MAPPING OF THE POTENTIAL SITES FOR ELECTRIC FERRY OPERATION USING GEOGRAPHIC INFORMATION SYSTEM (GIS) FOR GREEN INTER-ISLAND TRANSPORT

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ABSTRACT: One of the important industries for economic growth is the maritime industry, in which it serves as the major infrastructure that connects the country to global commerce and trade. But despite of the economic progress given by the shipping industry, this industry is one of the contributors to the environmental issue, in which 1 Gt of CO_2 emission annually is coming from the shipping industry that leads to a great pressure to reduce environmental impact due to CO_2 emission which is projected to increase to 50-250% by 2050. With the present environmental problem facing globally, transitioning to green energy solution for the maritime transport sector will be the answer for energy security, pollution, climate change impact, and marine ecosystem degradation. This study aims to map the potential sites for Electric ferry operation using Geographic Information System (GIS) for green Inter-island transport in the Philippines. At present, the Philippines has 83 ports, 110 terminal ferries and 34,263 registered domestic vessels as of December 2018. Mapping the potential sites coupled with the identification of the potential ferry for a green energy source for inter-island transportation helps identify the 14,457 vessels with the GRT $\geq$ 10 but $\leq$ 20 will be used as a kickoff in implementing green inter-island transport in the country. The result shows that, if all identified vessels will be electrified there will be a reduction of CO_2 emission for about 8.1Mt in a period of 8 years. With this reduction, it prevents the increase of the ocean acidity, solves the energy security, pollution, and climate change impact.

1. INTRODUCTION

With the present environmental problems facing nowadays due to the impact of CO_2 emission, it is timely to adapt and promote renewable energy in different sectors. In promoting the RE gives more security in response to the needs of the consumers and to the climate change impact which becomes essential in transitioning to a sustainable future (Vidadili, Bulut, Suleymanov, & Mahmudu, 2017).

The transition of energy in different sectors faces challenges towards sustainability of the suitable technologies and energy sources, but because of the availability of the RE such as wind, wave, tidal and the solar energy tied with innovative technologies, transitioning to green energy is very feasible nowadays. This transition can also be extended in the maritime sector, wherein the shipping industry is one of the contributories of the CO_2 emission in the environment. In general, shipping is fuel-efficient (Gagatsi, Estrup, & Halatsis, 2016), however, because of the rapid growth, it becomes a major consumer of fossil fuel and a source of carbon dioxide emission in which 11% of the global petroleum usage, about five million barrels per day used by the shipping industry that is equivalent to 1Gt of carbon dioxide emission annually (Gagatsi, Estrup, & Halatsis, 2016), because of this emission, shipping industry are put into a great pressure to reduce environmental impact of the CO_2 emission which is projected to increase 50-250% by 2050 (Geertsma, Negenborn, Visser, & Hopman, 2017). With the regulation on CO_2 emission imposed by the European Union and United Nation Framework Convention (UNFCCC) in all sectors, the International Maritime Organization (IMO) is working on the regulation of the emission in the shipping industries (Duan & Sherbaz, 2012) and working towards developing a comprehensive regime aimed to protect the environment from pollution caused by the ships (Prpic-Orsic, Faltinsen, & Valcic, 2014). With the problems in energy consumption, price and volume of CO_2 emission facing by the maritime sector, researchers and engineers find its way to solve the challenges by moving towards green energy source and electrification of the maritime transportation wherein study of (Bouchhima, Schnierele, & Valcic, 2017) shows that it is technologically possible to shift from a diesel engine into a battery-operated electric motor water transportation.

The utilization of renewable energy as the source either use in the main or auxiliary or hybrid system plays an important role in the marine sector (Nasirudin, Chao, & Utama, 2017) especially in transporting goods and passenger between two Islands. Electric ferry that operates close to the coast of Cinque Terre Natural Park in transporting passenger gives a good feature wherein it is noiseless and slow boating that allows transforming connection to

touristic journey in a wonderful natural site without impacting with the local environment by helping reduce the chemical pollution and operating cost of the public and private transport companies and promote social acceptance transport on waterways especially in the protected areas (Bianucci, Merlino, Ferrando, & Baruzzo, 2015). Another study proved that emerging into green energy source lessen the chemical pollution, study of (Spagnolo, Schirripa, Papalilo , & Martocchia, 2011)

With the growing interest to clean energy source in the maritime sector, this study aims to map the potential sites for electric ferry operation using geographic information system (GIS) for green inter-island transport in the Philippines. The Philippine maritime industry is considered as one of the vital components in achieving inclusive growth and socio-economic progress, which serve a major infrastructure in which Philippine islands are linked and connects the country to global commerce and trade (Carpenter & Springer, 2005). But also maritime industry in the country is responsible for the CO_2 emission that affects the marine life environment. The Philippines is accountable only for about 0.25% of the global carbon emission but still it gives a negative impact on the agriculture, fisheries, energy production and transportation sector, that further result of 2.5% losses in the gross domestic product annually leading to the expected losses of approximately $ 418 billion in 2030 (Planner, 2010). With the problem in CO_2, the Philippine government submitted to UN, Framework Convention on Climate Change last October 2015, the Intended Nationally Determined Contribution (INDC) included the intention to reduce greenhouse gas emission by about 70 percent by 2030. Mapping the potential site for electric ferry operation for green energy inter-island transport will serve as the springboard to solve the GHG emission,climate change impact, and saving the marine life environment.

1.1 Philippine Infographics

Philippine is an archipelago, with 2.2 million sq. km, with 12 percent equivalent to 267, 000 sq. km are coastal water and 88 percent equivalent to 1.934 million sq.km is oceanic water and it has also a total discontinuous coastline approximately 32,400 km with 80 percent of the provinces and 65 percent of cities and municipalities sharing the coast (Tyner, 2010). . The country has one of the most populous and diverse aquatics in the world, it contains significant habitat, in which 30 million Filipinos depend on the marine resource for survival and daily source for protein (Carpenter & Springer, 2005). Fishing is a major industry in the Philippines in which it provides livelihood and employment to over one million Filipinos.

1.1.1 Philippines Port and Vessels

Philippine ports and vessels were monitored by the government agencies, the Philippine Ports Authority (PPA) and the Maritime Industry Authority (MARINA) respectively. The Philippine ports connect the land and the maritime terminals that serve as the communication in trading, transporting good and passengers from different islands in the country, wherein it helps the economic progress, increase in productivity and improve the quality of life of the Filipino. At present, there are 83 ports and 110 terminal ferries in the country (Philippine Port Authority, 2016), wherein existing ferries and small boats can be a potential for electric maritime transport in the Philippines as shown in Figure 1. As of Dec 2018, there were 34,263 vessels with different types of services registered in the Philippines (MARINA, 2017). These vessels help the economy improve, but these are also contributors to the carbon dioxide emission and the depletion of fossil fuel.

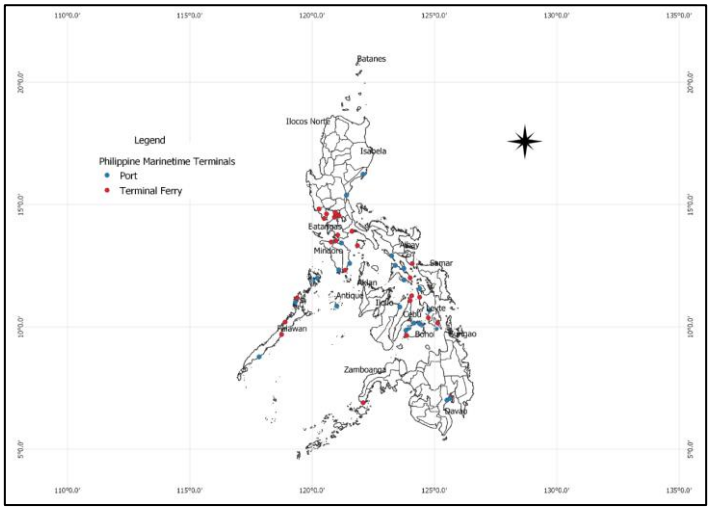

Figure 1. Philippine ports and terminal ferry

Currently, the Maritime Industry Authority (MARINA) monitors the different service type of vessels with corresponding numbers shown as in Figure 2 that operates in the country.

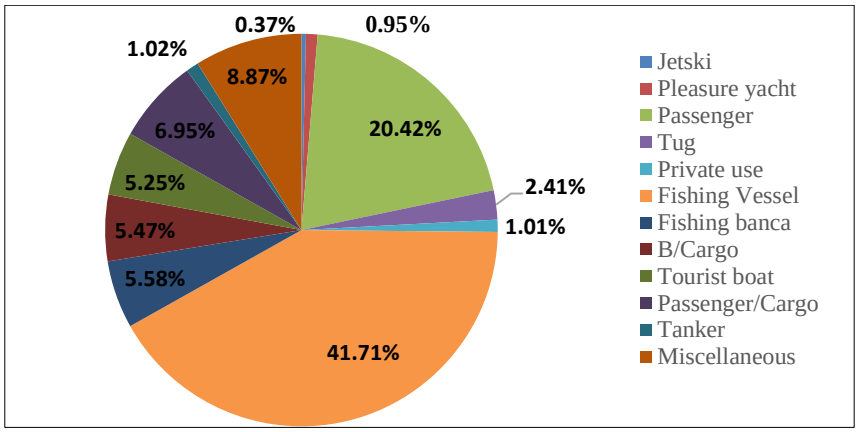

Figure 2. Registered domestics vessels in the Philippines per service type

These domestic registered are coming from the three major Island Luzon, Visayas and Mindanao, Figure 3 shows the breakdown of different service type of vessels in three major Islands in the Philippines. All these vessels that operate in the country help improve the economy and increase the quality of life. However, these are also the number of vessels that contribute to the increase in the CO_2 emission and depletion of fossil fuel.

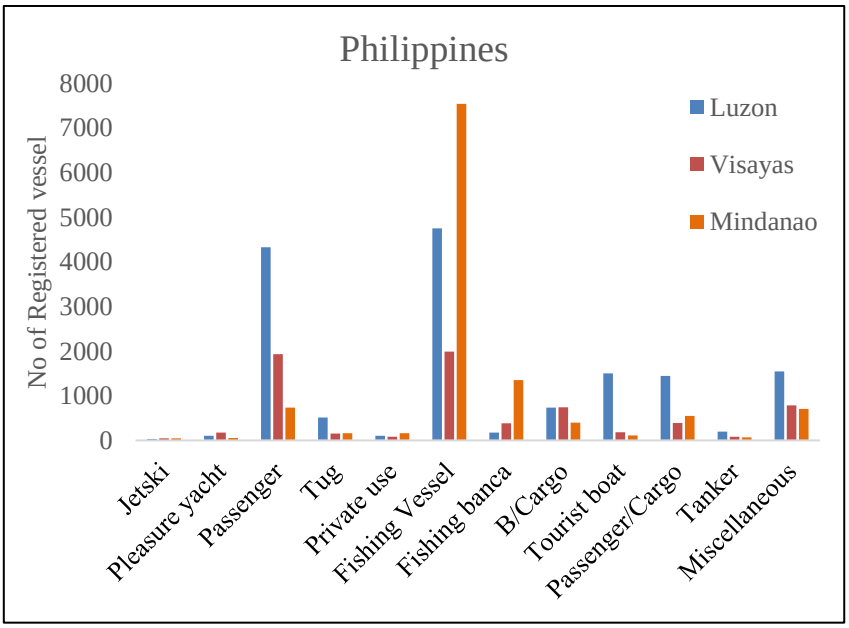

Figure 3. Registered vessel per group of Island per service type

All the data coming from the MARINA Philippine were analyzed, in order to derive the potential vessels for the electric ferry in the maritime transport sector. Table 1 displays the 14,457 vessels that under the GRT greater than and equal to three but less than or equal to twenty tons (GRT>=3 but <=20) that are potential for electric propulsion in the Philippines that transport goods and passengers in different ferry terminal. In Mindanao for instance, ferryboats that operate in Davao to Paradise Samal beach resort. The resort has twelve ferryboats that operate in the area, in which each boat operates sixteen times a day for six days a week. The operator uses sixteen liters of diesel fuel that cost Php 800 per day. In one liter of diesel fuel, it contributes a 2.68 kg of CO_2 in the environment. In one liter of diesel fuel, it contributes a 2.68 kg of CO_2 in the environment. Figure 4, shows the CO_2 emission for one ferryboat that operates on the island in a period of 8 years. If all identified vessels which are reflected in Table1 will

use a minimum of 16 liters a day, the total CO_2 emission of three groups of islands is equal to 8.15 Mt in a period of eight years as shown in Figure 5, this result gives an indicator that the Philippines need to address the CO_2 caused by transportation in the maritime sector by advocating the green energy source for ferryboat operation.

Table 2.1 Potential vessels for a green energy source

Place of Registry	No. of registered boats with GRT>=3 but <=20
Luzon	7,552
Visayas	3,583
Mindanao	3,322

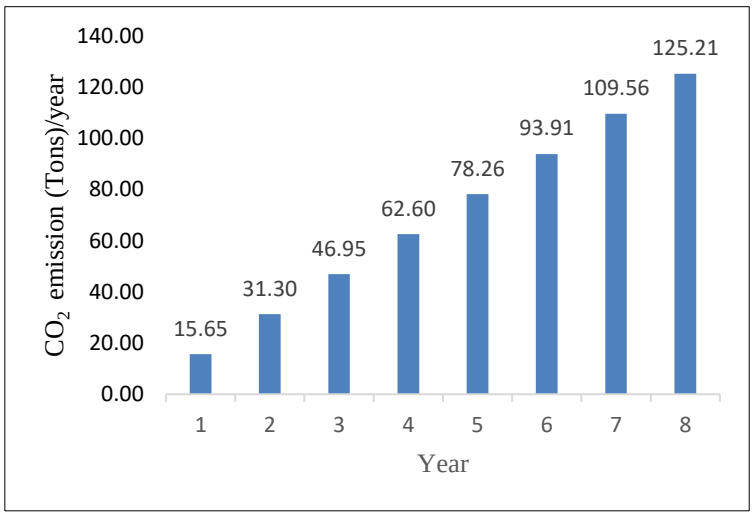

Figure 4. CO_2 emission of one ferryboat with GRT= 8 Tons and LOA= 16.69 m

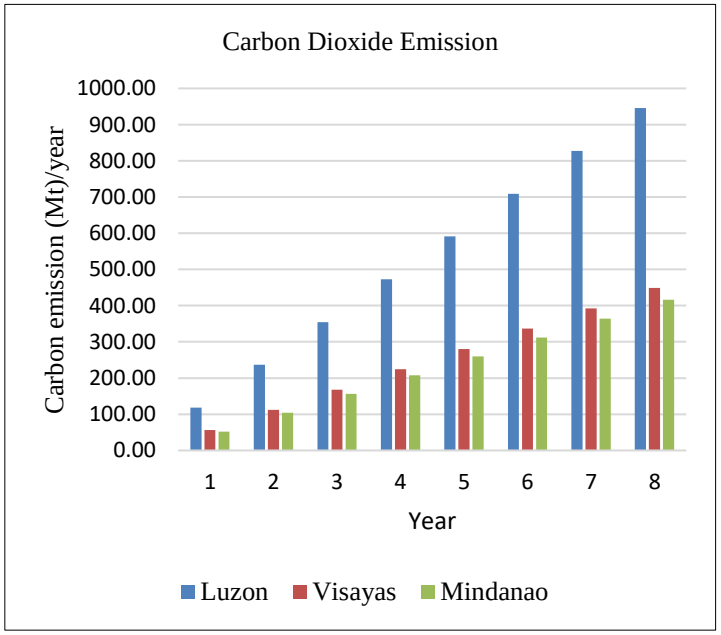

Figure 5. CO_2 emission per Island based on fuel usage

At present, there are 14,457 registered vessels under the GRT≥3 but ≤20 potential for electrification in the maritime transport sector, but as a kickoff for electrification tourist, passenger, passenger/cargo and the fishing vessel with a total of 11,104 vessels under the same GRT were put into consideration for electric propulsion. Figure 6 shows the population density of the potential vessels for electrification that operate in the corresponding places of registry in

the country, Figure 6a is the Tourist vessels, Figure 6b is the Passenger vessels, Figure 6c is the Passenger/Cargo vessels and Figure 6d is Fishing vessels, the gradient color was applied to indicate the different density of the vessels, where light color means it has a less occurrence of vessel while the dark color means dense occurrence of the vessels in different areas. If 11,104 vessels will use clean energy source, it has a CO_2 eduction of 6.24 Mt but if all the potential vessels will be electrified the reduction of CO_2 will be equal to 8.1 Mt in a period of 8 years.

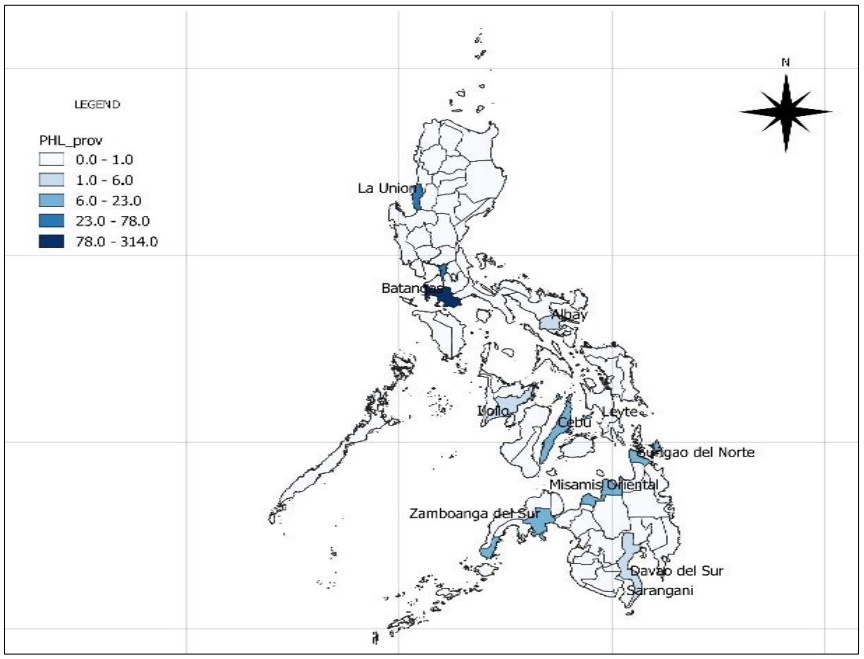

Figure 6a. Tourist vessels

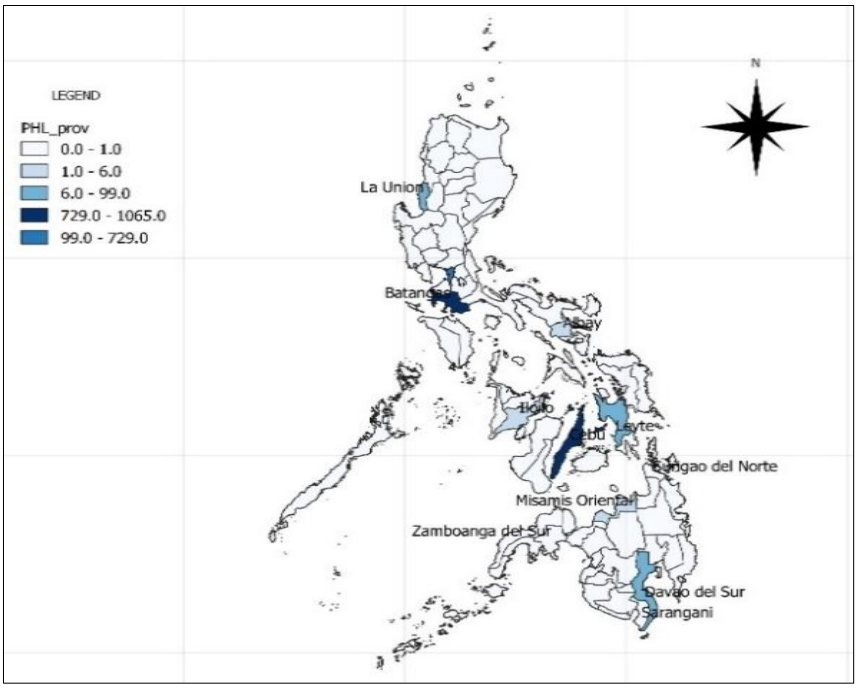

Figure 6b Passenger vessels

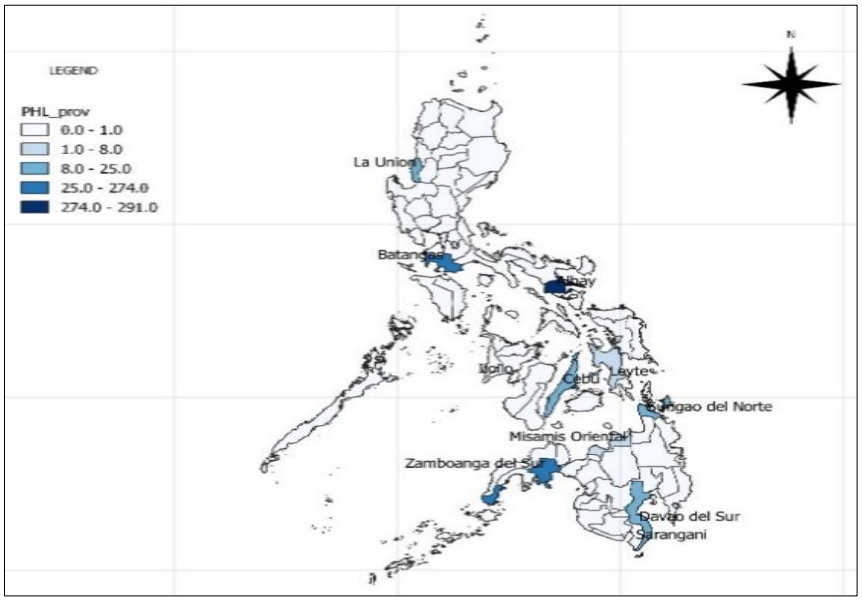

Figure 6c Passenger/Cargo vessels

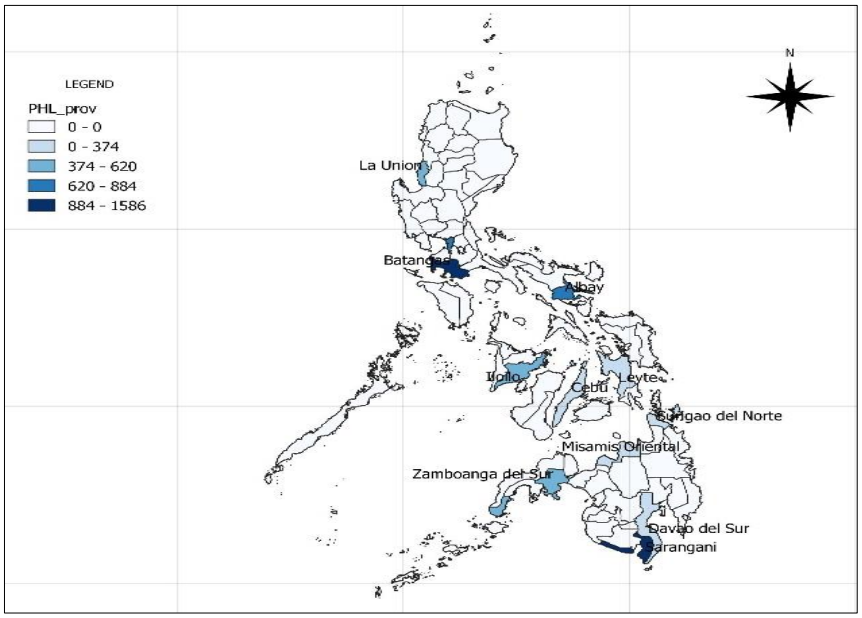

Figure 1.6d Fishing Vessels

Figure 6 Population density maps of the potential vessels for electrification

Transitioning to green maritime transportation is significant because, according to (Buck & Folger, 2009) that one ton of CO_2 fixes six trees, so therefore, with a CO_2 reduction of 8.1 Mt it saves 48, 600, 000 trees in a period of 8 years. In the case of the ocean, some of the CO_2 are absorbed in the water, the study of (Briffa, de la Haye, & Munday, 2012) that one ton of CO_2 fixes six trees, so, therefore, with a CO_2 reduction of 8.1 Mt, it saves 48, 600, 000 trees in a period of 8 years. In the case of the ocean, some of the CO_2 are absorbed in the water, study of (Buck & Folger, 2009) that 7 billion tons of CO_2 release in the world into the atmosphere per year, the ocean takes 2 billion tons, that causes the increase of 26% in the concentration of the hydrogen ion, that causes the pH decreases to 0.1 pH unit, in which marine species will be put into risk. With a CO_2 reduction of 8.1 Mt, it contributed to about 35% reduction of CO_2 caused by the transportation sector in the Philippines.

2. Methodology

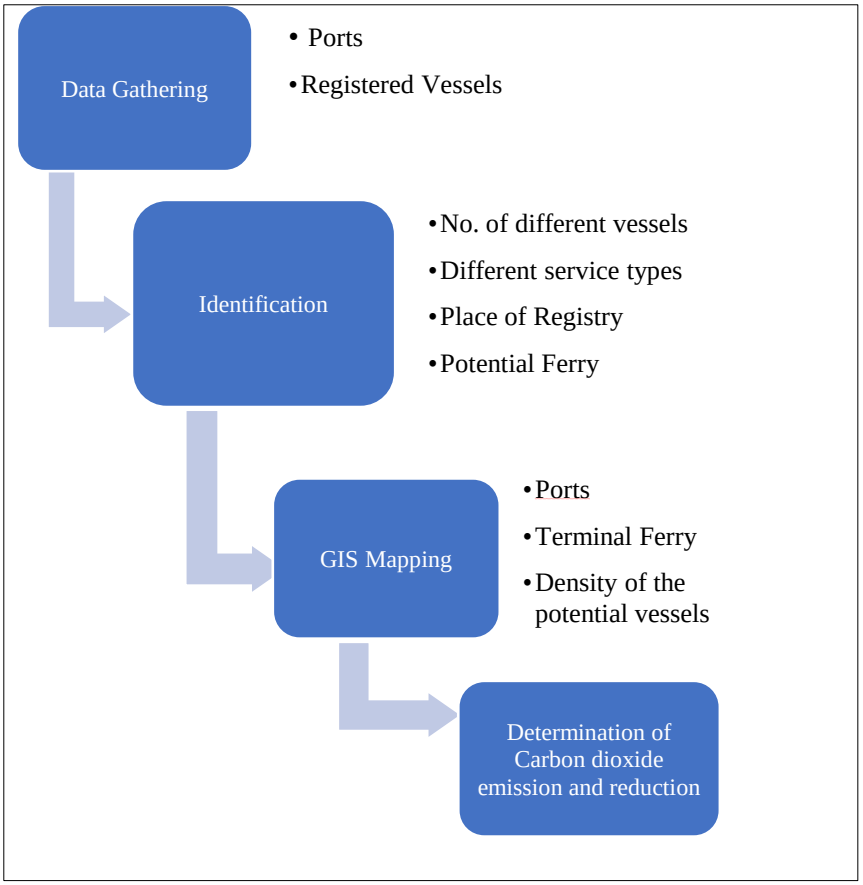

Figure 7. Methodology

Figure 7 shows the methodology of the study, wherein data gathering is the first condsideration in this research, the registered vessels and port are coming from the Maritime Industry Authority and Philippine Port Authority respectively. The data were segregated and identify in order to get the number of domestic registered vessels with the corresponding service types and place of registry. After the identification, it then identified the potential vessels to be used as kick-off for electrification in the country. GIS mapping is then used to map the ports, terminal ferry, and density of the potential vessels that operate in different places in the Philippines. The reason for the mapping is to identify the CO_2 emission caused by the shipping industry and to see how much CO_2 reduction if all the potential vessels will be electrified.

3. Conclusion

To fight the climate change impact in the country, transitioning to a green energy source for inter-island transportation plays a vital role in reducing carbon dioxide emission. Philippines is not one of the major emitters of CO_2 emission in the world, but it is ranked 4th in Asian countries. That is why Philippines government find its way to solve the problem in the CO_2 emission caused by different sectors, wherein transportation sector contributed 34% CO_2 emission. With mapping the potential site and vessel for electrification, it was identified that there were 14, 457 registered potential vessels for electrification with a GRT$\geq$3 but $\leq$20. If green energy source in marine transportation will be implemented in all 14,457 vessels, it reduces CO_2 emission by 35% in the transportation sector. The reduction of the CO_2 helps solve energy security, pollution,climate change impact, prevent the increase of the ocean acidity and decrease fuel dependency.

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