53	50	29.41	50	530
2	Olugrate	10	8	127	10	57	80	7.87	100	570
3	Odiyampet	10	6	113	10	119	60	8.85	100	1190
4	Jaya nagar	10	3	161	3	64	30	1.86	30	640
5	Kambamnagar	10	3	206	5	53	30	2.43	50	530
6	Sultan pet	10	2	110	2	14	20	1.82	20	140
7	Villianur-Pudunagar	10	10	133	15	227	100	11.28	150	2270
8	Villianur-Town	10	7	166	15	241	70	9.04	150	2410

Table 2: Common people perception on dengue epidemic transmission and its vector mosquitoes breeding habitats

Epidemic Transmission by dengue vector mosquitoes	No. of Respondents	Percentage
Dengue	64	16
Chikungunya	56	14
Malaria	36	9
Filariasis	25	6.25
Dengue and Chikungunya	61	15.25
Chikungunya and malaria	28	7
Dengue, chikungunya and malaria	31	7.75
Dengue, chikungunya and filariasis	25	6.25

Dengue, chikungunya and diarrhoea	40	10
Dengue, chikungunya, malaria and filariasis	34	8.5
Modes of spread of dengue fever	**No. of Respondents**	**Percentage**
Mosquito bites	27	6.75
Air	6	1.5
Flies	7	1.75
Garbage	12	3
Mosquito bites and flies	25	6.25
Mosquito bites and air	25	6.25
Mosquito bites and garbage	43	10.75
Mosquito and water	36	9
Mosquito bites, water and person to person contact	61	15.25
Mosquitoes, water, personal contacts and garbage	37	9.25
Mosquito bites, water, food and personal contacts	34	8.5
Mosquito bites, Flies and air	47	11.75
Don't know	40	10

Modes of chikunqunya transmission	**No. of Respondents**	**Percentage**
Mosquito bites	46	11.5
Air	25	6.25
Flies	32	8
Garbage	9	2.25
Mosquito bites and flies	36	9
Mosquito bites and air	20	5
Mosquito bites and garbage	32	8
Mosquito and water	49	12.25
Mosquito bites, water and person to person contact	52	13
Mosquitoes, water, person to person contacts and garbage	22	5.5
Mosquito bites, water , food and person to person contacts	18	4.5
Mosquito bites, Flies and air	34	8.5
Don't know	25	6.25
Dengue vector mosquitoes breeding places	**No. of Respondents**	**Percentage**
Cement tanks	25	6.25
Plastic drums	40	10
Cement tanks and plastic drums	97	24.25
Cement tanks, plastic drums and aluminium utensils	115	28.75
Cement tanks, plastic drums, aluminium utensils, and other plastic containers	89	22.25
Don't know	34	8.5
Biting time of dengue vector *Aedes* mosquitoes	**No. of Respondents**	**Percentage**
Morning	40	10
Afternoon	70	17.5
Night	31	7.75
Morning and evening	75	18.75
Morning, Evening and night	34	8.5
Morning ,evening and afternoon	79	19.75
Any time	40	10
Don't know	31	7.75

Table 3: People perception for protection measures against mosquitoes biting

Personal protection measures against bite of mosquitoes	**No. of Respondents**	**Percentage**
Mosquito coil/mats/vaporizer	70	17.5
Mosquito net	45	11.25
Spray insecticides	60	15
Electrical Fans	38	9.5
Spray insecticides and fan	34	8.5
Spray insecticides and mosquito net	52	13
Mosquito net and mosquito coil/mats/vaporizer	45	11.25
Spray insecticides and mosquito net and fans	40	10
Don't know	16	4
Ways to prevent mosquitoes breeding	No. of Respondents	Percentage

Cleaning of houses	46	11.5
Spray insecticides	57	14.25
Burn garbage	22	5.5
Change of stored water frequently, and spray insecticides	40	10
Containers covered with water and spray insecticides	25	6.25
Remove stagnant frequently and cover water filled containers	16	4
Cleaning of houses and spray insecticides	61	15.25
Cleaning of houses and burn garbage	31	7.75
Burn garbage and spray insecticides	34	8.5
cleaning of houses, burn garbage and spray insecticides	43	10.75
Don't know	25	6.25

6. Conclusion
GIS based master plan for mosquito control was found to be not only very low cost, but also rapid methods and accuracy, which need to be used in most of the metropolitan cities in India. The unplanned and the sea change population was creating conducing environment for fueling to huge amount of vector mosquito breeding in the cities in India. The virtual GPS under the GIS umbrella was used to conduct a rapid survey with 0.5 km distance interval (grid sampling procedures) for assessing the mosquitogenic condition and for mapping the sectors positives for dengue and chikungunya vector mosquitoes (*Aedes aegypti* or *Ae. albopictus*) breeding habitats (water storage vessels, plastic and cement containers, tires, plastic cups, coconut cells, tree holes, flower vessels, fridge, stone grinder, etc.,) with accurate site specifications. To beyond the all these problems, the available GIS technique was found useful and has provided the datum of useful guidelines for giving priority with site specification of the areas to fixing the adult *Aedes* mosquitoes trap with <1 km distance interval for Aedes species adult mosquito collection, and making awareness among the people for source reduction of mosquito breeding to control the present situation and management of the dengue epidemics in the Pondicherry urban areas. The result provided that socioeconomic and environmental condition in the study region, estimates for identifying the socioeconomic and environmental key variables associated with dengue and chikungunya epidemics, visualising the risk of epidemic and vulnerable areas, estimates the population at risk of exposure to the epidemic, prioritization of areas / wards / blocks for vector control and management, GIS based spatial solution for vector control and management and a protective measures against dengue vector biting, and to be calling attention to the importance of dengue transmission at work, schools and other public spaces. The spatial component of transmission could be isolated, after controlling for variables of interest, thus contributing to future studies that consider new hypotheses and added variables in the geospatial analysis to classify the areas as whole at different level risk of epidemic transmission.

7. References

1. Adriano Mondinil and Francisco Chiaravalloti Neto, Socioeconomic variables and dengue transmission. Rev Saúde Pública 2007; 41(6).
2. Almeida AS, MedronhoRde A, Valencia LI. Spatial analysis of dengue and the socioeconomic context of the city of Rio de Janeiro (Southeastern Brazil). Rev Saude Publica 2009; 43(4):666-73.
3. Gluskin RT, Johansson MA, Santillana M, Brownstein JS. Evaluation of Internet-Based Dengue Query Data: Google Dengue Trends. PLOS Neglected Tropical Diseases 2014; 8(2):e2713.
4. Khormi HM, Kumar L. Assessing the risk for dengue fever based on socioeconomic and environmental variables in a geographical information system environment Geospatial Health 2012; 6(2)171-176.
5. Palaniyandi M. Remote Sensing and GIS for mapping the geographical distributions and the ecological aspects of vector borne diseases in India: review article. Journal of GIS India 2013; 22(1):4-7.
6. Palaniyandi M, PH Anand. Spatial Cognition: A geospatial analysis of vector borne disease transmission and the environment, using Remote Sensing and GIS: A review article. International Journal of Mosquito Research 2014; 1(3):39-54.
7. Palaniyandi M. Need for GIS based dengue surveillance with Google internet real time mapping for epidemic control in India. International Journal of Geomatics and Geosciences 2014; 4(4)14.
8. Palaniyandi M. Web mapping GIS: GPS under the GIS umbrella for *Aedes* species dengue and chikungunya vector mosquito surveillance and control International Journal of Mosquito Research 2014; 1(3):18-25.
9. Palaniyandi M. The environmental aspects of dengue and chikungunya outbreaks in India: GIS for epidemic control, International Journal of Mosquito Research 2014; 1(2):38-44.
10. Palaniyandi M. GIS based site selection for fixing UV light adult mosquito trap and gravity adult mosquito trap for epidemic control in the urban settlements. International Journal of Scientific and Technology Research Vol 2014; 3(8):156-160.
11. Winch PJ, Leontsini E, Jose´ G, Rigau-Pe´ R, Ruiz-Pe´ MR, Clark GG *et al*. Community-Based Dengue Prevention Programs in Puerto Rico: Impact on Knowledge, Behavior, and Residential Mosquito Infestation. Am J Trop Med Hyg 2002; 67(4):363-370
12. Prasad R. Dengue Nation: the rise and spread of a viral challenges, *The Hindu,* (National Daily News Paper), 2012.
13. Cordeiro1 R, Donalisio1 MR, Andrade VR, Mafra1 ACN, Nucci LB, Brown JC *et al.* Spatial distribution of

the risk of dengue fever in southeast Brazil, 2006-2007, BMC Public Health 2011, 11:355.
14. Sivagnaname N. Urgent need for a permanent dengue surveillance system in India. Current Science 2012; 102(50):672-675.
15. Koyadun S, Butraporn P, Kittayapong P. Ecologic and Sociodemographic Risk Determinants for Dengue Transmission in Urban Areas in Thailand, Interdisciplinary Perspectives on Infectious Diseases, 2012, 12.
16. Marriappan T. Defective rainwater harvesting structure and dengue vector productivity compared with peridomestic habitats in a coastal town in southern India Journal of Medical Entomology 2008; 45(1):148-56.
17. The report of National Vector borne Disease Control Programme (NVBDCP), Ministry of Health & family Welfare, The Union Government of India, 2012.
18. WHO (World Health Organization) Dengue report, 2010.