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Geo-Spatial Dynamics of COVID-19 Pandemic Onset in Davao City

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ABSTRACT

Davao City, a major urban center in the Philippines with its various landforms and population distribution has been affected by COVID-19. This study aimed to identify and locate areas with COVID-19 cases in Davao City, create a location map of COVID-19 cases in Davao City and determine association between number of COVID-19 cases and population density. Data were obtained from the Philippines Statistics Authority, Davao City LGU and, the Department of Health Davao Region. QGIS application was used to generate location maps of COVID-19 cases and Pearson r correlation was the statistical method used. Most of the COVID-19 occurrence are in Poblacion, Talomo, Agdao and Buhangin. areas with high population densities record the high occurrence of COVID-19 cases There is a high correlation between number of COVID-19 infection and population densities for this study. This indicates that dense population may have contributed to the spread of the COVID-19 infection in the city. The occurrence of population densities in Davao City should be addressed to prevent public health threats brought about by infectious diseases such as COVID-19.

Keywords: COVID-19, Davao City, Urban Center, Correlation, Population Density

INTRODUCTION

There is a new public health crisis threatening the world with the emergence and spread of the 2019 novel coronavirus (COVID-19) or the severe acute respiratory syndrome coronavirus 2. The virus originated in bats and was transmitted to humans through yet unknown intermediary animals in Wuhan, Hubei province, China in December 2019 (Singhal, 2020).

In a global scenario, the World Health Organization officially declared the novel coronavirus (COVID-19) outbreak a Public Health Emergency of International Concern (PHEIC) last January 30, 2020, one month after the Wuhan Municipal Health Commission, China, first reported a cluster of pneumonia cases. This has been the 6th time WHO declared a PHEIC since the establishment of International Health Regulations (IHR) in 2005. The 30th also marked the rise of the ongoing outbreak in the Philippines which has 20,382 confirmed cases as of June 5, 2020. Out of these confirmed cases, 4,441 recoveries and 984 deaths were recorded (WHO, 2020). In the Philippines, on 30 January of 2020, the Department of Health reported the first case of COVID-19 in the country with a 38-year-old female Chinese national and on the 7th day of March with the same year, the first local transmission of COVID-19 was confirmed. World Health Organization (WHO) is working closely with the Department of Health in responding to the COVID-19 outbreak and in the case of the Davao region, the COVID-19 pandemic was confirmed to have spread to the Davao Region, Philippines on March 15, 2020, when the first case of COVID-19 was confirmed in Tagum City, Davao del Norte. All provinces as well as Davao City has at least one confirmed COVID-19 case. The majority of the cases in the region are attributed to Davao City (Department of Health, 2020).

Since it is really necessary to identify the different areas with positive cases of COVID-19 which will help the community to assess in order to prevent more transmission of this disease thus, this study aims to identify districts with COVID-19 cases in Davao City, to create a location map of COVID-19 districts and to determine any correlation between the number of COVID-19 cases in the districts and the population densities.

A study on the early stages of COVID-19 was conducted in China by Kang (2020) to determine spatial association between adjacent places. The data considered in this study includes the number of COVID-19 cases in the different provinces of China, the populations and population densities. The study revealed that COVID-19 is highly likely to spread between geographically adjacent regions and that more people are likely to be infected with the virus in densely populated regions, which leads to the active spread of COVID-19 to other areas (Kang, 2020).

In another study about geographical dynamics of COVID-19 in Nigeria, Okafor (2020) discussed that one of

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its states has a high risk of infection because of its high population and it is considered the most densely populated state in that country. Olusola (2020) also focused his study on Nigeria and found out that a significant relationship between population density and COVID-19 cases in Nigeria which suggests that high population densities catalyze the spread of COVID-19. In a wider scope, Onafeso et al. (2021) considered the entire continent of Africa in the study about geographical trend analysis of COVID-19 pandemic onset in the region. The study highlighted the variables that show significant association with COVID-19 cases in the region to include both population and population densities as well as average annual air transport passengers carried. It stated that annual air transport passengers from each countries in Africa played a significant role on both the onset and spread of reported COVID-19 cases and this is aided by the corresponding population density condition of each country (Onafeso et al., 2021). A similar finding was determined by Yu (2021) that at country level, population density is a critical factor in the outbreaks and transmission which implies that countries with higher population density are more likely to be affected by COVID-19. Yu pointed out that this is due to the fact that faster spread within higher population density makes it difficult to control the transmission.

Cuadros et al, (2020), in another study, discussed the spatio-temporal transmission dynamics of the COVID-19 pandemic in Ohio state. The study reveal that a large number of confirmed COVID-19 cases are found in 5 counties that are characterized with high population densities. In contrast, the magnitude of infection is lower in the 31 counties which are located in rural and less connected areas in Ohio. A similar result was discussed by Pequeno (2020) in his study concerning higher COVID-19 incidence in cities in Brazil with higher population densities as a significant predictor of infection.

Sahasranaman and Jensen (2020) discussed in their study the spread of COVID-19 in urban neighborhoods of the developing world such as Brazil, India, South Africa, Nigeria and the Philippines. Most commonly found in these countries are the high population densities in the urban slums which, according to the study, become the most vulnerable in the COVID-19 pandemic. Most of the COVID-19 cases are found in these high density areas making the people in these areas vulnerable and at a high risk in the pandemic. At the onset of COVID-19 infection in the Philippines, Villarama (2020) discussed the COVID-19 occurrence in high density area of Manila City which recorded higher cases compared to adjacent less dense areas. It is noted that people living in high density area will pose challenges to isolate infected individuals to avoid further transmission.

Population and population densities has been cited by the studies discussed above to have a significant factor in occurrence of COVID-19 cases in the context a continent, a country, and a state. However, there are only limited studies on the dynamics of COVID-19 infection and population density in the developing regions of the world including the Philippines. There is also few studies focusing on the different cities in the Philippines with regards to COVID-19 and its geo-spatial dynamics. This study will fill in this research gap by determining the association of COVID-19 cases and population densities in the context of a smaller spatial dimension which is the city and its sub-geographical units of administrative districts.

Figure 1. Map of the Philippines showing Davao City.

Figure 2. Geographic Boundaries of Davao City

METHODOLOGY

Study Area:

The study is focused on the eleven (11) administrative districts of Davao City where each district is comprised of different barangays. Davao city is situated in the southeastern part of the Philippines as can be seen in the map (Figure 1) below. Davao City serves as the regional center for Region XI. It is bounded in the north by Davao Del Norte Province, in the east by the Davao Gulf, in the south by Davao del Sur Province, and in the west by North Cotabato Province (see Figure 2). It was inaugurated as a chartered city on March 1, 1937, under President Manuel L. Quezon. The Davao City Comprehensive Land Use Plan 2013- 2022 described the land area as follows: "Davao City has an area of 244,000 hectares or 8 percent of the land area of Southern Mindanao Region or Region XI. It is divided into 3 congressional districts and divided into 11 administrative districts. Poblacion and Talomo District comprises District I, meanwhile District II is composed of the Agdao, Buhangin, Bunawan and Paquibato, District III includes Toril, Tugbok, Calinan, Baguio and Marilog.

Figure 3 shows the eleven (11) administrative districts of Davao City while Table 1 shows the corresponding population, land area, and the number of barangays for each district.

The districts of Bunawan, Buhangin, Poblacion, Talomo, and Toril commonly have a coastal section wherein these districts are considered the urbanized zone of Davao City where, commercial, industrial, residential and built-up land uses currently exist. Bunawan district is the industrialized center where numerous manufacturing establishments with port operations are located while Buhangin, Agdao, and Poblacion are largely commercial areas with numerous residential structures are found at the coastal sections which are dense in proportion.

The coastal portion of Talomo District are also lined up with high to medium dense residential area which may be comparatively lower in density compared to Poblacion and Agdao Districts. Suburban residential areas are found about 5 to 15 kilometers away from the Poblacion District. These areas are lesser in density compared to the coastal shanties commonly in the districts as described above. Lesser population densities are found in the rest of the districts of Davao like Toril, Tugbok, Baguio, Calinan, Marilog, and Pacquibato. The predominantly agricultural land use is found in the northern portion of Toril, Baguio, Tugbok, Calinan, Marilog, and Pacquibato Districts. The hinterland portion of Davao City is found in the eastern portion of Toril and Baguio, Marilog, and Pacquibato. About 8.6 percent of Davao City's land area is hinterland or part of the Mount Apo Natural Park with an area of 20,957.15 hectares which comes from Toril, Baguio, and Marilog Districts.

Figure 4 shows the map of Davao City indicating the different barangays from the different administrative and congressional districts. A total of 182 barangays comprise Davao City. The CLUP of Davao City indicates that the barangays in Davao City are classified as either urban or rural barangays. District 1 which covers Poblacion and Talomo districts consists of urban barangays. Districts 2 and 3 have a mix of both urban and rural barangays. Mostly the southern portion of these districts are urban and the northern portion is rural areas. All three districts, however, have a coastal portion in their respective areas. District 1 is the smallest in terms of land area compared to the other two and District 3 has the largest land area

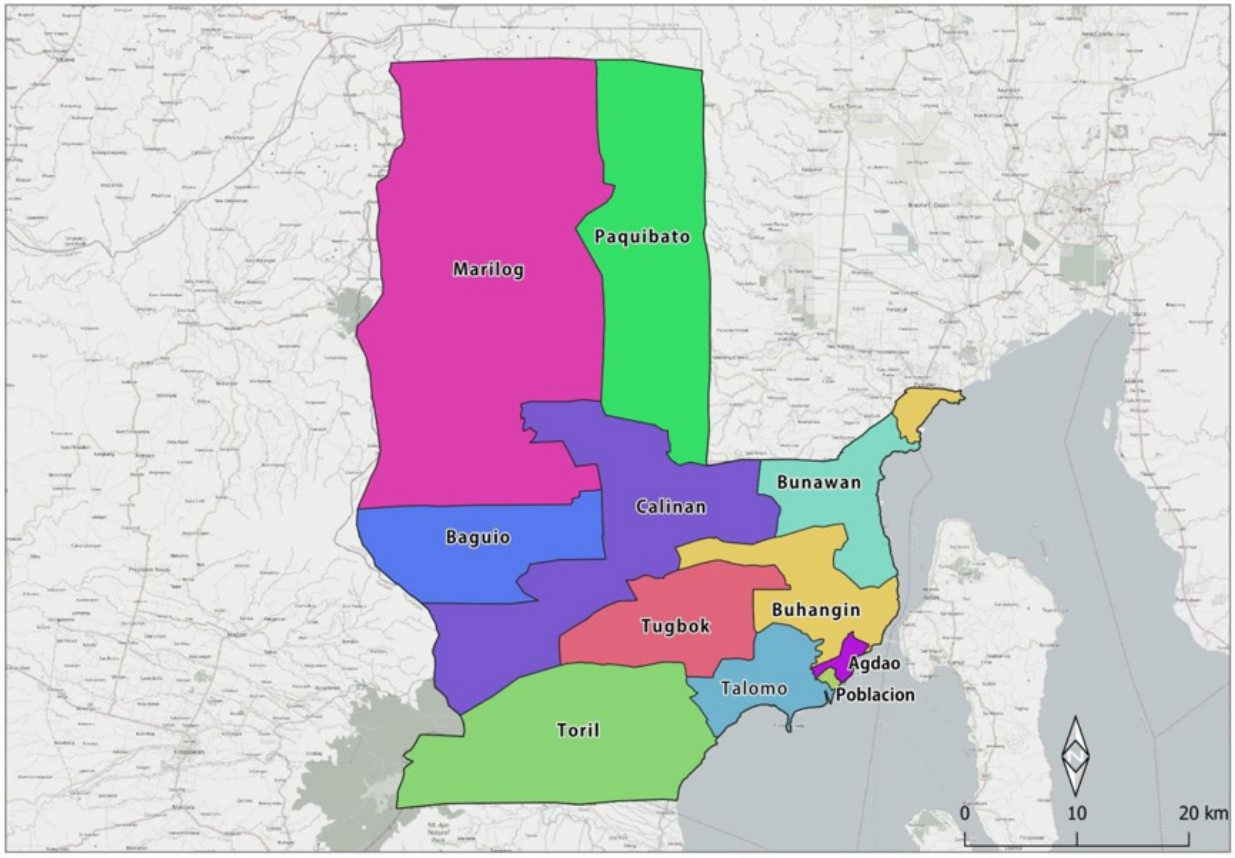

Figure 3. The eleven (11) administrative districts of Davao City

among the three.

Land Area and Population Distribution of Davao City

Table 1 shows the population for each administrative district of Davao City and their corresponding land areas. Shown also is the number of barangay covered by each district. Marilog and Pacquibato have the largest land area among the districts while Talomo and Buhangin are the most populous.

Table 1. Administrative Districts in Davao City with corresponding land area, number of barangays, and actual population.

Sources of Data:

The population data of Davao City was obtained from the Census of Population for the Year 2015 by the Philippines Statistics Authority while the land area of the barangays of Davao City was gathered from the Comprehensive Land Use Plan of Davao City (2013-2022). The administrative district's data of Davao City was lifted from The Davao City Socio-Economic Indicators (2018).

The Department of Health Davao Region Facebook Page is the source for the data on COVID-19 Positive cases in Davao City. This case study included positive COVID-19 cases in Davao City as of June 7, 2020.

Spatial Analysis

For this study, QGIS application is used to generate maps of Davao City and to illustrate the location of COVID-19 cases in the city. The table for number of COVID-19 cases for each district are incorporated in the QGIS to generate a geographic illustration of where this COVID-19 cases are located in Davao City. The same geographic illustration are presented in the study of Onefaso (2021), Okafor (2021), Olusala (2020), Kang (2020) and Cuadros (2020).

Statistical Analysis

Empirical analysis employed in this study includes computation of population densities per administrative districts and barangays of Davao City. Given the land area per district and the population per district, population densities can be readily computed. Statistical analysis for this study involve simple distribution counts and correlation analysis which is the same method employed by Onafeso et al. (2021). Pearson r correlation analysis was used in this study to determine the association between the number of COVID-19 cases and the population densities of different districts in Davao City. This is the same method applied by Onafeso (2021) in his study to determine the relevance and significance of variables. Correlation analysis is also conducted in the study of Okafor (2021) to describe the geographical dynamics of COVID-19 cases in Nigeria.

RESULTS AND DISCUSSION

Table 2 shows the different administrative districts and the computed population density for each. Population density is the number of individuals that occupy a certain land area. It shows that Agdao District ranks No. 1 in terms of population density followed by Poblacion and Talomo Districts as No. 2 and No. 3 respectively. These districts have coastal portions which are where the dense

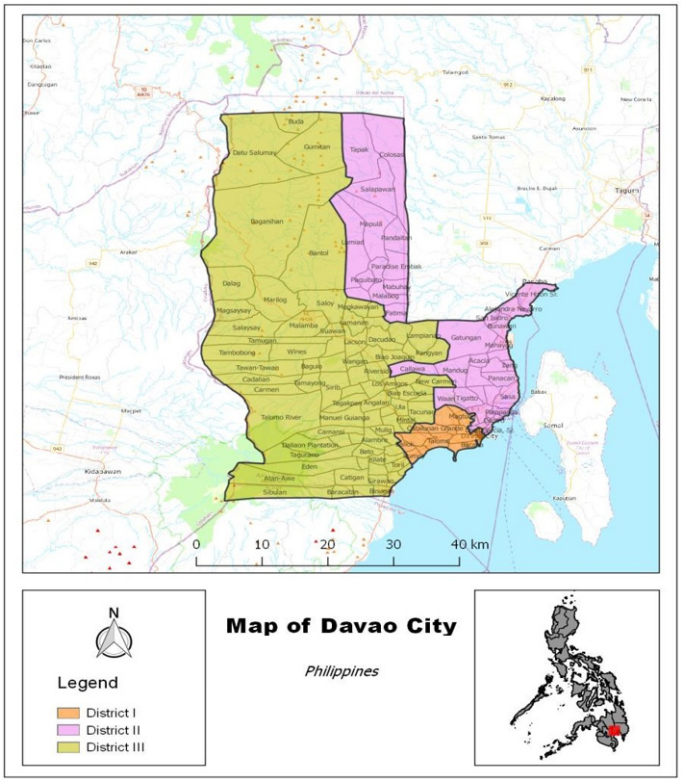

Figure 4. Barangay level map of Davao City.

Table 2. Population Density (Population Per Hectare) In The Different Districts of Davao City

Rank	District	Area (hectares)	No. of Barangays	Population (2015 Census)	Population Density (Population / Hectare)
1	Agdao	593	11	102,267	172
2	Poblacion	1,138	40	174,121	153
3	Talomo	8,916	14	418,615	47
4	Buhangin	9,508	13	293,118	31
5	Bunawan	6,694	9	152,102	23
6	Tugbok	15,391	18	121,334	8
7	Toril	29,459	25	148,522	5
8	Calinan	23,236	19	92,075	4
9	Baguio	19,023	8	33,873	2
10	Marilog	63,800	12	52,201	1
11	Paquibato	66,242	13	44,763	1

population normally occurs. Urban settlers encroaching in coastal areas is prevalent in most highly urbanized centers in the Philippines such as Davao City.

Davao City has not been spared from the COVID-19 pandemic. As of June 7, 2020, Davao City has recorded a total of 314 persons that are positive for COVID-19 infections. The breakdown or distributions of COVID-19 cases per district are shown in Table 3 below.

The table ranks the districts in terms of population density from the highest to the lowest. The four districts, Agdao, Poblacion, Talomo, and Buhangin show a significantly high number of COVID-19 positive cases among the districts. These districts are also considered as densely populated districts of Davao City. This goes to show that the prevalence of COVID-19 cases occurs in densely populated areas of Davao City as can be seen in the table above. Fifty-seven (57) barangays in Davao City have confirmed positive cases of COVID-19 out of the total 182 barangays of the city. Figure 5 shows the location of the COVID-19 positive cases in Davao City per administrative district.

The areas with the highest incidence of COVID-19 positive cases have coastal areas where the over-densities can be found as shown in the map. The only district with the coastal area not having higher cases is Toril and Bunawan districts. Inland districts not having coastal sections have lower cases of COVID-19, wherein these areas are marked by lower population densities in the city. At this time of pandemic due to infectious diseases such as COVID-19, wherein the disease is transmitted from one infected person to another, dense communities are the ones highly

Table 3. COVID-19 Infectious Disease Positive Cases in Davao City according to Administrative District.

District	No. of Barangays With COVID-19 Positive Cases	Population Density (Person/Ha)	No. of COVID- 19 Positive Cases
Agdao	9	172	72
Poblacion	13	153	80
Talomo	11	47	71
Buhangin	9	31	62
Bunawan	4	23	8
Tugbok	4	8	9
Toril	4	5	9
Calinan	1	4	1
Baguio	1	2	1
Marilog	0	1	0
Paquibato	1	1	1
Total	57		314

(Source: Department of Health Region XI and Davao City Comprehensive Land Use Plan)

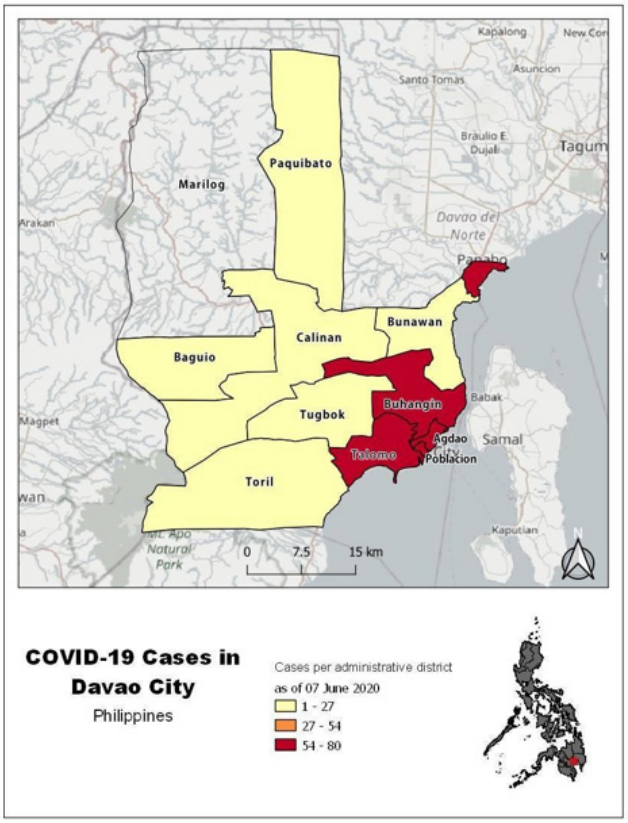

Figure 5. COVID-19 cases in Davao City per district

affected by the local transmission of the disease.

Figure 6 shows a graph of the COVID-19 cases in the different districts of Davao City and the population density of each district. The graph shows an increase in COVID-19 cases as the population density increases.

Result of statistical analysis showed a high correlation (correlation coefficient r = 0.8186) between number of COVID-19 infection and population densities. It shows that prevalence of infection are occurring in areas with high population concentrated in a smaller areas in Davao City. This means densely populated area contributed to prevalence of COVID-19 infection in the city context such as Davao. This result is consistent with the findings of Kang (2020) wherein it is cited that more people are likely to be infected with the virus in densely populated regions. Similar pattern is true in the case of COVID-19 infection in the different states in the whole country of Nigeria (Okafor, 2020). Higher infections occurred in densely populated states in Nigeria.The findings of this study also confirm the result of Olusola et al. (2020) and Yu (2021) that an association exists between population densities and COVID-19 infection. In terms of the entire continent particularly in Africa, the study of Onifeso (2021) also cited a strong association between population densities and COVID-19 cases. The same finding was cited by Cuadros (2020) and Pequeno (2020) wherein areas that are densely

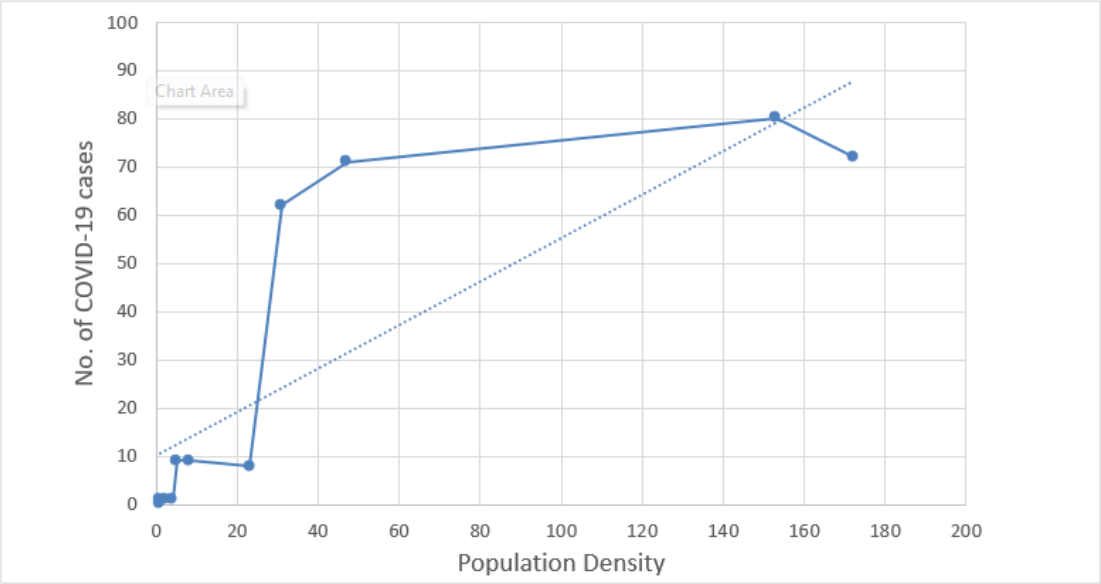

Figure 6. Number of COVID-19 cases and population density in Davao City

populated recorded large number of confirmed COVID-19 cases.

These studies reveal that at different geographic levels such as continent, country, state, province and city, the presence of densely populated areas record high prevalence of COVID-19 infections. Even in the developing world where the Philippines is situated, the result of this study is consistent with the study of Sahasranaman and Jensen (2020) and Villarama (2020) citing that the areas with higher population density are vulnerable to the rise of COVID-19 infection.

As one of the major cities in the Philippines, the presence of built-up areas and the densely populated areas in Davao City may have somewhat contributed to the rising cases of viral infection that are now affecting the country and the whole world. These densities may have contributed to the COVID-19 viral infection in urbanized cities like Davao.

For District 1 (covering Poblacion and Talomo administrative districts), Barangays 23-C, 19-B located in the Poblacion area posted the highest cases of positive COVID-19 infections while Barangays Catalunan Grande and Talomo Proper have the highest cases for Talomo area. The barangays in Talomo are less dense in population compared to Barangays 23-C and 19-B. The barangays with white color indicate zero cases of COVID-19 infections. Most cases are located in the coastal area of the barangays except for Catalunan Grande which is an upland barangay considered to be a suburban area with numerous subdivisions mostly occupied by middle-income class people, but patches of urban poor dwellers also exist within the barangay creating densities in clusters. The subdivisions in Catalunan Grande make the positions of houses more evenly and widely spaced from one another thereby reducing cluttering or densities of people. Subdivision houses are designed to be single detached from one another unlike in urban poor areas where houses are constructed side by side leaving only small gaps in between.

For District 2 (covering Agdao, Buhangin, Bunawan, and Paquibato administrative districts) Barangays Leon Garcia, Sr., and Agdao Proper have the highest number of COVID-19 positive cases. Most of the cases in this district are located within the coastal area of the city. This is where the population densities exist. The same case is true for District 1 where the coastal sections are the ones with a high number of cases except for Barangay Catalunan Grande. Inland Barangays of Tigatto, Cabantian and Indanagan also posted positive cases for COVID-19 and one hinterland barangay in Paquibato District has one case in the record.

District 3 (covering Toril, Tugbok, Bagiuo, Calinan and Marilog administrative districts) posted the least number of COVID-19 positive cases for Davao City. A minimum of three cases are tallied for barangays with infected cases and one barangay with a minimum of eight cases is recorded for District 3. Most of the land features in this district are residential, agricultural, grassland where less dense communities are present.

A typical land feature in coastal area in Davao City can be seen in Figure 7. It shows the densely populated residential area at the coastline of Poblacion District wherein the high incidence of COVID-19 infections is situated. Note that farther away from the coastline, the density becomes moderate where a mix of commercial and residential area can be seen at the bottom of the figure.

Figure 8 shows a portion of the Poblacion District of Davao City. At the top of the figure at the coastline, the dense urban residential area can be found, a portion of which is where most of the COVID-19 positive cases are recorded.

The middle portion of Figure 8 shows the commercial and institutional area of the Poblacion District. Commercial and business establishments are found in this section of the city where high-rise buildings exist. Several institutional buildings of schools, government offices, and churches also can be found in this section. The lockdown on

Figure 7. The densely populated coastal zone of Poblacion Davao City area

Figure 8. The Poblacion district of Davao City – commercial and residential area

mid-March 2020 may have prevented significant infections to COVID-19 in this area due to work stoppage thereby minimizing or eliminating possibilities of contamination of people due to close contact in the workplace.

The lower portion of Figure 8 shows a typical residential subdivision in the Poblacion area of Davao City wherein houses are built in a particular pattern most single-detached concrete house structures with the adequate easement and lot spaces between houses. These residential subdivisions are provided with adequate water, sanitation, and electrical facilities. More spaces in between houses can be seen in this area making it lesser dense in configuration compared to the shanties at the coastal areas. Lesser to no record of COVID-19 infections have been noted in this area.

CONCLUSION

Davao City has not been spared from the COVID-19 pandemic as infection has hit the city just like in other parts of the country as well as the entire world. The early stage of COVID-19 pandemic in Davao City has recorded 314 cases as of June 7, 2020 and areas with high population densities have recorded high cases of COVID-19 infections.. Most of the high density areas in Davao City can be seen at the coastal section of Poblacion, Agdao, Buhangin, and Talomo districts where the cases occur. Inland districts have fewer COVID-19 positive cases because of lesser population densities. A high correlation exist between the number of COVID-19 cases and the population densities in the city which indicates that higher number of cases are located in densely populated areas. This indicates that dense population may have contributed to the spread of the COVID-19 infection in the city.

The land characteristics of Davao City are a mix of urban human settlements, commercial and institutional establishments, agricultural and recreational areas, and even forested areas. As a major city in Mindanao, Davao City is experiencing economic and population growth. The level of urbanization of the city is marked by influx of people that tend to cluster in a particular area creating urban densities specifically residential dense areas as can

be seen in Davao City itself.

Long-term solutions should be implemented in addressing high population density areas of Davao City marked by human settlements.

Further research can be done to include other urban attributes in the analysis such as transport system, road networks and building description. comparative analysis can also be done for two or more different cities to assess the geospatial dynamics of COVID-19 using population density and other urban attributes. It is important to exhaustively study and make comparison in order to come up with more scientific conclusions that will help in formulating policies to address the pandemic now and even in the future.

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