SRI LANKA

Area-Based Risk Assessment in Porativu Pattu Divisional Secretariat Division

Batticaloa District

June 2024

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IMPACT Initiatives is a leading Geneva-based think-and-do tank which aims to improve the impact of humanitarian, stabilisation and development action through data, partnerships and capacity building programmes. The work of IMPACT is done through its three initiatives: REACH, AGORA and PANDA.

About CEFE NET

CEFE NET Sri Lanka is an association of CEFE facilitators in Sri Lanka founded in 2001. Our Mission is to facilitate competency based economies through formation of enterprise and enabling the creation of a conducive environment for entrepreneurship development in Sri Lanka. We are a member of CEFE International in Germany, the network of CEFE global community.

About ACTED

ACTED (Agency for Technical Cooperation and Development) is a non-governmental organization with headquarters in Paris, founded in 1993. ACTED's vocation is to support vulnerable populations affected by wars, disasters and/or economic and social crises, and to accompany them in building a better future.

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SUMMARY

Sri Lanka's high temperatures throughout the year, unique and complex hydrological regime, and exposure to extreme climate events make it highly vulnerable to climate change. A rise in extreme events and natural hazards due to climate change will considerably threaten Sri Lanka's economy and human health. In recent years, Sri Lanka has experienced a series of recurrent crises, including the 2019 Easter Attacks and the global COVID-19 pandemic[1], followed by the 2022 economic crisis. These crises have severely affected marginalized communities' capacity to withstand the impacts of even minor external shocks[2].

According to local authorities data, Sri Lanka's eastern provinces are highly susceptible to floods, drought, and human-animal conflict hazards and experience high vulnerability due to the high share of low-income families and dependency on agriculture and fisheries, and few protection measures in place. Within this context, IMPACT Initiatives, in partnership with Acted, conducted an Area based Risk Assessment (ABRA) in Porativu Pattu (Vellavaly) Divisional Secretary's Divisions (DSD) in Batticaloa district, Eastern Province, funded by the US Bureau for Humanitarian Assistance (BHA).

The study is anchored on the Sri Lanka Disaster Management Plan 2018-2030 and the National Action Plan for Climate Change Adaptation 2016-2025. The objective is to analyse the main hazards threatening communities within the target DSD, identifying the Grama Nilahadari Divisions (GNDs) most at risk for multiple hazards. The findings intend to assist Acted, the national Government, local authorities, humanitarian partners, and affected communities to better predict, prepare for, and respond to existing and future events through resilience and adaptation initiatives targeting the most exposed and vulnerable territories and communities.

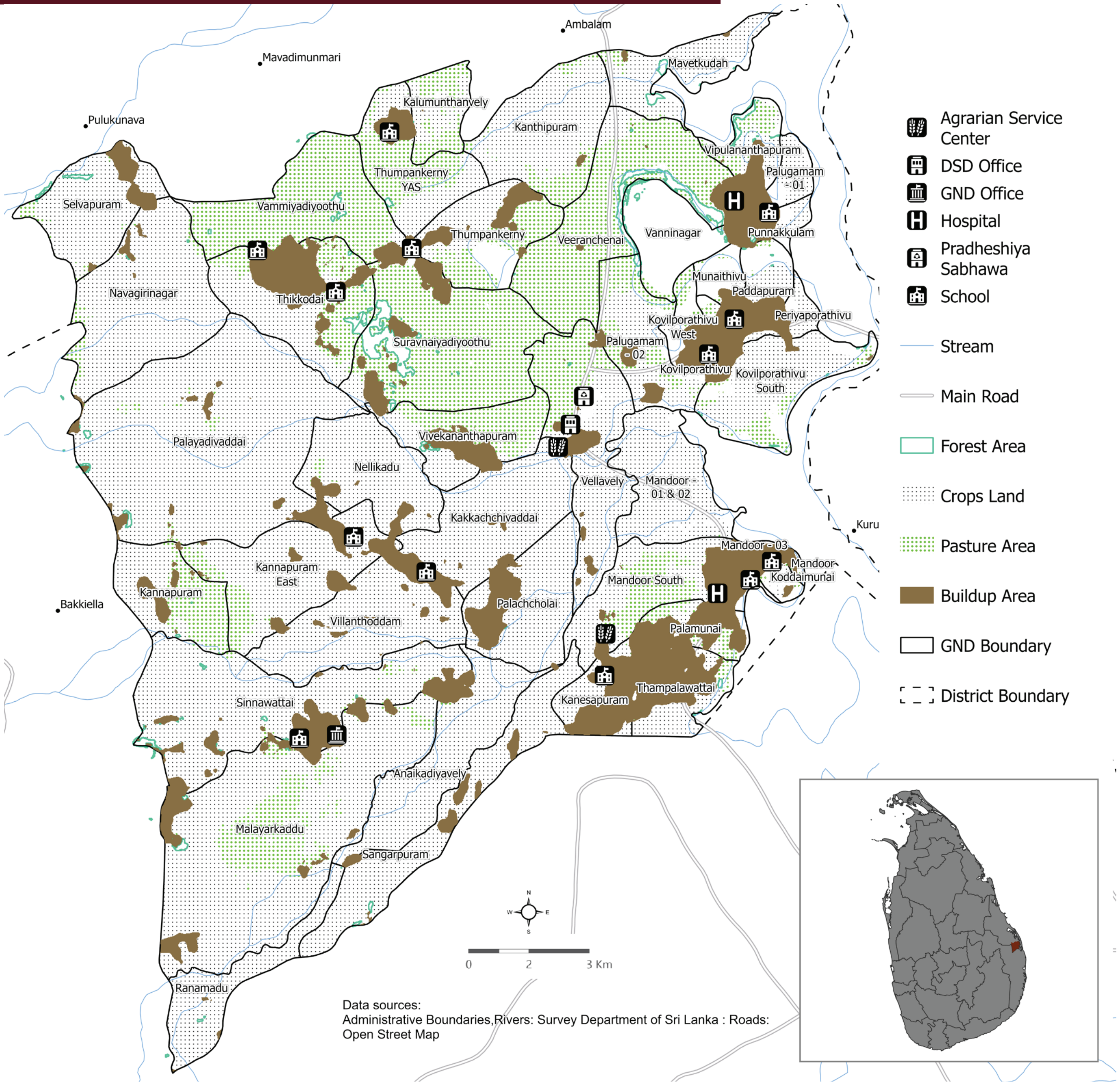
Through local consultations, IMPACT Initiatives identified the eight most recurrent hazards in the eastern and northern provinces of Sri Lanka: drought, flood, human/animal conflict, cyclones, storms, water supply failure, explosives remnants of war (ERW), and land degradation. The communities and local authorities reported during the preliminary consultations in Porativu Pattu, among all hazards, floods, droughts, and human-elephant being the most prominent. Therefore the three were selected to calculate the risk through an adapted World Risk Index Methodology, by which the risk is a multiplication of hazard, exposure, and vulnerability (including susceptibility and lack of coping capacity) of all GNDs in Porativu Pattu.

Through the study, IMPACT identified three GNDs, namely Palayadivaddai, Navagirinagar, and Selvapuram, as the most at risk for multiple hazards, especially drought in Palayadivaddai and floods in Navagirinagar and Selvapuram. Palayadivaddai is the most at risk due to its high exposure, having the largest drought area in the DSD and almost all its crop area and pasture land affected by drought. The large share of families with low-income levels increases the vulnerability of the Navagirinagar and Selvapuram populations to cope with external shocks. Both GNDs have a large crop area within a flooded zone (78 and 94%, respectively), almost 50% of their build-up area and the highest road length in flood-prone areas. In Palayadivaddai, the population has the highest level of vulnerability regarding social dependency, with a high share of low-income families, unemployed people, and children and elderly density. Social dependency is when an individual or group relies on another individual or group for resources, support, or guidance.

According to the analysis, Thikkodai was identified as the most at risk of elephant attacks, along with Palamunai, due to a combination of the presence of forest areas, population density, and a large number of female-headed households among the residents. The unemployment and low-income rates are social insecurity indicators that present a low financial capacity to prepare and recover from hazards. Kannapuram West, Kanesapuram, and Kovilporathivu West are the least at risk of the assessed hazards. Their territories are less exposed, and their economic situation allows for higher coping capacity.

Overall, the study's findings underscore the importance of a localised approach to understanding risk and informing disaster risk reduction strategies. The specific risk profile of each GND must guide how to prioritize and customize preparedness interventions for drought management, flood control, and human-elephant conflict (HEC). Stakeholders can use this assessment as a valuable tool to design targeted interventions to enhance the resilience of communities and territories in Vellavaly against single and multi-hazard scenarios.

Map 1. Overview map of Porativu Pattu DSD



Data sources:
Administrative Boundaries,Rivers: Survey Department of Sri Lanka : Roads: Open Street Map

CONTENTS

Senalfernando. (2019). Sri Lankan Elephant. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Sri_Lankan_Elephant.jpg

BACKGROUND

Located in the Eastern province, Batticaloa district, Porativu Pattu covers an area of 182 km², with a population of 46,149 individuals, of whom 50,3% are female, living across 43 Grama Nilhadari Divisions (GNDs)[3]. It is estimated that the dependency ratio reaches 54%, which is the population below 15 and above 60 years old[4]. The average population density is 243 inhabitants per km². The terrain in Porativu Pattu is diverse, ranging from lagoon coastal areas to inland areas with flat plains. It is bordered by the lagoon to the east, providing access to water resources and activities such as fishing.

Additionally, several rivers and water bodies in the DSD contribute to agriculture and livelihood activities. The vegetation in Porativu Pattu includes coastal vegetation, such as mangroves and palm trees along the shoreline, and inland vegetation consisting of forests, shrubs, and croplands. Porativu Pattu experiences a tropical climate with distinct wet and dry seasons, and significant rainfall during the northeast monsoon (Maha season) from November to February, while the southwest monsoon (Yala season) from May to September is relatively drier. Paddy farming, highland crop cultivation, home gardening, and livestock rearing are the predominant seasonal income generation activities, employing 3,472 people, in addition to 3,223 people with foreign employment, 1,310 working for the government, and 244 in fishing activities.

During heavy monsoon rains, low-lying areas in Porativu Pattu may be prone to flooding, leading to property damage and disruption of livelihood activities, especially agriculture. Periods of drought can affect water availability for agricultural purposes, impacting crop yields and livestock health. Being located near the coast, Porativu Pattu is also vulnerable to the influence of cyclones and tropical storms in the Bay of Bengal which can significantly impact weather patterns in Sri Lanka. The intense rainfall and the presence of many water bodies may cause an elevated risk of flooding, resulting in coastal erosion, damage to infrastructure, crops and displacement of communities.

With limited coastal areas protected by Manmunai South and Eruvil Pattu DSDs in the East, Porativu Pattu was partially affected by the Tsunami in 2004. Batticaloa district experienced greater inundation since the tsunami hit directly, the water levels were generally high with low terrain to a considerable distance inland (JPL-NASA, 2005[5]), causing the displacement of 63,717 families, 2,975 deaths, including 1,229 fishermen, and 346 missing people in the District[6] and 1,270 affected families, with 37 deaths and 5 missing in the DSD[7]. Porativu Pattu was also the theatre of conflict and multiple displacements throughout the years, housing a large number of IDPs[8].

The ABRA measured the risk in the 43 GNDs in Porativu Pattu DSD, covering its entire area. By gathering and analysing secondary data including global and regional geospatial datasets and socio-economic statistics shared by local authorities it was possible to calculate hazard exposure and vulnerability in each GND. The contribution and support of local authorities by providing relevant vulnerability and hazard data for each GND during IMPACT's data collection phase was key to achieving the results presented in this document. By providing a tailored risk assessment of Porativu Pattu that considers specific local environmental, social, and economic factors, the study is intended to address a data gap and contribute to inform initiatives to enhance the resilience of communities and territories to stand with external shocks.

Why an ABRA?

- It provides localized analysis of risks, working as a strategic tool to contribute to operational and programmatic purposes of local authorities and other relevant stakeholders.
- The findings will inform Acted's implementation work with communities, addressing the most affected areas while improving livelihoods and the humanitarian and development community.
- It utilizes remote sensing and GIS technologies to identify and visualise hazards and exposure and helps triangulate scientific data with available knowledge.

METHODOLOGY

The ABRA methodology was adapted by IMPACT based on the World Risk Index (WRI), using a multi-hazard risk equation. The concept of the WRI, including its modular structure, was developed by the Bündnis Entwicklung Hilft with the United Nations University's Institute for Environment and Human Security (UNU-EHS)[9]. In this assessment, IMPACT analysed key hazards, exposure, vulnerability and risks across the DSD, based on the following definitions:

- **Hazard:** A process, phenomenon, or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption, or environmental degradation (UNGA, 2016[10]).
- **Exposure:** The situation of people, infrastructure, housing, production capacities, and other tangible human assets located in hazard-prone areas (UNGA, 2016).
- **Vulnerability**: The conditions determined by physical, social, economic, and environmental factors or processes which increase the susceptibility of an individual, a community, assets, or systems to the impacts of hazards (UNGA, 2016).
- **Disaster risk:** The potential loss of life, injury, or destroyed or damaged assets that could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability, and capacity (UNGA, 2016).

Through the ABRA, IMPACT collected, processed, and analised existing openly available geospatial data on hazard exposure, and secondary data, mainly provided by local authorities, on vulnerability to assess risks in the target areas. The secondary data review included an analysis of several published disaster and climate risk assessments' data and projects' key findings conducted at the national and regional levels.

The remotely sensed data was processed to represent the spatial distribution and other characteristics of the hazards and determine the exposure to the population and agricultural lands. The vulnerability index was calculated based on identified indices of susceptibility, and lack of coping capacities, the adaptive capacity was excluded from the calculation due to lack of data. The risk calculation was based on the formula Risk=Hazard x Exposure x Vulnerability.

The results present the GNDs most at risk in Porativu Pattu, according to the multi-hazard risk index (detailed methodology for multi-hazard risk index calculation in Annex 2). In consultation with local authorities and communities, these results supported Acted in the selection of areas of intervention for resilience-building activities. It is important to highlight that the objective was to assess the risk of the main hazards primarily identified by communities during the consultation process. However, it is not inclusive or exhaustive of all natural hazards in Porativu Pattu.

HAZARD EXPOSURE

The exposure of communities to these multiple hazards needs to be better understood at the local level with proper response and contingency plans in place. This analysis hopes to raise awareness of hazard exposure at the local level.

Natural hazards:

Drought

The drought severity index was calculated by equally weighting the long-term Vegetation Condition Index[11] (VCI) spanning from 2003 to 2023, the Vegetation Health Index (VHI) during the drought period in 2023, and the 12-month Standardized Precipitation Index (SPI) of 2023. The Vegetation Condition Index (VCI) highlights the impacts of drought on vegetation health (greenness) by detecting the areas prone to drought based on a 20-year anomaly of satellite-derived vegetation index (MODIS EVI[12]). MODIS Normalized differentiated vegetation index (NDVI[13]) and MODIS Land Surface Temperature (LST[14]) data are used to calculate the VHI during the drought period to highlight the drought manifestation and impact in the last drought event. The SPI index reflects the precipitation anomalies during 2023 compared to long-term observations based on CHIRPS datasets[15]. The analysis covered agricultural, croplands, and rangelands to reflect the drought exposure.

Hazard indicator 1.1: Drought area (ha)

Exposure indicator 2.1: Population density

Exposure indicator 2.2: Crop area prone to drought (%)

Exposure indicator 2.3: Pasture land prone to drought (%)

Exposure indicator 2.4: Share of affected fisheries families

Flood

The assessment used images from Sentinel-1 to delineate historic floods from 2018 to 2022. The chosen timeframe encompassed pre and post-flood acquisitions, facilitating change detection and monitoring flood evolution. The GEE script from the UN-Spider methodology[16] guided the extraction of the flood-prone zones.

Hazard-Exposure indicator 3.1: Affected population density index

Population density in flooded afected areas

Hazard-Exposure indicator 3.2: Crop area within a flood zone (%)

Hazard-Exposure indicator 3.3: Build up area within a flood zone (%)

Hazard-Exposure indicator 3.4: Road length and railways within a flood zone (km)

Human-elephant conflict

This method identifies and examines forest fragmentation patterns, where deforestation causes disruptions to elephant habitat and elephant migration corridors, leading to human-wildlife conflict. Local authorities provided secondary data on reported human deaths due to elephant attacks.

Hazard indicator 4.1: Human deaths reported due to elephant attacks

Hazard indicator 4.2: Forest area

Hazard indicator 4.3: Forest distrubances

Deforestation area during last 5 years

Exposure indicator 5.1: Population density

SUSCEPTIBILITY

Population groups that are more susceptible to a hazard have increased vulnerability. Several components drive susceptibility, livelihood dependency, social dependency, and economic situation were used to define the indicators.

Livelihood dependency:

Indicator 6.1: Share of families engaged in agricultural activities (paddy, chena)

Indicator 6.2: Share of families engaged in inland fishery activities

Indicator 6.3: Share of families engaged in marine fishery activities

The high dependence on reliable weather patterns and natural resources and usual location in flood-prone areas makes these families more susceptible. Hazards like drought and flood can reduce access to farming and fishing resources.

Social dependency:

Indicator 7.1: Share of female headed households

These households are more affected by disasters and susceptible to hazard shocks due to limited opportunities to diversify livelihoods, restricted access to land, assets, credit, social networks, risk-sharing, and insurance. They also face the dual burden of income generation and domestic work.

Indicator 7.2: Share of families with members with a disability

Apart from the potential physical inability to evacuate during a disaster, their reliance on others to ensure evacuation to safety may involve reliance on public services.

Indicator 7.3: Children density (0-18)

Children are more susceptible to hazards due to their dependency on others and inability to protect themselves or evacuate. Their developing systems also make them particularly sensitive to extreme heat and cold, limiting their ability to adapt to climate changes.

Indicator 7.4: Elderly density (60+)

Elders are more susceptible to hazards as they depend more on others and may be unable to protect themselves or evacuate if necessary.

Economic situation:

Indicator 8.1: Share of families earning a daily income between 2,000 and 3,000 LKR

Indicator 8.2: Share of families earning a monthly income from 1,000 to 20,000 LKR

Indicator 8.3: Share of unemployed individuals

Low income and unemployment limit the capacity to prepare for and cope during and after the shock of the hazard.

COPING CAPACITY

The ability of a population to cope after a hazard occurs is crucial in reducing negative consequences and influences one's vulnerability and risk level to a hazard. These are the measured factors that drive coping capacity.

Indicator 9.1: Number of evacuation centers

Indicator 9.2: Number of boats available for evacuation, logistics, and transportation purposes

Indicator 9.3: Number of fences built to protect from elephants

DROUGHT

Drought in Sri Lanka has been a recurring problem, impacting agriculture, water availability, and the livelihoods of people dependent on farming and inland fishery. During the last El Niño in 2016 and 2017, Sri Lanka suffered its worst drought in 40 years, and its rice output fell by nearly 50 per cent year on year to 2.4 million metric tonnes over both harvests. In 2023, According to the National Disaster Relief Service Centre (NDRSC), nearly 150,000 people lacked safe drinking water.

According to the drought severity analysis of all GNDs in Porativu Pattu (Map 2), the exposure index is considerably high across the DSD with 89% of the total area and an average of 83% of cropland affected by drought and 76% of pasture land. In total terms, Palayadivaddai presents the highest risks, with the largest drought area, 99% and 100% of cropland and pasture land affected by drought, respectively. Eleven GNDs have 100% of cropland affected by drought and other sixteen over 90% as for pasture land, fifteen have 100% affected area and another fourteen over 90%. Mandoor 3 and Mandoor Koddaimunai have nearly zero drought-exposed areas.

Palayadivaddai presents high levels of social and agricultural livelihood dependency, with large shares of children and elderly and 39% of families engaged in agriculture. The GND has the highest share of unemployed individuals, 42%, and 80% of families with daily wages between 2,000 and 3,000 LKR, respectively. Other 7 GNDs have over 50% of families engaged in agriculture.

High drought exposure leads Malayarkaddu and Sinnawattai to high risk, as they present high child density, over 65% of low-income families, and above-average unemployment. GNDs characterized by high population density, such as Palamunai, Thikkodai, and Vammiyadiyoothu, might encounter intensified pressure on resources and heightened vulnerability due to the impact of drought on their livelihoods.

The exposure analysis was run for agricultural, croplands, and rangelands to calculate population density, percentage of crop area, and pasture land prone to drought and share of affected fishery families. The analysis suggests a risk of severe agricultural and livestock production decline in Porativu Pattu.

The data presented in Figure 1 relates the extension of drought over crop and pastureland with the economic dependency on farming activities. The share of families engaged in agriculture was provided by local authorities during the consultation phase. Besides the GNDs previously mentioned, the high share of farming families in Thumpankerny with all farming land affected stands out as indicators of possible livelihood and economic impact.

Map 2. Drought exposure

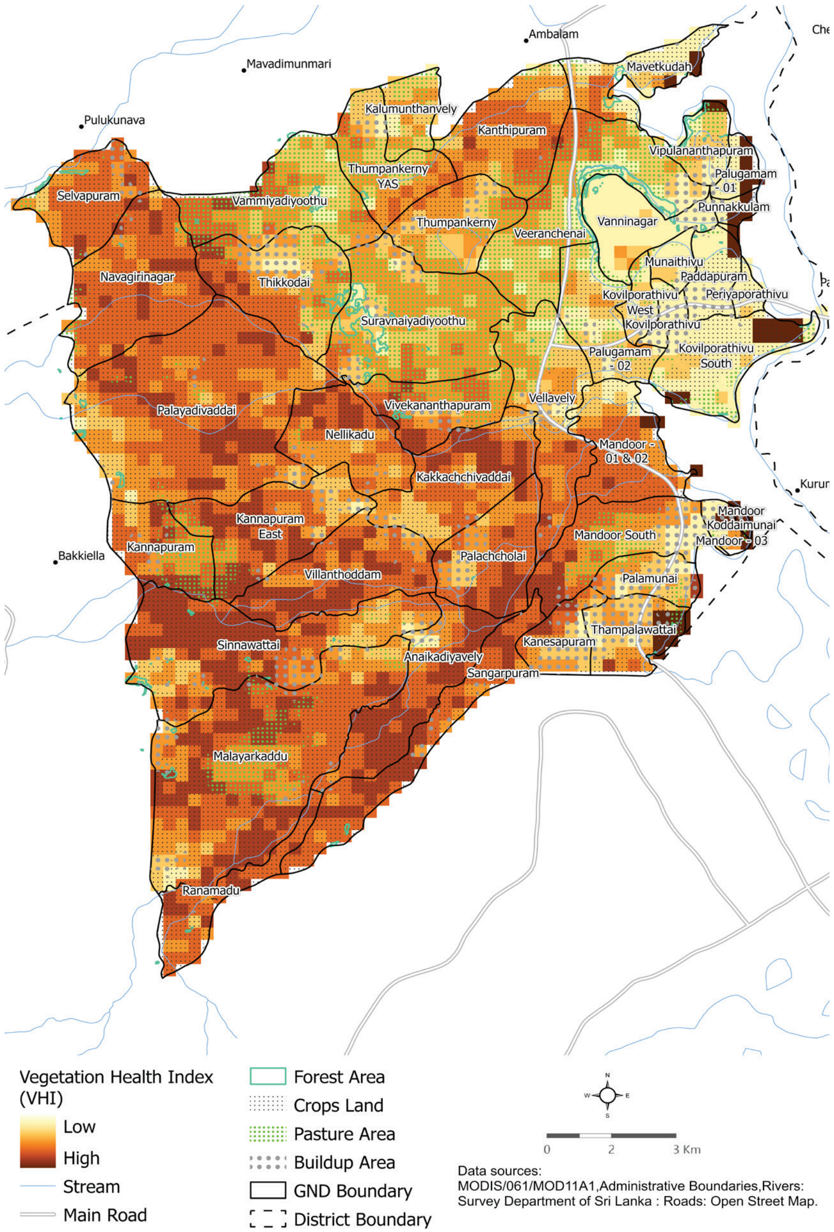


Table 1. Drought risk index

GND	Hazard	Exposure	Vulnerability	Risk
Palayadivaddai	**1.00**	**0.66**	**0.58**	**0.388**
Malayarkaddu	**0.90**	**0.70**	**0.34**	**0.210**
Sinnawattai	**0.53**	**0.69**	**0.49**	**0.177**
Vellavely	0.37	0.71	0.50	0.131
Navagirinagar	0.45	0.69	0.32	0.099
Suravnaiyadiyoothu	0.52	0.71	0.26	0.097
Veeranchenai	0.47	0.72	0.29	0.097
Kakkachchivaddai	0.30	0.67	0.46	0.091
Thumpankerny	0.24	0.70	0.51	0.086
Sangarpuram	0.30	0.92	0.30	0.084
Thikkodai	0.29	0.89	0.29	0.073
Vammiyadiyoothu	0.33	0.92	0.24	0.073
Kannapuram	0.35	0.76	0.26	0.070
Selvapuram	0.25	0.83	0.34	0.068
Kanthipuram	0.31	0.76	0.25	0.059
Mandoor - 03	0.21	0.76	0.33	0.054
Kovilporathivu South	0.23	0.74	0.28	0.047
Nellikadu	0.26	0.75	0.23	0.045
Vivekananthapuram	0.22	0.75	0.26	0.044
Palugamam - 01	0.22	0.46	0.41	0.042
Mandoor Koddaimunai	0.16	0.83	0.29	0.038
Ranamadu	0.18	0.71	0.28	0.036
Anaikadiyavely	0.30	0.42	0.29	0.036
Villanthoddam	0.35	0.39	0.25	0.034
Mavetkudah	0.23	0.60	0.21	0.029
Kannapuram West	0.19	0.67	0.23	0.028
Palachcholai	0.22	0.45	0.27	0.027

* Hazard, exposure and vulnerability values were calculated as a relative indicator (for more details and full table please see the Annex 2)

Figure 1. Percentage of drought-affected areas and agricultural families[17]

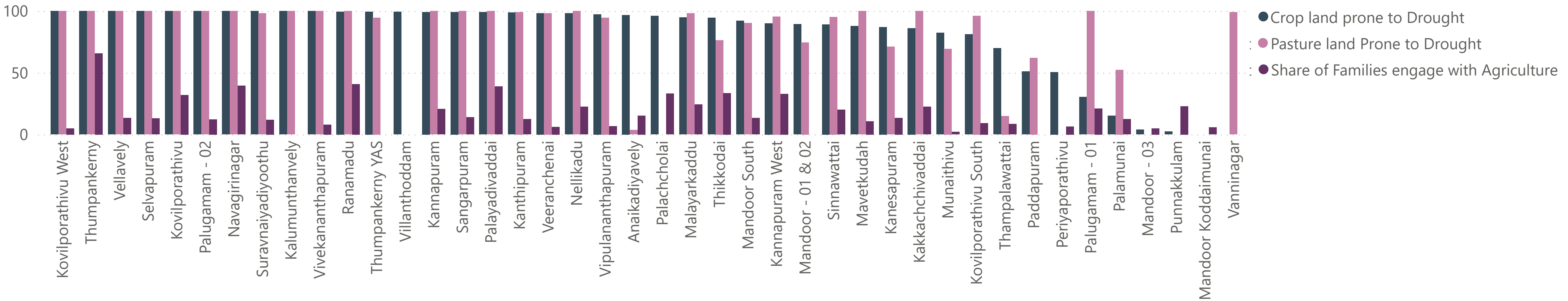
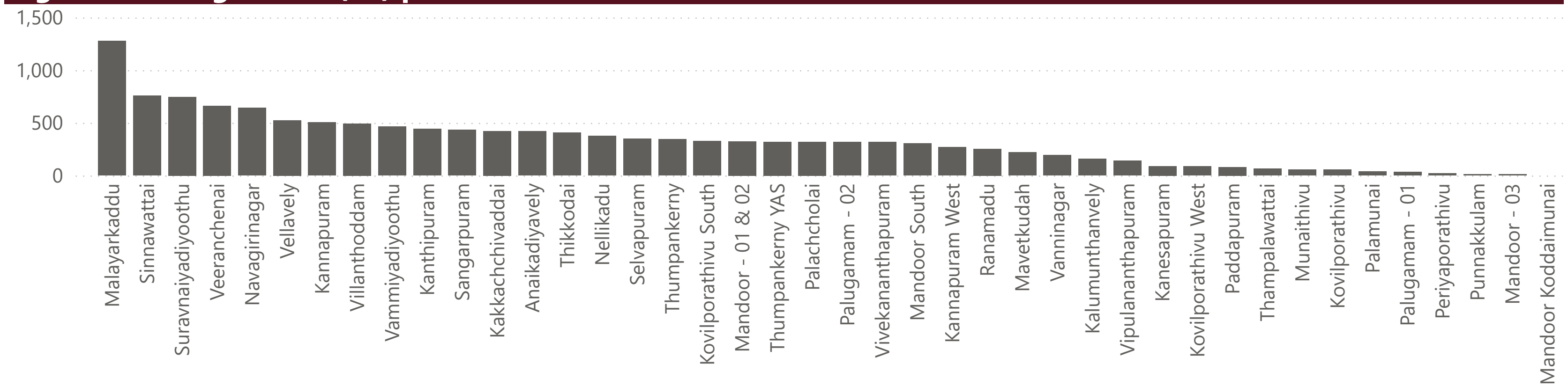


Figure 2. Drought area (ha) per GND[18]



FLOODS

The rainy season in Porativu Pattu lasts from September to February, with most floods typically happening from November to January (Map 3), caused by heavy rainfall, improper drainage systems, land use changes, and unplanned cultivation[19].

Between 2018 and 2020, satellite images showed that 2868 hectares of Porativu Pattu were flooded. Navakirinagar was the most affected area, accounting for 17% of the total flooded area in Porativu Pattu and covering 76% of its territory. Selvapuram, Kovilporativu South, and Mandur 1 and 2 North had 88%, 59%, and 57% of their areas affected by floods, respectively. The exposure indicators assessed included the affected population density, the percentage of crop area and built-up area, and the lengths of roads and railways within flooded zones.

Table 2 indicates that Navakirinagar is at the highest risk due to its high exposure and vulnerability. It has the third largest share of families engaged in agriculture, 93% of its families earn daily wages between 2000 and 3000 LKR, and there is a significant proportion of female-headed households and families with members with disabilities. Selvapuram follows, with a high share of low-income families, female-headed households, and families with members with disabilities. Kovilporathivu South is also notable for its highly affected population density and female-headed households, according to data from local authorities.

In contrast, Palamunai, Kannapuram, and Kovilporathivu West have the lowest risk. They had no flooded areas during the assessed period, with Palamunai and Kannapuram having a low share of families engaged in agriculture, and all three areas having low unemployment rates.

The distribution of flood risks in Porativu Pattu underscores the need for flood management plans, especially during agricultural seasons, to mitigate adverse effects. Seven GNDs have over 50% of cropland within flood zones. Selvapuram and Punnakkulam are particularly affected, with 94% and 91% of cropland prone to floods, respectively, indicating a significant impact on agricultural activities. This is critical for the livelihood of Porativu Pattu's families and the food security of Batticaloa communities, as Porativu Pattu accounts for 15% of the paddy harvest in the district, the fourth highest among the 14 DSDs. The paddy season in Porativu Pattu runs from October to February and heavily relies on rainfall patterns.

Map 3. Flood exposure

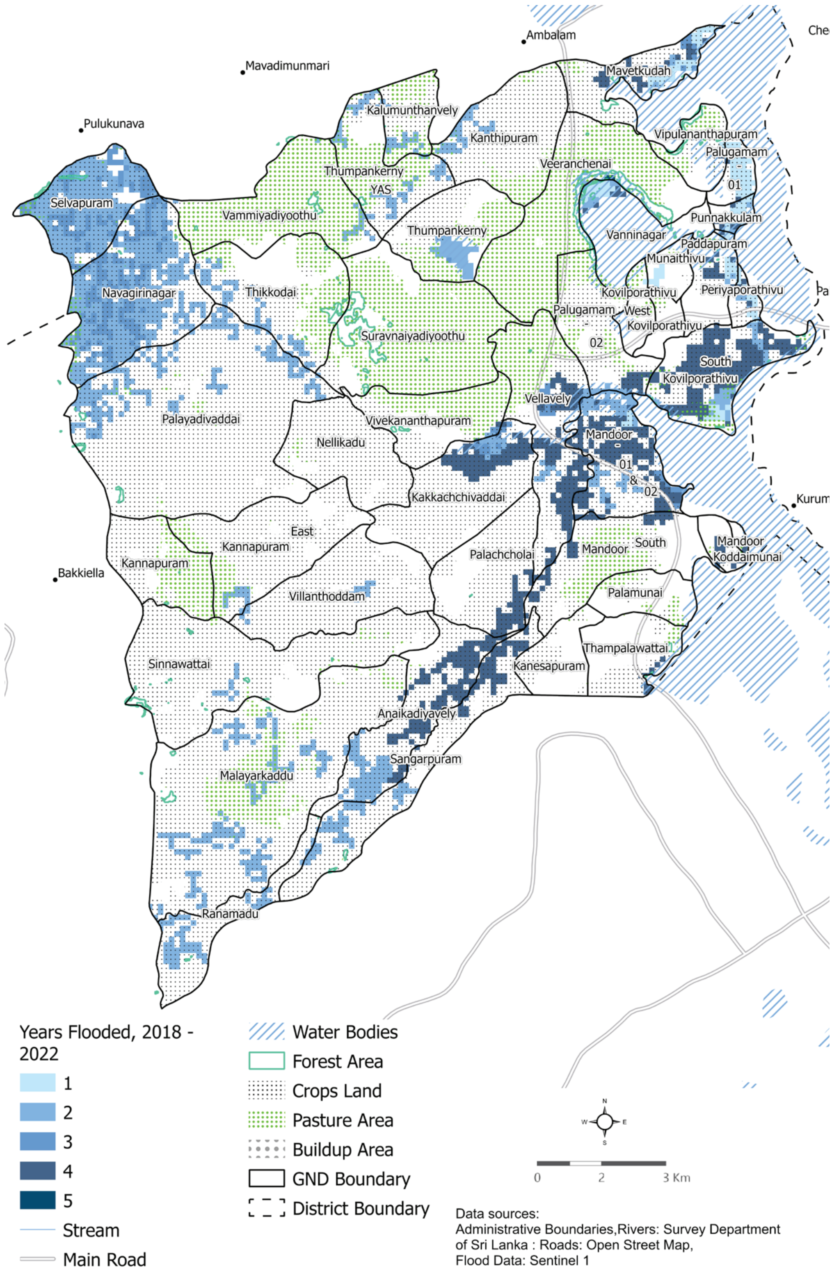


Table 2. Flood risk index

GND	Hazard-Exposure	Vulnerability	Risk
Navagirinagar	**0.60**	**0.67**	**0.401**
Selvapuram	**0.56**	**0.68**	**0.375**
Kovilporathivu South	**0.39**	**0.63**	**0.245**
Punnakkulam	0.35	0.68	0.237
Ranamadu	0.34	0.65	0.219
Mandoor - 01 & 02	0.26	0.65	0.166
Mandoor South	0.20	0.65	0.132
Palayadivaddai	0.17	0.77	0.131
Sangarpuram	0.19	0.64	0.120
Mandoor - 03	0.18	0.68	0.119
Thumpankerny YAS	0.18	0.58	0.106
Periyaporathivu	0.16	0.61	0.100
Paddapuram	0.49	0.18	0.089
Thikkodai	0.13	0.64	0.084
Kalumunthanvely	0.15	0.56	0.082
Malayarkaddu	0.11	0.65	0.075
Vellavely	0.29	0.23	0.067
Mandoor Koddaimunai	0.09	0.65	0.061
Anaikadiyavely	0.40	0.15	0.060
Palugamam - 01	0.25	0.21	0.052

* Hazard, exposure and vulnerability values were calculated as a relative indicator (for more details and full table please see the Annex 2)

Figure 3. Flood-affected areas and inland fishery and agricultural families[21]

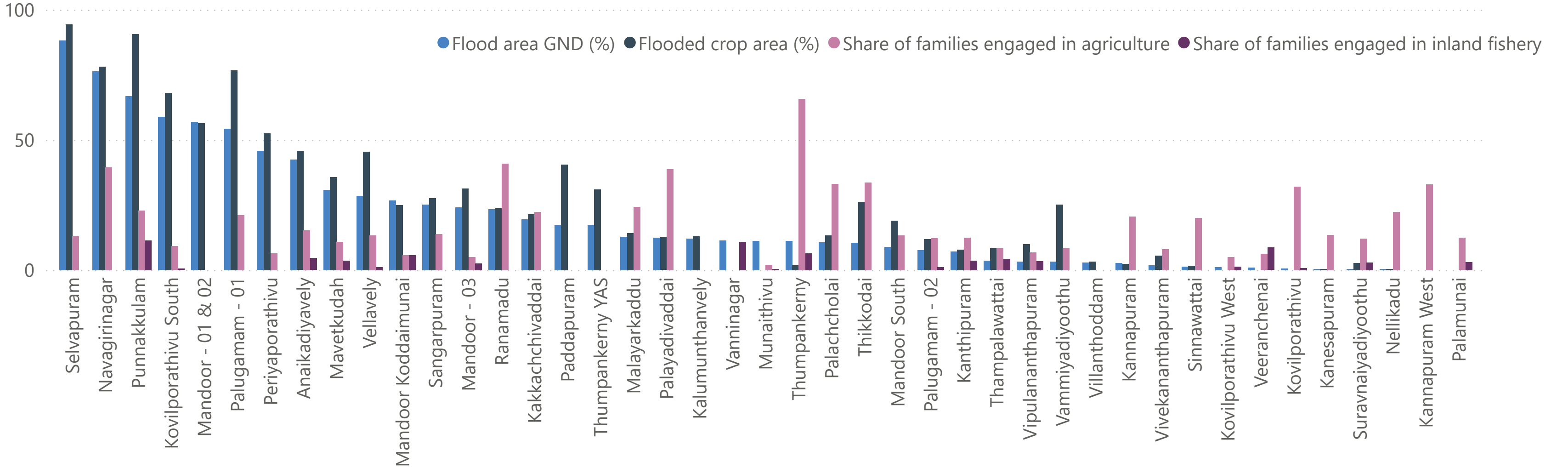


Figure 4. Crop area, flood area, and flooded crop area per GND[20]

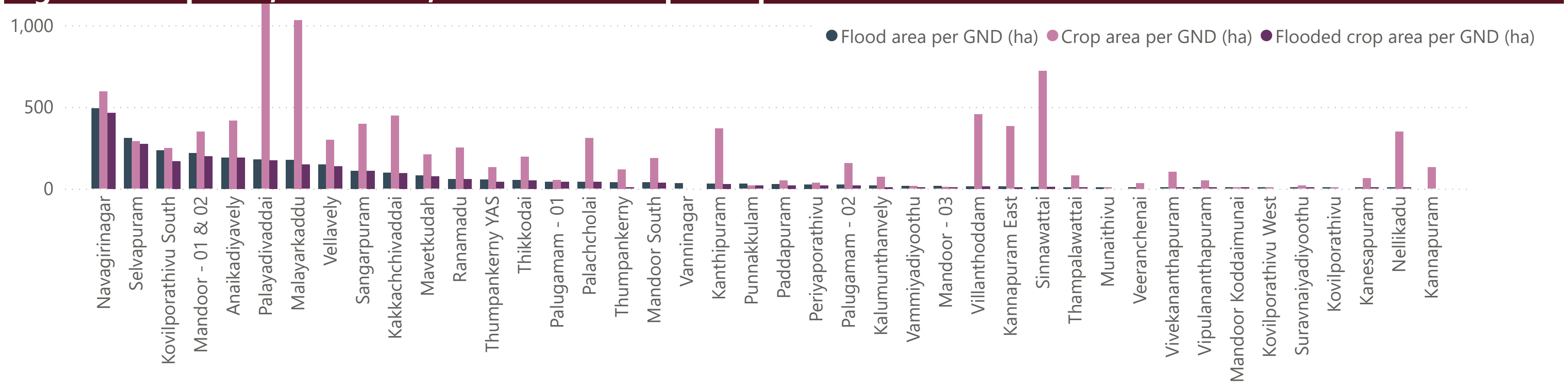
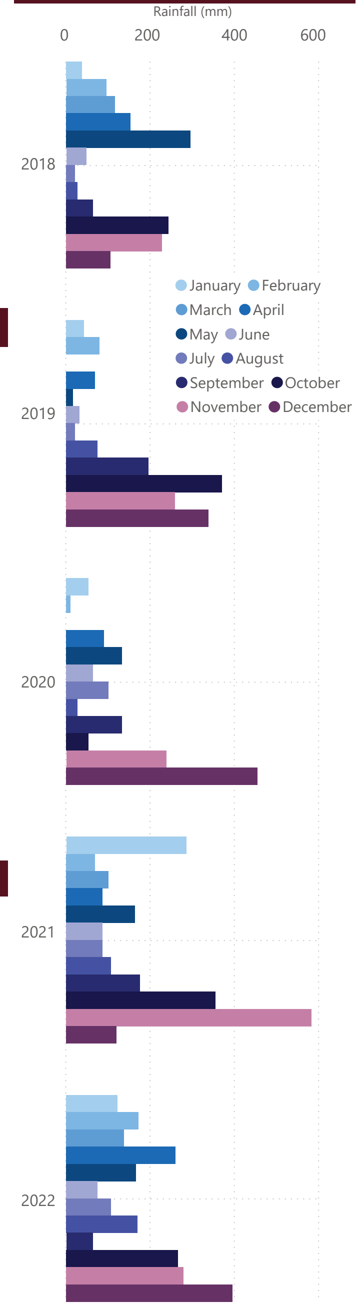


Figure 5. Annual rainfall in Vellavaly[22]



HUMAN-ELEPHANT CONFLICT

Human-elephant conflict (HEC) has emerged as a significant socio-economic and conservation challenge in Sri Lanka. The country has the highest annual elephant deaths globally and the second-highest human deaths attributed to such conflicts. This issue stems from competition for essential natural resources, as urban and agricultural expansion encroach upon elephant's natural habitats. Sri Lanka has the highest density of Asian elephants, with 10–20% of the global population and less than 2% of the worldwide range.

Deforestation leads to the loss and fragmentation of natural habitats and wildlife corridors used for migration, resulting in a decline in available food and water sources. This often drives elephants to raid agricultural fields and human-occupied areas, leading farmers to view elephants as threats to their livelihoods, increasing the likelihood of retaliatory measures. Between 2015 and 2021, 54% of incidents in Sri Lanka happened in open forests, while 62% occured within 2 km of the forest edge. GNDs with high human populations and activities coupled with increased forest disturbances, may exacerbate conflicts over access to resources between humans and elephants. Interventions to tackle this issue are crucial to maintaining healthy ecosystems.

Table 3 shows Thikkodai as the GND most at risk with 4 registered elephant attacks. The high risk is driven by high population density, the largest share of families engaged in agriculture, 94% of families

Map 4. Human-elephant conflict exposure

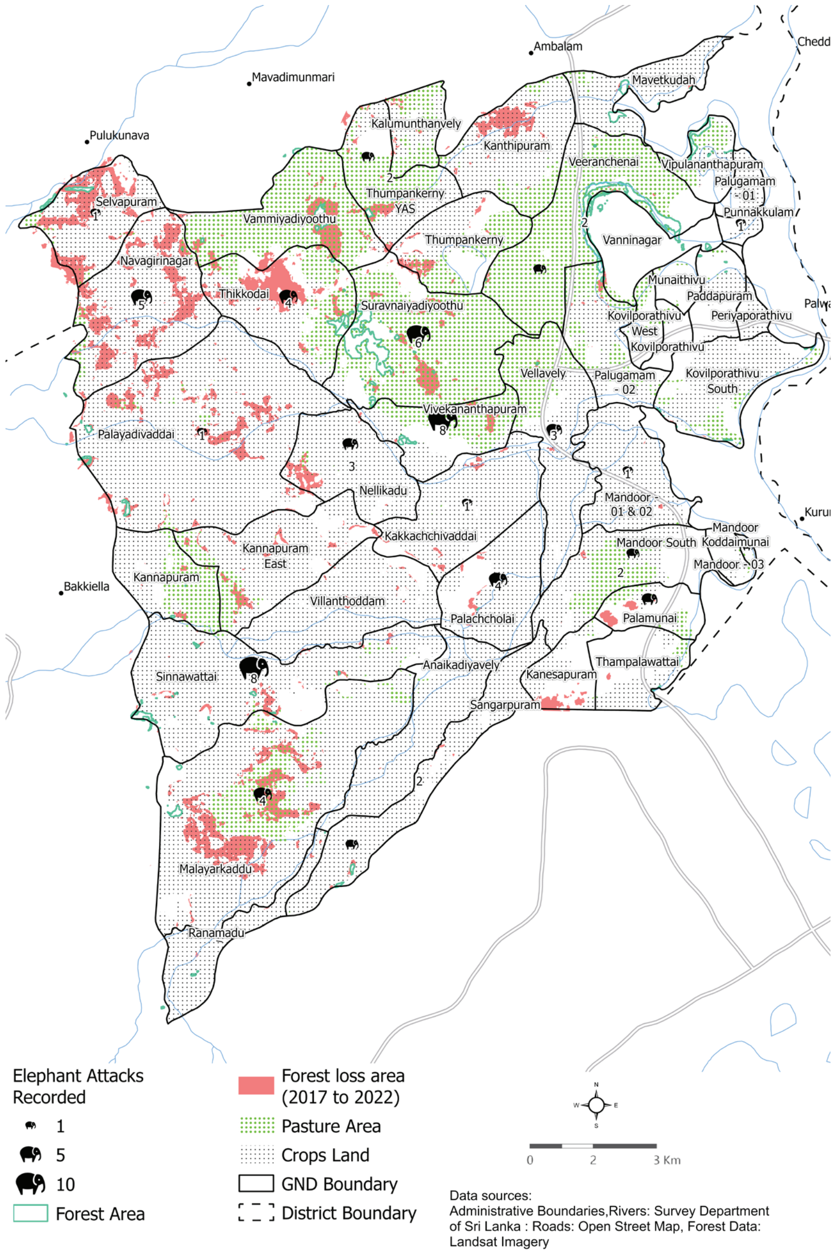
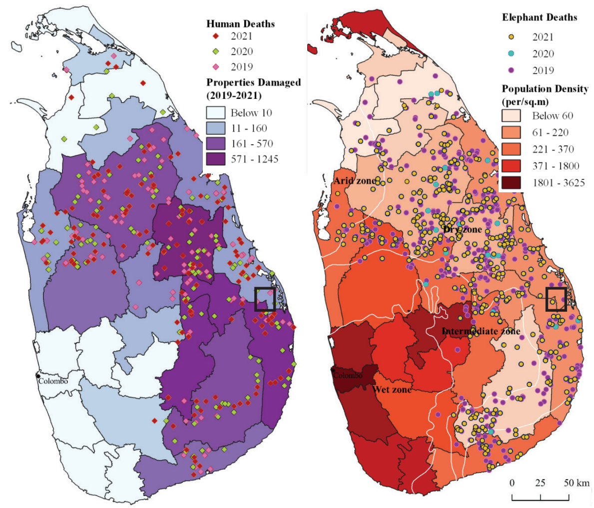


Figure 6. Human death and property damage caused by elephants/Elephant death and human density[23]



earning daily wages between 2000 and 3000 LKR, and 22% of female-headed households. Palamunai and Vammiyadiyoothu follow, both with high population density and, a large share of female-headed households and low-income families. Palamunai has 16% unemployment, and Vammiyadiyoothu has the third-highest share of families with members with disabilities.

According to local authorities data, Sinnawattai and Vivekananthapuram registered 8 elephant attacks each, while Suravnaiyadiyoothu and Navagirinagar 6 and 5, respectively, with Sinnawattai presenting the largest forest area. Due to their low population index, they present a low exposure index and, consequently a lower risk. The impact of deforestation is evident across Porativu Pattu, where crop and pasture land cover most of the DSD, as seen in Map 4, with 36 out of the

Table 3. HEC risk index

GND	Hazard	Exposure	Vulnerability	Risk
Thikkodai	**0.38**	**0.96**	**0.35**	**0.126**
Palamunai	**0.14**	**1.00**	**0.49**	**0.071**
Vammiyadiyoothu	**0.18**	**0.87**	**0.42**	**0.066**
Sangarpuram	0.10	0.78	0.55	0.043
Selvapuram	0.29	0.48	0.31	0.042
Sinnawattai	0.42	0.22	0.41	0.037
Vivekananthapuram	0.38	0.25	0.29	0.027
Vanninagar	0.13	0.55	0.23	0.017
Suravnaiyadiyoothu	0.67	0.15	0.16	0.017
Malayarkaddu	0.52	0.16	0.18	0.015
Mavetkudah	0.05	0.61	0.38	0.012
Palachcholai	0.18	0.39	0.13	0.009
Mandoor South	0.09	0.46	0.18	0.007
Vellavely	0.13	0.13	0.41	0.007
Veeranchenai	0.25	0.20	0.12	0.006
Thumpankerny YAS	0.13	0.29	0.15	0.006
Kanthipuram	0.08	0.29	0.21	0.005
Navagirinagar	0.46	0.07	0.15	0.005
Kakkachchivaddai	0.06	0.16	0.45	0.005
Nellikadu	0.17	0.26	0.10	0.004

* Hazard, exposure and vulnerability values were calculated as a relative indicator (for more details and full table please see the Annex 2)

43 GNDs with less than 5 ha of forest cover. Malayarkaddu, Navagirinagar, Selvapuram, and Palayadivaddai have lost over 100 ha of forest over the last five years. A combination of factors, including geographic location, land use patterns, conservation initiatives, and human activities, contributes to the observed variability in degraded forest areas.

Veeranchenai and Vanninagar have the second and third largest forest areas in Porativu Pattu and comparatively low forest loss. With proper protection and conservation efforts application, these GNDs have the potential to sustainably host human and elephant populations. Fifteen GNDs present no risk of HEC, driven mostly by the absence of forest cover and in seven of them no recorded elephant attacks, with one record in Palayadivaddai.

Figure 7. Human and elephant deaths in Sri Lanka[25]

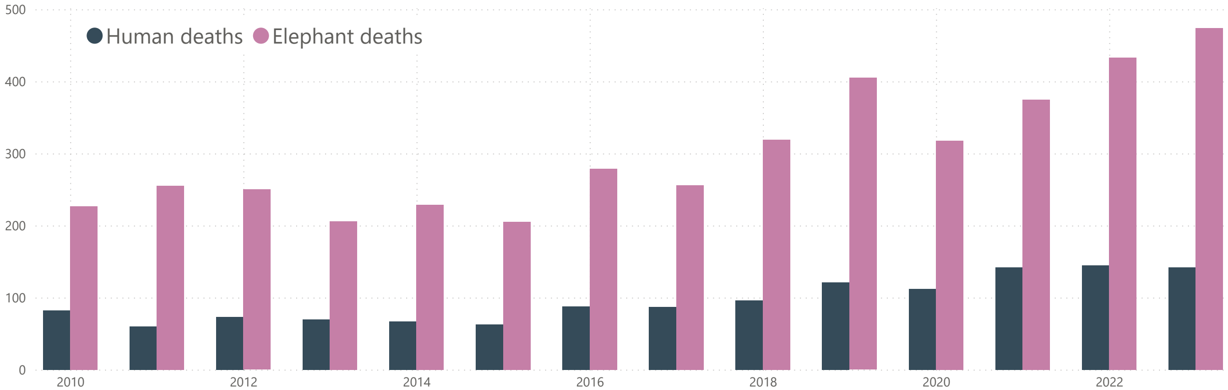
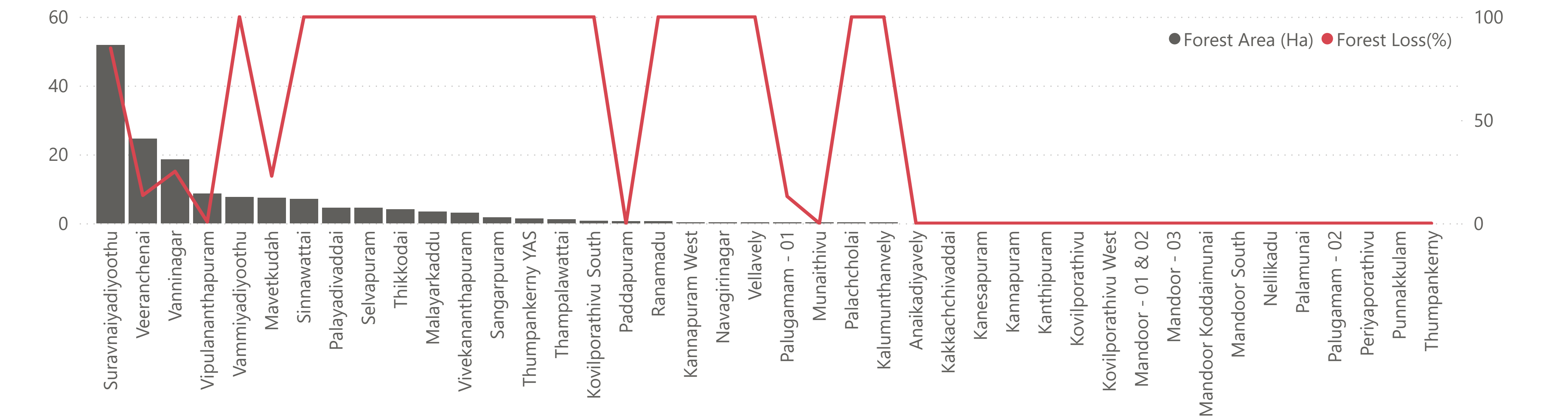


Figure 8. Forest disturbance in the last 5 years[24]



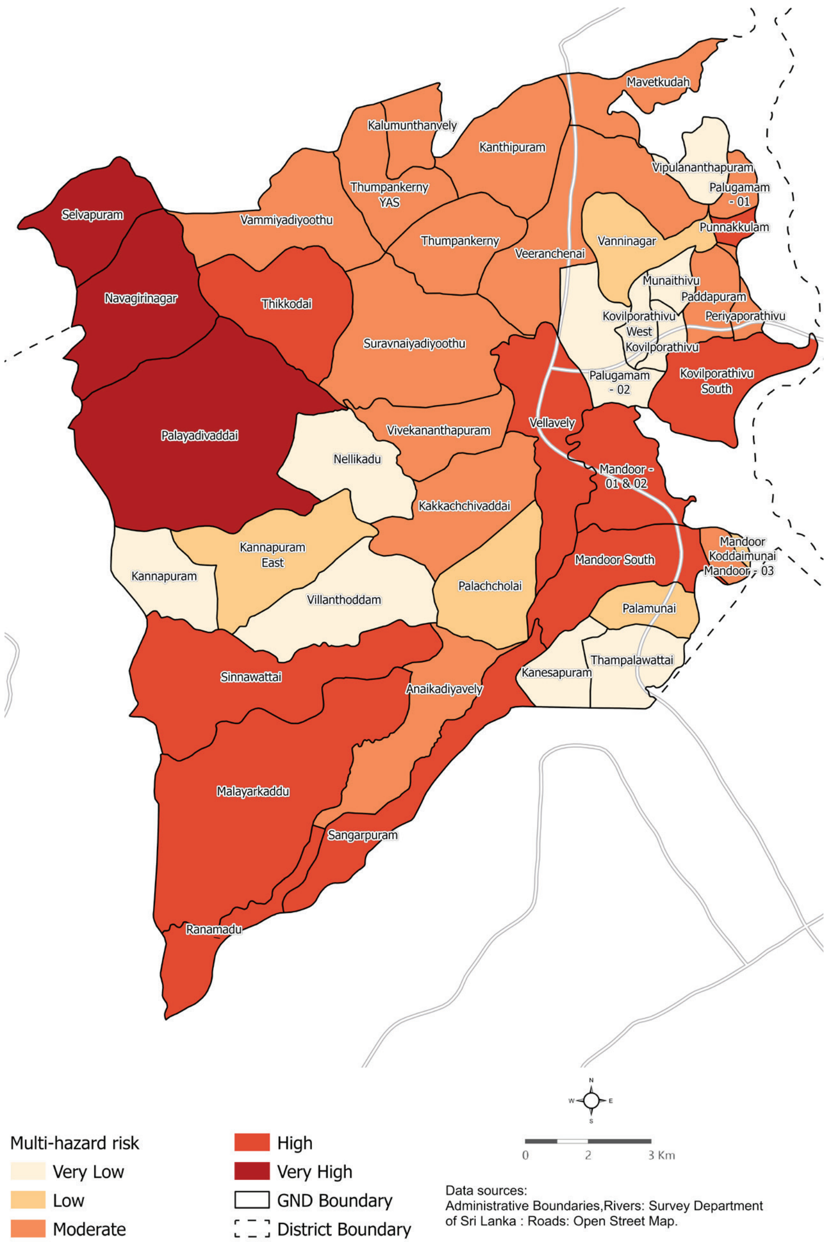
MULTI-HAZARD RISK

Porativu Pattu's multi-hazard risk analysis, presented in Table 4 and Map 5, was calculated based on the three assessed risks: flood, drought, and HEC. The GNDs with the highest risk (≥0.15 out of 1) in Porativu Pattu are Palayadivaddai, Navagirinagar, and Selvapuram.

Palayadivaddai presents high drought and moderate flood indexes. Navagirinagar presents the highest flood index and the fifth highest drought. Finally, Selvapuram's high multi-hazard risk results from its high flood risk, moderate drought risk, and fifth-highest HEC risk. The three GNDs have 20% of female-headed households and Palayadivaddai has a high density of children and elderly and the highest share of unemployment.

The higher exposure to natural hazards, especially drought and flood, and the socio-economic vulnerability of the population in the three GNDs increases the risk to communities highly dependent on natural resources for their livelihoods. This further impacts their ability to prepare for, respond to, and recover from shocks. The high percentage of families earning daily wages between 2,000 and 3,000 LKR—over 90% in Navagirinagar and Selvapuram, and 80% in Palayadivaddai—demonstrates their low coping capacity.

Map 5. Multi-hazard map



In Palayadivaddai and Navagirinagar, the multi-hazard risk is increased due to the lack of livelihood diversification, with nearly 40% of families engaged in agriculture. It is important to look at other GND individual risks and define targeted actions, as some GNDs may present a low multi-hazard risk despite having a single prominent risk. Kovilporathivu West, Kanesapuram, and Kannapuram present the lowest multi-hazard risk, having low flood and drought hazard indexes and no registration of elephant attacks. They show a low share of families engaged in agriculture, female-headed households and unemployment.

The multi-hazard risk analysis conducted with this study can inform both disaster risk reduction and social protection programmes, as the GNDs most at risk in Porativu Pattu present opportunities for a multi-pronged approach to mitigating disaster risks and their impact on communities.

Table 4. Multi-hazard risk index

GND	Flood	Drought	HEC	Multi-hazard risk
Palayadivaddai	**0.13**	**0.39**	**0.00**	**0.173**
Navagirinagar	**0.40**	**0.10**	**0.00**	**0.168**
Selvapuram	**0.38**	**0.07**	**0.04**	**0.162**
Malayarkaddu	0.07	0.21	0.01	0.100
Kovilporathivu South	0.24	0.05	0.00	0.097
Thikkodai	0.08	0.07	0.13	0.094
Ranamadu	0.22	0.04	0.00	0.085
Sangarpuram	0.12	0.08	0.04	0.082
Punnakkulam	0.24	0.00	0.00	0.080
Sinnawattai	0.01	0.18	0.04	0.073
Vellavely	0.07	0.13	0.01	0.068
Mandoor - 01 & 02	0.17	0.03	0.00	0.065
Mandoor South	0.13	0.05	0.01	0.064
Vammiyadiyoothu	0.01	0.07	0.07	0.050
Thumpankerny YAS	0.11	0.03	0.01	0.046
Mandoor - 03	0.12	0.00	0.00	0.040
Suravnaiyadiyoothu	0.00	0.10	0.02	0.039
Kakkachchivaddai	0.02	0.09	0.00	0.039
Veeranchenai	0.00	0.10	0.01	0.036
Paddapuram	0.09	0.01	0.00	0.034
Periyaporathivu	0.10	0.00	0.00	0.034
Thumpankerny	0.01	0.09	0.00	0.032
Anaikadiyavely	0.06	0.04	0.00	0.032
Palugamam - 01	0.05	0.04	0.00	0.031
Mavetkudah	0.04	0.04	0.01	0.031
Kanthipuram	0.03	0.06	0.01	0.031
Vivekananthapuram	0.02	0.04	0.03	0.031
Kalumunthanvely	0.08	0.01	0.00	0.031
Kannapuram East	0.00	0.07	0.00	0.026
Palamunai	0.00	0.00	0.07	0.025
Palachcholai	0.03	0.03	0.01	0.023
Vanninagar	0.03	0.02	0.02	0.023
Mandoor Koddaimunai	0.06	0.00	0.00	0.021
Thampalawattai	0.04	0.01	0.00	0.017
Nellikadu	0.00	0.05	0.00	0.017
Villanthoddam	0.01	0.03	0.00	0.016
Palugamam - 02	0.04	0.01	0.00	0.015
Munaithivu	0.03	0.01	0.00	0.014
Vipulananthapuram	0.02	0.02	0.00	0.012
Kovilporathivu	0.03	0.01	0.00	0.011
Kannapuram	0.00	0.03	0.00	0.010
Kanesapuram	0.01	0.01	0.00	0.009
Kovilporathivu West	0.00	0.01	0.00	0.005

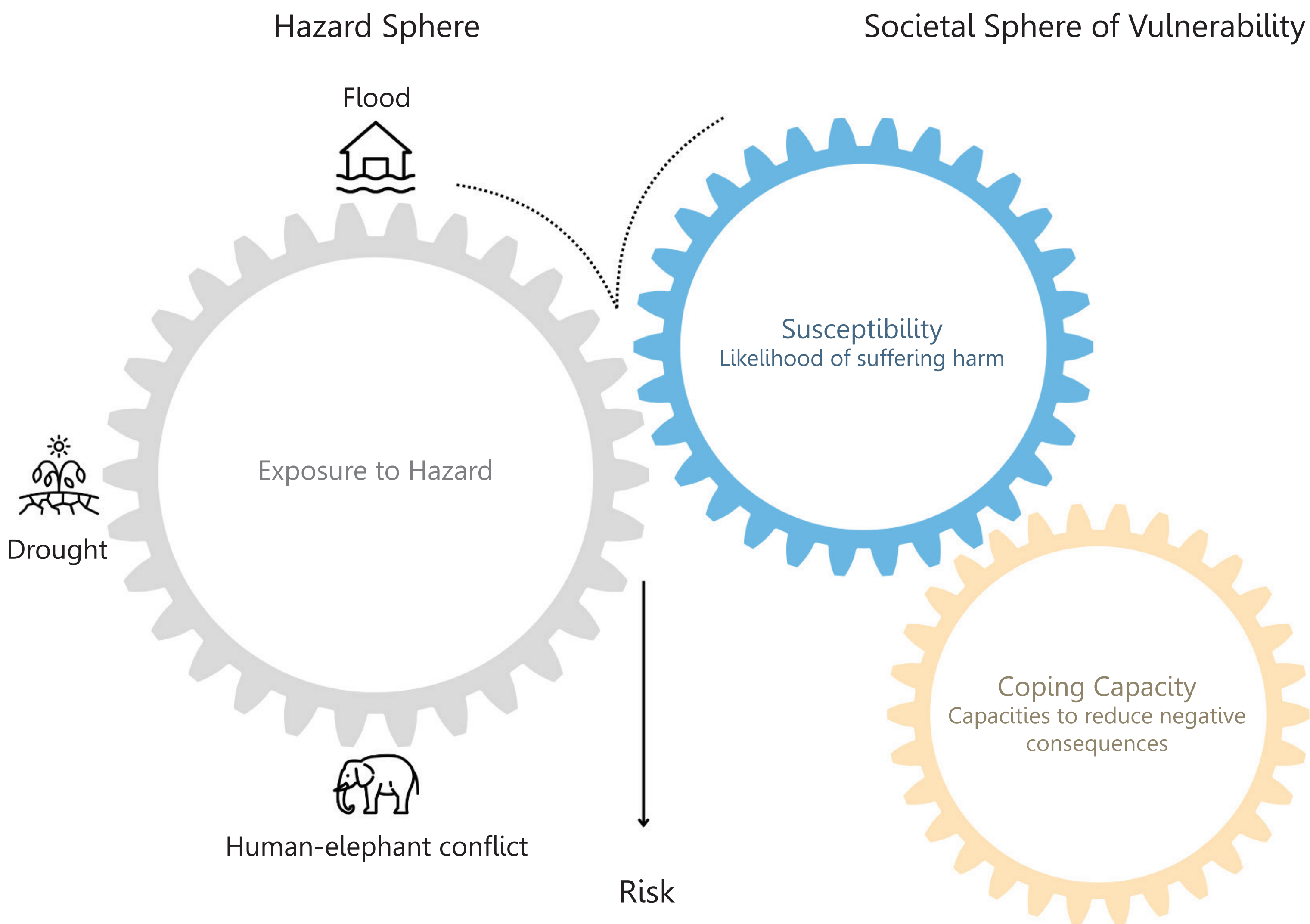
OTHER POTENTIAL HAZARDS

Other hazards also affect the population in Vellavaly, the combination of **land degradation**, **epidemics**, and **water scarcity** significantly impact livelihood resilience activities, posing additional challenges to the communities in Vellavaly. Firstly, land degradation reduces agricultural productivity and drains land's natural resources, causing reduced yields and economic losses. Additionally, disease outbreaks and pandemics disrupt livelihood activities and reduce access to markets and resources. These health crises worsen vulnerabilities, particularly in communities reliant on sectors like tourism or healthcare services.

Moreover, water scarcity intensifies these challenges, as it restricts access to clean water for drinking, sanitation, and irrigation. In regions facing prolonged drought or inadequate water infrastructure, livelihoods dependent on water-intensive activities suffer, leading to increased food insecurity and economic instability. Collectively addressing these interconnected challenges requires holistic approaches that promote sustainable land management, disease prevention, and equitable access to water resources, bolstering the resilience of livelihood activities and enhancing community well-being in the face of adversity.

ANNEX 1

Graph 1. Multi-hazard risk concept



ANNEX 2

Table 1. Drought risk index

GND	Hazard	Exposure	Vulnerability	Risk
Palayadivaddai	1.00	0.66	0.58	0.388
Malayarkaddu	0.90	0.70	0.34	0.210
Sinnawattai	0.53	0.69	0.49	0.177
Vellavely	0.37	0.71	0.50	0.131
Navagirinagar	0.45	0.69	0.32	0.099
Suravnaiyadiyoothu	0.52	0.71	0.26	0.097
Veeranchenai	0.47	0.72	0.29	0.097
Kakkachchivaddai	0.30	0.67	0.46	0.091
Thumpankerny	0.24	0.70	0.51	0.086
Sangarpuram	0.30	0.92	0.30	0.084
Thikkodai	0.29	0.89	0.29	0.073
Vammiyadiyoothu	0.33	0.92	0.24	0.073
Kannapuram	0.35	0.76	0.26	0.070
Selvapuram	0.25	0.83	0.34	0.068
Kanthipuram	0.31	0.76	0.25	0.059
Mandoor - 03	0.21	0.76	0.33	0.054
Kovilporathivu South	0.23	0.74	0.28	0.047
Nellikadu	0.26	0.75	0.23	0.045
Vivekananthapuram	0.22	0.75	0.26	0.044
Palugamam - 01	0.22	0.46	0.41	0.042
Mandoor Koddaimunai	0.16	0.83	0.29	0.038
Ranamadu	0.18	0.71	0.28	0.036
Anaikadiyavely	0.30	0.42	0.29	0.036
Villanthoddam	0.35	0.39	0.25	0.034
Mavetkudah	0.23	0.60	0.21	0.029
Kannapuram West	0.19	0.67	0.23	0.028
Palachcholai	0.22	0.45	0.27	0.027
Thumpankerny YAS	0.22	0.74	0.16	0.026
Vanninagar	0.14	0.51	0.35	0.024
Vipulananthapuram	0.10	0.73	0.22	0.016
Kovilporathivu West	0.06	0.88	0.25	0.014
Paddapuram	0.06	0.51	0.39	0.011
Kanesapuram	0.06	0.75	0.23	0.011
Kalumunthanvely	0.11	0.76	0.11	0.010
Munaithivu	0.04	0.75	0.25	0.007
Thampalawattai	0.04	0.52	0.29	0.007
Palugamam - 02	0.02	0.76	0.36	0.007
Kovilporathivu	0.04	0.81	0.20	0.006
Palamunai	0.03	0.56	0.27	0.004
Periyaporathivu	0.01	0.29	0.23	0.001
Punnakkulam	0.01	0.06	0.34	0.000
Mandoor - 01 & 02	0.00	0.14	0.35	0.000
Mandoor South	-	0.13	0.32	0.000

Table 2. Flood risk index

GND	Hazard-Exposure	Vulnerability	Risk
Navagirinagar	0.60	0.67	0.401
Selvapuram	0.56	0.68	0.375
Kovilporathivu South	0.39	0.63	0.245
Punnakkulam	0.35	0.68	0.237
Ranamadu	0.34	0.65	0.219
Mandoor - 01 & 02	0.26	0.65	0.166
Mandoor South	0.20	0.65	0.132
Palayadivaddai	0.17	0.77	0.131
Sangarpuram	0.19	0.64	0.120
Mandoor - 03	0.18	0.68	0.119
Thumpankerny YAS	0.18	0.58	0.106
Periyaporathivu	0.16	0.61	0.100
Paddapuram	0.49	0.18	0.089
Thikkodai	0.13	0.64	0.084
Kalumunthanvely	0.15	0.56	0.082
Malayarkaddu	0.11	0.65	0.075
Vellavely	0.29	0.23	0.067
Mandoor Koddaimunai	0.09	0.65	0.061
Anaikadiyavely	0.40	0.15	0.060
Palugamam - 01	0.25	0.21	0.052
Thampalawattai	0.07	0.65	0.044
Mavetkudah	0.31	0.14	0.043
Palugamam - 02	0.06	0.66	0.038
Munaithivu	0.05	0.62	0.033
Palachcholai	0.05	0.63	0.033
Kanthipuram	0.05	0.62	0.028
Vanninagar	0.17	0.16	0.028
Kovilporathivu	0.04	0.60	0.026
Vivekananthapuram	0.03	0.66	0.022
Kakkachchivaddai	0.10	0.21	0.021
Vipulananthapuram	0.16	0.10	0.017
Kanesapuram	0.02	0.62	0.014
Villanthoddam	0.02	0.63	0.013
Vammiyadiyoothu	0.10	0.12	0.012
Thumpankerny	0.01	0.75	0.010
Sinnawattai	0.01	0.72	0.006
Veeranchenai	0.03	0.13	0.004
Kannapuram	0.01	0.63	0.004
Suravnaiyadiyoothu	0.01	0.62	0.004
Nellikadu	0.00	0.62	0.000
Kannapuram West	0.00	0.61	0.000
Kovilporathivu West	0.00	0.11	0.000
Palamunai	0.00	0.63	0.000

Table 3. HEC risk index

GND	Hazard	Exposure	Vulnerability	Risk
Thikkodai	0.38	0.96	0.35	0.126
Palamunai	0.14	1.00	0.49	0.071
Vammiyadiyoothu	0.18	0.87	0.42	0.066
Sangarpuram	0.10	0.78	0.55	0.043
Selvapuram	0.29	0.48	0.31	0.042
Sinnawattai	0.42	0.22	0.41	0.037
Vivekananthapuram	0.38	0.25	0.29	0.027
Vanninagar	0.13	0.55	0.23	0.017
Suravnaiyadiyoothu	0.67	0.15	0.16	0.017
Malayarkaddu	0.52	0.16	0.18	0.015
Mavetkudah	0.05	0.61	0.38	0.012
Palachcholai	0.18	0.39	0.13	0.009
Mandoor South	0.09	0.46	0.18	0.007
Vellavely	0.13	0.13	0.41	0.007
Veeranchenai	0.25	0.20	0.12	0.006
Thumpankerny YAS	0.13	0.29	0.15	0.006
Kanthipuram	0.08	0.29	0.21	0.005
Navagirinagar	0.46	0.07	0.15	0.005
Kakkachchivaddai	0.06	0.16	0.45	0.005
Nellikadu	0.17	0.26	0.10	0.004
Kannapuram	0.05	0.28	0.20	0.003
Mandoor Koddaimunai	0.04	0.39	0.14	0.002
Vipulananthapuram	0.06	0.28	0.15	0.002
Punnakkulam	0.04	0.16	0.27	0.002
Kanesapuram	0.01	0.68	0.21	0.002
Thampalawattai	0.01	0.72	0.22	0.002
Thumpankerny	0.04	0.10	0.27	0.001
Mandoor - 01 & 02	0.04	0.17	0.10	0.001
Kalumunthanvely	0.01	0.29	0.12	0.000
Paddapuram	0.00	0.40	0.19	0.000
Kannapuram West	0.01	0.15	0.15	0.000
Ranamadu	0.01	0.14	0.27	0.000
Villanthoddam	0.01	0.19	0.14	0.000
Palugamam - 02	0.00	0.29	0.15	0.000
Munaithivu	0.00	0.75	0.17	0.000
Palugamam - 01	0.00	0.06	0.15	0.000
Anaikadiyavely	0.00	0.25	0.13	0.000
Kovilporathivu	0.00	0.44	0.00	0.000
Kovilporathivu South	0.01	0.45	0.00	0.000
Kovilporathivu West	0.00	0.65	0.24	0.000
Mandoor - 03	0.00	0.38	0.19	0.000
Palayadivaddai	0.28	0.00	0.53	0.000
Periyaporathivu	0.00	0.35	0.11	0.000

ANNEX 2

Hazard, exposure and vulnerability index calculations

The risk calculation, for each GND, was done following these steps:
1. Define hazard, exposure, and vulnerability indicators.
2. Collect data for the indicators. Hazard and exposure are explained in the tables below, vulnerability was provided by local authorities on request.
3. Calculate the relative number (%) of indicators when they are presented in absolute numbers for comparability .
4. Normalize all data (with a min-max approach) using formulas:

$$I = (Ix - Imin) / (Imax - Imin) \text{ - if indicator increase vulnerability (S)}$$
$$I = 1 - ((Ix - Imin) / (Imax - Imin)) \text{ - if indicator decreases vulnerability (CC)}$$

where I is an indicator, Ix - hazard, exposure or vulnerability value for the particular GND, Imin - minimal hazard/exposure or vulnerability value through all the GNDs, Imax - maximum hazard/exposure or vulnerability value through all the GNDs.
5. Aggregate data calculating the average number for Hazard (H), Exposure (Ex), and Vulnerability (V) into indexes for each hazard using the formulas:

$$H = (h1+h1)/2$$
$$Ex=(ex1+ex2+ex3)/3$$
$$V=((s1+s2+s3+s4+s5)/5+(lcc1+lcc2+lcc3)/3)/2$$

where h, ex, s, and lcc are each indicators for hazard, exposure, susceptibility, and lack of coping capacity, respectively
6. Calculate the risk (R) for each hazard using the formula:

$$R = H \times Ex \times V$$

7. Calculate the multi-hazard risk index (MHRI) using the formula:

$$MHRI = (R1+R2+R3)/3$$

where R1, 2, and 3 are each of the risks calclulated for drought, flood and HEC

ANNEX 2

Hazard, exposure and vulnerability index calculations

Hazard	Data source	Methodology
Drought	NASA Modis data[26] for vegetation and land-surface temperature data as well as CHIRPS rainfall datasets[27] from Earth Engine Data Catalog[28]	VCI data derived from Modis EVI[29] (2003-2023) using the UN-Spider methodology (GEE code[30]). VHI was calculated using NDVI[31] and LST[32] data based on UN-Spider methodology[33] (GEE code). The SPI[34] was calculated to highlight the rainfall anomalies in 2023, using CHIRPS rainfall data processed using the GEE code. The analysis was run for agricultural, croplands, and rangelands Copernicus land cover data[35].
Flood	European Space Agency's Sentinel-1 synthetic aperture radar (SAR) data 2019-2022 from Earth Engine Data Catalog[36]	Spider flood assessment methodology[37] for each of the years from 2018 to 2022 comparing pre-flood and post-flood acquisitions dates also related to the yearly rain season.
HEC	Landsat Satellite Imagery (1990-2022) from Earth Engine Data Catalog[38]	Forest fragmentation was detected using LandTrend methodology[39] based on Landsat satellite imagery acquired from 1990 to 2022

ANNEX 2

Hazard, exposure and vulnerability index calculations

Exposure	Data source	Methodology
Population density	Population density raster-Socioeconomic Data and Applications Center (SEDAC)	The affected population value for each GND was extracted from the global raster that indicates population density.
Percentage of crop area prone to drought	VCI data derived from MODIS EVI (2003-2023). (VHI/SPI-2023)	Using ArcGIS Pro spatial analysis tool and related statistical analysis tools, the percentage of crops susceptible to drought is determined based on the area's drought frequency.
Percentage of pasture land prone to drought	VCI data derived from MODIS EVI (2003-2023). (VHI/SPI-2023)	Using ArcGIS Pro spatial analysis tool and related statistical analysis tools, the percentage of crops susceptible to drought is determined based on the area's drought frequency.
Share of affected fisheries families	Secondary data from local authority.	Acted prepared and shared a questionnaire with local authorities to collect the information.
Affected population density index	Population density raster-Socioeconomic Data and Applications Center (SEDAC)	The affected population value for each GND was extracted from the global raster that indicates population density.
Percentage of crop area within a flood zone	Sentinel-1 synthetic aperture radar (SAR) data 2019-2022 -European Space Agency's Copernicus Open Access Hub and other repositories.	Using ArcGIS Pro spatial analysis tool and related statistical analysis tools, the percentage of crops susceptible to drought is determined based on the area's drought frequency.
Percentage of build up area within a flood zone	Sentinel-1 synthetic aperture radar (SAR) data 2019-2022 -European Space Agency's Copernicus Open Access Hub and other repositories.	Using ArcGIS Pro spatial analysis tool and related statistical analysis tools, the percentage of crops susceptible to drought is determined based on the area's drought frequency.
Road length and railways within a flood zone (km)	Open street map, Survey Department of Sri Lanka	Using the ArcGIS Pro spatial analysis tool and related statistical analysis tools.
Population density	Secondary data from local authority.	Acted prepared and shared a questionnaire with local authorities to collect the information.
Share of affected fisheries families	Secondary data from local authority.	Acted prepared and shared a questionnaire with local authorities to collect the information.

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