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Ecological and demographic factors associated with dengue virus incidence in Cagayan de Oro city, Philippines: a geographic information system application

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Abstract

Dengue fever is the most widespread mosquito-borne viral disease globally. Transmission of dengue virus is essentially influenced by climatic factors and there is much concern as to whether climate change would spread the disease to areas currently unaffected. The main aim of this study was to analyze the incidence of dengue virus in Cagayan de Oro City and to determine the geographic and ecological factors associated with dengue disease. Dengue fever incidence of 42 barangays, monthly rainfall, annual temperature, precipitation, age and gender distribution of dengue fever cases were determined from 2014-2016. Areas in Cagayan de Oro with incidence of dengue were identified based on ecological and demographic factors. The data showed that rainfall, temperature, age, gender and the actual location of respondents affected by dengue have higher influence on dengue incidences. Population and house density has revealed that dengue generally occurred in areas with high population, thus contribute to high-risk area such as neighboring community and households. Further studies on the development projection map on the basis of geo-tagging of the actual location of respondents affecting dengue virus and the flying distance of mosquito are highly recommended to significantly continue monitoring and surveillance of the affected barangays. The incidence of dengue is continues to be emerging over the next few years, thus requires continuous monitoring and surveillance especially in barangays in Cagayan de Oro with high dengue incidence.

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Introduction

Dengue fever is a disease in humans transmitted by *Aedes aegypti* mosquito (Maidana & Yang, 2008). The incidence of dengue virus cases have been on a rise in the recent decade and currently present in more than 100 countries (Buonsenso *et al.*, 2014; Villabona-Arenas & Zanotto, 2013). The world is facing a great challenge from this emerging disease which has become a major international public health concern(Anders *et al.*, 2011; Bouzid, Colón-González, Lung, Lake, & Hunter, 2014; Villabona-Arenas & Zanotto, 2013). There have been outbreaks and high incidence of dengue disease in tropical and subtropical regions around the world and our country, Philippines is not an exemption.

Various factors affect the spread and incidences of dengue have been shown in various literatures over the world (Su, 2008). Environmental changes such as ecological like increased rainfall (Su, 2008), drought or higher temperature(Pham, Doan, Phan, & Minh, 2011) have a major contribution to the pattern of dengue incidence and can also affect the behavior and geographical distribution of mosquitoes. This dengue virus carrying mosquitoes are sensitive to changes in rainfall and temperature. Consequently, their transmission intensity may be regulated by weather and climate (Johansson, Dominici, & Glass, 2009).

Urbanization also influence the risk of acquiring dengue virus and it was shown that in a given country, dengue risks are amplified in urbanized communities (Bouzid *et al.*, 2014; Wilder-Smith & Gubler, 2008). The risk for acquiring dengue disease can be influenced by changes in human behavior such as increased exposure to mosquitoes while being outside, movement from one place to the other, suspension of disease control activities, and overcrowding (Bouzid *et al.*, 2014; Ooi & Gubler, 2009b). Changes in habitat can also influenced risk transmission, since it can promote mosquito breeding such as landslides, deforestation, river damming and re-routing of water, or even various environmental changes (Ooi & Gubler, 2009b). Furthermore, several factors have contributed to dengue incidence, but the main drivers have been human population growth, unplanned urban growth and lack of effective mosquito control that empower mosquitoes and making the disease vectors worse (Thai & Anders, 2011).

Disease does not occur sporadically across the landscape; rather there are physical characteristics of a place such as topography, land use, temperature and vegetation that contribute to disease expression (Pavlovskiĭ, 1966). To a greater extent, the spread of dengue disease is influenced on the relationship among the vector, the environment, and the population. Hence, each element is equally important because each relies on the others.

Moreover, several studies on dengue disease have been conducted both in local and foreign settings, however, high dengue incidence continue to occur every year and the disease is extending to other geographical areas in the country. In the absence of with effective drugs, one of the best strategic option is disease management by identifying first the geographic and ecological factors that is associated with dengue virus. Thus, this study seeks to analyze the incidence of dengue virus in Cagayan de Oro City and to determine geographic and ecological factors associated with dengue disease. Hence, it is imperative that this study requires an empirical data as an input to the Department of Health data based on public health and preventive medicines vis-a-vis its geological and ecological characteristics.

Materials and methods

This research employed a descriptive method with massive utilization of GPS/GIS (Arc GIS) in the conduct of the study and showed the distribution of dengue incidence and the possible factors that affect the (re)-emergence of dengue in a defined population, obtained additional information relating to the onset and (re)-emergence of dengue and determined the current status of Cagayan de Oro City, thus, led to important risk interventions or protective measures of the dengue disease. Other source of data such as temperature, rainfall, topography, land use classification and reported incidence of Dengue was also included.

Study Area

Cagayan de Oro (CDO) is the gateway to Northern Mindanao. It is geographically nestled between the central coastline of Macajalar Bay (north), Bukidnon and Lanao del Norte (south), municipality of Opol (west), and municipality of Tagoloan (east). Cagayan de Oro city has a land area of 57,851 hectares and characterized by a narrow coastal plain along the Macajalar bay and by highland areas separated by steepy inclined slope (Walag & Canencia, 2016). The lowland is relatively flat and its elevation is not more than 10 meters above the mean sea level. Cagayan de Oro is a highly urbanized city of Misamis Oriental which comprises of 80 barangays. Based on the 2010 Census of Population and Housing (CPH), it has a total population of 602,088. The increase in population count from 2000 to 2010 explained the annual growth rate of 2.69%, hence the population of Cagayan de Oro City is projected to be doubled in 26 years. The climate in Cagayan de Oro is tropical, it has significant rainfall most of the months, and a short dry season. The average annual temperature is 32.4˚C and average monthly rainfall is 139.10 mm (City Planning and Development Office, 2016). Furthermore, the general topographic features of CDO are found in Fig. 1.

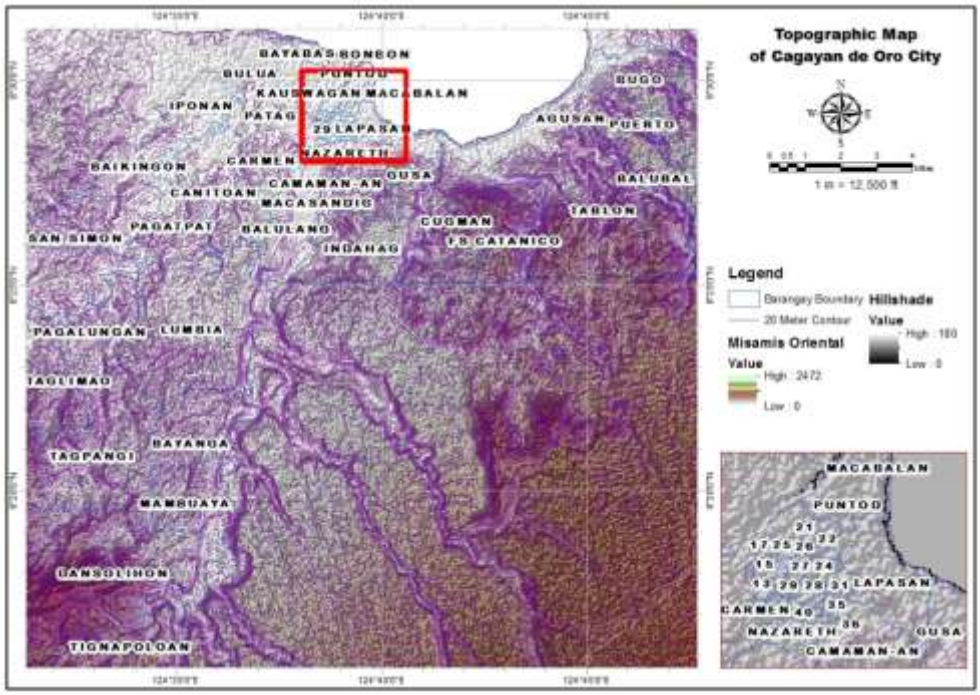

Fig. 1. Topographic Map of Cagayan de Oro City.

Data Collection

Dengue incidence data were gathered from the Department of Health Region 10, (2014-2016). This data includes information about all the suspected and confirmed Dengue cases reported during the year 2014 to 2016 in the city of Cagayan de Oro. Data was available with 5,475 suspected or confirm dengue cases in the 41 barangays in Cagayan de Oro City as illustrated in Fig. 2. Using the Slovin's formula, the 301 respondents were randomly selected for an interview. The major factors considered for analysis of the (re)-emergences of Dengue cases were geographical location, population and house densities, rainfall and temperature. Climatic and demographic data were collected from the other related agencies.

Primary data were collected through a field survey/interview. A questionnaire was designed to acquire information on family details, human dwellings, occupation, awareness and knowledge about Dengue disease, program/management done by other concern agencies and health care. Other sources of data were also included such as

demographic information about the city, its rainfall and temperature, physical environment (land use, land cover), topographic and administrative map were also used to analyze dengue incidence cases.

Data Analysis

Data analysis was focused on the three (3) major components considered in this study; the ecological factors (land use, topography, water source, rainfall and temperature), health factor (existing dengue incidence data), and the demographic factors (age and gender).

Results and discussion

Dengue Incidence Distribution of Cagayan de Oro City

Geographic distribution of dengue incidence in CDO were determined using the available data from the Department of Health Region 10 and was further classified and categorized into different identified urban and rural barangays. As shown in Fig. 2, the distribution of Dengue virus incidence in the identified barangays in Cagayan de Oro City, Philippines from year 2014-2016 indicates a variation of prevalence among the different barangays.

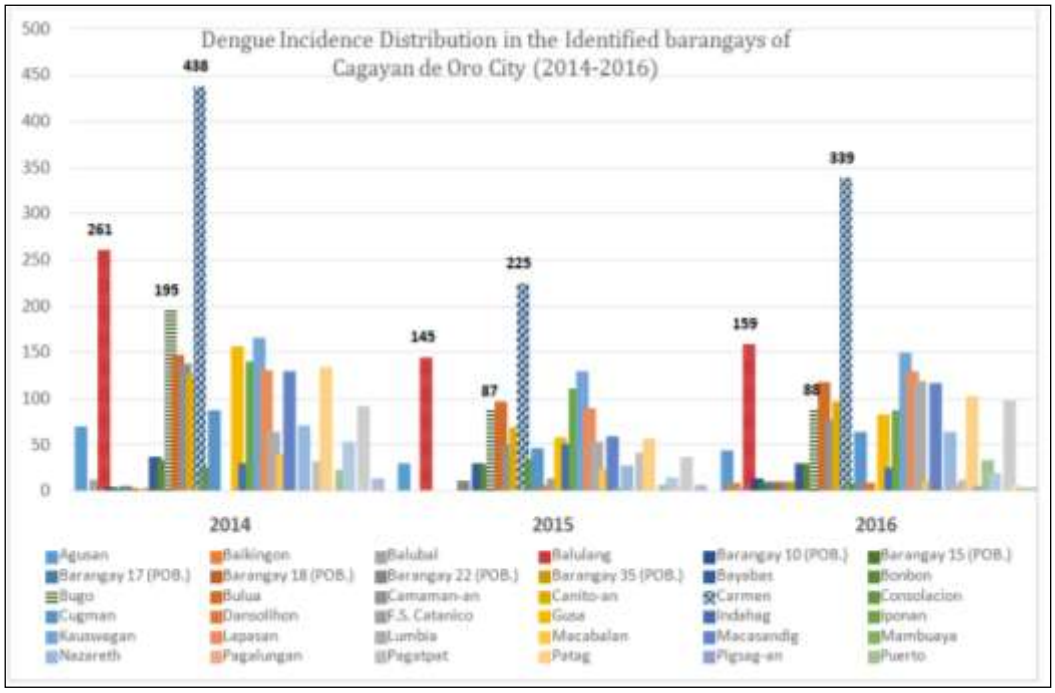

Fig. 2. Distribution of Dengue Incidence in the identified barangays of Cagayan de Oro City.

As presented in Fig. 2, Forty-two (42) barangays from 2014-2016 in CDO had cases of dengue. Barangay Carmen (1,002 dengue cases) consistently displayed the highest incidence among the barangays, seconded by barangay Balulang with 565 dengue cases. For three (3) years, a total of 6,708 dengue cases in CDO were recorded by the Department of Health Region 10. Concurrently, barangay Carmen is the most populous followed by barangay Balulang, it is inhabited by different class of people and informal settlers. Several commercial establishments, schools, supermarkets, subdivisions can also be found in this barangay. Moreover, high reported dengue cases in these barangays indicate that the area is crowded, and many people living within the short flight range of the mosquitoes and its breeding source have a great possibility and could be highly exposed to transmission of dengue disease.

The results are similar to the results of various studies around the world where high degree of urbanization is correlated to high incidence of dengue virus (Bouzid *et al.*, 2014; Ooi & Gubler, 2009a; Pham *et al.*, 2011; Thai & Anders, 2011). This can also be observed in Fig. 3, showing a 500 meter buffer from the identified affected respondents.

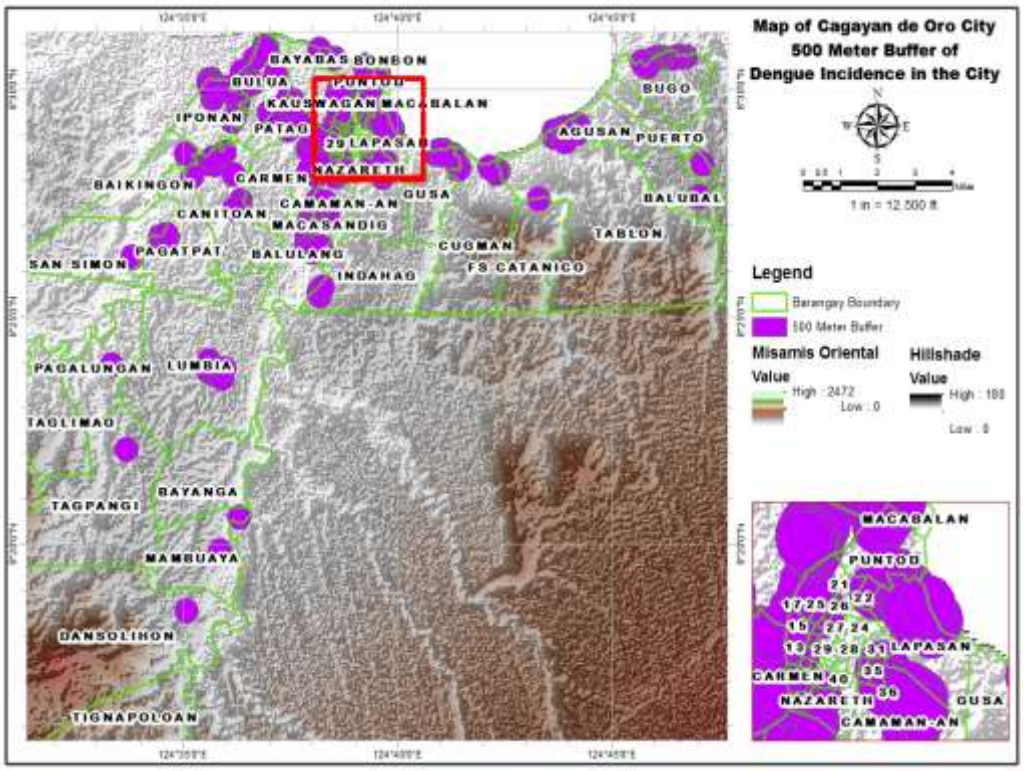

Fig. 3. 500 meter Buffer Map of Dengue Incidence in Cagayan de Oro City.

Land cover and the respondents affected with dengue as the base, was buffered to determine the vulnerability and exposure of the neighboring community or residents on dengue incidence. Buffering on dengue incidence was done based on the flying range/distance and highly populated area as breeding place of the dengue incidence.

The flight distance of *Aedes aegypti* could range from a few meters to more than 50 meters in a closed urban environment (Reiter, Amador, Anderson, & Clark, 1995). Meanwhile, other barangays in CDO especially in upland areas such as Mambuaya, Pigsag-an, San Simon, Baikingon, Tagpangi and Tuburan had less dengue incidence (<10), since, their houses are not interconnected or near from another.

The distance and separate nature of houses limits the flight range of *Aedes aegypti* and reduces the transmission of the disease which explains the low incidence of dengue virus in the barangays mentioned above. Residential areas like the downtown of CDO, as enclosed in the red box, is mostly prone to dengue virus due to urbanization and pollution, among many other factors, which is similar to the study conducted by Hazrin *et al*., (2016).

Ecological Related Factors Associated with Dengue Incidence in Cagayan de Oro City

Dengue incidences for the year of 2014-2016 were also compared in terms of its relation to monthly rainfall and temperature. As shown in the Fig.s 4-6, the highest incidence of dengue was consistently obtained on the month of September while the month of May was the lowest incidence. It was further observed that Dengue transmission occurs all year round but its seasonal peak started during the 3rd quarter and decreasing on the 2nd quarter of the each year. It implies that, temperature and rainfall are critical to mosquito survival, reproduction and development can influence the abundance of mosquitoes (Bouzid *et al*., 2014; Johansson *et al*., 2009). Further, higher temperatures reduce the time required for the virus to replicate and disseminate in the mosquito and if the climate is too cold, viral development is slow and mosquitoes are unlikely to survive long enough to become infectious (Johansson *et al*., 2009).

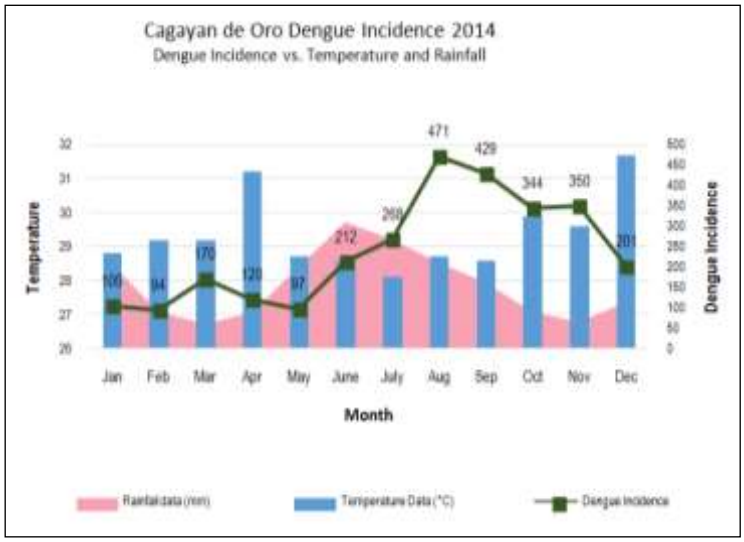

Fig. 4. Dengue Incidence 2014 (monthly basis) in relation to Temperature and Rainfall.

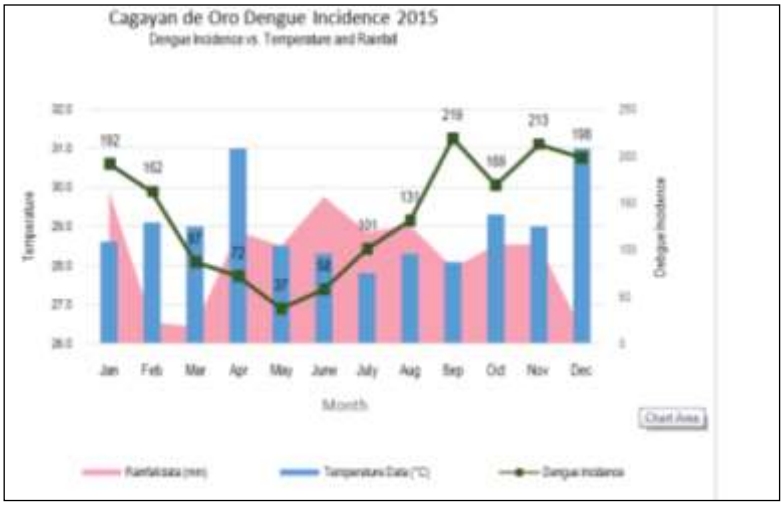

Fig. 5. Dengue Incidence 2015 (monthly basis) in relation to Temperature and Rainfall.

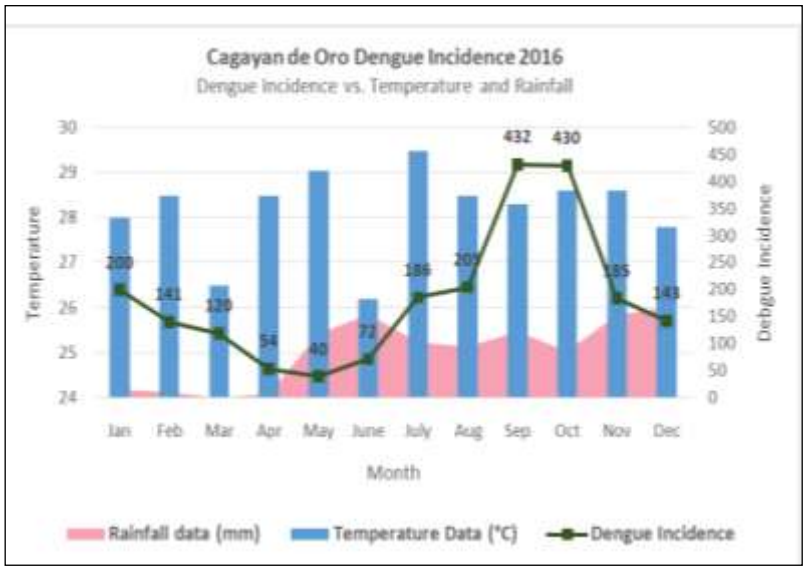

Fig. 6. Dengue Incidence 2016 (monthly basis) in relation to Temperature and Rainfall.

GIS application was also done to present dengue incidence and annual temperature. Fig. 7, 8 & 9 displays the annual temperature and Fig. 10, 11 and 12 shows the rainfall pattern in the barangays of CDO.

The Fig. below depicts the annual average temperature for the year 2014 (29.4°C), 2015 (29°C) and 2016 (28.2°C) respectively. It was noticed that there was a slight decreased in the temperature pattern from 2014 to 2016.

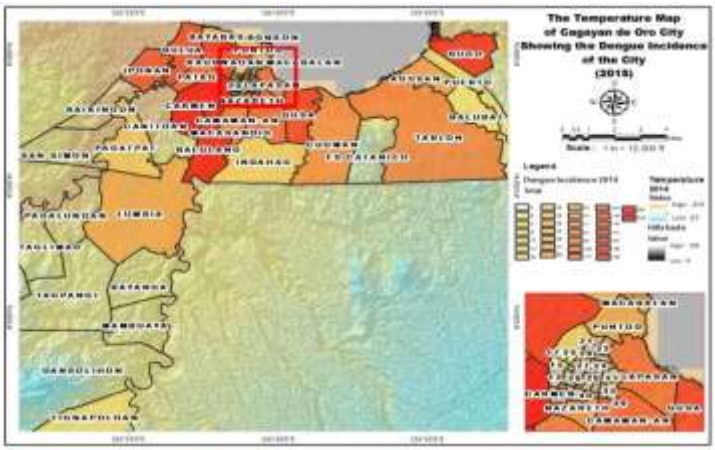

Fig. 7. Temperature map showing dengue incidence in Cagayan de Oro City (2014).

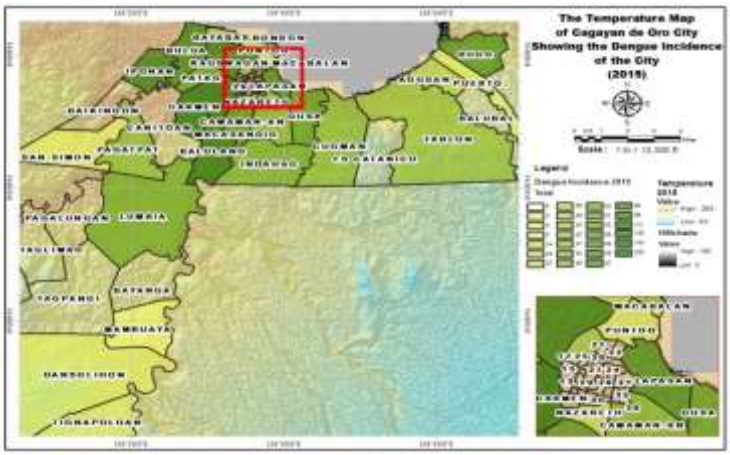

Fig. 8. Temperature map showing Dengue Incidence in Cagayan de Oro City (2015).

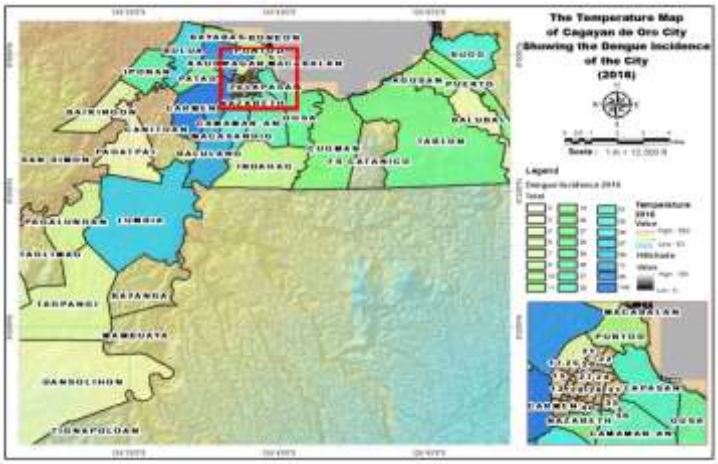

Fig. 9. Temperature map showing Dengue Incidence in Cagayan de Oro City (2016).

Furthermore, the barangay with high dengue incidence is in the lowland area such as Barangays Carmen and Kauswagan. It was observed that Cagayan de Oro experienced less rainfall in the year 2016 with an average annual rainfall of 86.47 mm compared to 2015 (94.9 mm) and the highest was in the year 2014 (156.2mm). Thus, this supports idea that, the strength of the association between monthly changes in temperature and rainfall, and the monthly changes in dengue incidence varies on the difference in local climate (Johansson *et al.*, 2009; Su, 2008). Furthermore, diseases like dengue may be particularly responsive to both periodic variation and sustained local climate changes, because vector biology and viral replication are both temperature-dependent and moisture-dependent (Thai & Anders, 2011).

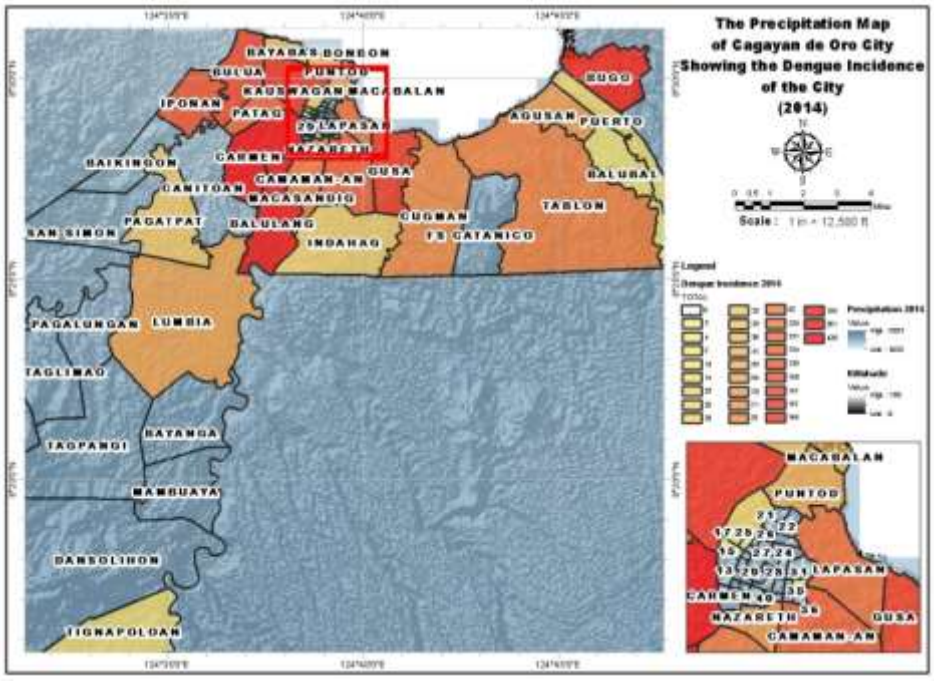

Fig. 10. Precipitation map showing Dengue Incidence in Cagayan de Oro City (2014).

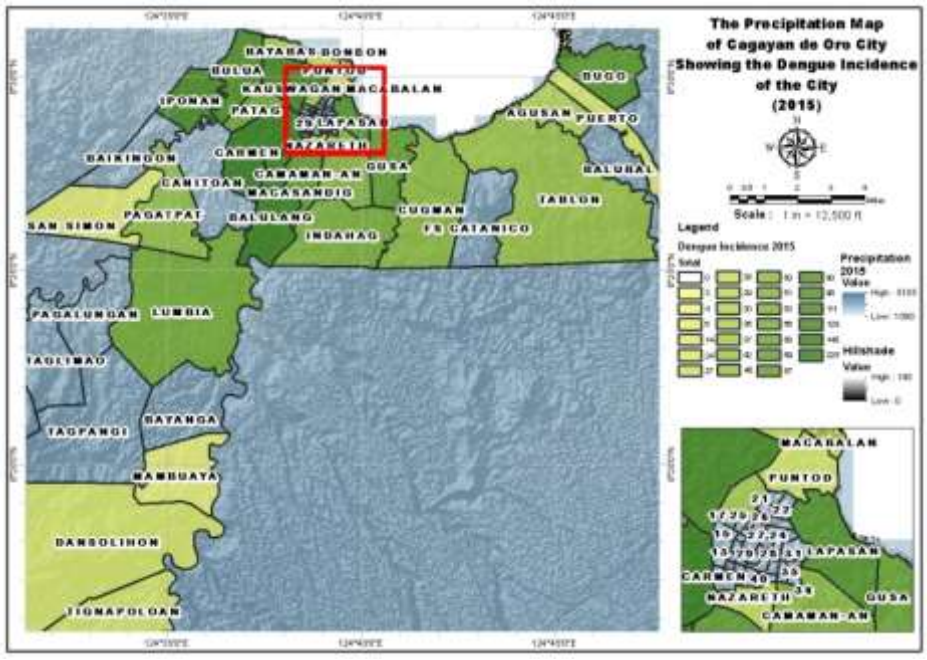

Fig. 11. Precipitation map showing Dengue Incidence inCagayan de Oro City (2015).

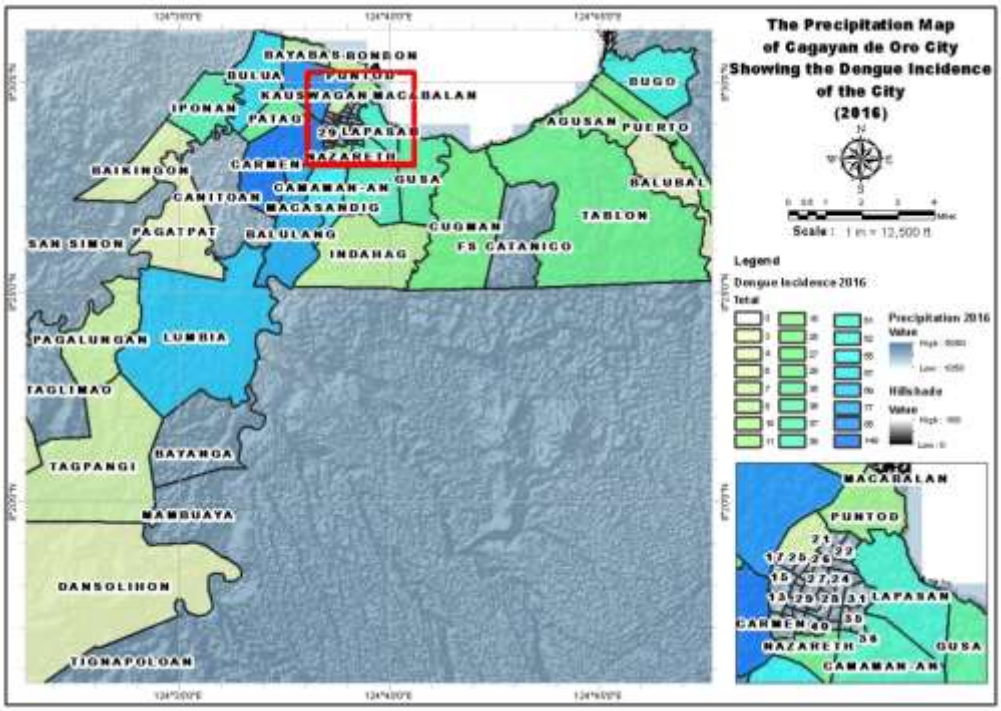

Fig. 12. Precipitation map showing Dengue Incidence in Cagayan de Oro City (2016).

Demographic Factors Associated Dengue Incidence in Cagayan de Oro City

Age Distribution

Age distribution of dengue incidence in Cagayan de Oro City is describe in Fig. 13. Among the respondents (n=301), age 0-12 y.o. (103=34%) displayed the highest dengue incidence, followed by age 20-29 y.o. (72=24%) and age 13-19 y.o (59=20%). Senior citizens with an age group of 60-79 y.o. comprised 19 (6%) respondents.

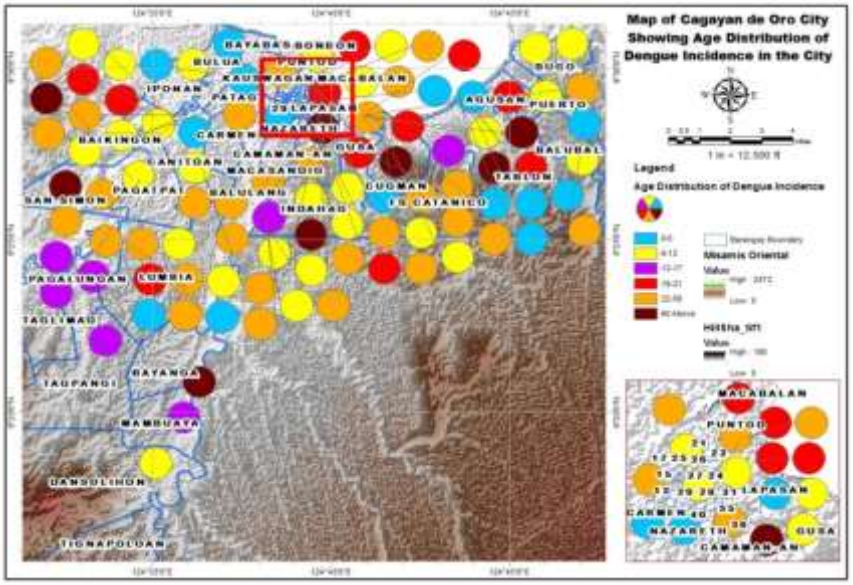

Fig. 13. Age Distribution of Dengue Incidence in Cagayan de Oro City.

Likewise, the most vulnerable age group are the infants, children under 5, women of childbearing age, and the elderly due to their difference in immunity, mobility, contact patterns and health status. According to García-Rivera, Rigau-Pérez, Garcia-Rivera, & Rigau-Perez (2003), Elderly are actually

more likely than children and younger adults to develop severe illness when infected with dengue virus similar to infants. Hence, awareness of the affected age-pattern is essential for public health monitoring and efficiency of preventive strategies. Similarly, in the study conducted in Vietnam, majority of those suffering from dengue virus are children aging 6-10 years old and mortality was the highest. Furthermore, young children had the highest risk of death when suffering from dengue virus (Anders *et al*., 2011).

Gender Distribution

Fig. 14 presents the respondents' gender distribution of Dengue incidence in CDO. The map shows, among the 301 respondents,58% (174) of the respondents are female and male with 42% (127). Dengue infection was significantly more prevalent among females, since, they are the one who often stays at home and takes care of the family and do some household chores, buying groceries and go to supermarkets, etc. In contrast, males had a stronger immunity and can have fast recovery in their illnesses.

The results of the study is similar to Anders *et al*., (2011), where majority females had higher risks of dengue virus. However, there were no other statistically significant differences in the gender characteristics of respondents that were affected by dengue virus.

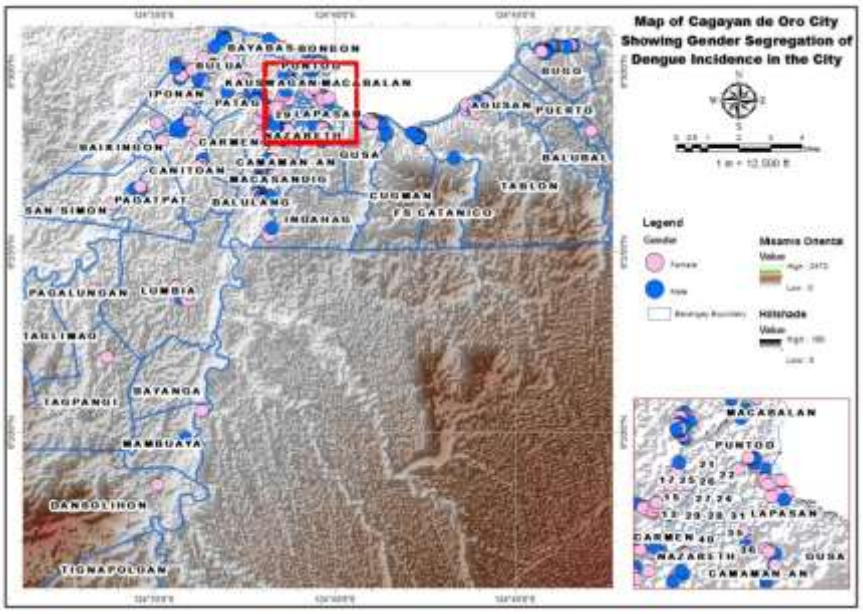

Fig. 14. Gender Segregation Map of Dengue Incidence in Cagayan de Oro City.

Conclusion and recommendation

Areas in Cagayan de Oro with incidence of dengue were identified based on ecological and demographic factors. The data showed that rainfall, temperature, age, gender and the actual location of respondents affected by dengue have higher influence on dengue incidences. Population and house density has revealed that dengue generally occurred in areas with high population, thus contribute to high-risk area such as neighboring community and households. No available serological test laboratory for Dengue virus to confirm the suspected dengue cases in CDO. As such, it very difficult to identify Dengue serotype and other similar disease cause by *Aedes aegypti* such as chikungunya, zika and malaria, hence signs and symptoms of the disease are very similar. Projection map on the basis of geo-tagging of the actual location of respondents affecting dengue virus and the flying distance of mosquito are significantly valuable for continuous monitoring and surveillance of the affected barangays. The incidence of dengue had continue to emerge over this past few years, it requires continuous monitoring and surveillance especially in barangays in Cagayan de Oro with high dengue incidence.

References

Anders KL, Nguyet NM, Chau NVV, Hung NT, Thuy TT, Lien LB, Simmons, CP. 2011. Epidemiological factors associated with dengue shock syndrome and mortality in hospitalized dengue patients in Ho Chi Minh City, Vietnam. The American Journal of Tropical Medicine and Hygiene, **84(1),** 127-134.
http://doi.org/10.4269/ajtmh.2011.10-0476.

Bouzid M, Colón-González FJ, Lung T, Lake IR, Hunter PR. 2014. Climate change and the emergence of vector-borne diseases in Europe: case study of dengue fever. BMC Public Health, **14,** 781. http://doi.org/10.1186/1471-2458-14-781.

Buonsenso D, Barone G, Onesimo R, Calzedda R, Chiaretti A, Valentini P. 2014. The re-emergence of dengue virus in non-endemic countries: a case series. BMC Research Notes, ***7*(1),** 596. http://doi.org/10.1186/1756-0500-7-596.

City Planning and Development Office. 2016. Annual Report. Cagayan de Oro City.

Departm**ent of Health Region 10.** 2014. Disease Surveillance Report. Regional Epidemiology, Sruveillance, and Disaster Response Unit, Regional Office 10, Northern Mindanao.

García-Rivera EJ, Rigau-Pérez JG, Garcia-Rivera EJ, Rigau-Perez JG. 2003. Dengue severity in the elderly in Puerto Rico. Revista Panamericana de Salud Publica = Pan American Journal of Public Health, **13(6),** 362-368. http://doi.org/10.1590/S1020-98920030005000004.

Hazrin M, Hiong HG, Jai N, Yeop N, Hatta M, Paiwai F, Othman W. 2016. Spatial Distribution of Dengue Incidence : A Case Study in Putrajaya. Journal of Geographic Information System, 2016, 8, 89-97, (February), 89-97. http://doi.org/10.4236/jgis.2016.81009.

Johansson MA, Dominici F, Glass GE. 2009. Local and global effects of climate on dengue transmission in Puerto Rico. PLoS Neglected Tropical Diseases, **3(2).**
http://doi.org/10.1371/journal.pntd. 0000382.

Maidana NA, Yang HM. 2008. Describing the geographic spread of dengue disease by traveling waves. Mathematical Biosciences, **215(1),** 64-77. http://doi.org/10.1016/j.mbs.2008.05.008.

Ooi E-E, Gubler DJ. 2009a. Dengue in Southeast Asia: epidemiological characteristics and strategic challenges in disease prevention. Cadernos de Saude Publica/Ministerio Da Saude, Fundacao Oswaldo Cruz, Escola Nacional de Saude Publica, 25 Suppl **1,** S115-S124.
http://doi.org/10.1590/S0102-311X20090 01300011.

Ooi E-E, Gubler DJ. 2009b. Global spread of epidemic dengue: the influence of environmental change. Future Virology **4,** 571–580.
http://doi.org/ 10.2217/fvl.09.55.

Pavlovskiĭ E. 1966. Natural nidality of transmissible diseases, with special reference to the landscape epidemiology of zooanthroponoses. Illinois: University of Illinois Press.

Pham HV, Doan HTM, Phan TTT, Minh NNT. 2011. Ecological factors associated with dengue fever in a Central Highlands province, Vietnam. BMC Infectious Diseases **11(1),** 172.
http://doi.org/10. 1186/1471-2334-11-172.

Reiter P, Amador M, Anderson R, Clark, G. 1995. Short report: dispersal of Aedes aegypti in an urban area after blood feeding as demonstrated by rubidium-marked eggs. American Journal of Tropical Medicine Hygeine **52(2),** 177-179.

Su GLS. 2008. Correlation of climatic factors and dengue incidence in Metro Manila, Philippines. Ambio **37(4),** 292-4.
http://doi.org/10.1579/00447447(2008)37[292:COCFAD]2.0.CO;2.

Thai KTD, Anders KL. 2011. The role of climate variability and change in the transmission dynamics and geographic distribution of dengue. Experimental Biology and Medicine (Maywood, N.J.) **236(8),** 944-954.
http://doi.org/10.1258/ebm.2011.010402.

Villabona-Arenas CJ, Zanotto PM, de A. 2013. Worldwide spread of Dengue virus type 1. PloS One **8(5),** e62649. http://doi.org/10.1371/journal.pone. 0062649.

Walag AMP, Canencia MOP. 2016. Physico-chemical parameters and macrobenthic invertebrates of the intertidal zone of Gusa, Cagayan de Oro City, Philippines. AES Bioflux, **8(1).** Retrieved from http://www.aes.bioflux.com.ro.

Wilder-Smith A, Gubler DJ. 2008. Geographic Expansion of Dengue: The Impact of International Travel. Medical Clinics of North America. http://doi.org/10.1016/j.mcna.2008.07.002.