MAPPING THE SUITABILITY OF EXISTING AND PROBABLE ISOLATION FACILITIES

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***Abstract*— This study aimed to map the accessibility of the existing isolation facilities in Cabagan, Isabela, and propose probable locations suitable for establishing isolation facilities using the Geographic Information System (GIS), where the data were inputted and processed. Geocam Pro was used to collect data specifically, the geographic coordinates of the existing facilities, and Google Maps were utilized to determine their accessibility to the Milagros Albano District Hospital (MADH). A suitability map was projected, in which 100% of the proposed isolation facilities are accessible to any road network of Cabagan, Isabela, with low and moderate susceptibility to flooding and low susceptibility to landslides. The location also belongs to the non-exposed group having a radius of more than three (3) km from the sanitary landfill. The proposed location of the isolation facilities is also readily accessible to the community and a hospital accepting suspected or confirmed Covid-19 patients.**

***Keywords*— covid-19, QGIS, isolation facilities, suitability map**

I. INTRODUCTION

The Municipality of Cabagan is a first-class municipality in the Province of Isabela that houses a population of 53,897 as determined by the 2020 Census [1]. The Municipality recorded its first Covid case despite the efforts of the national government to inhibit the spread of the virus. The alarming number of cases recorded in the Municipality contributed to the province being classified as High-risk with a fatality rate of 2.7%. The Philippines recorded its first Covid case last January 2020 [2]. Covid 19 is a disease caused by a new coronavirus called Severe Acute Respiratory Syndrome Coronavirus-2 (SARS CoV-2) [3], which is primarily transmitted through respiratory droplets [4]. As of March 13, 2022, over 455 million confirmed cases and over 6 million deaths have been reported globally [5]. In this matter, the World Health Organization (WHO) highlighted identifying, testing, and isolating suspected individuals as a countermeasure against the virus [6]. The abrupt increase in the cases of COVID-19 overwhelmed the healthcare system and resulted in a shortage of isolation facilities, which added to a high mortality rate [7] that took many people's lives and affected the economy [8, 9].

Wuhan strictly implemented strategies, including lockdown of public spaces and communities and sometimes even apartments. The government strictly implemented a hierarchical diagnosis and treatment system to allocate the pandemic-related medical facilities, including clinics, designated hospitals, etc. At the same time, all the patients and people were required to follow the principle of "no cross-district treatment and visiting the pandemic-related medical facilities nearby"; both the lockdown and hospital exclusively designated were relatively scarce in history. The pandemic condition in Wuhan made researchers study the spatial accessibility of COVID-19 patients to healthcare facilities using the Geographic Information System (GIS) and Application Programming Interface (API) of Baidu Map. In the study, the researchers believed that people living in areas of a dense population were disproportionately disadvantaged in terms of access to medical facilities and healthcare [10]. In this way, spatial distribution and the accessibility of medical facilities framed access, and potential service affordance for

the residents consequently influencing the prevention and treatment of Covid-19.

In response to the Covid-19 pandemic in the Philippines, the national government implemented measures that were meant to be temporary [8], such as lockdowns that resulted in a period where the government gave out food and some financial assistance to the citizens, the use of face masks, social distancing, detection, and isolation of suspected positive cases. In the case of the Municipality of Cabagan, the Local Government Unit (LGU) converted schools and gymnasiums into isolation centers as the schools were closed and people were limited from going outside. Isolation is the separation of people who have contracted an infectious disease from non-infected individuals, which impedes the virus transfer [11]. The COVID-19 pandemic is an eye-opener to all, including the government that the country needs to prepare for future surges and viral outbreaks. The national government will have to focus on building quarantine and other health facilities and rehabilitating existing ones to increase the healthcare system's capacity [12]. Moreover, 53 billion pesos are allotted for the Health Facilities Operations program, wherein 19.6 billion pesos are for the health facilities enhancement program [13].

The same study was conducted in Korea and Wuhan, China [7,10], wherein, both considered the travel time from the health service providers. The study did not mention the guidelines and parameters for locating the probable isolation facilities. Additionally, the use of Geocam was not utilized in determining the coordinates of the isolation facilities.

Cabagan and Isabela also experienced the problem of the COVID-19 pandemic. In response to the pandemic, this study aimed to map the suitability of the existing isolation facilities in Cabagan, Isabela, and proposed probable locations for establishing isolation facilities using GIS since the Municipality does not have any isolation facilities primarily intended for isolation. Moreover, the Inter-Agency Task Force (IATF) and Department of Health (DOH) classified the province as high-risk during the pandemic's peak. Hence, this study also wants to contribute to the preparation for current and emerging viruses or infectious diseases. Furthermore, there is no evidence that researchers in the Philippines studied the accessibility of medical facilities in Cabagan. The study also proposed to the LGU that suitable locations for isolation facilities can also be used as evacuation centers as they have also met the standard and criteria for these kinds of facilities.

II. Related Works

The world continues its battle against a life-threatening virus known as Covid-19 caused by SARS-Cov-2 [3]. The Covid-19 virus was first reported to WHO on December 31, 2019 [3]. The virus is mainly transmitted via respiratory droplets [4]. However, WHO does not disregard the concept of airborne transmission of the virus [4], which may increase its transmissibility. The virus may cause complications that may lead to death, including respiratory failure, acute respiratory distress syndrome, sepsis, septic shock, thromboembolism, and multiorgan failure, including injury to the heart, liver, or kidneys [3], and may lead to intestinal infection [4]. The virus took the lives of millions of people, including their livelihoods, and subsequently affected the global and international economy [8,9] and educational institutions [8]. Due to the high transmissibility of the virus, the chances of death alongside the overwhelmed health sectors, and its effects on the economy, governments worldwide strategically came up with a plan to prevent its prevalent spread.

The Covid-19 virus is not the first respiratory virus recorded in the history of humankind; there has been the existence of the Middle East Respiratory Syndrome Coronavirus (MERS-Cov) [7, 14], SARS CoV-2 [7,14] and H1N1 (Influenza A) [14]. It is good to note that despite the existence of other coronaviruses, Covid-19 has a higher number of fatalities than its predecessor, the SARS [2]. Since the world has experienced outbreaks of other coronaviruses, the governments and healthcare systems responded relatively the same as the other outbreaks experienced in the past [7]. It focuses on rapid identification, testing, and isolation [6,7,9,15]. Hospital capacities were increased [15] due to the high transmissibility of the virus that resulted in the surge of Covid cases; there had also been restricted travel and controlled movement of people [10,15,8]. With the sudden appearance of the virus, lockdowns were temporarily implemented wherein, only essential establishments were open [15], to control the spread of the virus. The governments have also been creating drive-thru testing areas for the asymptomatic or suspected patients who may have contracted the virus [7] for easier and faster collection of samples that leads to quicker identification and isolation of positive individuals. Makeshift wards are also created to cater to Covid-19 patients [7]. Most importantly people were advised to use face masks, practice social distancing, disinfect hands and surfaces, and proper hygiene [4,9,15].

The building of isolation facilities is evident in controlling the spread of infectious diseases by reducing virus transmission [7, 14,15], which subsequently causes a delay in the increase of cases and flattens the curve [15]. The governments then prioritized funding for the establishment of isolation facilities [7]. However, isolation facilities are not cheap, therefore due to the high demand for isolation facilities, existing public or private establishments have been converted into isolation facilities, including hotels and accommodations [7].

In addition, isolation is the separation of people who have contracted an infectious disease from non-infected individuals, which impedes the virus transfer [7, 14, 15]. Due to the high numbers of Covid cases and the startling attack of the virus, health facilities are overwhelmed, resulting in the lack of isolation facilities. These facilities can cater to mild to moderate cases of COVID-19 that do not need hospitalization to recover [7]. The overwhelming number of cases led to the healthcare sector's collapse, subsequently affecting the death rate [7]. The shortage of isolation facilities made the government and people opt for the formation of home isolation. Home isolation is advantageous provided that a person has a support system at home, which speeds up the recovery. However, patients with mild cases transfer the virus more easily [7] due to their more active lifestyle. Hence, the patients who opted to isolate themselves at home quickly spread the virus to their family or domestic contacts [7].

On the other hand, hospital-based Isolation has its cons too. Wherein the healthy individuals being exposed to the hospital, where the suspected and positive cases are catered, contributed to the transmission of the infections [14]. There is then a need for special healthcare [14] facilities primarily intended for isolation.

GIS is a great tool for data analysis and is a useful tool to provide an evidence-based approach to solving problems including the pandemic [10]. The Covid-19 pandemic is a revelation of the importance of healthcare facilities as a countermeasure against pandemic outbreaks. To have an effective response to the pandemic, the location of the facilities should be accessible [10]. The improved methods for the accessibility of the facilities include the estimated travel distance and time [10,14] from the settlements to the medical facilities in the urban area by using the Baidu Map API [10]. The maximum time in the Philippines from a Level 2 hospital to a facility should be less than two (2) hours [16]. This enables the healthcare worker of the facility to have ample time to transfer a patient who needs hospitalization. Furthermore, the supply and demand for the facilities [10,14] are also one the ways to locate suitable facilities.

In selecting the location of the facilities there should be a consideration of the hazards and risks to obtain an optimal location. The Philippines experiences disasters that include flooding, storms, and earthquakes [17]. Hence, the location of the health facility should be above flood level [17]. Furthermore, to lessen the hazard in an area it is important to note that the people settling within a 2.5-kilometer radius of a landfill are considered exposed and are more prone to have negative health effects [18].

With the pandemic and the existence of contagious viruses and diseases that challenge people, there should be enough facilities that contribute to the containment of viruses. The call to establish isolation facilities is enormous, as the Covid-19 pandemic is an eye-opener that coronaviruses or other sorts of infectious diseases may again threaten and challenge humans [8]. It is best to learn in these distressing circumstances to have a better response in the future. The temporary measures executed by the government are not a solution to the present and future pandemic provided that the country is gradually adapting to the new normal [8]. There should be a preparation for establishing isolation facilities [14] which should be effective.

Moreover, the selection for the location of isolation facilities should have an evidence-based approach that considers the distribution of the risks provided by the disease alongside the need for the facilities [14]. The scarcity of isolation facilities and the abrupt increase in Covid cases calls for more isolation facilities [7,14]. It should be wisely designated [14] to have a more effective and efficient impact.

III. METHODS

A. Study Area

Cabagan is a first-class municipality in the province of Isabela. The municipal center of Cabagan is situated at approximately 17° 26' North and 121° 46' East on the island of Luzon as shown in Fig. 1. The municipality has a land area of 430.40 square kilometers or 166.18 square miles, which constitutes 3.28% of Isabela's total area. Its population, as determined by the 2020 Census, was 53,897.

Being included in one of the municipalities that the IATF classified as high-risk areas in the Philippines, the LGU utilized non-medical facilities such as schools and gymnasiums. Thus, Level 2 Hospitals, such as the MADH, were part of the must-haves according to the guidelines provided by the health department.

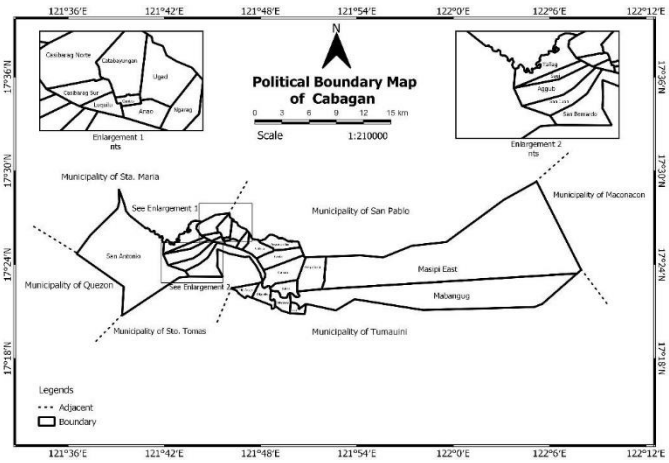

Fig. 1. Political Boundary Map of the Study Area.

B. Data Acquisition

The researchers requested from the Municipal Planning and Development Office (MPDO) for the available datasets, specifically shapefiles such as the political barangay boundary of Cabagan, road network, hazards, land use, and landfill. The lists of existing isolation facilities were given by the Rural Health Unit (RHU). As for the location of the existing isolation facilities, geotagging using GeoCam Pro was applied. Travel time was gathered using Google Maps features and was validated on the ground using Global Positioning System (GPS). Furthermore, a structure map was generated through digitization. Moreover, a tabulation for the Covid cases was made to know the number of cases in each barangay.

C. Map Creation

The data gathered were subjected to further processing using Quantum Geographic Information System (QGIS) toolsets to harmonize and use them. All datasets were projected into a common projection, the World Geodetic System 1984 (WGS84) Universal Traverse Mercator (UTM) Luzon 51N.

The study made use of digital datasets of the existing isolation facilities as well as the factors that are to be accounted for in selecting the viable locations of isolation facilities which include land uses, hazards, landfills, and road networks. These factors are by the parameters set by DOH. GIS methods,

specifically overlay analysis tools were used to process and generate layers associated with the criteria. The layers were aggregated and overlaid to map out and project a suitability map of probable isolation facilities in Cabagan, Isabela. QGIS version 3.22.6 was utilized for data processing and data analysis.

The buffer tool of QGIS was used in the land use map, where the sanitary landfill is shown. The buffer tool is used to determine the facilities close to the sanitary landfill. A suitability map was generated by overlaying all the processed datasets. This map exhibits all the suitable locations for the establishment of isolation facilities.

Table 1 shows the parameters for considering the probable location of an isolation facility in Cabagan, Isabela in which the guidelines are properly cited in the DOH [16], and Philippine Health Facility Development Plan 2020-2040 [17].

TABLE I. GUIDELINES FOR SELECTING PROBABLE LOCATIONS

Parameters	Description
Environment [10] [23] [25]	An isolation facility must be easily accessible to the community. Relatively free of excessive noise, smoke, dust, foul odor, and flooding. Railroads, freight yards, children's playgrounds, airports, industrial plants, or disposal plants must not be located nearby.
Location Features [10] [19] [23] [25]	Can travel to a Level two or Level three hospital that accepts suspected or confirmed Covid-19 patients within two (2) hours. An isolation facility shall use an approved public water supply system when available An isolation facility shall use an approved public water supply system. The water supply must be potable, safe to drink, and sufficient, and it must be brought into the building without any cross-connections. Have access to public roadways. The emergency access shall be marked to facilitate entry from the public roads or streets serving the site. Access to emergency services must be located so that floods and other natural disasters cause the least amount of damage.

IV. RESULTS AND DISCUSSION

Table II shows that the highest number of used facilities in response to the Covid-19 pandemic in Cabagan are health centers, gathering a total of 42.31 %. This signifies that the local government unit of Cabagan utilized the health centers more than other facilities. Moreover, due to the lack of isolation facilities, the government temporarily used the schools as isolation facilities. In the previous table, it is seen that 12 out of 26 of the existing isolation facilities are schools in which the Department of Interior and Local Government (DILG) [20] allowed the LGU to coordinate with the Department of Education (DepEd) to convert schools into isolation facilities. However, it is seen in the DepEd Memorandum [21] that LGUs are not permitted to employ schools as isolation facilities and must refrain from utilizing schools as isolation facilities as a general rule unless it was authorized by the DepEd.

TABLE II. GUIDELINES FOR SELECTING PROBABLE LOCATIONS

Description of the facility	Number of existing isolation facilities	Percentage (%)
Rural Health Unit	1	3.85
Health Center	11	42.31
Elementary School	7	26.92
High School	3	11.54
Primary School	1	3.85
Daycare Center	1	3.85
Evacuation Center	1	3.85
Gymnasium	1	3.85
Total	26	100

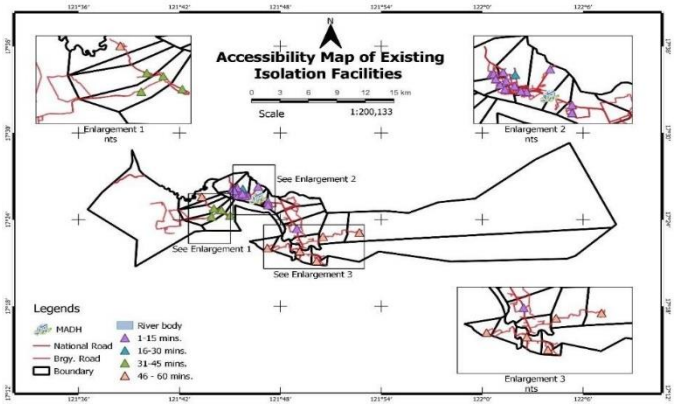

Fig. 2. Accessibility of existing isolation facilities.

Fig. 2 indicates the existing isolation facilities which reveal that 15 out of 26 existing isolation facilities are accessible to MADH with a travel time of fewer than 15 minutes. The facilities that have a travel time of 15 minutes and below are classified as elementary schools, health centers, daycare centers, primary schools, and evacuation centers. Wherein, the facilities are located following barangays, namely, Cubag, Ugad, Cansan, Centro, Catabayungan, Luquilu, Casibarag Norte, and Casibarag Sur. Furthermore, the data show that only 5 out of 26 existing facilities have a travel time of 46-60 minutes from the MADH, a Level 2 hospital. These 5 existing isolation facilities are also considered to have the farthest distance from the MADH.

Table III shows that more than half or 57.69% of the isolation facilities are close to MADH with up to 15 minutes of travel using a four-wheeled vehicle as a mode of transportation. This means that the majority of the isolation facilities are accessible to the district hospital, wherein, Covid positive patients can be readily transferred to the said hospital in case of a critical situation. Additionally, there are only 4 out of the 26 isolation facilities that have more than 45 minutes of travel to MADH. As per the guidelines released by the DOH, isolation facilities should be accessible within two (2) hours to

a Level 2 or Level 3 hospital. The data above reveal that there is no issue in the accessibility of the existing isolation facilities to MADH, a Level 2 hospital located in Cabagan, Isabela.

TABLE III. ACCESSIBILITY OF EXISTING ISOLATION FACILITIES TO MADH IN TERMS OF TRAVEL.

Travel time (in minutes)	Number of existing isolation facilities	Percentage (%)
1-15	15	57.69
16-30	1	3.85
31-45	5	19.23
46-60	5	19.23
61 and above	0	0
Total	26	100

Findings in certain research from Wuhan, China [10] support these data. This means that they considered the travel time in terms of minutes that residents could reach the community's health facilities in which the mode of transportation of the residents in the area is walking, using a bike, electric scooter, or car. This study is further supported by [22] from which, the researchers considered the mode of transportation. Another result was found in Portugal [23], the method they used resulted in the classification of the time of arrival of respondents to the evacuation centers.

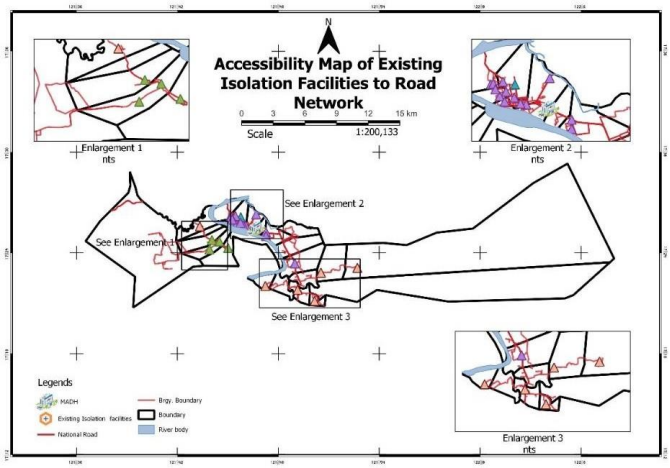

Fig. 3. Accessibility map of existing isolation facilities to the road network.

TABLE IV. ACCESSIBILITY MAP OF EXISTING ISOLATION FACILITIES TO THE ROAD NETWORK.

Frontage	Number of existing isolation facilities	Percentage (%)
National Road	9	34.62
Barangay Road	17	65.38
Total	26	100

Fig. 3 displays the existing isolation facilities with the road network of Cabagan. It shows that all isolation facilities are accessible to MADH since all of them are adjacent to national or barangay roads.

Table III presents that 34.62% of the existing isolation facilities are fronting a national road and 65.38% are adjacent to a barangay road. This denotes that all existing isolation facilities are accessible to any road network in Cabagan, Isabela. Thus, the existing isolation facilities have good access to the public roads.

A study from Crete Island, Greece [23] related to this project has analyzed that the accessibility of road networks has an impact on the calculated shortest path distances. From the result of the study, they used the road network as a reference in observing the duration of time from the residence to the destination. This study has similar results to [25] in which the accessibility of isolation facilities to the road network is of great importance.

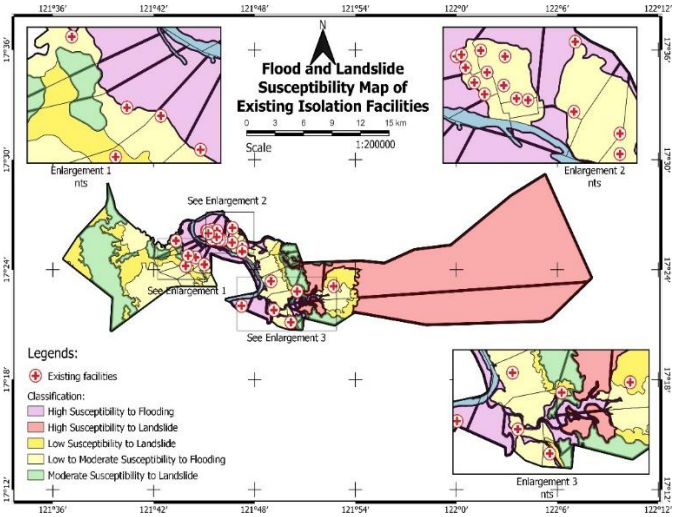

Fig. 4. Flood and landslide susceptibility map of existing isolation facilities.

TABLE V. ACCESSIBILITY MAP OF EXISTING ISOLATION FACILITIES TO THE ROAD NETWORK.

Classification	Number of existing isolation facilities	Percentage (%)
High Susceptibility to Flooding	7	26.92
High Susceptibility to Landslide	0	0
Low Susceptibility to landslide	2	7.69
Low to Moderate Susceptibility to Flooding	17	65.38
Moderate Susceptibility to Landslide	0	0
Total	26	100

Fig. 4 portrays the suitability of existing isolation facilities before floods and landslides in which violet is classified as high susceptibility to floods, red as the high susceptibility to landslides, dark yellow as low susceptibility to landslides, light yellow in low to moderate susceptibility to flooding and green as the moderate susceptibility to landslide. Only 7 out of 26 isolation facilities belong to the group of high susceptibility to flooding, while the majority of the existing isolation facilities belong to the group of low to moderate susceptibility to flooding.

Table V indicates that more than half or 65.38% of the isolation facilities belong to low to moderate susceptibility to flooding and 26.92% are under high susceptibility to flooding. This signifies that most of the isolation facilities are free from flood, and only 7 out of 26 existing isolation facilities belong to high susceptibility to flooding. These isolation facilities are health centers and elementary schools which 4 out of 7 existing isolation facilities under high susceptibility to flooding are health centers and 3 out of 7 of which are elementary schools. This implies that the majority of existing isolation facilities are located in areas that are not prone to flooding; hence, it indicates that most of the existing isolation facilities are suitable. This current study supports that in Morocco and Portugal [23] the flood-prone evacuation center was categorized as a non-appropriate evacuation center, whereas the flood-free evacuation center was classified as a suitable evacuation center. Another finding in [25] from which the flood map analysis is used to determine the level of the flooded area; thus, the analysis shows the suitable distance from the flood area. Table V results conform with [25], wherein it presents the affected area and considers the percentage of the affected areas.

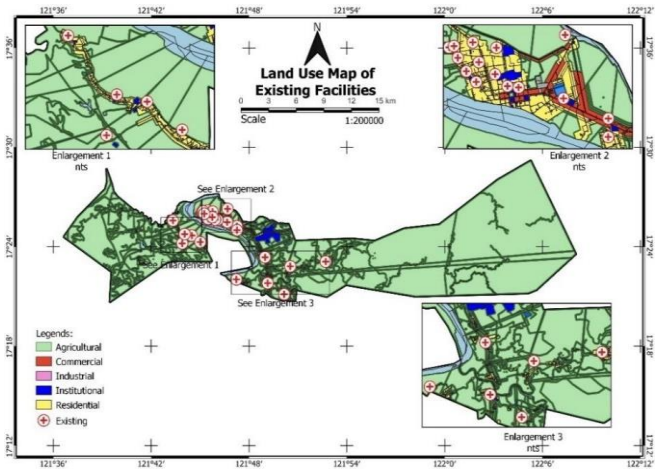

Fig. 5. Land use map of existing isolation facilities.

TABLE VI. ACCESSIBILITY MAP OF EXISTING ISOLATION FACILITIES TO THE ROAD NETWORK.

Classification	Number of existing isolation facilities	Percentage (%)
Residential	14	53.85
Commercial	2	7.69
Institutional	0	0
Agricultural	10	38.46
Total	26	100

Fig. 5 displays the accessibility of the existing isolation facilities to land use in Cabagan. Green illustrates the agricultural area of Cabagan, while red belongs to the commercial area of Cabagan, pink shows the industrial part of Cabagan, blue covers the institutional area of Cabagan, and yellow for the residential part of Cabagan.

Table VI indicates that 53.85% of the existing isolation facilities are located in a residential area, 7.69%, and 38.46% in commercial and agricultural areas. This implies that all isolation facilities are accessible to the community. DOH guidelines indicate that isolation facilities must be accessible to the community.

In the study in Wuhan, China [10], the results of the study considered accessibility to the community. The study identified the population of the said area to determine the accessibility of the community to health facilities. As supported by [26] access to community services, such as health centers, is a significant parameter.

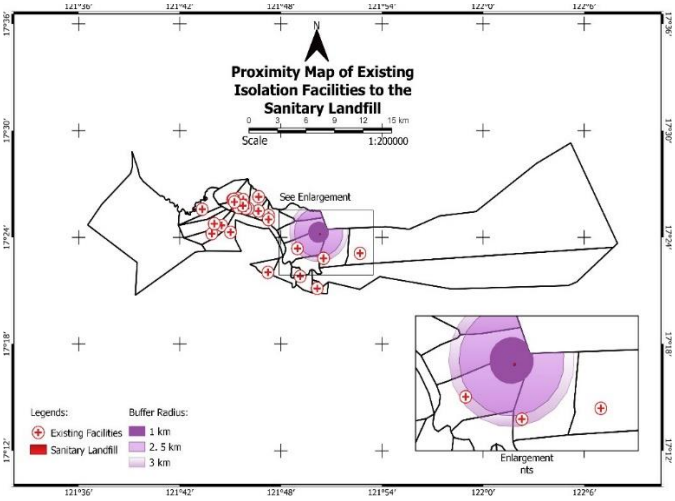

Fig. 6. Proximity map of existing isolation facilities to the sanitary landfill.

TABLE VII. THE PROXIMITY OF EXISTING ISOLATION FACILITIES TO THE SANITARY LANDFILL.

Buffer Radius	Number of existing isolation facilities	Percentage (%)
Below 1 km	0	0
1km-2.5km	0	0
More than 2.5km	26	100
Total	26	100

Fig. 6 displays the proximity of the existing isolation facilities to the sanitary landfill of Cabagan. It depicts that all of the existing isolation facilities within a range of more than 2.5km are not exposed to the sanitary landfill. Figure 7 shows that two isolation Suitability maps of proposed isolation facilities are within a radius of 3 kilometers but are still considered safe as per the guidelines used

Table VII portrays that 100% of the isolation facilities belong to the non-exposed group having a radius of more than 2.5 km from the sanitary landfill. No isolation facilities are exposed. The result unveils that there is no issue regarding the location of the existing isolation facilities in terms of their proximity to the sanitary landfill, thus, all isolation facilities

reside in the non-exposed group. This research finding correlates with that of research in a community health survey of residents living near a solid waste open dumpsite in Sabak, Kelantan, Malaysia [18] that the non-exposed subjects were residents between a 2.5 and 4.0 km radius of the dumpsite. The same results from the study on Health and Environmental Risks of Residents Living Close to a Landfill in Limpopo Province, South Africa [24] showed that participants who live nearby to the landfill are more vulnerable than those who live further away, notably respondents who live within a 1 km radius.

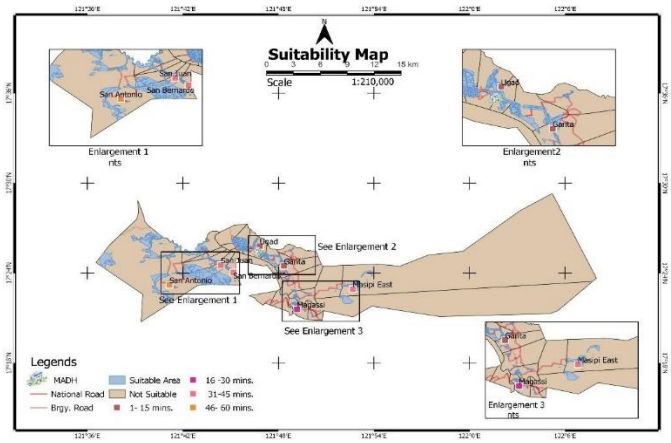

Fig. 7. Suitability map of proposed isolation facilities.

Fig. 7 displays the suitability map of proposed isolation facilities in which 100% of the proposed isolation facilities are accessible to any road network of Cabagan, Isabela, with low and moderate susceptibility to flooding and low susceptibility to landslides. The proposed isolation facilities are also readily accessible to the community, accessible to a hospital accepting confirmed Covid-19 patients and belonging to a non-exposed group under sanitary land within a more than 3 km radius.

This present study is supported by [25] in determining a proposed location of an evacuation center as the researchers determined the suitability of the location and the road access that connected it. In a similar study with [25] that used GIS techniques to determine the suitability location, the results showed that the 7 new locations were considered suitable criteria for the proposed evacuation center. The result of [26] supports the study wherein they considered the hazard map in terms of flooding and accessibility to health facilities.

V. Conclusion

This suitability map identifies the probable location for establishing an isolation facility. Thus, there are still areas for proposed isolation facilities aside from existing isolation facilities in Cabagan, Isabela. Wherein the existing isolation facilities' function will not be hindered or obstructed. The repurposed schools as isolation facilities will remain as schools intended for educational purposes and health centers designed for health care services that can accept other patients aside from Covid patients. Cabagan, Isabela does have suitable locations to put up isolation facilities as projected using GIS, in which the isolation facilities are intended for isolation.

This study exhibits the suitable locations for the establishment of probable isolation facilities in Cabagan, Isabela. For further improvement of the study, the researchers recommend considering the population per barangay and the capacity of each facility present in the study area. Moreover, checking for updated guidelines in building and locating isolation facilities is also recommended.

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