DETERMINATION OF HIGH-RISK MUNICIPALITY OF COVID-19 CASE IN AGUSAN DEL SUR, MINDANAO, PHILIPPINES USING GIS APPROACH

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ABSTRACT: The greatest battle that Filipinos face today was the fight of Corona Virus Disease or the SARS-CoV 2. COVID-19 pandemic is life-threatening in terms of our public health. Many lives were killed, and some are survived this pandemic brought that. The typical living of Filipinos was turned into a catastrophic form of living because the enemy was unseen. The economic and public health sector was put to balances to ensure the general welfare of the public. Government efforts in battling this disease were extremely advantageous because public safety is of paramount importance at all. We come out with this study to mitigate, respond, and prioritize those areas with its riskiest for the mass. This study aims to determine and visualize the high-risk municipalities of Agusan del Sur using the method of min-max normalization and the percentile ranking by quartiles. Percentile Ranking is used to determine the range of classified as low, moderate, high, and very high. In determining the overall risk in the Province of Agusan del Sur, we used the Analytical Hierarchy Process, a multi-criteria decision-making platform. We chose the experts of this field to respond in the AHP Form. Pairwise comparison is being used in this study to determine each risk factor indicator; all of their ratings will be used in processing weighted overlay analysis in Arc GIS which is one of the major activities of this study. The study can aid the local government plan, and direct mitigation plans to suppress and preclude the COVID-19 pandemic. The result shows that the Municipality of Prosperidad was the very high-risk Municipality of Agusan del Sur of COVID-19. On the other hand, Bayugan, San Francisco, Talacogon, and Trento were placed at high risk. In contrast, Esperanza, San Luis, Lapaz, Rosario, Bunawan, Santa Josefa and Sibagat, Veruela, Loreto were placed under the category of moderate and low respectively.

1. INTRODUCTION

Coronavirus disease infects animals, including humans, causing acute and chronic diseases. The first COVID-19 case was reported in Wuhan City, China, in early December 2019 (WHO, 2020). The sudden emergence of the SARS-CoV 2 became a recent public health emergency and one of the major problems across the countries, and this was called a pandemic. COVID-19 was declared a pandemic when it has been reached 200 countries across the world on 14th June 2020 and has been infected 8 million people so far (Naqvi, A.A.T, 2020). Many countries are experiencing the rapid growth of COVID-19 cases and the fatality rate country by country, resulting in high fatality rates (Musa, S.S. et al., 2020). This particular problem caught the researcher's attention to find immediate interventions and solutions to mitigate the rapid transmission of SARS-CoV 2 in public. Real-time reverse transcription-polymerase chain reaction (RT-PCR) is the primary means of diagnosis for detecting the SARS-CoV 2 based on the previous laboratory protocols (WHO, 2020). Rampant investigation reports have shown that COVID-19 transmission can be particularly effective in confined indoor areas and crowded facilities (CDCP, 2020). The authorities had imposed maximum health protocols to avoid spreading the virus, especially to the most risk individuals above 60 years old, who have underlying medical conditions, and feel unwell (WHO, 2020). Isolation/Quarantine Facilities is the significant risk for COVID-19 transmission, which came into a massive evaluation to follow the health protocols to avoid spreading the virus. Quarantine facilities may be evaluated based on the guidelines imposed by the health authorities (ISC, 2020).

Risk Levels may be categorized into low-risk, moderate-risk, high-risk, and high-risk areas for all geographic regions in the Philippines (DOH, 2020). Low risk can be identified through a simple quarantine implementation based on the health protocols, following maximum health standards and passing the evaluation on the isolation facilities, small figures reported on the infected aged above 60, low cases, and low fatality rate. Moderate risk can also be identified by satisfying at least 75% of the low-risk modification. The high risk could be found out if 100% of the quarantine protocols and stringent implementation of maximum health standards are not followed; also, the high fatality rate and

the number of cases could be considerations (WHO, 2020). Determination of low risk, moderate risk, and high-risk areas of the COVID-19 case can be used to mitigate the harmful effects of the virus to the riskiest individual ages below 21 and 60 above, people with underlying medical conditions, and to stop the spread and containment of the SARS-CoV 2.

The rising case of COVID-19 is a significant challenge for the researcher on mitigating the containment of the virus. Thus, the researcher came up with the research regarding determining the high-risk Municipality of the COVID-19 case in the Province of Agusan del Sur to provide maps that can help identify the risk municipality. Moreover, it could be used for a preparedness and reduction plan of the specific Local Government Unit (LGU) in the Province by providing on the map of the low-risk areas, moderate-risk areas, and high-risk and very high-risk areas municipality with the following risk factor indicators in the Province of Agusan del Sur.

Analytical Hierarchy Process is the most common multi-criteria decision-making method worldwide. The AHP uses alternatives and attributes and structures alternatives within a hierarchy of attributes for evaluation. This method is based on three principles: model structure, a comparative judgment of the criteria or alternatives, and synthesis of the priorities. It also specifies and sets priorities for alternatives that are subjected to the judgment of the decision-making group (Nappi, M.M.L., et al., 2019). Then the factors were combined in the form of a weighted linear combination:

The weighted Overlay Analysis tool is an element of the Overlay and Spatial Analyst toolbox. In the suitability analysis, weights can be assigned to layers, and raster data can be classed into a common category (ESRI, 2014). This analysis was used in many suitability studies, like what was reported in (Madurika, HKGM, et al., 2017). They included the AHP methodology in the decision-making process, and the derived weights are used in the Weighted overlay analysis.

The researcher would like to assess the risk of the Province of Agusan del Sur municipalities in COVID-19 using the GIS approach. Outputs (Maps) of this study will be used to boost the planning specifically in mitigating, preventing, and responding purposes that will address public safety in the Province of Agusan del Sur. This will also help the Local Government Unit (LGU) prioritize the high-risk municipalities in seeking a medical response, implementing the appropriate health protocols, and other health necessities, which are also used for decision-making in decreasing the COVID-19 containment and response measures.

2. MATERIALS AND METHODS

2.1 Study Area

Agusan del Sur is derived from "agasan," which means "where the water flows," referring to the Agusan River. Agusan del Sur is a province of Caraga Region situated in the northeastern section of Mindanao which comprises thirteen (13) Municipalities namely; Loreto, La Paz, Trento, Bunawan, Veruela, Esperanza, Sibagat, Talacogon, San Luiz, Prosperidad, San Francisco, Rosario, Sta. Josefa and one (1) component city (Bayugan City), which is divided into two (2) congressional districts. Agusan del Sur has a total population of 700, 653 as of the 2015 Census. Prosperidad is the capital of Agusan del Sur (Wikipedia, 2020).

2.2 Identification of Risk Factors

COVID-19 has different forms of transmission it can be droplets or by physical contact with the infected person that surrounds the environment. Most of the cases reported are those who are in weak immunization and those who are under medication. Therefore, the identified risk factors are based on the data sets reported by the health authorities such as; (i) Percent of People Violates Health Protocols, (ii) Number of Cases in each Municipality, (iii) Population Density, (iv) Percent of People below 21 and above 60, (v) Percent of Medical Frontliners treating COVID-19 Patient. More information about the identified risk factors is specified in the following subsections.

2.2.1. Number of People Violates Health Protocol

According to the Philippine News Agency, there are many people who have violated health protocols, especially the passengers of Public Utility Vehicles (PUV's) (PNA, 2020). The preventive measures have been imposed by the Department of Health (DOH) together with the Inter-Agency Task Force for COVID- 19 (IATF) are the following: wearing of facemask, physical distancing, and regular handwashing. These preventive measures and health protocols

are not followed, which results in the rapid increase of the SARS-CoV 2 (DOH, 2020). Violation of preventive measures is one factor at risk in which the movement of the people is uncontrollable. Shown in Figure 1 are the gathered data from Agusan del Sur – Police Provincial Office.

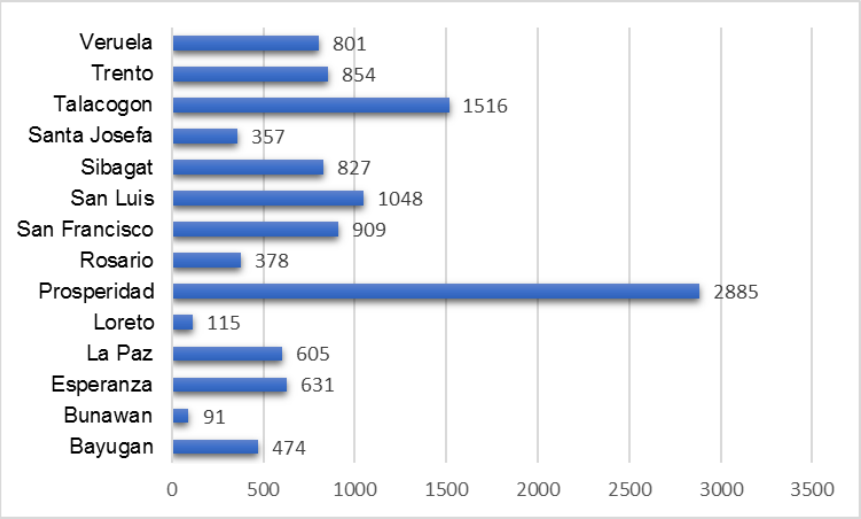


Figure 1. Number of Health Protocol Violator.

2.2.2. Number of COVID-19 Cases in each Municipality

The total number of cases in the Philippines is continuously rising, from which RITM and DOH collaborate to contain the spread of coronavirus disease (WHO, 2020). On 20th March, World Health Organization released new categories for COVID-19 these are suspect, probable, and confirmed cases. A suspect case is a person who has a severe respiratory illness like having 38◦C or higher, cough or sore throat, shortness of breath, and even pneumonia that is undetermined before testing for coronavirus. A probable cause is a person that tested positive for COVID-19, but the result is inconclusive. A confirmed case is a person who tested positive in national and subnational reference laboratories or confirmatory molecular laboratories (DOH, 2020). Shown in Figure 2 is the total confirmed cases in Agusan del Sur.

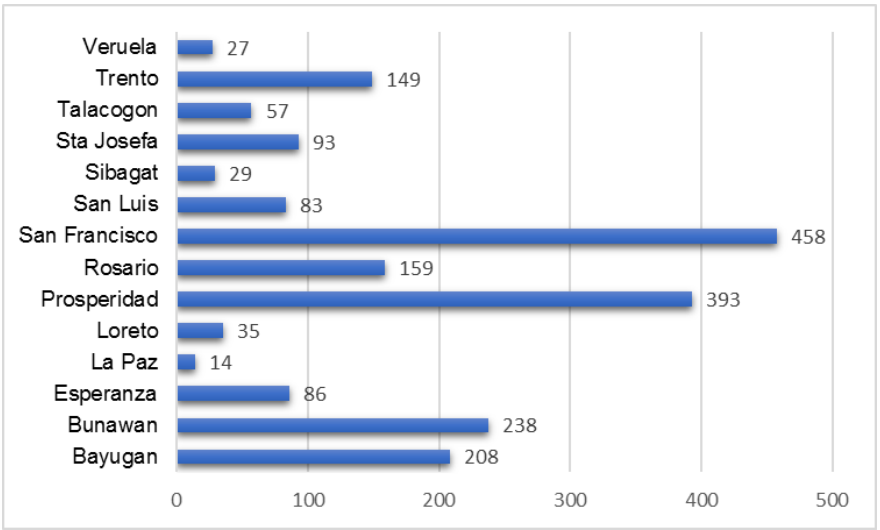


Figure 2. The Number of Confirmed COVID 19 Cases in Agusan del Sur.

2.2.3. Population Density

Population Density (Figure 3) is one of the risks factors the researcher considers, which corresponds to the number of people living in each unit area (such as a square mile). Its population densities will measure every city/municipality in the Province of Agusan del Sur. The results data will be used to analyze if areas are at high population density because COVID-19 has a high effect on populated areas and a common effect on less populated areas. These may be a risk factors due to the physical distancing and the uncontrollable movement of the people.

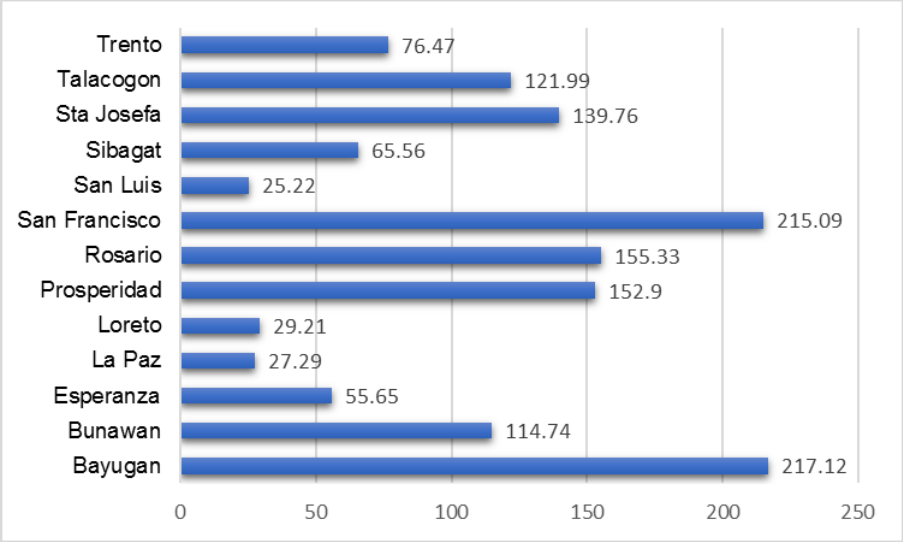
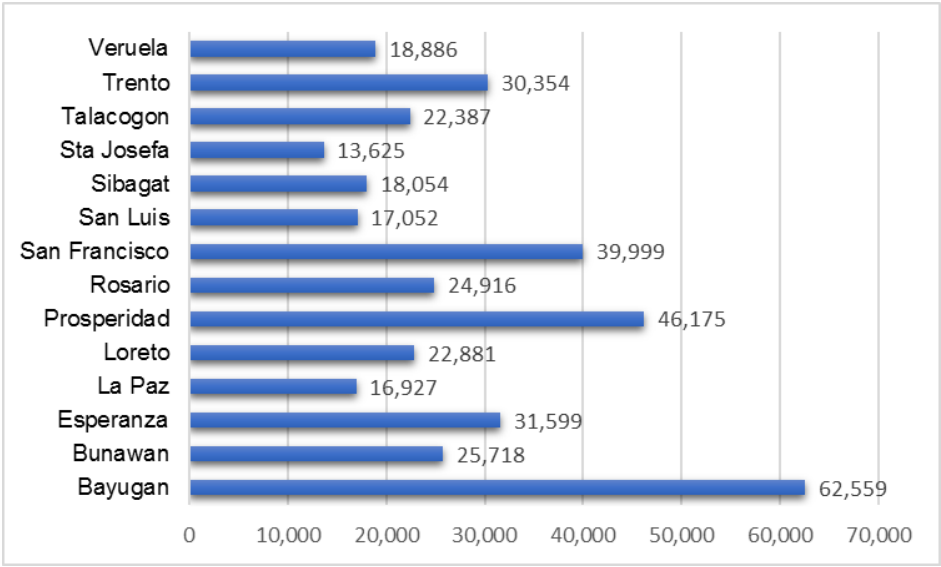


Figure 3. Population density of each municipality in Agusan del Sur.

2.2.4. Number of below 21 and above 60 years old

SARS-CoV 2 can infect individuals ages 21 below to 60 years old, especially those who have underlying medical conditions. COVID-19 will enter the body if the person has a severe respiratory illness and a low immune system. These individuals will need extra precautions to stop the spread of coronavirus. Older adults are required to refrain from going outside for which they cannot be infected. In a recent report, the percent of affected older adults is impressively increasing. As such, to mitigate the increasing case of COVID-19 the Centers for Disease Control and Prevention releases list of people who needs extra precautions such as people living in the rural areas, people with disabilities, people with a developmental and behavioral disorder, people experiencing homelessness and pregnant people and breastfeeding (DOH, 2020). According to World Health Organization (WHO), more than 30% of Filipinos who died of coronavirus disease were aged 60-69 years old, while 35% were 70 years old above and 21.2% were 20-29 years old (Inquirer.net, 2020) Data are shown in Figure 4.



. Figure 4. The Number of below 21 and above 60 years old in Agusan del Sur.

2.2.5. Number of Medical Frontliners treating COVID-19 Patient

The Province of Agusan del Sur has always been reported for the continued growth of the COVID-19 Patient, especially those who took care of them. Over 91.3% of 5,008 total coronavirus infections among health care professionals, 38 cases of fatalities. Among the Heath care profession with COVID 19 are nurses (1,734), doctors (1,100), nursing assistants (338), medical technologists (210), and radiologic technologists (119) (Nguyen, L. H.,

2020). In the UK and the USA, the highest contribution in the increase of the COVID-19 case were the frontline health care workers who treated COVID-19 cases. As such, the health care system should be the Government's utmost priority to ensure that they will not be infected by giving them adequate availability of PPE and developing additional strategies to protect health care workers (Nguyen, L. H., 2020). Shown in Figure 5 is the number of Medical Frontliners treating COVID 19 Patients.

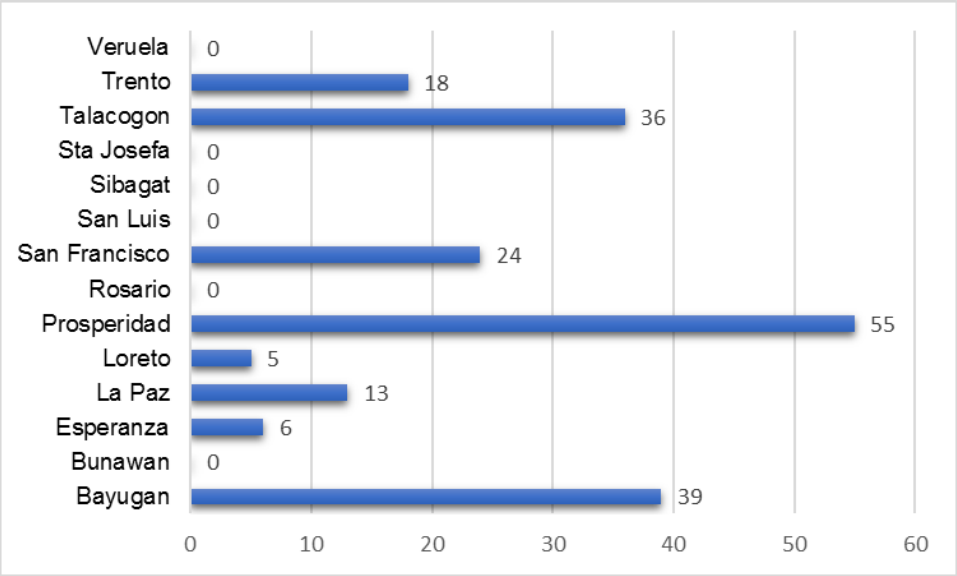


Figure 5. Number of Medical Frontliners treating COVID-19 Patient in Agusan del Sur.

2.3 Normalized/Standardized Risk Assessment Scoring

In most cases, normalizing data can eliminate the units of measurement for data, enabling comparison data from different places more easily. Data transformation using z scores, or t scores is called standardization. Due to the percentile by quartile, the method being used was min-max scaling. Rescaling ranging from 0 to 1 is the basis in determining the low risk (0) and high risk (1) municipality as shown in Equation1.

$$Xnorm = (X - Xmin)/ (\text{Xmax} - \text{Xmin}) \quad (1)$$

2.4 COVID 19 RISK ASSESSMENT

Based on the expert's facts on determining the high-risk Municipality in the Province, the weights of each criterion will be determined. We select five (5) experts coming from the different government offices/agencies in the Province, namely; Talacogon Municipal Health Office (TMHO), Agusan del Sur-Police Provincial Office (ADS-PPO), Provincial- Department of Health (PDOH), Provincial Planning and Development Office (PPDO) and Provincial Health Office (PHO). These offices/agencies were working together for the public's general welfare and were given one (1) Analytical Hierarchy Process Form.

The application of the pairwise comparison was set to all criteria using the fundamental standardized scale, which has a significant part in the AHP method. The weight of each criterion was calculated by first determining the Nth root, which can be derived from the formula shown in Equation 2. The Eigenvector value exemplified the weight of each risk factor indicator shown in Equation 3.

$$\text{Nth root} = (X1 * X2 * X3 \ldots\ldots Xn) / (1/n) \quad (2)$$

Where:

X = Rating of experts in pairwise comparison
n = Number of Indicator

$$\text{Eigenvector} = \text{Nth root} / \Sigma (\text{Nth root}) \quad (3)$$

In shepherding Analytical Hierarchy Process, Consistency Ratio (CR) can also be determined. It refers to the judgment of the experts which is being consistent. The CR can be derived using the Consistency Index (CI) and the Random Index (RI). Since the researcher has only chosen five (5) experts for the study, the allowable Consistency Index ranges from 0.10 to 0.20, respectively. It is shown in Equation 4 and Equation 5 below how these are being derived.

$$CI = (\lambda - n) / (n - 1) \quad (4)$$

Where: CI = Consistency Index
λ = Lamda max; derived from the summation of the products between each criteria Eigenvector and the sum of each respective column on the matrix
n = Number of Indicator

Then, the Consistency Ratio is being calculated using the equation below,

$$CR = CI / RI \quad (5)$$

Where:CR = Consistency Ratio
CI = Consistency Index
RI = Random Index

The Random Consistency Index (RI) was used to compute the CR in Analytical Hierarchy Process. The required ratio is not greater than 0.1; thus, the decision is relatively consistent if the evaluator attains the required ratio.

The reclassified maps of each risk factor indicator in the form of a raster are being generated to be input in the Weighted Overlay Tool. The percent of Influence has been distributed to the assigned risk factor indicator in the tool. The highest percent of Influence is considered the factor that contributes a more significant influence in determining the high risk. The lowest percent of Influence is considered the factor was contributing to the lower Influence in determining the high risk of COVID-19. The weight of each indicator that the experts have given is the basis for determining the high-risk Municipality of COVID-19 Case in the Province of Agusan del, which is the primary output of this research. The scale values were set into 9,8,7,6,5,4,3,2,1 (Table 1) from strong importance to equal importance factor of the high-risk Municipality.

Table 1. The Fundamental Standard Scale in Pairwise Comparison

INTENSITY OF IMPORTANCE	DEFINITION	EXPLANATION
1	Equal Importance	The two indicators haveequal contributions to the risk factor component
3	Moderate Importance	Contribution of indicator iis slightly favored over indicator j.
5	Strong Importance	Contribution of indicator iis strongly favored over indicator j.
7	Very Strong Importance	Contribution of indicator iis slightly favored over indicator j.
9	Extreme Values	The indicator I have the highest possible contribution overindicator j.
2,4,6,8	Intermediate Values	When compromise isneeded

3. RESULTS AND DISCUSSIONS

3.1. Weight of Risk Factors

Shown in Table 2 are the weights of each factor in deriving the risk map of Agusan del Sur. It shows that the number of medical frontline treating COVID 19 patients and number of COVID 19 cases gains the highest weight with 28% and 23%, respectively. The number of health protocol violators, the number below 21 and above 60 years old, and population density followed them with 19%, 16%, and 14%, respectively.

Table 2. The percentage of influence of each risk factors.

Risk Factor Indicator	Total Average Weight/Percentage of Influence
Number of COVID 19 Cases	**23**
Population Density	**14**
Number of Health Protocol Violators	**19**
Number of Medical Frontline treating COVID 19Patients	**28**
Number of below 21 and 60 years old	**16**
TOTAL	**100**

3.2. COVID 19 Risk Map

Figure 6 shows the map of the overall risk of Agusan del Sur due to COVID-19. It shows that the Municipality of Prosperidad was the very high-risk Municipality of Agusan del Sur of COVID-19. On the other hand, Bayugan, San Francisco, Talacogon, and Trento were placed at high risk. In contrast, Esperanza, San Luis, La paz, Rosario, Bunawan, Santa Josefa and Sibagat, Veruela, Loreto were placed under the category of moderate and low respectively.

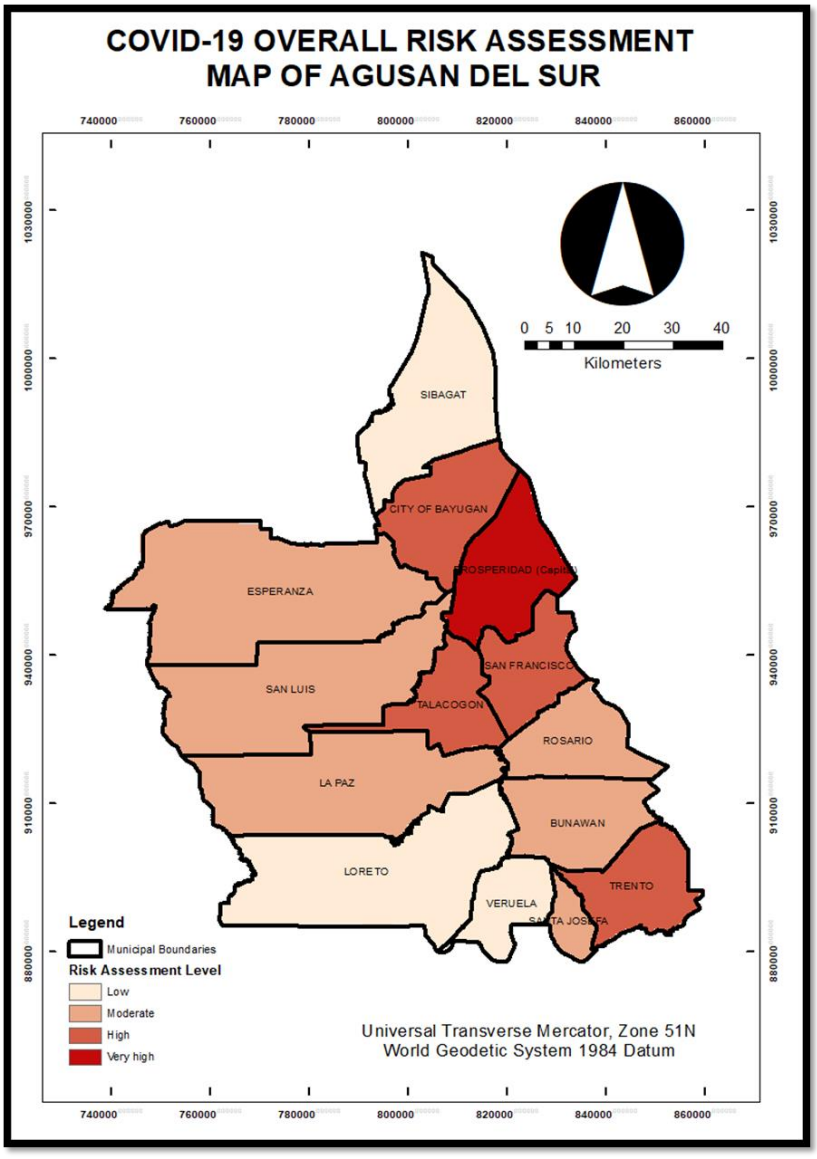


Figure 6. Overall COVID-19 Risk Assessment Map of Agusan del Sur.

4. CONCLUSION

In this study, the Analytical Hierarchy Process (AHP) was used to determine the overall very high-risk Municipality in the Province of Agusan del Sur. The basis for its low, moderate, high, and very high classification was that the researcher uses the percentile ranking and quartile method through the ArcGIS Tool to assess the five (5) COVID-19 risk factors to determine which among the data processed are lowest and the highest. Although the study produces good output, it can be explicitly improved by considering other factors such as biophysical and bioclimatic factors and utilizing Web-based GIS to update the risk factors easily. All these concerns are considered for future studies.

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