SRI LANKA

Area-Based Risk Assessment in Poonakary Divisional Secretariat Division

Kilinochchi 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. Increased 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 northern provinces are highly susceptible to floods, drought, and human-animal conflict hazards. They experience high vulnerability due to the high share of low-income families, 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 Poonakary Divisional Secretary's Divisions (DSD) in Kilinochchi district, Northern 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 predict better, 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. Local authorities and communities reported during the preliminary consultations in Poonakary that floods, droughts, and human-elephant conflict (HEC) are the most prominent. Therefore they 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 Poonakary.

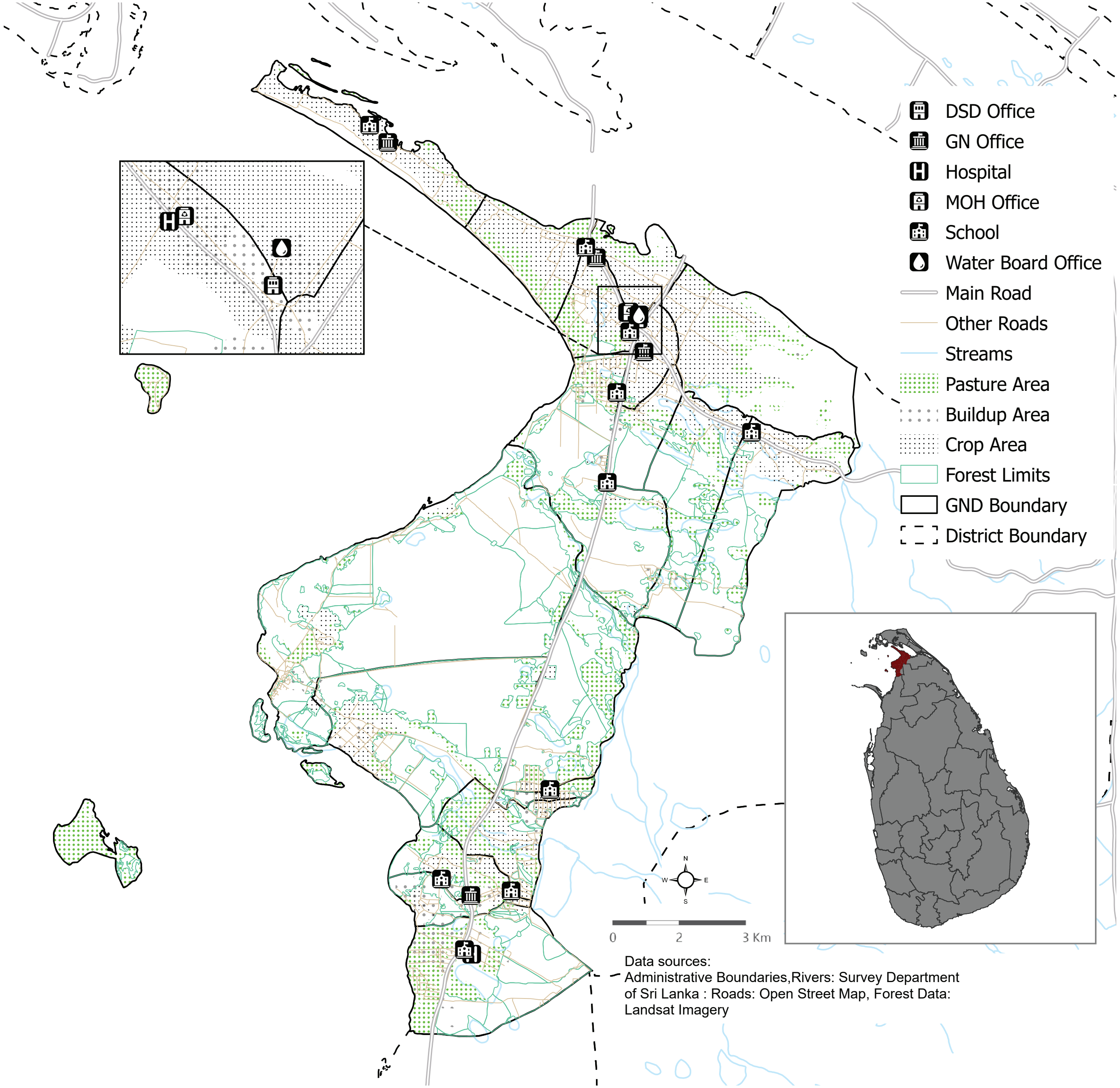
Through the study, IMPACT identified three GNDs, namely Pallikuda, Mulankavil, and Ponnaveli as the most at risk for multiple hazards. Pallikuda presents high risk across all assessed hazards, Mulankavil has high drought and HEC risks, and Ponnaveli has high flood and HEC risks. Ponnaveli is the most at risk due to its high population density and exposure, with 25 registered elephant attacks, the largest in the DSD and 74% of low income families. Mulankavil has a large population density, registering a large drought-affected area and the largest forest disturbance, the GND has 78% of low-income families. Ponnaveli has a large population density affected by floods, 56% of its families engaged in fishery, and a large child density.

In Iranaithivu and Kollakurichchi, the population has a high level of vulnerability regarding social dependency, with a high share of female-headed households, families with members with disabilities, and child density. Iranaithivu has the largest share of elders in the DSD. Social dependency is when an individual or group relies on another individual or group for resources, support, or guidance. The unemployment and low-income rates are social insecurity indicators for low financial capacity to prepare and recover from hazards.

Nachchikuda, Iranaithivu, and Jeyapuram South are the least impacted by the combination of droughts, floods, and elephant attacks. Their territories are not affected by flood, with small areas affected by drought and no registered elephant attacks. Nachchikuda and Iranaithivu families are not dependent on agriculture, with a smaller share of low-income families allowing higher coping capacity.

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

Map 1. Overview map of Poonakary DSD



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

CONTENTS

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

BACKGROUND

Located in the Northern province, Kilinochchi district, Poonakary DSD covers an area of 535 km², this area contains 449 km² of land area and 86 km² of water. The total population is 27,120 individuals, 50% of them female[3]. The average population density is 46,25/ km², living across 19 Grama Nilhadari Divisions (GNDs). It is estimated that the dependency ratio reaches 37%, which is the population below 15 and above 60 years old[4].

The terrain in Poonakary is diverse, ranging from coastal areas with sandy beaches to inland areas with flat plains and some hilly terrain. It is bordered by the Indian Ocean to the east, providing access to coastal resources and activities such as fishing. Additionally, several lagoons and water bodies in the region contribute to agriculture and fishing activities. The vegetation in Poonakary includes coastal vegetation, such as mangroves and palm trees along the shoreline, and inland vegetation consisting of forests, slough, and croplands. Poonakary experiences a tropical climate with distinct wet and dry seasons, with 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.

Overall, Poonakary's geography significantly shapes its economy, with livelihood activities primarily revolving around agriculture and fishery. In Poonakary, paddy cultivation stands out as the predominant agricultural activity, 2600 families are involved in agriculture, and the activity employs 2903 individuals (1931 male and 992 female) who cultivate the 15,850 acres for paddy and high land crops in Poonakary[5]. The DSD has 1494 families involved in fishery activities, according to the data provided by local authorities.

During heavy monsoon rains, low-lying areas in Poonakary 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, Poonakary 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 leads to an elevated risk of flooding, resulting in coastal erosion, damage to infrastructure, and displacement of communities. Poonakary's natural environment, surrounded by forest and in the migration path of elephants, may result in human-elephant conflict, loss of lives, and damage to infrastructure and agricultural land.

With 115 km of coast, the landscape supports a mosaic of diverse ecosystems such as estuaries, lagoons, mudflats, sandy beaches, dunes, and forests. Poonakary was also a battle area during the 26-year Sri Lankan civil war, causing large civilian displacement, deaths, and damage to housing and infrastructure.

The ABRA measured the risk in the 19 GNDs in Poonakary, 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 Poonakary that considers specific local environmental, social, and economic factors, the study is intended to address a data gap and contribute to inform initiatives aimed at enhancing 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)[6]. 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[7]).
- **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 Poonakary, 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 Poonakary.

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[8] (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[9]). MODIS Normalized differentiated vegetation index (NDVI[10]) and MODIS Land Surface Temperature (LST[11]) 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[12]. 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[13] 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

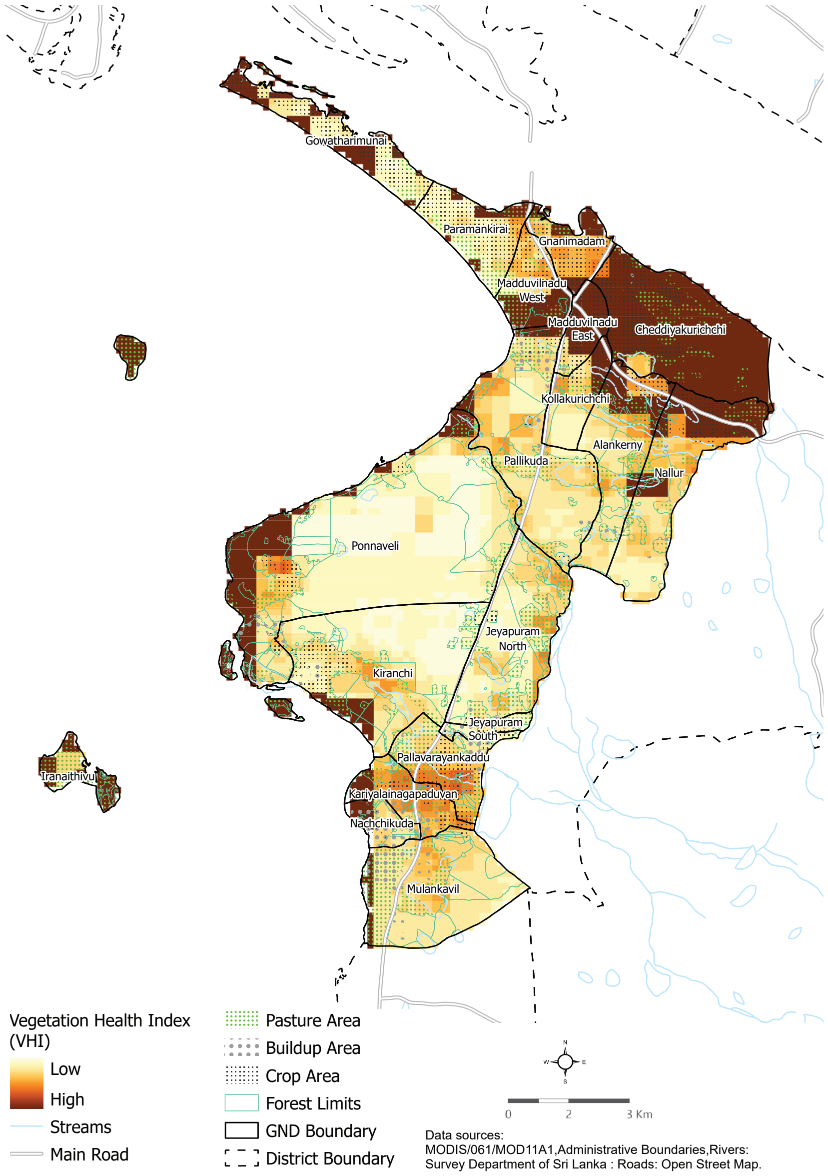
DROUGHT

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 in Poonakary (Map 2), the exposure index is moderate across the DSD with 28% of the total area and an average of 12% of cropland affected by drought and 41% of pasture land. In total terms, Pallikuda presents the largest drought area, 1679 ha, covering almost 40% of its territory and accounting for 13% of Poonakary's drought area, the GND has 54% of its pasture land affected. Nallur, Jeyapuram North, and Mulankavil also present large drought-affected areas. Kariyalainagapaduvan has 87% of its area affected by drought, 44% and 93% cropland and pasture land, respectively. Its neighbour, Pallavarayankaddu, has 73% of its area affected by drought, 51% and 71% cropland and pasture land, respectively.

Mulankavil is the GND most at risk of drought, caused by the combination of high exposure indexes, large affected population density, 32% of families engaged in agriculture and 78% of families with daily wages between 2,000 and 3,000 LKR.

Map 2. Drought exposure



High drought exposure leads Pallikuda and Pallavarayankaddu to high risk, both GNDs have over 74% of low-income families and an above-average share of female-headed households. Pallikuda has 40% of its families engaged in inland fishery activities and Pallavarayankaddu has 60% in agriculture. GNDs characterized by high population density, such as Nachchikuda, Mulankavil, and Pallikuda, 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 Poonakary.

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. Poonakary has an average of 40% of families in agriculture. The increasing drought exposure, if not faced with sustainable water resources management and climate-smart agriculture, will result in more livelihood and food security challenges.

Figure 1. Percentage of drought-affected areas and agricultural families[15]

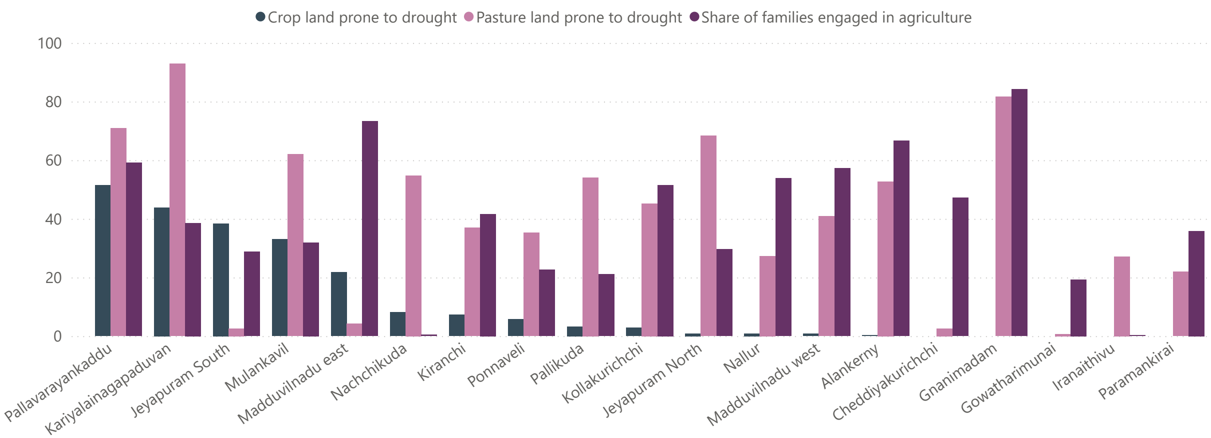


Figure 2. Drought area (ha) per GND[14]

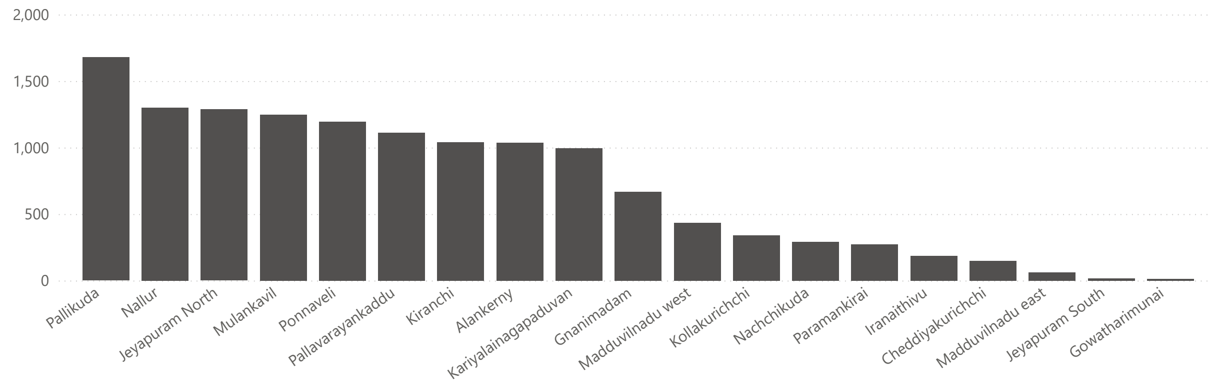


Table 1. Drought risk index

GND	Hazard	Exposure	Vulnerability	Risk
Mulankavil	**0.74**	**0.72**	**0.30**	**0.159**
Pallikuda	**1.00**	**0.50**	**0.31**	**0.153**
Pallavarayankaddu	**0.66**	**0.68**	**0.31**	**0.137**
Kariyalainagapaduvan	0.59	0.81	0.26	0.123
Kiranchi	0.62	0.35	0.38	0.082
Nallur	0.77	0.28	0.37	0.079
Ponnaveli	0.71	0.32	0.32	0.074
Jeyapuram North	0.77	0.30	0.31	0.071
Gnanimadam	0.39	0.30	0.41	0.049
Alankerny	0.61	0.19	0.26	0.030
Kollakurichchi	0.20	0.26	0.42	0.021
Nachchikuda	0.17	0.58	0.17	0.017
Madduvilnadu west	0.25	0.20	0.29	0.015
Iranaithivu	0.10	0.20	0.52	0.011
Paramankirai	0.16	0.10	0.47	0.008
Madduvilnadu east	0.03	0.17	0.45	0.002
Cheddiyakurichchi	0.08	0.05	0.40	0.002
Jeyapuram South	0.00	0.31	0.35	0.000
Gowatharimunai	0.00	0.02	0.44	0.000

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

FLOODS

The rainy season in Poonakary lasts from September to February, with most floods typically happening from November to January (Map 3), caused by heavy rainfall, improper maintenance of existing natural drainage systems, and inadequate availability of masonry drains[16]. Paddy seasons in Poonakary go from mid-September to January (Maha season) and from April to mid-July and rely heavily on rainfall patterns.

Between 2018 and 2020, satellite images showed that 2866 hectares of Poonakary were flooded. Cheddiyakurichchi was the most affected area, accounting for 16% of the total flooded area in Poonakary and covering 11% of its territory. Iranaithivu had 25% and Gnanimadam and Kollakurichchi had 12% of their areas affected by floods. 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 Nallur is at the highest risk due to its high exposure and vulnerability. It has the third largest affected population density, with almost 10% of flooded affected cropland, 54% of families engaged in agriculture, and nearly 80% of its families earning daily wages between 2,000 and 3,000 LKR.

Jeyapuram North follows with 12% of cropland affected area, the largest in the DSD, 20% of female-headed households, and 83% of its families earning daily wages between 2,000 and 3,000 LKR, which increases its susceptibility. Cheddiyakurichchi comes third, with the largest flooded area, the largest share of female-headed households, 24%, and 47% of families engaged in agriculture according to data provided by local authorities.

Pallikuda is the GND most exposed to floods in Poonakary, with the largest affected population density index and the largest road and railway length within a flood zone. Paramankirai also presents high exposure, with 33% of its build-up area within flood zones. The GND also has 25% of female-headed households and 22% of unemployed individuals, the largest share in the DSD, that contribute to the vulnerability.

In contrast, Iranaithivu, Nachchikuda, and Jeyapuram South have the lowest risk. They presented no flooded areas during the assessed period, the lowest affected population density, and Iranaithivu and Nachchikuda present almost no families engaged in agriculture.

Map 3. Flood exposure

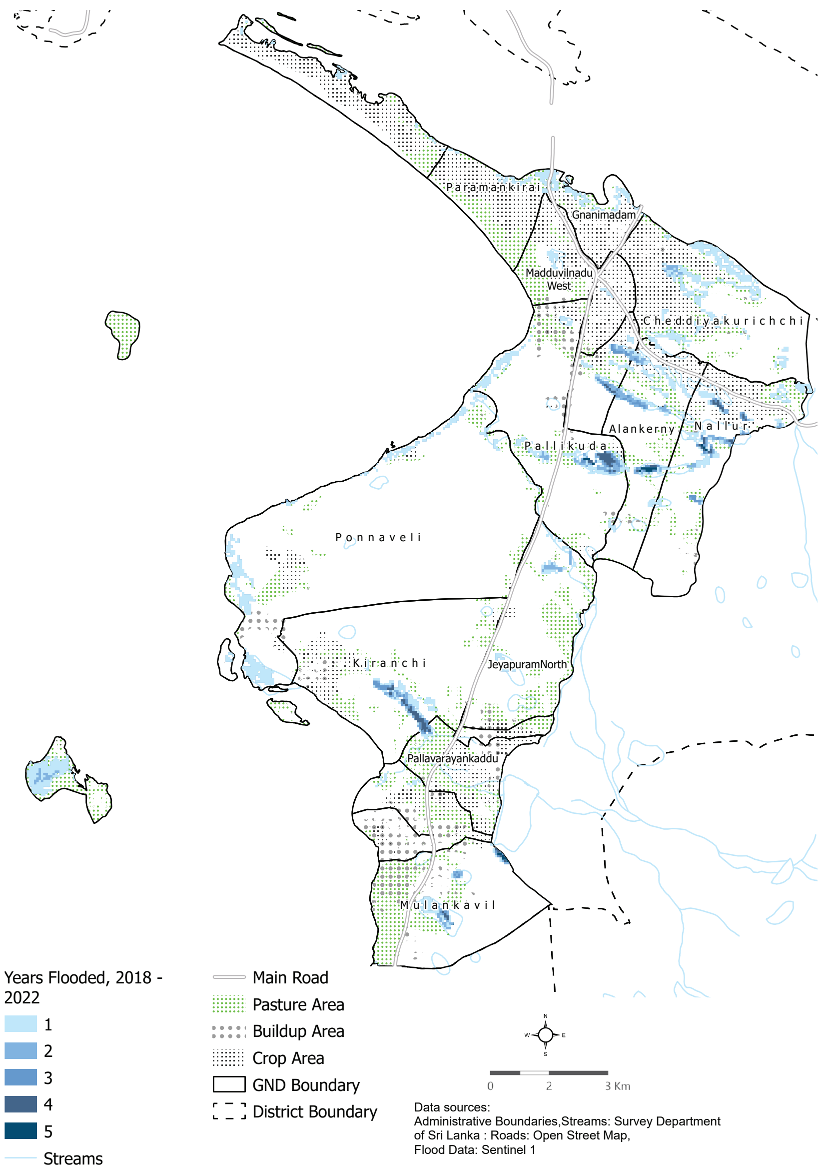
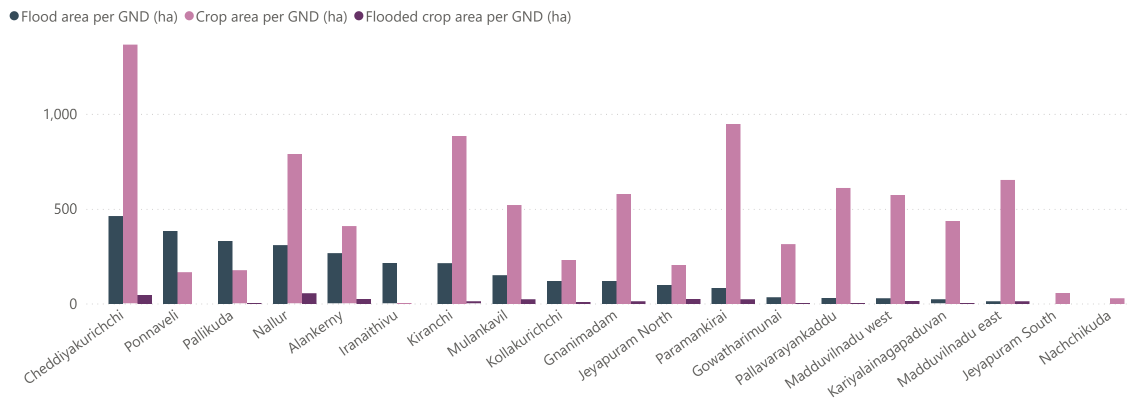


Table 2. Flood risk index

GND	Hazard-Exposure	Vulnerability	Risk
Nallur	**0.32**	**0.57**	**0.184**
Jeyapuram North	**0.26**	**0.65**	**0.167**
Cheddiyakurichchi	**0.21**	**0.71**	**0.152**
Pallikkudah	**0.52**	**0.29**	**0.152**
Paramankirai	0.31	0.47	0.146
Ponnaveli	0.26	0.56	0.145
Alankerny	0.22	0.62	0.134
Kollakurichchi	0.26	0.48	0.125
Mulankavil	0.16	0.53	0.084
Gowtharimunai	0.10	0.73	0.070
Gnanimadam	0.10	0.61	0.058
Madduvilnadhu East	0.08	0.71	0.057
Madduvilnadu West	0.08	0.40	0.033
Kiranchi	0.04	0.69	0.028
Kariyalainagapaduvan	0.05	0.40	0.021
Pallavarayankadhu	0.10	0.17	0.016
Jeyapuram South	0.00	0.69	0.002
Nachchikudah	0.00	0.33	0.001
Iranaithivu	0.00	0.27	0.000

Figure 4. Crop area, flood area, and flooded crop area per GND[18]



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

Figure 5. Annual rainfall in Poonakary[19]

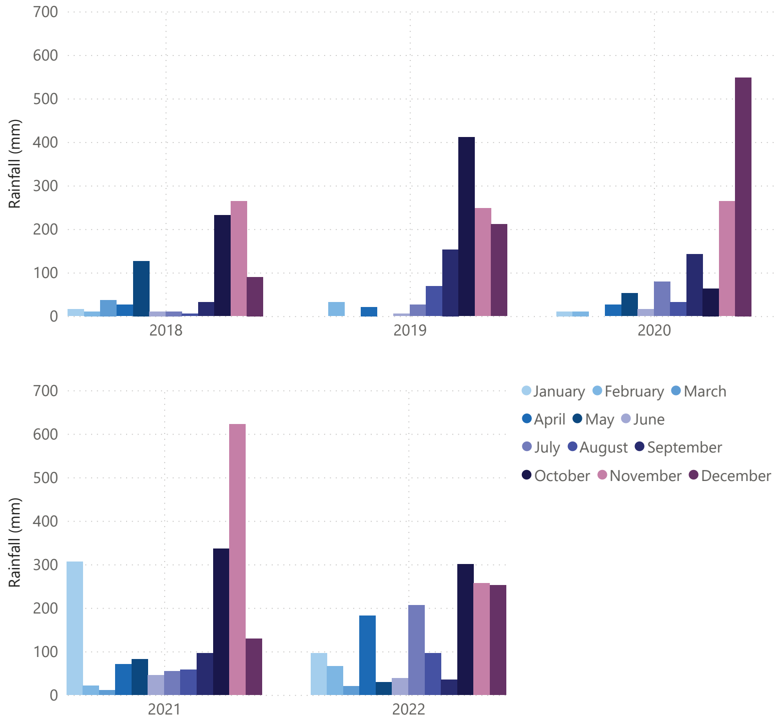
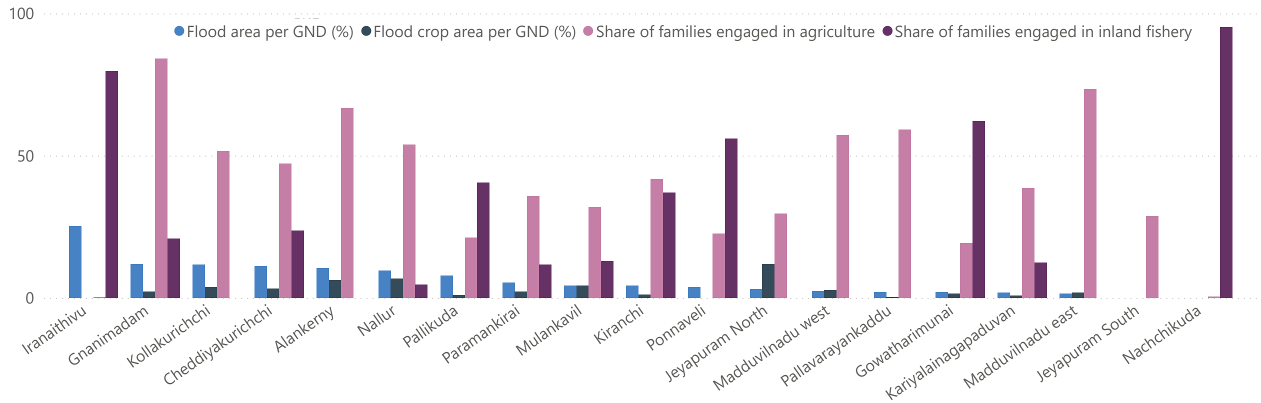


Figure 3. Flood-affected areas and inland fishery and agricultural families[17]



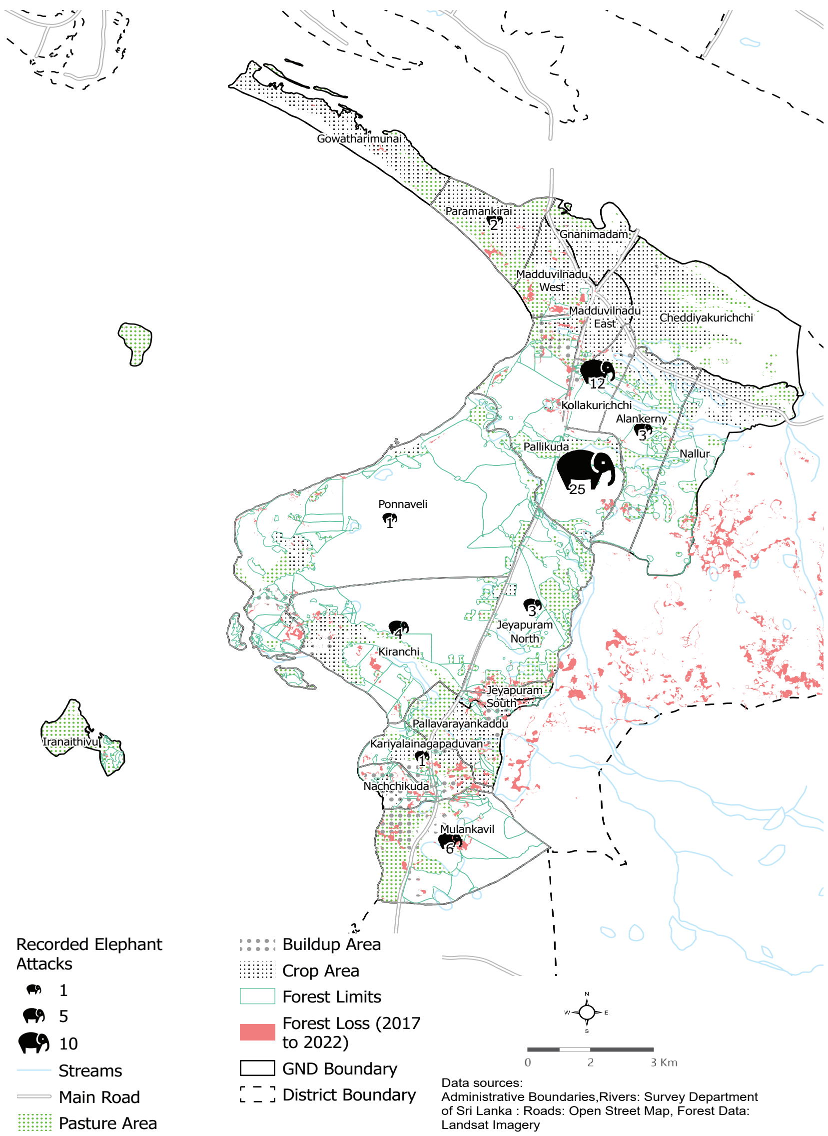
HUMAN-ELEPHANT CONFLICT

Human-elephant conflict 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 [20].

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 croplands and urban areas, leading farmers to view elephants as threats to their livelihoods, increasing the likelihood of retaliatory measures. Between 2015 and 2021, 54% of incidences in Sri Lanka happened in open forests, while 62% occurred within 2 km of the forest edge[21]. GNDs with high human populations and activities coupled with increased forest disturbances, may exacerbate conflicts over resource access between humans and elephants.

Table 3 shows Pallikuda as the GND most at risk with 25 registered elephant attacks. The high risk is driven by a high affected population density, and forest disturbance, with 74% of families earning daily wages

Map 4. Human-elephant conflict exposure



between 2000 and 3000 LKR, and 17% of female-headed households.

Mulankavil, the second most at risk, has the largest forest loss, the third-largest affected population density, and 78% of low-income families. Ponnaveli follows with the largest forest area and, a large share of children and families with members with disabilities.

According to local authorities' data, Kollakurichchi, Mulankavil, and Kiranchi registered 12, 6, and 4 elephant attacks, respectively. Kollakurichchi's small forest area reduces its exposure and risk, but as it neighbours Pallikuda, the number of attacks is high due to the elephant's migration movements. Cheddiyakurichchi, Gnanimadam, and Madduvilnadu East have the lowest HEC risk because of their low population density, low forest area and disturbance.

The impact of deforestation is evident across Poonakary, where nine GNDs lost over 50 ha of forest cover over the last five years. Mulankavil presents the largest loss, with an area of 122 ha. A combination of factors contributes to the observed variability in degraded forest areas, including geographic location, land use patterns, conservation initiatives, and human activities. Ponnaveli and Kiranchi have the largest forest areas in Poonakary and comparatively low recorded elephant attacks. With the correct protection and conservation efforts application, these GNDs have the potential to sustainably host human and elephant populations. Ten GNDs present no elephant attacks.

Table 3. HEC risk index

GND	Hazard	Exposure	Vulnerability	Risk
Pallikuda	**0.64**	**0.86**	**0.33**	**0.182**
Mulankavil	**0.50**	**0.86**	**0.30**	**0.129**
Ponnaveli	**0.53**	**0.49**	**0.36**	**0.092**
Kiranchi	0.40	0.50	0.38	0.077
Kariyalainagapaduvan	0.22	0.59	0.30	0.038
Nallur	0.14	0.53	0.39	0.028
Kollakurichchi	0.25	0.23	0.46	0.026
Nachchikuda	0.15	1.00	0.16	0.024
Pallavarayankaddu	0.16	0.27	0.33	0.014
Jeyapuram North	0.29	0.15	0.30	0.013
Madduvilnadu west	0.19	0.16	0.30	0.009
Jeyapuram South	0.09	0.16	0.37	0.005
Paramankirai	0.11	0.08	0.44	0.004
Iranaithivu	0.01	0.31	0.55	0.002
Gowatharimunai	0.03	0.05	0.47	0.001
Madduvilnadu east	0.02	0.05	0.41	0.000
Gnanimadam	0.00	0.04	0.47	0.000
Cheddiyakurichchi	0.00	0.12	0.42	0.000
Alankerny	0.16	0.00	0.23	0.000

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

Figure 6. Human and elephant deaths in Sri Lanka[24]

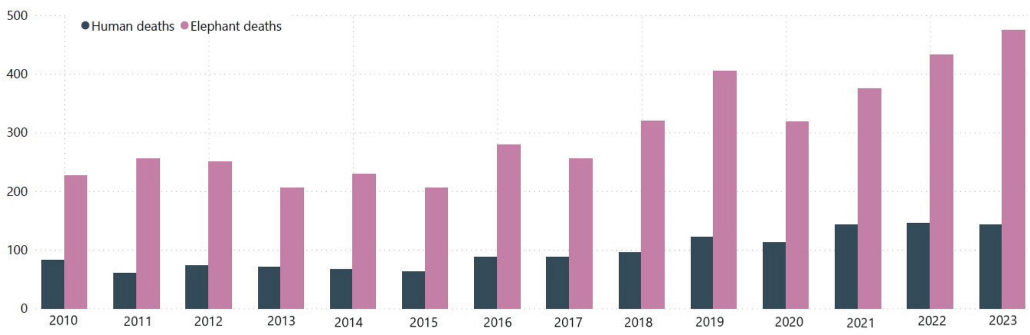


Figure 7. Forest disturbance in the last 5 years[22]

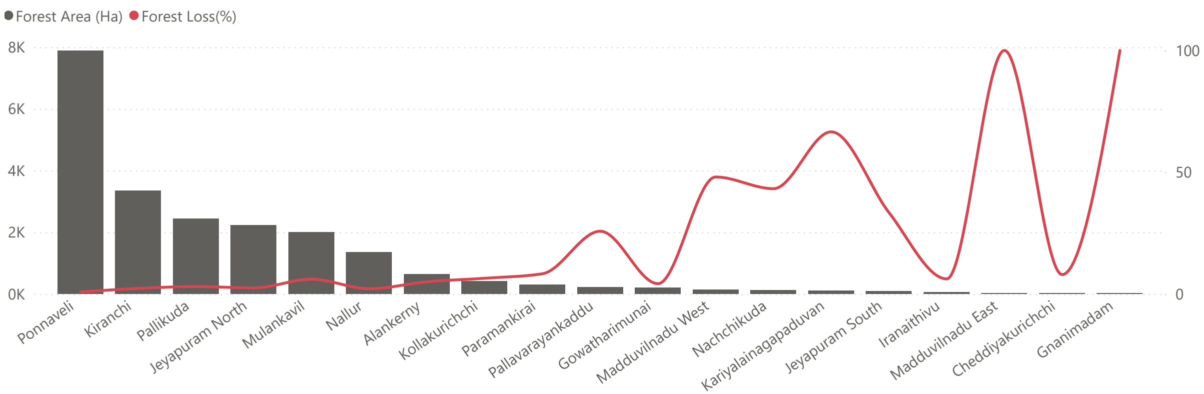
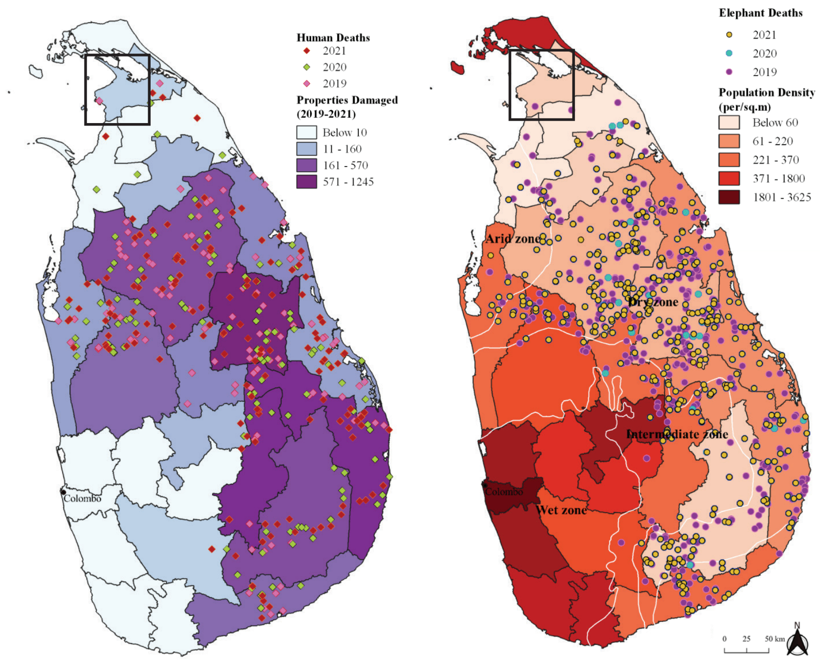


Figure 8. Human death and property damage caused by elephants/elephant death and human density[23]



MULTI-HAZARD RISK

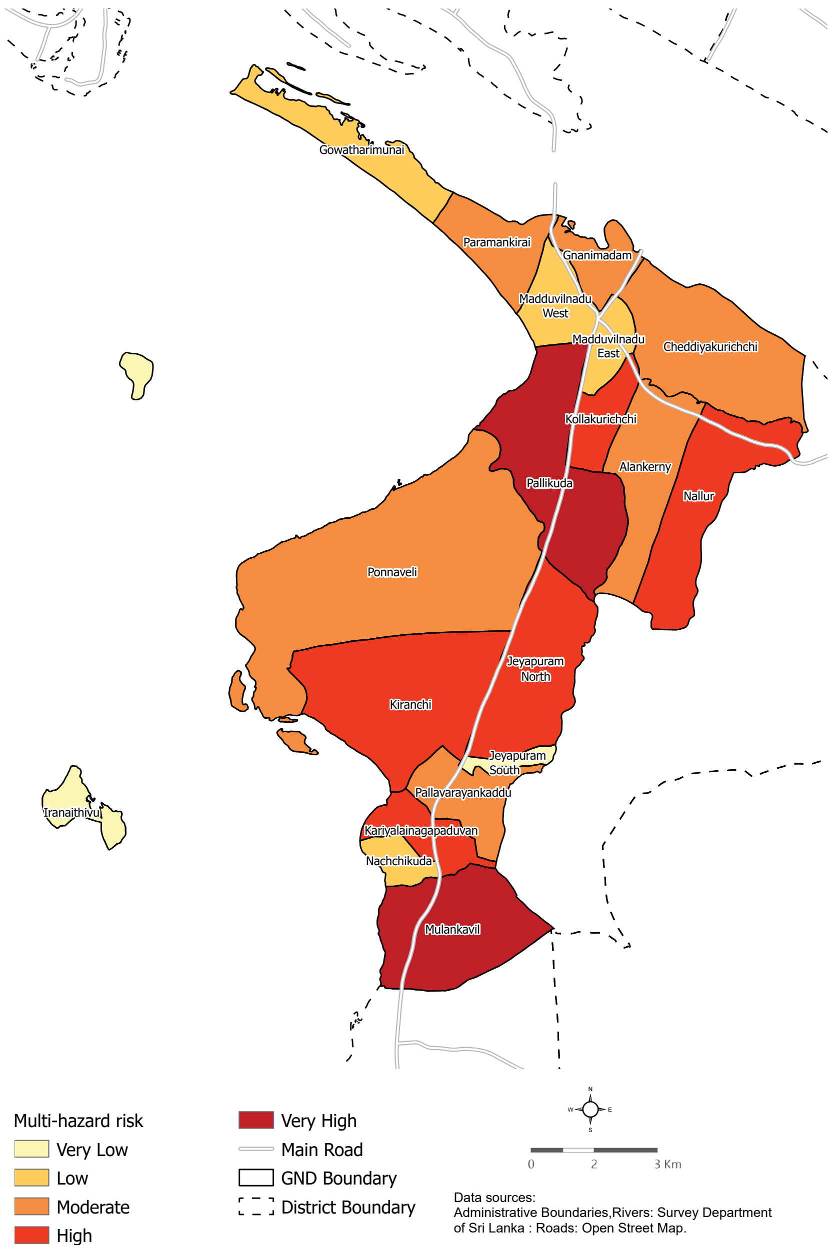
Poonakary's multi-hazard risk analysis, presented in Table 4 and Map 5, was calculated based on the three assessed risks: flood, drought, and HEC. The GNDs with very high risk (≥0.15 out of 1) in Poonakary is Pallikuda and with high risk (>=0,10 out of 1) are Mulankavil, and Ponnaveli

Pallikuda presents all high risks, the highest HEC, the second highest drought, and the fourth highest flood risks. Mulankavil has the highest drought and second highest HEC risks, followed by Poonaveli, with high HEC and moderate flood risks.

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 74% in Mulankavil and Palikuda demonstrates their low coping capacity. The vulnerability in Ponnaveli is increased due to having the second-highest concentration of children.

In the three GNDs, the multi-hazard risk is increased due to the lack of livelihood diversification, with over 20% of families engaged in agriculture. Ponnaveli and Palikuda have 56 and 41% of families engaged in inland fishery, respectively.

Map 5. Multi-hazard map



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. Jeyapuram South, Iranaithivu, and Nachchikuda 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 and low-income families, and despite a large share of families engaged in inland fisheries in the first two, the low exposure throughout all hazards reduces the risk.

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 Poonakary 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
Pallikuda	**0.15**	**0.15**	**0.18**	**0.163**
Mulankavil	**0.08**	**0.16**	**0.13**	**0.124**
Ponnaveli	**0.15**	**0.07**	**0.09**	**0.104**
Nallur	0.18	0.08	0.03	0.097
Jeyapuram North	0.17	0.07	0.01	0.084
Kiranchi	0.03	0.08	0.08	0.062
Kariyalainagapaduvan	0.02	0.12	0.04	0.061
Kollakurichchi	0.12	0.02	0.03	0.057
Pallavarayankaddu	0.02	0.14	0.01	0.056
Alankerny	0.13	0.03	0.00	0.055
Paramankirai	0.15	0.01	0.00	0.053
Cheddiyakurichchi	0.15	0.00	0.00	0.051
Gnanimadam	0.06	0.05	0.00	0.036
Gowatharimunai	0.07	0.00	0.00	0.024
Madduvilnadu East	0.06	0.00	0.00	0.020
Madduvilnadu West	0.03	0.02	0.01	0.019
Nachchikuda	0.00	0.02	0.02	0.014
Iranaithivu	0.00	0.01	0.00	0.004
Jeyapuram South	0.00	0.00	0.01	0.003

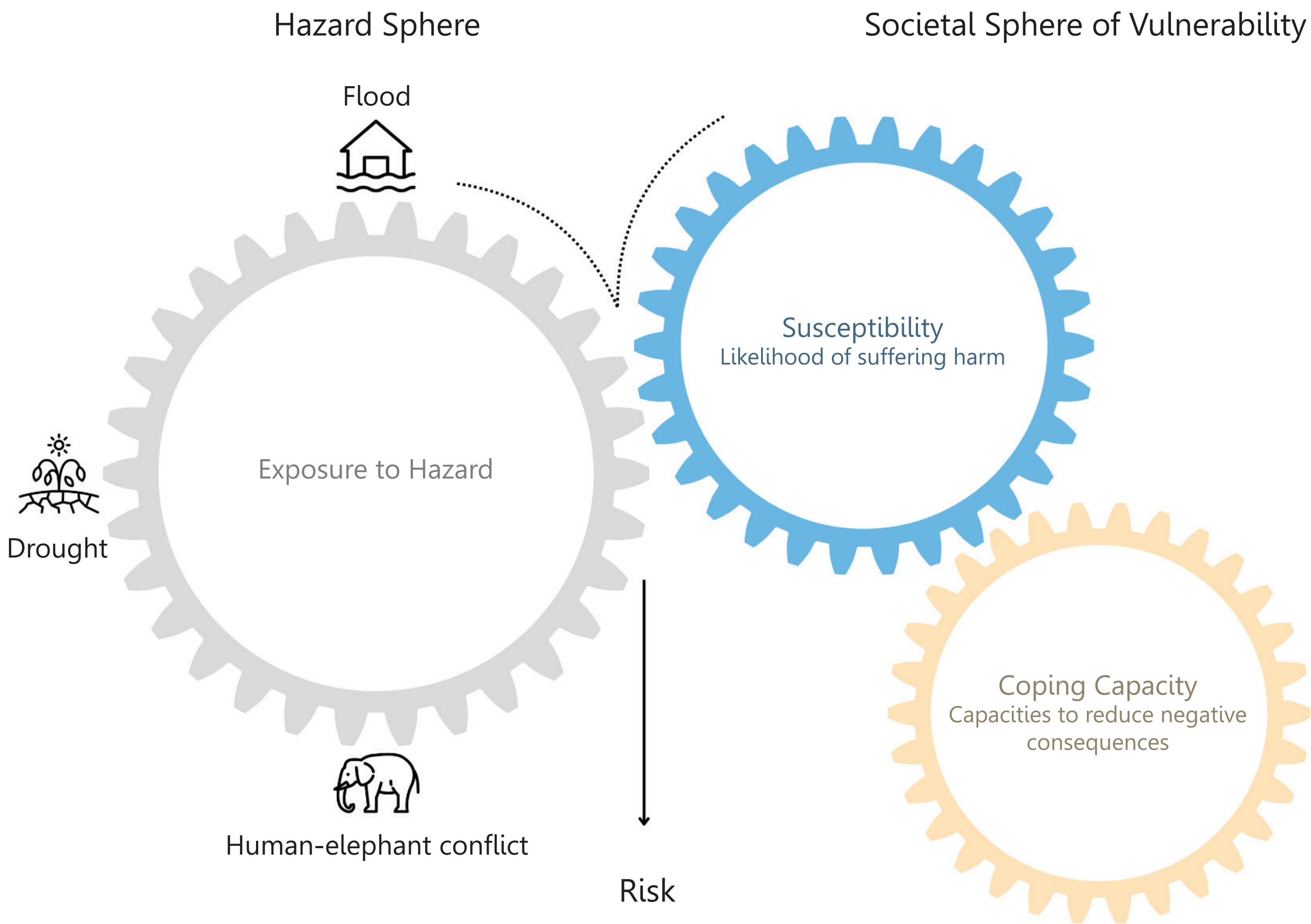
OTHER POTENTIAL HAZARDS

Other hazards also affect the population in Poonakary, a combination of **land degradation**, **epidemics**, and **water scarcity** significantly impact livelihood resilience activities, posing additional challenges to the local communities. 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

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 vulnerabilty value through all the GNDs, Imax - maximum hazard/exposure or vulnerabilty 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[25] for vegetation and land-surface temperature data as well as CHIRPS rainfall datasets[26] from Earth Engine Data Catalog[27]	VCI data derived from Modis EVI[28] (2003-2023) using the UN-Spider methodology (GEE code[29]). VHI was calculated using NDVI[30] and LST[31] data based on UN-Spider methodology[32] (GEE code). The SPI[33] 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[34].
Flood	European Space Agency's Sentinel-1 synthetic aperture radar (SAR) data 2019-2022 from Earth Engine Data Catalog[35]	Spider flood assessment methodology[36] 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[37]	Forest fragmentation was detected using LandTrend methodology[38] 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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