Mapping the pattern of distribution of Threatened Marine Species from the X-Press Pearl Ship explosion using GIS techniques

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Abstract*: Over 90% of global trade is done by shipping the world, the marine sector supports the transportation of a variety of critical items while balancing the global economy and keeping countries united in such a complex global market. Sri Lankan ports are strategically positioned ports for vessels going from west to east and east to west. The X-Press Pearl ship Explosion recorded on the 20th of May 2021 was investigated under the study by utilizing the Geographic Information Systems in the spatial domain. It severely polluted some of the coastal zones of Sri Lanka including Colombo, Kalutara, and Galle due to its chemical explosion and oil spreading. Under the research, we explored the marine species wash-out incident through records and reports on social media and news reports as the main source of data. First, all data is stored in the spatial database before the analysis and along with the location coordinates. Then the spatial analysis was carried out in the Arc GIS 10.5 platform and generated maps to illustrate the pattern of expansion. According to the study, it has found out the most vulnerable areas were western and southern coastal regions while some incidents were recorded in the east part as well. The data collected and reported on social media or news was utilized in the data collection phase and it indicates the public involvement in disaster management practices. Further, data analysis done through the GIS context would be significant in the decision-making and implementation phases as a future direction of the study.*

Keywords: *Coastal, GIS, Marine pollution*

1. Introduction

A. *Background of the study*

In the world, over 90% of global trade is done by shipping. It is considered a secure, cost-effective, and environmentally friendly mode of business transportation. Commodities and goods must be transported across oceans, in the air, and across railways and highways for the global economy to function. The marine sector supports the transportation of a variety of critical items such as fuel, chemicals, food, vehicles, clothing, and household appliances, as well as playing a significant role in the natural resource and energy trade. As a result, many communities rely heavily on their ports for revenue. There are numerous shipping routes and ports all over the world, and some of them are the busiest shopping channels.

International Maritime Organization in 2012 reports suggests that ship-generated pollution continues to pose a hazard to the maritime ecosystem. Even though pollution-related rules have reduced the frequency of accidents and incidents, ships continue to contaminate the marine environment around the world, including in Sri Lankan waters. Some of the incidents are the result of human error, while others are the result of physical circumstances. Whatever occurs, humans will not be able to change the fact that ship-caused "environmental disasters" devastate habitat and marine life, endanger the survival of marine flora and fauna, cause major ecosystem distress, and harm people's livelihoods and quality of life

B. *Case Study*

In comparison to other countries, Sri Lanka cannot respond to maritime emergencies such as oil spills and chemical spills, posing a considerable risk. It was discovered that the expansion of world industry has a direct impact on ocean pollution and poses a substantial risk to the marine environment in all states, both global and local. The rise of global industry has a direct impact on ocean pollution and poses a substantial risk to the marine environment, according to all states at the global and local levels.

The X-Press Pearl was registered in Singapore and departed the port of Hazira on 15 May 2021 and arrived in Colombo on 19 May, and was anchored off Colombo Port. On 21 May the vessel reported a fire on the deck which continued for up to 13 days. According to the views of the experts, X-Press Pearl Explosion was the biggest sea environment pollution. It affects not only for explosion area because chemical explosion and oil spreading affect the creature's life. It damages sea creatures and features in a huge area. Sri Lanka is still a developing country, so this type of pollution cannot be accepted in the future of the country. Most people in Sri Lanka do not have a great understanding of the problem of this case. Many species have died as a result of oil spills and chemical contamination. Experts estimate that about 10% of dead animals are dumped on the beach. According to the data we have obtained, the total number of animal deaths we have encountered is about 150.

The main objective of the study was to reveal and mapping the pattern of distribution of threatened marine species due to X-Press Pearl Ship explosion around the coastal belt of Sri Lanka by succeeding sub-objectives as follows,

- To prepare a spatial database of the incidents based on social media and News Reports
- To analyse the frequency of dead creatures reported to the coastal area statistically
- To map the pattern of distribution through GIS

2. Methodology

A. *Study Area*

In terms of the Sri Lankan setting, the Sri Lankan Ocean is one of a kind, with vibrant marine environments (whales, turtles, dugongs, and so on) and a diverse range of fauna and vegetation.

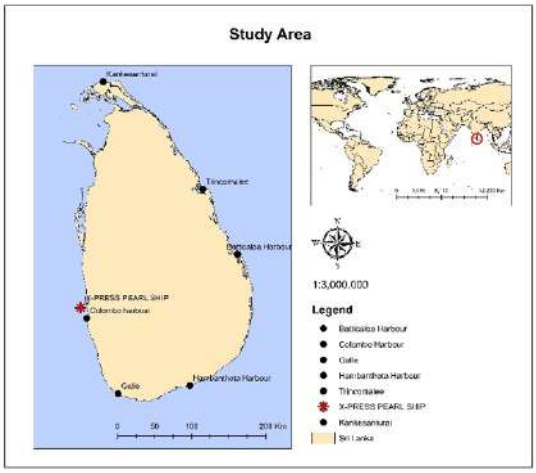

Figure 1: Study area of the experimental study

Nevertheless, incidents near or within the coastal area can have severe repercussions for vulnerable ecosystems. Furthermore, due to its central location in the global trade and shipping network, Sri Lankan ports are the most strategically positioned ports for vessels going from west to east and east to west. Colombo, Galle, Hambantota, and Trincomalee are the four largest seaports on the island of Sri Lanka. Colombo has a deep natural harbor that receives a lot of traffic from adjacent shipping routes, and the port of Colombo is one of the top 50 container ports in the world in terms of the volume of containers handled. Furthermore, as seen, many shipping channels are located throughout the country and are connected to major international shipping ports.

B. *Data*

Mainly, the data were collected through the various platforms that are available for free and open access. Interestingly the Facebook groups and news reports were used as the basic source

of data collection. The spatial database was prepared through the ArcMap software platform while adding appropriate attribute information as well.

ID	Date	Location	Y	X	Spices	Quant	Source	Spices_Com
1	2021.05.27	Wellawatte	6.876241	79.856722	Eel_Moray	1	Social media	Eel_Moray
2	2021.05.28	Dehiwala	6.848117	79.861944	Giant_Slender_	1	Social media	Giant_Slender
3	2021.05.29	Payagala	6.529646	79.97494	Green_Turtle	1	Social media	Green_Turtle
4	2021.06.01	Kalkawala	6.371277	80.01104	Puffer_fish	1	Social media	Puffer_fish
5	2021.06.01	Kalkawala	6.371277	80.01104	Dolphin	1	Social media	Dolphin
6	2021.06.02	Unawatuna	6.009439	80.248274	Turtle	1	Social media	Turtle
7	2021.06.05	Payagala	6.529646	79.97494	Turtle	1	Social media	Turtle
8	2021.06.05	Panadura	6.710885	79.906617	Turtle	1	Social media	Turtle
9	2021.06.05	Thalpitiya	6.682717	79.916654	Turtle	1	Social media	Turtle
10	2021.06.05	Dehiwala	6.848117	79.861944	Turtle	1	Social media	Turtle
11	2021.06.05	Thalaramba	5.937161	80.479273	Spotted Box Fi	1	Social media	Spotted Box F
12	2021.06.05	Agulana	6.794915	79.872671	Turtle	1	Social media	Turtle
13	2021.06.05	Morazgalla	6.445829	79.984834	Turtle	1	Social media	Turtle
14	2021.06.06	Egoda duwa	6.344736	80.022192	Turtle	3	Social media	Turtle
15	2021.06.06	Ahungalla	6.098387	80.032424	Turtle	1	Social media	Turtle
16	2021.06.06	Dehiwala	6.848117	79.861944	Turtle	1	NewsFirst	Turtle
17	2021.06.06	Iduruwa	6.368223	80.011372	Dolphin	1	Social media	Dolphin
18	2021.06.06	Payagala	6.529646	79.97494	Turtle	1	NewsFirst	Turtle
19	2021.06.06	Kosgoda	6.333678	80.027259	Turtle	3	NewsFirst	Turtle
20	2021.06.06	Kalpitiya	8.247967	79.738705	Turtle	1	NewsFirst	Turtle
21	2021.06.06	Agulana	6.794915	79.872671	Turtle	1	NewsFirst	Turtle
22	2021.06.06	Kalpitiya	8.247967	79.738705	Dolphine	1	Social media	Dolphine
23	2021.06.07	Puttlalama	8.025103	79.830836	Turtle	1	NewsFirst	Turtle
24	2021.06.07	Kosgoda	6.333678	80.027259	Whale	1	NewsFirst	Whale
25	2021.06.07	Thalpitiya	6.682717	79.916654	Dolphine	1	NewsFirst	Dolphine
26	2021.06.07	Pothupitiya	6.632713	79.937965	Turtle	2	Social media	Turtle
27	2021.06.08	Rekawa	6.043008	80.860604	Turtle	1	NewsFirst	Turtle
28	2021.06.08	Wellawatta	6.876241	79.856722	Turtle	1	NewsFirst	Turtle
29	2021.06.09	Kalpitiya	8.247967	79.738705	Dolphine	1	NewsFirst	Dolphine
30	2021.06.10	Ambalangoda	6.238226	80.049185	Turtle	1	Derana_News	Turtle
31	2021.06.10	Hikkaduwa	6.137466	80.099925	Turtle	1	Derana_News	Turtle

Figure 2: Spatial Database

LD 99 Sri Lanka grid was used as the geographical reference coordinate system of the study. To analyze the impact initially found the washed-up location coordinates including the name of the species, washed-up date, number of animals washed up at the place, and finally, the coordinate of the MV X-Press Pearl ship accident happen. To discover the details we have investigated the social media news reports by television channels and newspapers. All the latest updates were given on those social media groups and pages with the dead photo of the washed-up animals recorded in the spatial data based more than four months from the incident. Recorded the details to the spatial database with reference ID, Date, Location, X, Y, and spices Quantity and source were filled. The reference number was saved with the photograph of the washed-up animals. Coordinate of each location was taken by Google Earth Pro.

A. Methodology

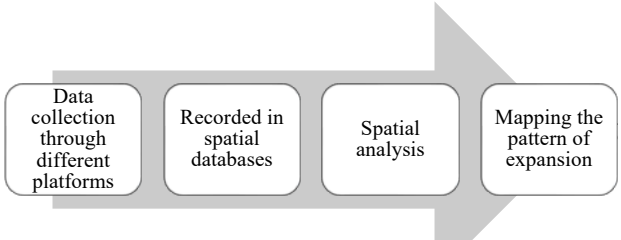

Figure 4: Methodology implemented over the study

flow map, hotspot analysis, and kernel density mapping.

The Flow Maps are a sort of cartographic themed map that depicts the flow of items between different places and were created to exhibit how the dead animals were distributed in Sri Lanka from the place of the ship accident. Hotspot and Cold spot analysis were employed in the study the measure the magnitude. Vectors are used in Hotspot Analysis to locate statistically significant hot and cold places in data. The Kernel Density tool determines the density of features in the vicinity of those features. Both point and line features were calculated. Thus, Kernel Density was used to create in which area high density of impact happens.

3. Results and Discussion

According to the data collected over four months from the incidents, we have recorded around 200 cases through the open-source platforms. As per the records, most of the sea

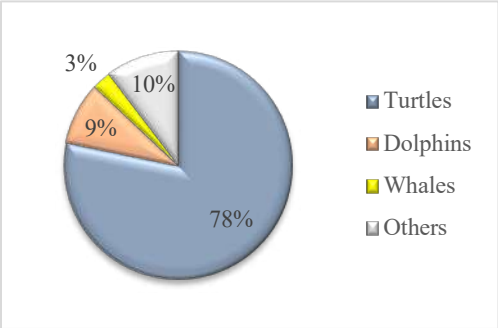

Figure 5: Number of species recorded

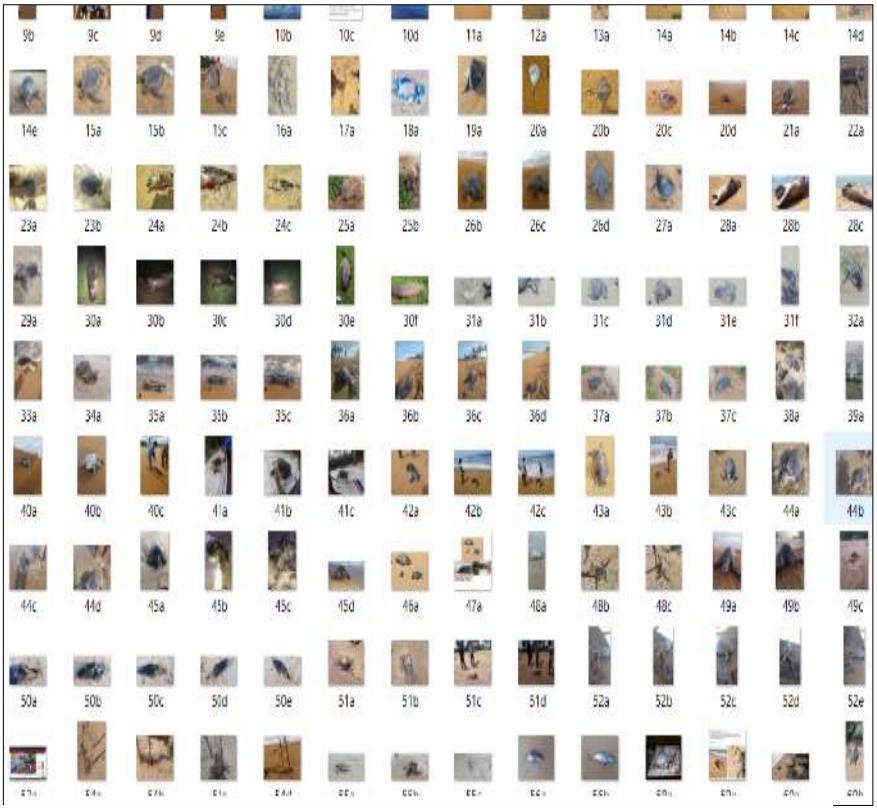

Figure 3: Photographs of the incidents recorded along with the spatial coordinates

Turtles were threatened (more than 75 %) by the accident while dolphins' and whales' deaths were at 9% and 3% respectively as in the pie chart below.

Throughout Sri Lanka, there were many sea creatures were washed out. From Colombo to Rekawa and there are several animals washed up to Batticaloa and Trincomalee because of inter-monsoon. From Colombo to Jaffna there were some sea creatures were washed up. Some animals were injured because of burning containers in the vessels and they washed up to the coastal due to disability to swimming through the deep-water rough waves. Moreover, Kaltura, Galle, and Gampaha were recorded as the highly affected districts as per the data collected by the study Hotspot analysis is a spatial examination and planning procedure inspired by the recognizable proof of grouping of spatial peculiarities.

These spatial peculiarities are portrayed as focusing on a guide and allude to areas of occasions or items. Such an investigation hotspot analysis helps to understand the magnitude of the incident relative to the location.

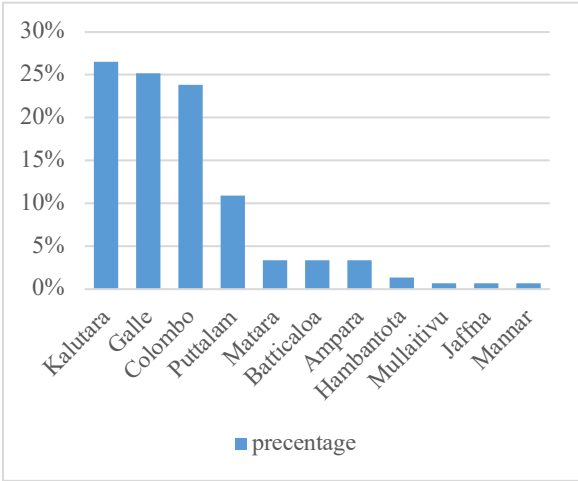

Figure 6: Species recorded in each region of the country

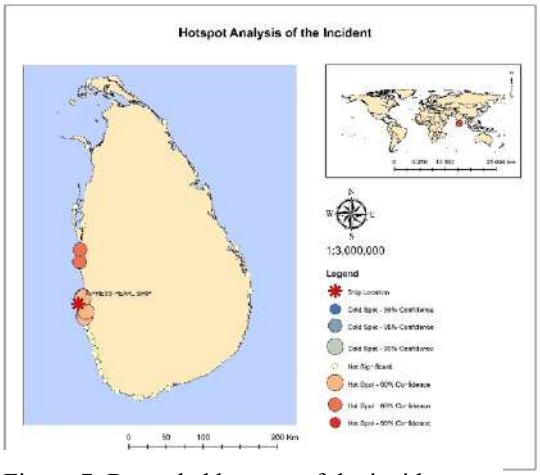

Figure 7: Recorded hotspot of the incident

The IDW model expects a weight for every estimation point in the relay of the distance between that point and the place of the point with value. These weights are then constrained by the weighting power. It implements that the assessed worth of a point is impacted more by neighboring known focuses than those farther. thus, under the investigation, the IDW interpolation was implemented to identify the hotspot and the pattern of distribution of the incident. As per the reported dead marine species, the effect not only on Sri Lankan coastal line but also affected the larger portion of the Indian ocean.

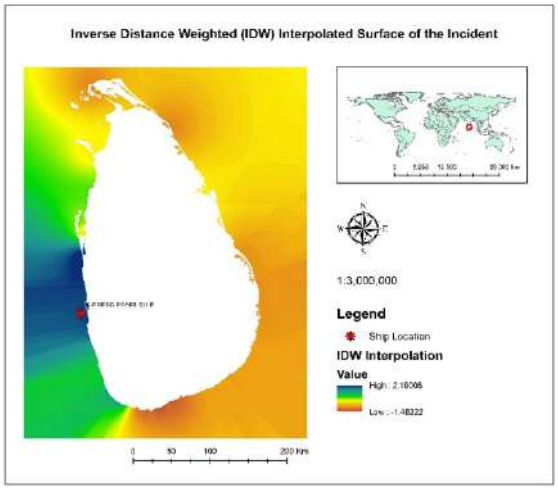

Figure 8: IDW Interpolation surface

Kernel density assessment is a significant nonparametric method for point-based or line-based data that use the technique for estimation of the probability density function.

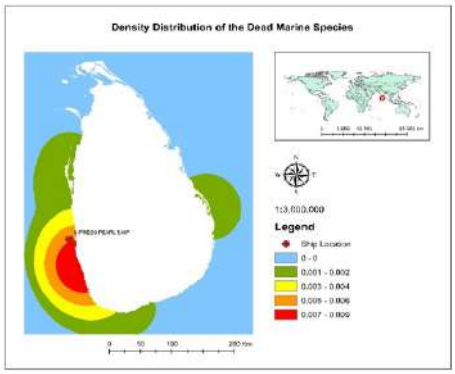

Figure 9: Density distribution of the dead

The kernel density estimation at an area will be the amount of the negligible parts of all perceptions at that area. In a GIS context, kernel density estimation normally brings about a density surface where every pixel is delivered a value in the cell center. Thus the resulted map illustrates the density distribution of the dead species. Nevertheless, it shows significant density in the Colombo area as well as the Batticaloa area mainly due to the surface water circulation, ocean currents, and monsoon pattern of the period.

Flow maps are a type of thematic map used in cartography to show the movement of items between various regions. Thus, under the study, the flow direction map indicates the flow of dead species from the accident location to various parts of the coastal zones of the island.

4. Conclusion and Recommendations

There are several reasons for facing such incidents in the Sri Lankan context, including a lack of resources to deal with such a fire, an absence of protocols in place to seek necessary assistance from better equipped marine powers, a lack of mutual agreements with other countries to deal with and avoid similar situations, and a lack of technical instruments and knowledgeable personnel. It should

establish a disaster planning and risk analysis body to avoid a repeat of the situation It is now time to begin risk analysis and disaster preparedness in the event of a maritime tragedy.

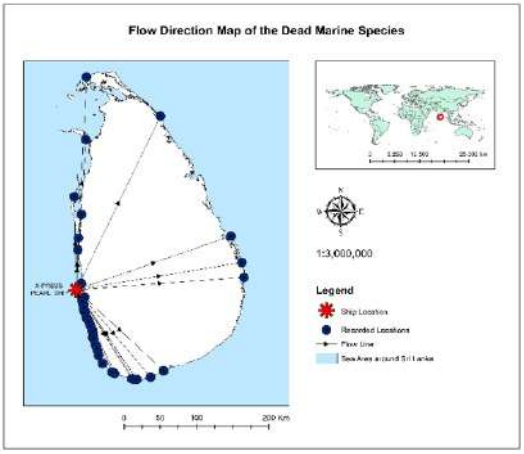

Figure 10: Flow direction map of the dead marine

However, integration between GIS as the main tool of analysis and public involvement in data collection would be beneficial to deal with such situations to overcome the difficulties. The data collected and reported on social media or news cannot be neglected and further, can be able to include in the data collection phase as in the disaster management practices. Further, data analysis done through the GIS context would be significant in the decision-making and implementation phases as a future direction o the study.

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