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GIS-Based Vulnerability Analysis for Sustainable Fish Drying Cottage Industry in Southern Province, Sri Lanka

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ABSTRACT

Dried fish manufacturing is a famous cottage industry in Sri Lanka. Due to various natural and manmade reasons, their locations are not set up in sustainable ways. As a result, industry locations have become more vulnerable. Therefore, hurdles are there to sustainably expanding this cottage industry. So, the industry's novelty and the enormous number of issues experienced have yet to be discovered or solved via research study. Therefore, the current study intends to conduct GIS-based vulnerability analysis of the fish drying cottage industry by identifying the socioeconomic, environmental, and industry-related backgrounds of existing manufacturers and the industry, challenges faced by manufacturers, and vulnerable sites in the village using geo-spatial analysis. The case study focuses on Kudawella of Tangalle local authority, in the southern province of Sri Lanka. Qualitative analysis was used to identify the existing situation using a structured questionnaire survey and descriptive analysis was performed on the obtained information. The constraints were revealed by a content analysis of qualitative data acquired from a judgemental sample via semi-structured and unstructured interviews. Furthermore, the relative positions of the cottages were determined using OpenStreet Map and the absolute coordinates of a sample of 27 cottages gathered using GPS. A Weighted Overlay Analysis was performed using Arc Map 10.8 to create a Vulnerability Index Map to identify vulnerable locations for the industry while taking nine socioeconomic and environmental parameters. The outcome indicated four categories of vulnerability: severe, moderately severe, moderate, and low vulnerability, with 4.13% of the village falling into the severely susceptible category. The index map assists relevant authoritative organisations in making industrial decisions to attain sustainability based on the amount of risk and underlines the importance of institutional and individual decision-making systems.

1. Introduction

The cottage industry alludes to the ancient artisanship of rural communities that make a variety of home objects out of locally accessible raw elements and creative talents passed down through the generations (Tasneem and Biswas, 2014). They handcraft creative objects representing the patterns and concept of nature and its individuals, birds and animals, foliage, plants and trees, lakes, streams, and sky for their personal use and income (McDonald, 2019). However, cottage industries offer economic possibilities for the poor and middle classes across the world, particularly in low-income and economically undeveloped

regions, through occupation and revenue creation programmes (Hareven, 2003). Handicrafts, artistic activities in timber and steel, amateur artworks, and rural agro and fish-based businesses are all considered to be part of the cottage industry. The cottage business has now spread throughout the metropolis, with the fish drying cottage industry being the most popular (Akter et al., 2018).

Drying is a well-known approach to preserving fish and an alternate approach to decreasing post-harvest wastage. The selection of appropriate fish, washing, separation of inside organs, salting, and drying are the main distinct steps of the dried fish production system. Dried fish is more prominent in developing countries than in advanced industrial countries, and the top dried fish manufacturers in Asia are Bangladesh, Thailand, India, and China (Omoruyi & Eronmhonbor, 2017). Hence, a cottage business focused on value-added fish products gives job possibilities while also assisting impoverished people's food security. Dried fish is quite popular among Sri Lankans, and there is considerable interest in them, particularly among rural residents who do not have access to fresh fish of excellent quality (Rupasena, 2014). While Sri Lankans' overall dried fish intake changes year to year, the typical yearly consumption stays about 90,000 Mt. Household-level manufacturers on a large, medium, and small basis is disseminated. The coastline strip of Sri Lanka caters for approximately 60–63 percent of the country's dried fish requirement, primarily through traditional manufacturing processes (Silva et al., 2013). Since the domestic output is insufficient to meet demand, value-added fish products are routinely supplied to the region, mostly from India, China, Thailand, and Norway (Nishanthan et al., 2018). Whereas the value-added fish product-based cottage industry performs an important function in the livelihood development of the seaside fisheries neighborhood and the nutrition protection of the Sri Lankan folks, no empirical study has been conducted in Sri Lanka to discover its current socioeconomic condition or challenges using a holistic approach. The industry's influence on society, the economy, and the environment is not examined, and concerns are not tackled. Nonetheless, the government and other associated organizations are taking steps to grow the business and provide assistance. Lack of research and study in the discussion area, as well as continual criticisms from stakeholders such as nearby communities and the producers themselves, highlight the need of having a comprehensive understanding of the sector before making judgments. It also means that there is an immediate requirement to draw the awareness of the necessary authorities to the industry, since coastal regions, people, and economies are very susceptible due to different factors such as environmental sensitivity, urban characteristics, and economic possibilities. Furthermore, since more than 80% of data utilized by decision-makers is linked to spatial characteristics (Synek and Klimánek, 2014), the use of spatial analysis tools such as GIS enables them to produce a more effective decision with records while eliminating the ambiguities associated with statistical and traditional decision-making approaches. As a result, it is important to focus decision-makers emphasis on using more industry-specific decision-making processes. The present study aims to carry out a GIS-based vulnerability assessment of the Kudawella fish drying cottage industry by recognizing the socioeconomic, environmental, and

industry-related contexts of existing producers and the industry, difficulties confronted by producers, and vulnerable locations in the village using geospatial analysis.

The key terms; cottage industry, challenges faced by cottage industry and vulnerability and vulnerability mapping are explored by using existing literature to direct the current study.

1.1 Cottage Industry

Securing a source of income has always had an impact on people's health, their children's education, and their whole way of life. Cottage industries are an example of a way of life that has existed since the dawn of time. It is necessary to identify 'Cottage Industries,' which have played a significant part in our country's economy. Village businesses, agro-industries, rural industries, and informal industries are all terms that have been used to describe cottage industries. The industrial strategies' wide categorization and recognition criteria are ambiguous and frequently perplexing when it comes to small-scale industries (Tasneem and Biswas, 2014). A cottage industry is run entirely or mostly with the support of family members, as a full-time or part-time vocation. Regrettably, there is no universally accepted definition of cottage businesses. Depending on the thing in question, these have been described variously. According to Hasan et al. (2017), cottage businesses employ a fairly small number of people and require a little quantity of capital. In certain cases, the owner is also the lone worker. Even when outside labor is engaged, the owner has a significant amount of responsibility for donating his time and effort. According to Rahman & Srivastava, (2018) in a cottage business, the house provides the workplace. Although some people believe the cottage industry to be their only form of income, several producers work part-time. The adoption of artisanal methods is a significant aspect of cottage industry operations, according to Bangladesh Small and Cottage Industries Corporation (BSCIC) (Rahman and Kumar, 2018). When it comes to cottage industries, manufacturers rely on family customs passed down through the generations. As a result, technology utilization is either non-existent or extremely limited. Small-scale and cottage businesses, according to Hasan et al., (2017), can be founded without formal authorization. Aside from that, there is evidence of the utilization of local raw resources and their consumption within the nation (domestic usage). The use of local raw resources gives the sector a competitive edge in terms of location.

The majority of manufacturing procedures are done using artisanal methods. As a result, there is a line drawn between cultural values in these businesses. Furthermore, these industries give an excellent opportunity for women entrepreneurs and other underserved groups in society to demonstrate their entrepreneurial and inventive abilities (Chutia, 2019). Most low-income households rely on the cottage industry to supplement their income. As a result, these people have the opportunity to generate money through cottage enterprises, a fair and equal distribution of national revenue is possible. Cottage businesses may be found in different types of settings, including urban, semi-urban, and rural. However, rural cottage industries are the ones that have received a lot of attention in the literature (Islam, 1993;

Tasneem and Biswas, 2014). Cottage industries, on the other hand, lay the way for infrastructural development, economic development, and social development, allowing rural areas to experience growth that can be witnessed across the country. As previously stated, raw materials for these businesses are obtained from the surrounding area. In addition, the labor is provided by local jobless people. As a result, cottage businesses make use of underused or non-utilized resources. Although Lumna & Banu, (2019) claim that significant returns may be obtained with little investment, this is not the case in every cottage enterprise. The degree of return varies depending on the kind, nature, and size of the industry's difficulties. However, in general, the amount of money invested is little. Because of considerations such as resource distribution and market availability, the majority of cottage businesses are clustered together. These agglomerations influence infrastructure expansion, market opportunities, and resource-sharing incentives. According to Rupasena, (2014) the need to manage living expenditures, family difficulties, dignity concerns, and the desire to employ formal training or experiences obtained can all be considered motivations for entering businesses. However, there may be other factors at play, which vary based on the business and the psychological makeup of the makers.

1.2 Challenges Faced by Cottage Industry

Cottage businesses have a variety of socioeconomic, economic, and environmental consequences. They might be either beneficial or detrimental. According to Ajayi (2004), cottage businesses lead to environmental degradation, although academics have given less focus to them than to SMEs. Furthermore, the use of artisanal methods causes physical discomfort for employees, such as musculoskeletal disorders (Kumar et al., 2014). The majority of these challenges arise as a result of intrinsic limits in small-scale industries. Such limits are defined as industry challenges. According to Raof et al. (2020), four major problems have been identified in SMEs in cottage industries in Kota Bharu, including human resource growth challenges, a lack of operational management, a lack of financial resources, and a lack of market power. Hence, four significant issues in the food processing industries in Ahmednagar district, India have been identified: production challenges, financial challenges, human resource challenges, and marketing challenges (Ramchandra, 2019). Three key problems were highlighted in the Sezhiyan and Gnanadeiveegam, (2020) investigations of cottage industries in Vilianur, Puducherry: political administration, financial limits, and occupational constraints. Marketing limits, financial concerns, difficulty with raw materials, transportation problems, and power shortages have all been cited as important challenges in studies of small and cottage enterprises in Uttar Pradesh (Pandey, 2013). According to Rahman and Kumar (2018), several challenges have been listed in cottage industries in Bangladesh's Khulna division, including a lack of working capital; high raw material costs; a lack of organizing capability; insufficient technology; inefficiency; a lack of policy support; a large knowledge gap; a lack of power supply; a lack of credit facilities; infrastructural problems; insufficient government support; a lack of government support; return from product.

1.3 Vulnerability and Vulnerability Mapping

Vulnerability of cottage industries may be defined as the capacity to withstand external pressures such as environmental risks, social concerns, and economic threats that have a detrimental impact on the industry's well-being (Ribot, 1996). Vulnerability mapping and geospatial analysis may be employed to discover vulnerable regions because most of these characteristics have spatial dimensions (Shen, 2000). For this type of study, a Geographic Information System (GIS) can be employed, which is defined as "a computer system for recording, storing, querying, analyzing, and presenting geographic data" (Murseli and Isufi, 2014). The data that is geo-referenced and processed in a way that allows a decision-maker to make decisions is the information employed in GIS. According to King and Kiremidjian, (1994) GIS is a risk assessment tool that decreases ambiguity and the utilization of less realistic assumptions in statistical risk assessment methodologies. Coastal vulnerability evaluations are well-known in GIS-based vulnerability assessments. Jana and Hegde, (2016) assessed the vulnerability of Karnataka's coastline line, Mohamed, (2020) used multi-criteria analysis to study the Nile Delta, and natural catastrophes or phenomena-related vulnerability evaluations are widespread in global and local GIS literature. Wijesundara, (2014) researched the Tsunami tragedy in Sri Lanka. However, planning-related research contains literature on vulnerability or risk evaluation of human-induced behaviors. Hence, Inanloo, et al., (2016) is one instance of a study that looked into the vulnerability of Miami's transport systems. Making decisions is a difficult process. If numerous criteria are used in the decision-making process, the decision-maker must examine all of them to make an effective conclusion that achieves the end goals (Synek & Klimánek, 2014). The weighted overlay analysis is a decision-making method that is mostly used to assess "suitability" (Jafari and Zaredar, 2010). When measuring the "vulnerability, resilience, and capacity of reaction of a territorial system to distinct threats," all important social, economic, cultural, and political variables must be taken into account (Erdogan and Terzi, 2022). This study emphasizes that such assessments are "site-dependent," meaning the necessity to use additional location and incident-specific parameters when assessing using GIS (McMaster et al., 1997). Accordingly, the current study aims to perform a GIS-based vulnerability analysis for the fish drying cottage industry by using geospatial analysis to describe the socioeconomic, environmental, and industry-related influences of operating producers and the industry, obstacles confronted by suppliers, and vulnerable places in the village

2. Methodology

2.1 Description of Study Area

Kudawella (shown in Figure 1) is a fishing community on Sri Lanka's southern coast. It is part of the Hambantota district and is close to the Matara district line. Tangalle Pradeshiya Sabha is the local authority to which it belongs. Hence, Kudawella has five Grama Niladhari Divisions: Kudawella East, Kudawella West, Kudawella North, Kudawella Central, and Kudawella South. The

village has a total land area of 1.87km². Coastal vegetation may be observed along the coastal belt, and there is mangrove cover near the Mawella Lagoon. The landscape of Kudawella is very flat. The altitudes vary between 0 and 45 meters. The overall population of the region is 4854 people, with 1495 families. Fishing is the major source of income for the inhabitants, and 1317 households are

involved in the industry.

Figure 1 Case study area (Survey Data, 2021)

2.2 Data Collection and Analysis

The data is collected via primary and secondary data sources. Past studies are scarce and the business is dynamic. Therefore, primary data is required to establish the industry's and manufacturers' current socioeconomic and industry-related backgrounds. Thus, primary data is used to identify industrial difficulties. The physical extent of the research region is limited, current secondary data is insufficient for geo-spatial analysis. A guided structured questionnaire survey done by a researcher recognized 381 businesses as of November 2021, and descriptive analysis was undertaken on the data received. A content analysis of qualitative data collected from a judgemental sample of 10 businesses through semi-structured interviews and two villagers, one labourer, and two government officers active in the field through unstructured interviews indicated the limits. In addition, observations and images are used as primary data in the study. The relative locations of the cottages were also calculated using OpenStreetMap, and the absolute coordinates of a sample of 27 cottages were acquired using GPS. However, a literature analysis is conducted first to identify and describe essential ideas and theoretical facts connected to the study using secondary data sources. Accordingly, secondary data is gathered through maps created by government agencies, documents, papers, and websites of government agencies, as well as journals, articles, and periodical publications.

Conversely using data from OpenStreetMap, GPS, and supplementary data sources, the weighted overlay analysis was performed in ArcMap 10.8 to build a vulnerability index map.

Data layers including population density, selection for government development projects, and elevation were transformed into raster format before reclassifying. The Euclidean distances of other discrete data layers were used to reclassify them. The reference layer for the raster transformation is GN Divisions of Kudawella, which was derived from the shape file of GN Divisions of Hambantota created by the Sri Lanka Survey Department. All additional data layers were collected from OpenStreetMap and confirmed in Google Earth Pro using KML layers. Figure 2 depicts the progressive methodological framework.
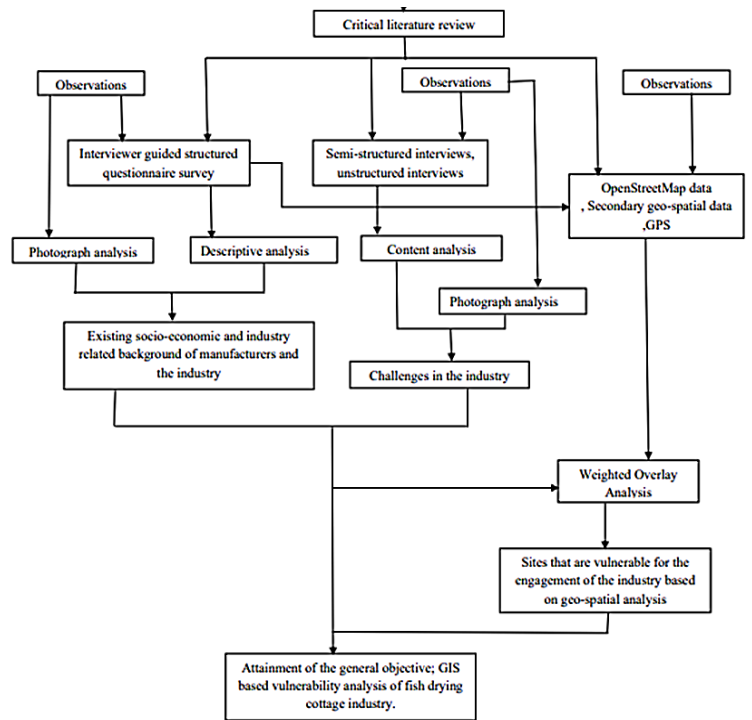

Figure 2 Stepwise methodological framework

3 Result and Discussion

3.1 Questionnaire Analysis

According to descriptive statistics, Kudawella-South has the largest percentage of factories since it is the nearest to the primary raw fish purchasing site, the Kudawella fisheries harbor. Kudawella-East has a smaller percentage of manufacturers than the rest of the hamlet due to its higher elevation and more difficult roadways. As a result, even if the GND is geographically closer to the harbor, transportation has become problematic. This demonstrates the industry's reliance on transportation. People have avoided the sector because they have susceptible age groups in their families, such as children. The majority of the elderly view the business to be a burden on children's education since it requires a lot of effort and manpower. Children are therefore preoccupied. According to the observations, households with elderly parents either shun the industry or employ a large number of outside personnel. The community has the opportunity to implement technology and advances due to its high literacy rate,

Fisheries have a close relationship with the industry since most of the shares acquired as the fisherman's share of the capture is used in the industry. In addition, most multiday-craft owners employ the industry catch if it appears that they will not be able to acquire a decent wholesale price at the auction.

According to Rahman and Kumar (2018), the dwelling provides the workplace in a cottage business. A residential parcel of land is regularly observed in the community in the fish drying cottage business of the study region. Almost half of the area used for industry (48.03 percent) is in the 11 to 15 perch range. Although the acreage necessary for this business is more than that required for residential usage, individuals are used to using their rooftops, surrounding roads, the seashore, and empty lands of others to engage in the activity. According to observations, most lenders are hesitant to rent out their property to the business since excavations and refilling are required at the end of the time. Furthermore, businesses that do not participate in the sector typically do not contemplate leasing since income creation in the business is unpredictable most of the time. Since the majority of the businesses lack mobility, new job possibilities are established for vehicle owners both inside and beyond the town. The amount of raw fish acquired, weather circumstances, labour engagement, technological involvement, market trends, and personal affairs of the manufacturers all influence how frequently they engage in the sector every month. Multiple spins in tiny numbers, on the other hand, deprive producers of internal economies of scale. Furthermore, the absence of a proper market may be noted. In addition, infrastructure conditions and labor satisfaction are also low. Only four producers have registered their businesses. Most notably, artisanal practices are employed to engage in the sector.

3.2 Challenges in the Industry

According to table 1, key challenges include laborer discontent, labor insufficiency, a lack of formal funding sources and mechanisms, unawareness, a lack of external assistance, unforeseen market and climatic circumstances, a lack of an industry for selling, political favoritism and initiatives, government policy decisions, and a lack of institutional decision-making organization.

Table 1 Identified challenges in the industry

Challenge Category	Challenges
Manufacturing challenges	• Price escalations of raw fish • Lack of concern for icing raw fish • Non-usage of containers for transporting raw fish • Unavailability of a formal and environment-friendly mechanism for disposal of solid residue • Lack of awareness on decisions made by authoritative bodies • Unexpected weather conditions • Inadequacy of physical infrastructure • Neighbor opposition • Lack of concern to gain knowledge and technology about preservation and storage
Financial challenges	• Usage of informal credit and informal pawning services which have high-interest rates • Reluctancy of banks and financial institutions for providing loans • Working capital deficiency
Labor-related challenges	• Scarcity of labor • Labor dissatisfaction because of the unavailability of, a fair payment determination method sanitary facility • Lack of concern and awareness on health
Selling related challenges	• Unavailability of a proper and common price determination mechanism for products • Perception of the retail buyers on the quality of the products
Political and legal challenges	• Influences on the determination of raw fish price • Political favoritism in giving aids • Central government policies on imports of dried and Maldive fish
Institutional challenges	• Unavailability of a long-term plan for education and training and constant supervision • Non- prevalence of informed and integrated decision making among institutions
Other challenges	• Visitor unrest • Personal misconceptions and misbeliefs of the manufacturers

3.3 Vulnerability Analysis

Since the mentioned difficulties produce risk in the sector, nine criteria were used to construct a vulnerability map. As mentioned earlier, vulnerability makes the cottage industry susceptible to external pressures. In other words, external pressures influence negatively and make the industry susceptible. So, the factors which influence negatively the well-being of the industry are recognized to define vulnerability. As a consequence of observations and literature, this section of the analysis has identified several criteria that define vulnerability. According to

the literature evaluation, incident-specific micro and macro data should be employed for the analysis. Table 2 shows the criteria for determining site vulnerability, the layer name in Arc Map 10.8

analysis, the weight for their relative level of relevance, and the vulnerability scores for each factor.

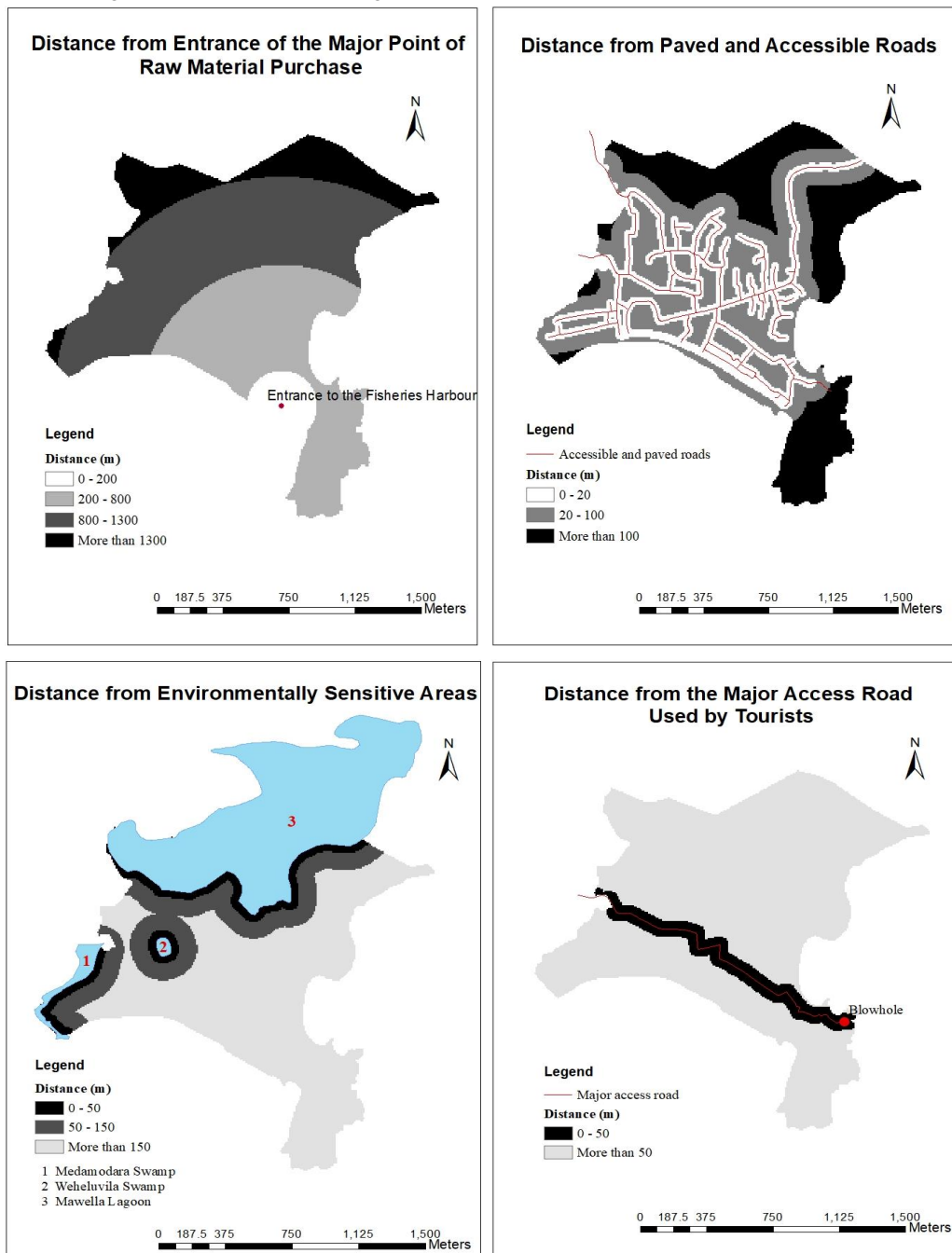**Table 2** Description of criteria, weights, values, and vulnerability scores

Criteria	Layer name	Weight	Values	Vulnerability Scores
Distance from the harbor (the major purchase point)	Reclass_MP	10%	Distance from the entrance of the harbor (market area) in meters	
			0-200	0
			200- 800	1
			800-1300	2
			1300-1700	3
			1700-2100	5
			2100-2500	6
			2500-2900	8
			Above 3000	9
Distance from a paved and accessible way	Reclass_roads	10%	Distance from paved and accessible roads in meters	
			0-20	0
			20-100	5
			More than 100	9
Distance from environmentally sensitive areas	Reclass_MESA	15%	Distances from the environmentally sensitive areas (m)	
			0-50	9
			50-150	3
			More than 150	0
Distance from the major access road used by tourists	Reclass_MARUT	10%	Distance from the major access road used by tourists (m)	
			0-50	9
			More than 50	0
Distance from the coast	Reclass_Coast	15%	Distance from the coast (m)	
			0 - 35	9
			More than 35	0
Location within the Tsunami warning zone	Reclass_Tsunam	5%	Tsunami setback consideration (m)	
			0-100	9
			More than 100	0
Population density	Reclass_GND	15%	Population Density/km^2	
			0-660	0
			661-1320	1
			1321-1980	2
			1981-2640	3
			2641-3300	4
			3301-3960	5
			3961-4620	6
			4621-5280	7
			5281-5940	8
			Above 5941	9
Selection for government projects	Reclass_Nishpada nagam	8%	The status of selection for the project	
			Selected	0
			Not selected	9
Distance from social institutions	Reclass_Social	12%	Distance from the social institution (m)	
			0-50	9
			50-100	8
			100-250	7
			250-500	6
			More than 500	0

According to table 2, the greatest influence on susceptibility is the distance from ecologically sensitive regions, population density,

distance from the shore, and distance from social institutions. It is primarily because most authority organizations' judgments ignore

the industry's environmental and social dimensions. As a result, there is an immediate need to include those two factors. Hence, Major environmentally vulnerable sites were recognized as Mawella lagoon, Veheluvila marsh, and Medamodara Swamps. People are significantly more influenced by the smoke and odor produced by industry when population density is high. Also, when population density is high, individuals have a lot of legal authority to oppose the industry. As a result, high population density exposes the sector to risks. Sites in the setback zone are deemed especially susceptible due to their proximity to the shore. Transportation parameters are prioritized next, as transportation expenditures create major costs and efforts. Furthermore, it is predicted that government initiatives would reduce a large number of industrial obstacles, such as marketing challenges. As a result, non-selection for government initiatives is regarded as

risky. According to the observations and perspectives of industry officials, there is the possibility to expand tourism and the industry at the same time. As a result, distance from main tourist access highways is weighted on a low scale in terms of vulnerability. Location inside the Tsunami warning has received the lowest grade since it is not a common factor. Hence, as the sector accumulates a substantial quantity of people and resources, attention is directed to natural occurrences that generate dangerous circumstances. Figure 2 depicts the weighted and classed criterion maps.
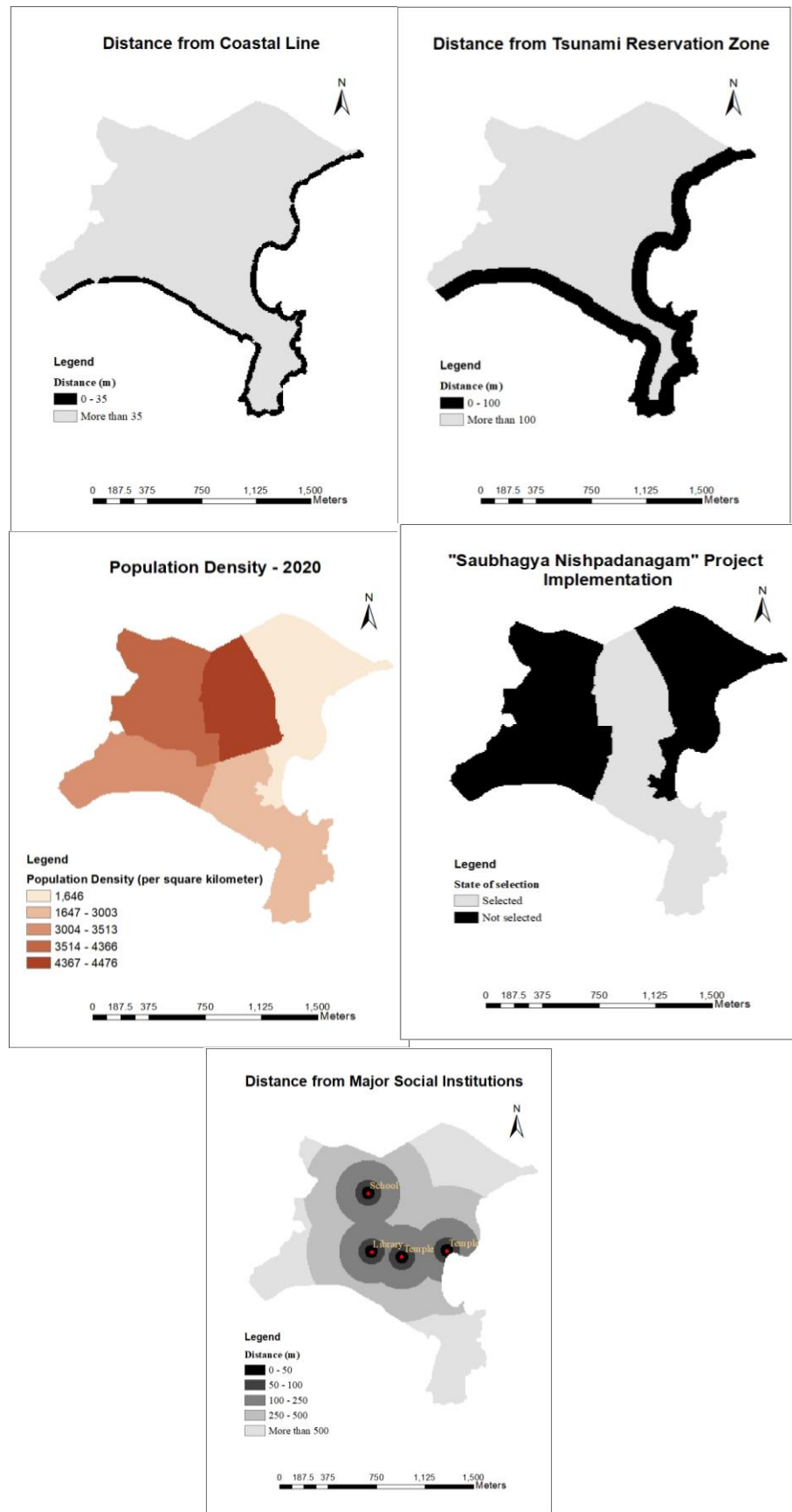

Distance from Entrance of the Major Point of Raw Material Purchase

Legend
Distance (m)
0 - 200
200 - 800
800 - 1300
More than 1300

Distance from Paved and Accessible Roads

Legend
Accessible and paved roads
Distance (m)
0 - 20
20 - 100
More than 100

Distance from Environmentally Sensitive Areas

Legend
Distance (m)
0 - 50
50 - 150
More than 150

1 Medamodara Swamp
2 Weheluvila Swamp
3 Mawella Lagoon

Distance from the Major Access Road Used by Tourists

Legend
Major access road
Distance (m)
0 - 50
More than 50

Figure 2 Criteria map

The Model Builder feature of Arc Map 10.8 was used to create and apply the multi-criteria analysis

on the classed maps. Figure 3 depicts the developed model.

Figure 3 Model used in ArcGIS for the Weighted Overlay Analysis
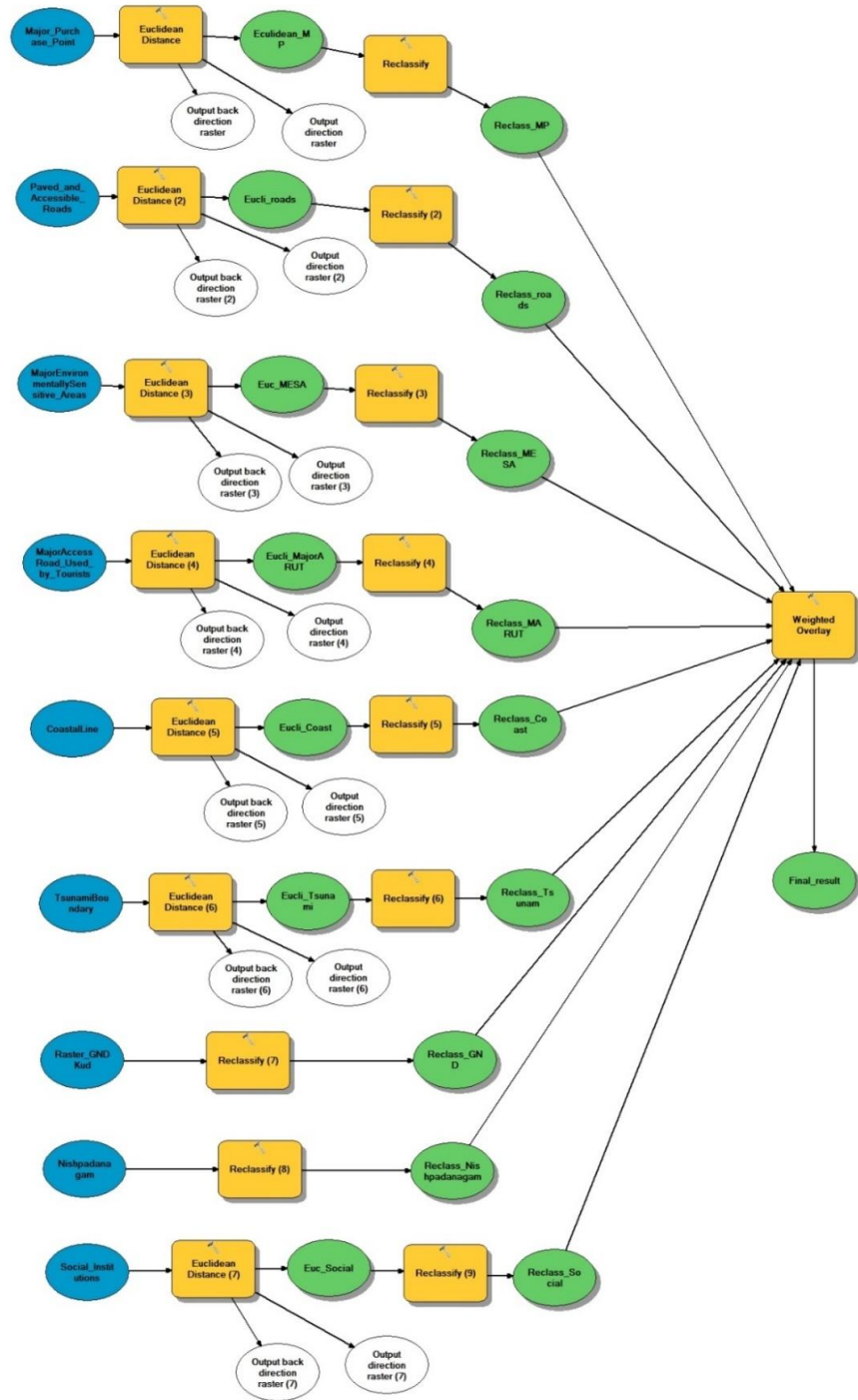
According to the weighted overlay study, the majority of businesses (65.62 percent) are in the intermediate vulnerability zone. There are 250 of them. The zone covers 1.2072 km², accounting for 58.52 percent of the village's total land area.

Figure 4 depicts the Kudawella vulnerability index map based on the parameters listed in table 2. Table 3 depicts the geographical area and percentage of a number of businesses in each vulnerability category.
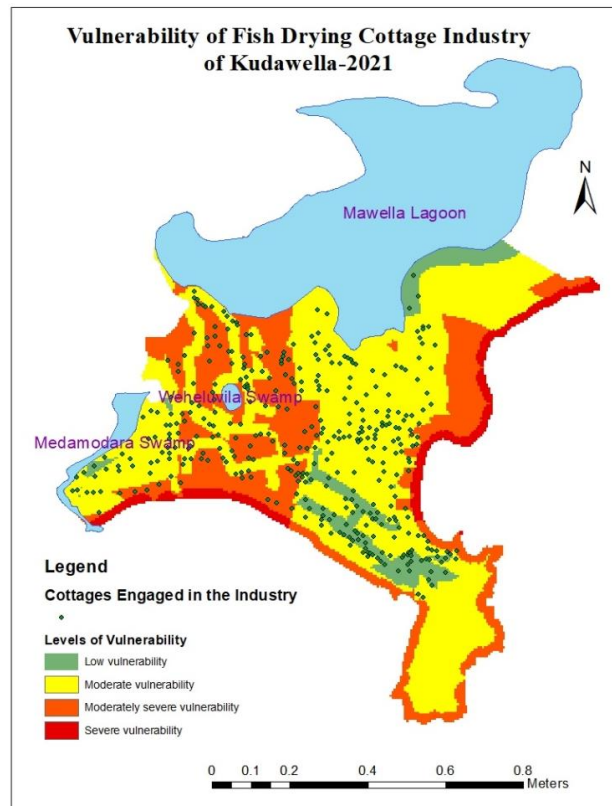
Figure 4 Vulnerability index map

Table 3 Percentage of land extents and percentage of manufacturers by vulnerability level

Level of vulnerability	Percentage of land extent	Percentage of manufacturers
Low vulnerability	7.64%	13.91%
Moderate vulnerability	58.52%	65.62%
Moderately severe vulnerability	29.72%	20.47%
Severe vulnerability	4.12%	0%

According to the final study, no manufacturer was in the highly susceptible zones between August and November 2021. The extremely vulnerable area lies along the coastal belt, and it displays vulnerability to environmental and transportation problems. Low susceptibility areas are primarily defined by the impacts of distance from social institutions, distance from accessible routes, population density, distance from the coastal line, and distance from the tsunami protection area. The low susceptible locations had the lowest proportion of manufacturers that existed throughout the studied period. All of these regions, though, are vulnerable in some way. As a result, depending on the criterion used, no location may be considered non-vulnerable.

4. Conclusion

Sri Lanka's coastal regions are appealing urban centers that offer a variety of commercial activities. Fisheries are a popular economic activity in coastal locations due to their closeness and availability of resources. Fisheries generate direct and indirect revenue for coastal towns, and these economic activities are strengthened if a fishing port is located closer. Tangalle has the highest fish production in the country, and it is no surprise that Kudawella contributes significantly to that total. Along with fishing, fish drying has long been a cottage business in Kudawella. However, in recent times, fish drying has grown as a commercial and large-scale cottage business, attracting an increasing number of producers. The business has provided direct and indirect job possibilities for locals while also efficiently preserving the excess production of multi-day crafts. However, the industry's environmental and social problems frequently cause a public uproar. However, it appears that government institutions do not consider social and environmental issues while making decisions. Furthermore, the industry's politically fascinating character has facilitated its fast development isolating and making some manufacturers vulnerable. The research was carried out primarily to enlighten key authorities, institutions, and stakeholders on the need to analyse the sector and adopt decisions to attain sustainability in the industry.

The study's main intention was to identify the manufacturers' and industry's socioeconomic and industry-related backgrounds, obstacles, and a GIS-based vulnerability index for the industry to meet the study's overall purpose of GIS-based vulnerability analysis of the fish drying cottage industry. The field survey found 381 manufacturers between August and November 2021. According to the descriptive study, the availability of modes of transportation, as well as the convenience of transportation, are critical to the sector. People have shied away from the sector because they have vulnerable age groups in their families, such as children. Due to its high literacy rate, the community also can introduce technology and advance. Fisheries have a strong link to industry and also own a portion of residential property. Additionally, the lack of a proper market may be noted. In addition, infrastructure facilities and labourer satisfaction are also low. It is also possible that less concern is devoted to business registration. Most crucially, the industry is run using artisanal methods. Buying raw fish, bringing it to the site, gutting and scaling it, boiling, removing vertebrae, smoking, drying in the sun, coating ash, and storing it for sale are all laborious phases in the method. Uncertainty; lack of external assistance; unpredictable market and environmental factors; absence of a selling market; political favoritism and interventions; policy decisions; and lack of organisation of institutional decision-making were highlighted as some of the industry's key challenges. Furthermore, the ambiguous nature of obstacles such as manufacturing, finance, labor-related, sales-related, political, legal, institutional, and other challenges would make it difficult for key authority entities to determine their responsibilities in resolving industry issues.

The study classified vulnerability into four thresholds: low vulnerability, moderate vulnerability, relatively severe vulnerability, and severe vulnerability. The level of severe vulnerability necessitates quick action by authority entities. For businesses located in the very susceptible region, either removal from those places, a high degree of monitoring, a large quantity of help, or the installation of restrictions will be required. Manufacturers in moderately sensitive locations will require less care than those in extremely vulnerable ones. However, ongoing oversight, assistance, and regulatory implementation are required. Moderately fragile places require less assistance than extremely vulnerable areas. However, monitoring will be required in this area as well. Low vulnerability zones may be empowered and concerns gradually eliminated. Based on the criteria involved, no manufacturer has been in the highly susceptible category; yet, the industry need assistance, oversight, awareness, and long-term planning. Furthermore, the authoritative organizations have the authority to assess the degree of "capital aid, technical know-how, and trade ties (Rupasena, 2014)." By taking into account the level of vulnerability, "awareness on financial schemes, counseling and guidance, efficient law to facilitate the industry" (Sezhiyan & Gnanadeiveegam, 2020), "processing technology, quality raw materials" (Teixeira, 2018), and "local branding" (Kurokawa, 2013) in association with tourism. Therefore, the vulnerability index map displays the speed with which judgments are made as well as the diversity of decisions. However, because the sector is dynamic, consistent and specified research projects are required. In addition, to arrive at challenge-specific conclusions, more criteria should be integrated into future GIS-based vulnerability analyses.

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