SRI LANKA

Area-Based Risk Assessment in Addalaichenai Divisional Secretariat Division

Ampara District

May 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 major 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. They experience high vulnerability due to the 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 Addalachchenai Divisional Secretary's Divisions (DSD) in Ampara 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 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 Addalachchenai 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 Addalachchenai.

Through the study, IMPACT identified three GNDs, namely Addalaichenai - 09, Oluvil - 01, and Palamunai - 05 as the most at risk for multiple hazards. Oluvil - 01 and Palamunai - 05 have the largest drought prone areas in the DSD with 81% and 95% of crop land affected, respectively.

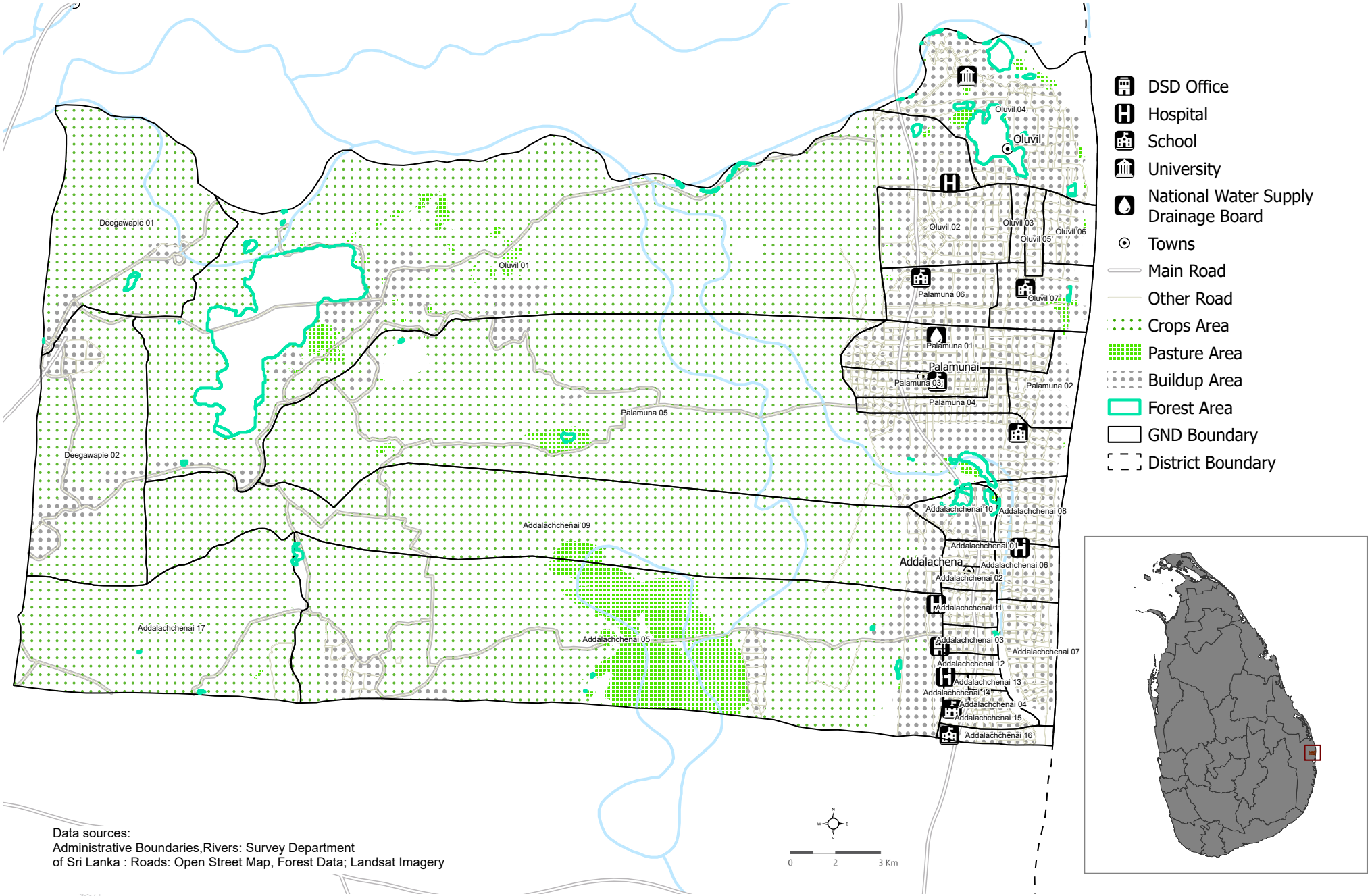
Addalaichenai - 09 is the most at risk from floods, with 33% of all cropland affected and 49% of low income families. The DSD had 650 families displaced due to floods, most of them in four GNDs (Palamunai - 06 and Addalaichenai - 10, 15, and 16). Four GNDs had over 20% of affected cropland.

In Oluvil - 03 and Deegawapiya - 01, the population has the highest level of vulnerability regarding social dependency, with a high share of female-headed households as well as many children and older people. Social dependency is when an individual or group relies on another individual or group for resources, support, or guidance.

According to local authorities, 10 out of the 32 GNDs have registered elephant attacks. The DSD had 205 ha of forest loss between 1990 and 2022, accounting for 113% of the current forest area. In Addalaichenai, 65% of families have daily incomes between 2000 and 3000 LKR and 1,2% of individuals are unemployed. The unemployment and low-income rates are social insecurity indicators, that present the financial capacity to prepare and recover from hazards.

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 Addalachchenai against single and multi-hazard scenarios.

Map 1. Overview map of Addalaichenai 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 Eastern province, Ampara district, Addalaichenai covers an area of 688 km², with a population of 53,384 individuals, of whom 50,2% are female, living across 32 Grama Nilhadari Divisions (GNDs). It is estimated that the dependency ratio reaches 37%, which is the population below 15 and above 60 years old[3]. The average population density is 77,6/ km². The terrain is diverse, ranging from lagoons, areas of all minor streams, areas of all ponds, areas of all tanks, areas of all water holes, forest–unclassified, grassland, homesteads, and marsh[4].

With 7 km of coastal area, Addalaichenai was one of the DS divisions severely affected by the Tsunami in 2004. Ampara district experienced great inundation with the tsunami's direct hit. The water levels were generally high with low terrain to a considerable distance inland causing the displacement of 38,624 families, 10,436 deaths, and 876 missing people[5].

The terrain in Addalaichenai is mostly flat, with several lagoons and water bodies in the region that contribute to agriculture, livestock and fishing activities. Addalaichenai vegetation comprises of agricultural land, forests and marshes. Addalaichenai experiences a tropical climate with distinct wet and dry seasons, 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[6].

Overall, Addalaichenai geography significantly shapes its economy, with livelihood activities primarily revolving around agriculture, in addition to 2016 individuals engaged in fishing activity in the region, the secondary contributor to the division's economy. Apart from that, 2557 individuals work for the government and 2676 are self-employed. According to data shared by the government, 12,480 individuals are unemployed in Addalachchenai, which harms its economic development.

Out of its 688 km², 34.66 km² are used for agriculture. The paddy cultivation stands out as the predominant agricultural activity and the average yield of the paddy in the region was 1846.4 kg per acre in both seasons[7]. The farmers primarily engage in highland crop cultivation apart from paddy cultivation in this region.

During heavy monsoon rains, low-lying areas 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. Addalaichenai 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, damage to infrastructure, and displacement of communities.

Addalaichenai'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.

The ABRA measured the risk in the 32 GNDs in Addalaichenai, 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 Addalaichenai 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 faced 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)[8]. 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[9]).
- **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 analysed 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 Addalaichenai, 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 nor exhaustive of all natural hazards in Addalaichenai.

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[10] (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[11]). MODIS Normalized differentiated vegetation index (NDVI[12]) and MODIS Land Surface Temperature (LST[13]) 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[14]. 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[15] 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 Addalaichenai (Map 2), the exposure index is considerably high, particularly in the center of the DSD. Four GNDs have almost all area affected, and other seven range between 45% and 90%. The DSD has 40% of drought affected land and an average of 16% of cropland. In total terms, Oluvil - 01 presents the highest risks, with the largest drought area, almost 1000 ha, covering 76% of the GND area, 81% of affected cropland, and 21% pasture land.

Oluvil - 02, 03, and 05 and Palamunai - 06 have nearly 100% of their territory affected by drought. Palamunai - 05, Deegawapiya - 01,

Map 2. Drought exposure

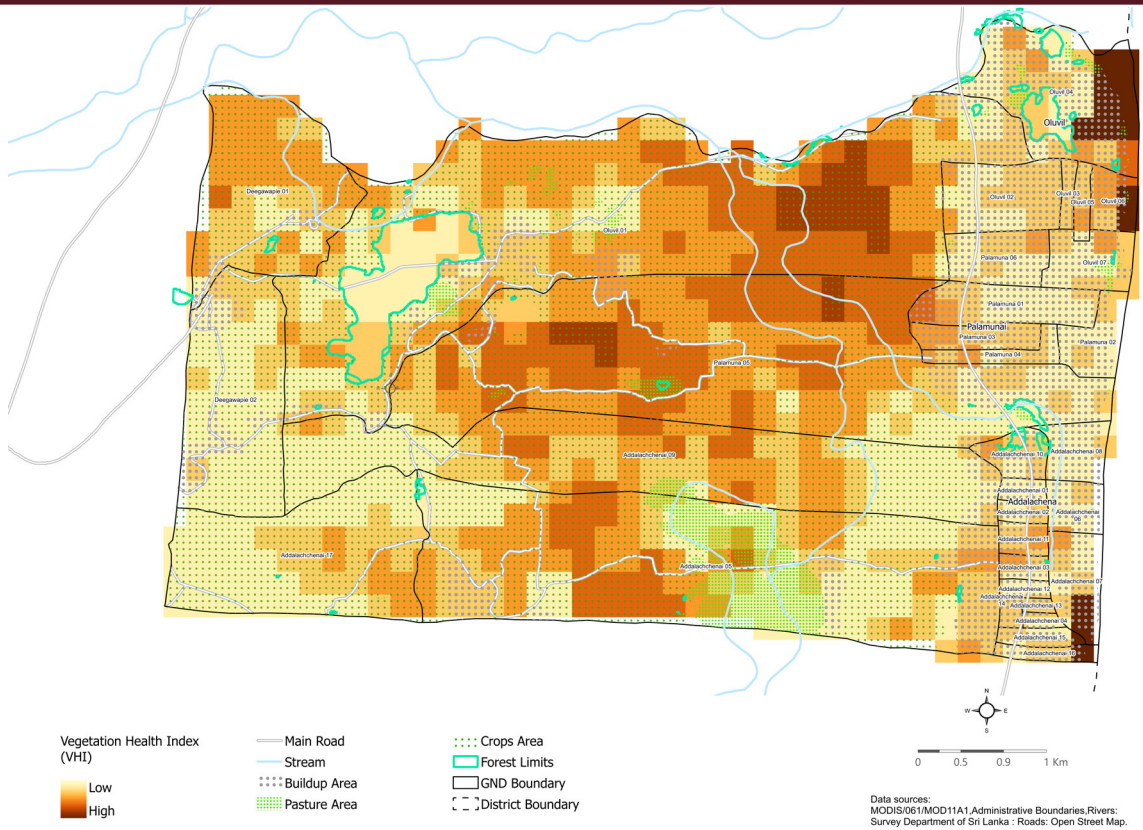


Figure 1. Drought area (ha) per GND[16]

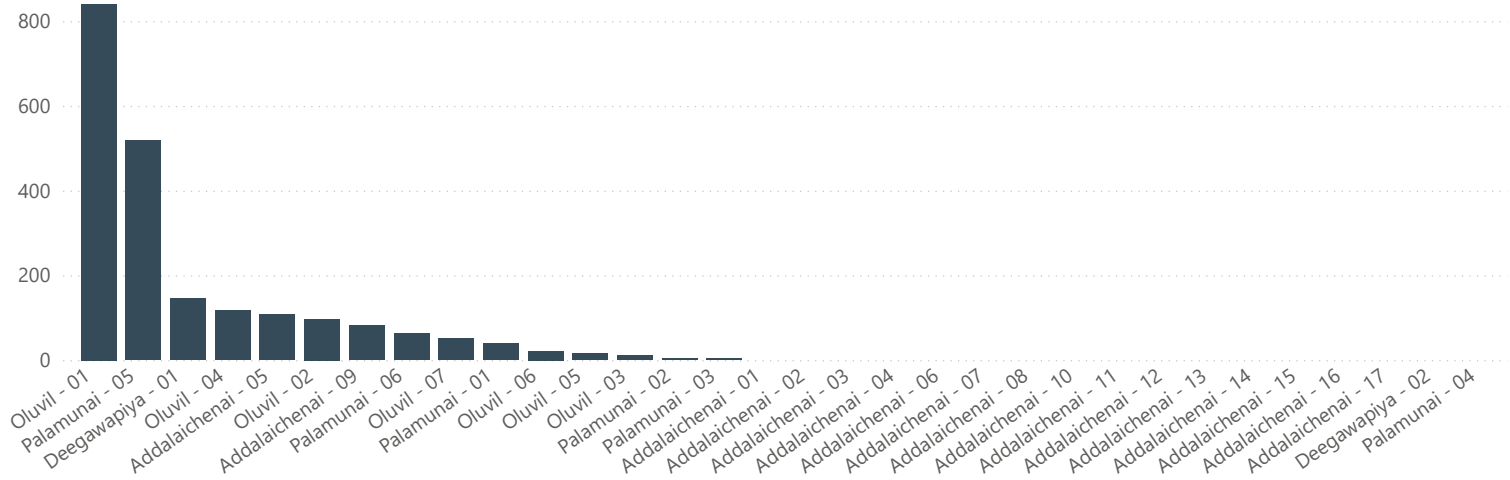


Table 1. Drought risk index

GND	Hazard	Exposure	Vulnerability	Risk
Oluvil - 01	**1.00**	**0.72**	**0.15**	**0.107**
Palamunai - 05	**0.52**	**0.72**	**0.12**	**0.044**
Deegawapiya - 01	**0.15**	**0.46**	**0.41**	**0.028**
Addalaichenai - 09	0.08	0.51	0.19	0.008
Addalaichenai - 05	0.11	0.42	0.14	0.007
Oluvil - 02	0.10	0.31	0.12	0.004
Oluvil - 04	0.12	0.27	0.04	0.001
Palamunai - 01	0.04	0.25	0.10	0.001
Oluvil - 06	0.02	0.13	0.36	0.001
Oluvil - 05	0.02	0.07	0.34	0.000
Oluvil - 07	0.05	0.17	0.04	0.000
Palamunai - 06	0.06	0.01	0.34	0.000
Oluvil - 03	0.01	0.01	0.69	0.000
Palamunai - 02	0.00	0.16	0.08	0.000
Palamunai - 03	0.00	0.20	0.12	0.000
Addalaichenai - 08	0.00	0.33	0.16	0.000
Addalaichenai - 06	0.00	0.26	0.23	0.000
Addalaichenai - 15	0.00	0.24	0.21	0.000
Palamunai - 04	0.00	0.22	0.13	0.000
Addalaichenai - 04	0.00	0.19	0.13	0.000

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

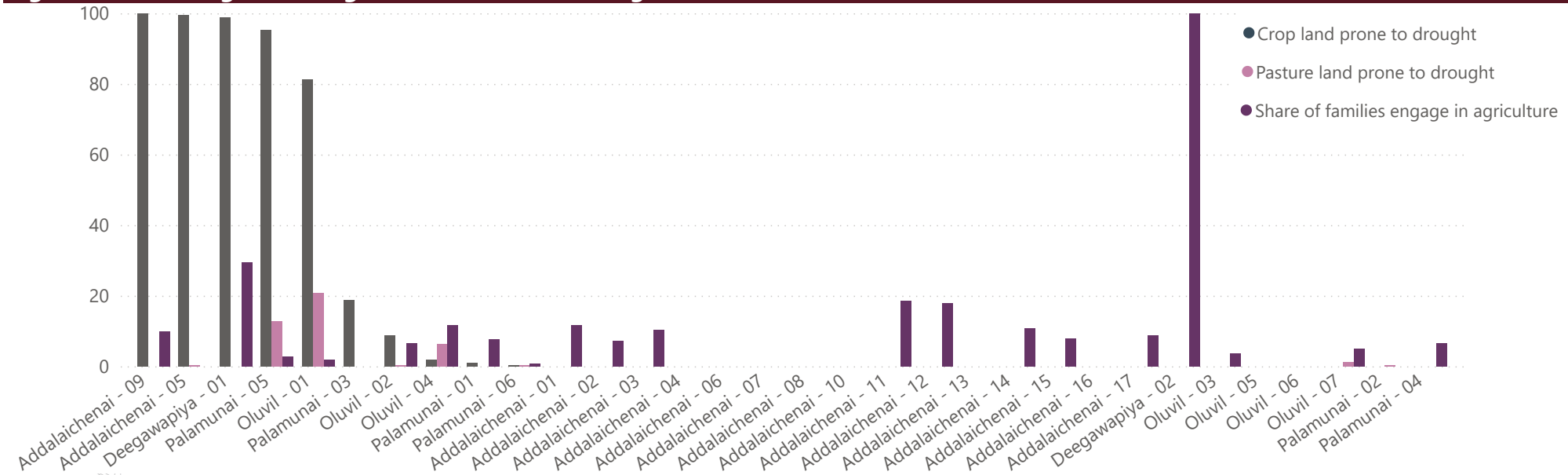
Addalaichenai - 09, and Addalaichenai - 05 have over 95% of their cropland affected by drought. Seventeen GNDs have no affected area, most at the south coast.

The high share of female headed households (28%) and families earning daily wage between 2,000 and 3,000 LKR (59%) contribute to the social dependency and difficult economic situation in Oluvil - 01. The second largest drought area leads Palamunai - 05 to high risk. The GND has 95% of drought prone farming land and 38% of low-income families. The third GND most at risk is Deegawapiya - 01 with 99% of drought prone pasture land, 37% of female headed households, 30% of families engaged in agriculture, and high density of children and elderly.

GNDs characterized by high population density 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, pasture land prone to drought, and share of affected fishery families. The analysis suggests a risk of severe agricultural production decline in Deegawapiya - 01, the GND has 30% of families engaged in agriculture and almost all drought affected cropland.

The data presented in Figure 2 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.

Figure 2. Percentage of drought-affected areas and agricultural families[17]



FLOODS

The rainy season in Addalaichenai lasts from September to February, with most floods typically happening from November to January (Map 3), caused by heavy rainfall and improper maintenance of existing natural drainage systems, and inadequate availability of masonry drains.

Between 2018 and 2020, satellite images showed that 843 hectares of Addalaichenai were flooded. The largest flooded areas were registered in Addalaichenai - 05, Palamunai - 05, and Addalaichenai - 09, with 242 ha, 202 ha, and 191 ha respectively. The flooded areas in the three GNDs represented over 75% of flood cover in Addalaichenai. Addalaichenai - 09 and 05 had around 30% of their territories 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 within flooded zones.

Table 2 indicates that Addalaichenai - 09 is at the highest risk due to its high hazard exposure and vulnerability. It has the second largest percentage of cropland within a flood zone, 33%. Beyond having a large affected population density and having 40 displaced families, it has

Map 3. Flood exposure

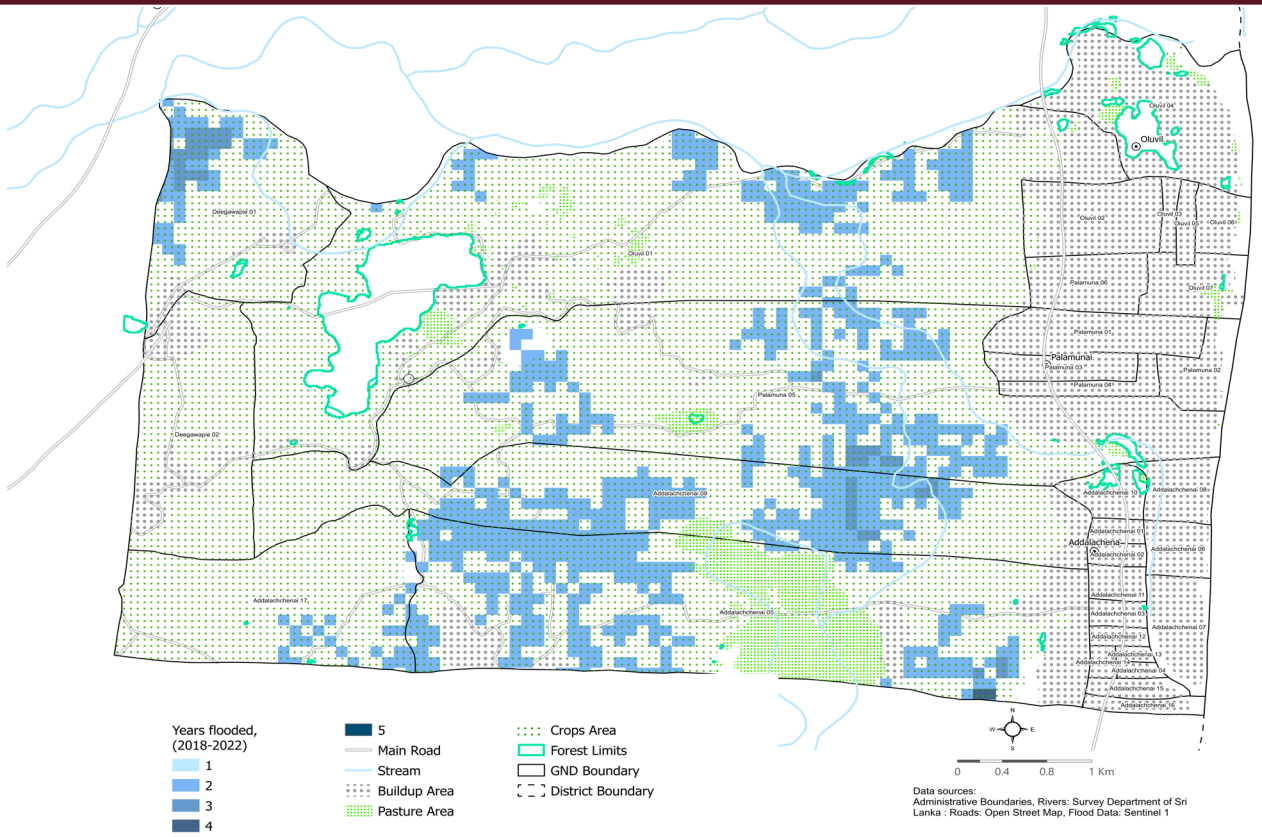


Figure 3. Flood-affected areas and inland fishery and agricultural families[18]

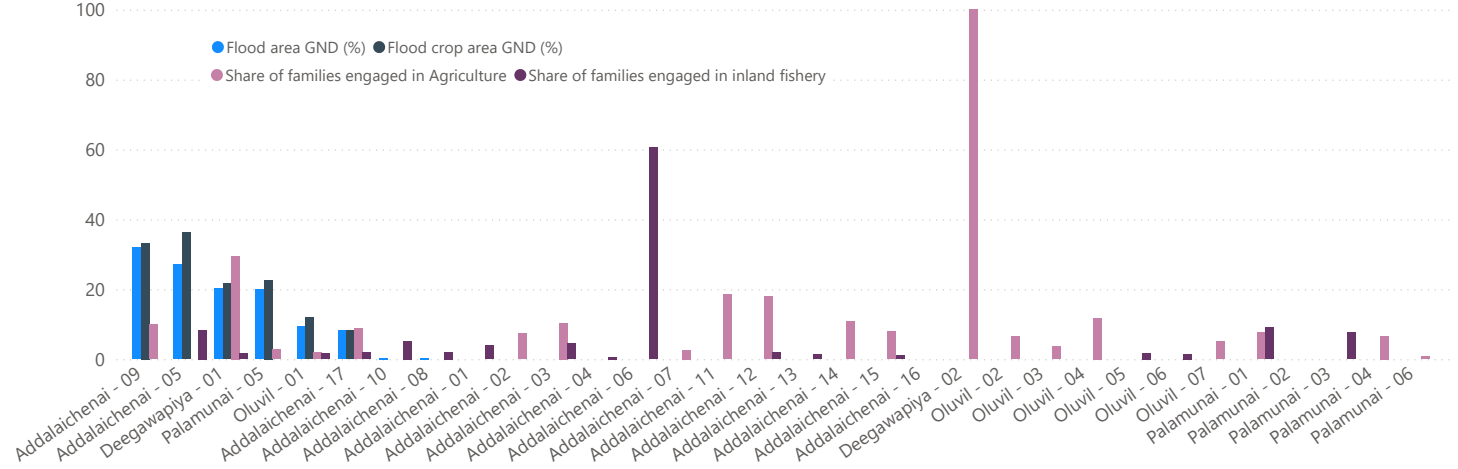


Table 2. Flood risk index

GND	Hazard-Exposure	Vulnerability	Risk
Addalaichenai - 09	**0.45**	**0.60**	**0.269**
Palamunai - 05	**0.35**	**0.55**	**0.193**
Oluvil - 01	**0.26**	**0.57**	**0.151**
Addalaichenai - 17	0.21	0.59	**0.126**
Deegawapiya - 01	0.15	0.72	0.109
Palamunai - 06	0.14	0.70	0.099
Addalaichenai - 16	0.10	0.58	0.058
Addalaichenai - 05	0.65	0.07	0.046
Addalaichenai - 10	0.32	0.08	0.027
Addalaichenai - 15	0.28	0.08	0.022
Addalaichenai - 08	0.17	0.09	0.016
Addalaichenai - 06	0.07	0.17	0.012
Addalaichenai - 03	0.01	0.58	0.008
Addalaichenai - 07	0.01	0.06	0.000
Oluvil - 03	0.00	0.80	0.000
Oluvil - 05	0.00	0.66	0.000
Deegawapiya - 02	0.00	0.69	0.000
Addalaichenai - 14	0.00	0.60	0.000
Addalaichenai - 12	0.00	0.61	0.000
Oluvil - 06	0.00	0.65	0.000
Addalaichenai - 11	0.00	0.60	0.000
Addalaichenai - 01	0.00	0.58	0.000
Addalaichenai - 13	0.00	0.59	0.000

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

15% of female headed households and 49% of its families earn daily wages between 2000 and 3000 LKR. Palamunai - 05 and Oluvil - 01 follow, with the largest flood affected road lengh, and 38% and 59% of low income families. Palamunai - 05 had 23% of crops affected by flood.

In Addalaichenai, 19 GNDs registered no risk of flood due to no hazard exposure in the coastal areas. Oluvil - 07, Palamunai - 02, and Addalaichenai - 07 present the lowest vulnerability indexes, with low dependency in agriculture and inland fishery, female-headed households, low income families, and unemployement.

The distribution of flood risks in Addalaichenai underscores the need for flood management plans focused on inland GNDs, that have larger areas and where crops and pasture lands are located, especially during agricultural seasons, to mitigate adverse effects. Four GNDs had over 20% of cropland within flood zones, indicating a significant impact on agricultural activities. Agricultural production is critical for the livelihood and food security of families.. The paddy seasons in Addalaichenai go from mid-September to January (Maha season) and from April to mid-July and rely heavily on rainfall patterns.

Figure 5. Annual rainfall in Addalaichenai[20]

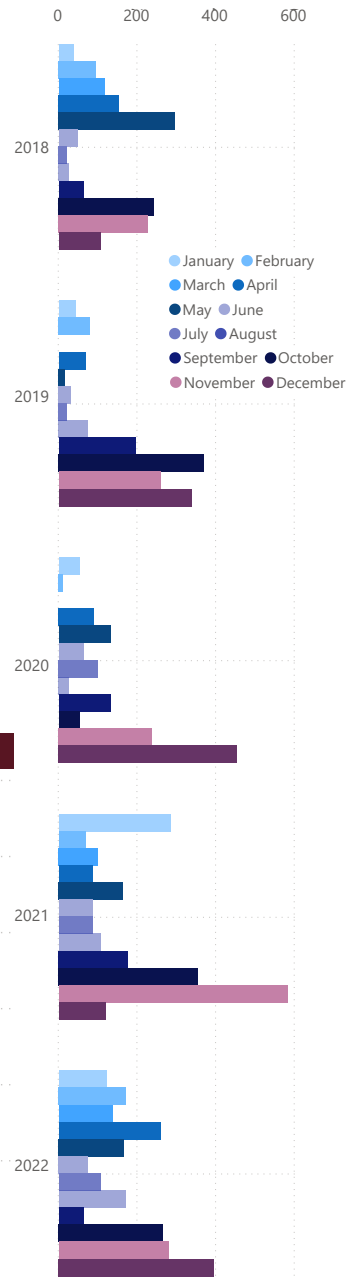
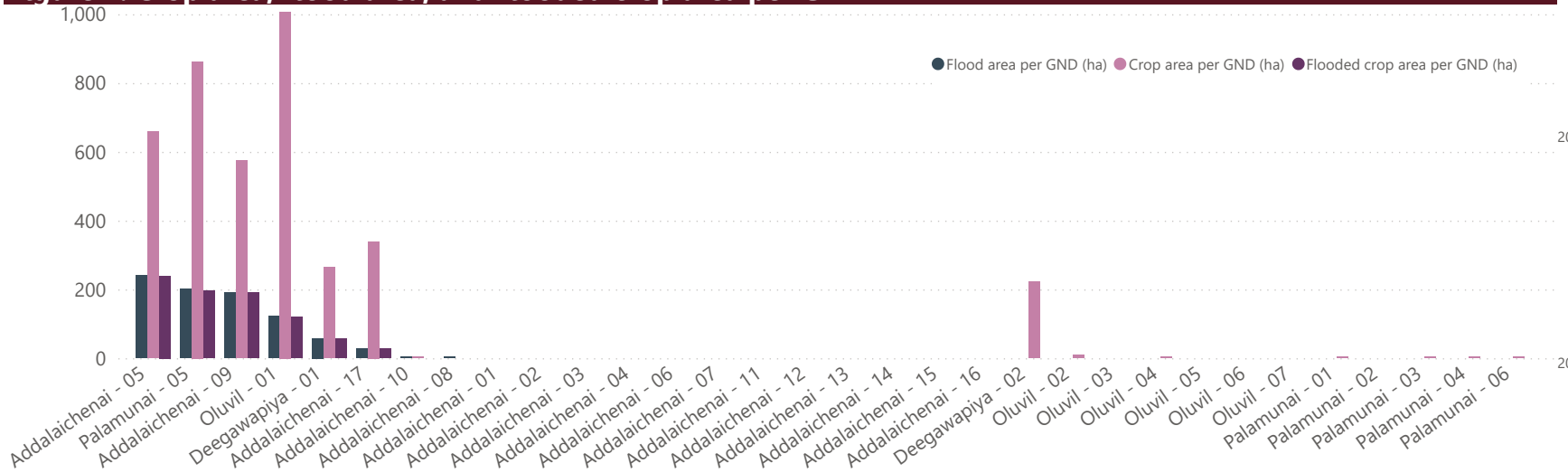


Figure 4. Crop area, flood area, and flooded crop area per GND[19]

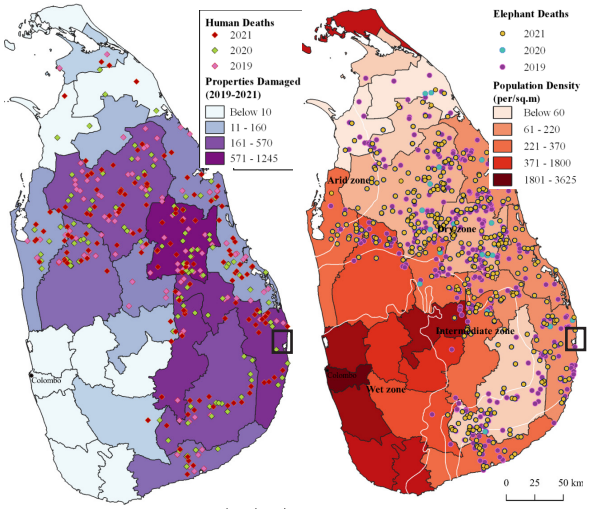


HUMAN-ELEPHANT CONFLICT

HEC has emerged as a significant socio-economic and conservation challenge in Sri Lanka, with the highest annual elephant deaths globally and the second-highest human deaths attributed to such conflicts. It is rooted in the competition for essential natural resources, with urban and agricultural expansion into 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[21].

Deforestation causes the loss and fragmentation of natural habitats and wildlife corridors used for migration and a decline in the availability of food and water sources. This often drives elephants to raid

Figure 6. Human death and property damage caused by elephants/Elephant death and human density[24]



Map 4. Human-elephant conflict exposure

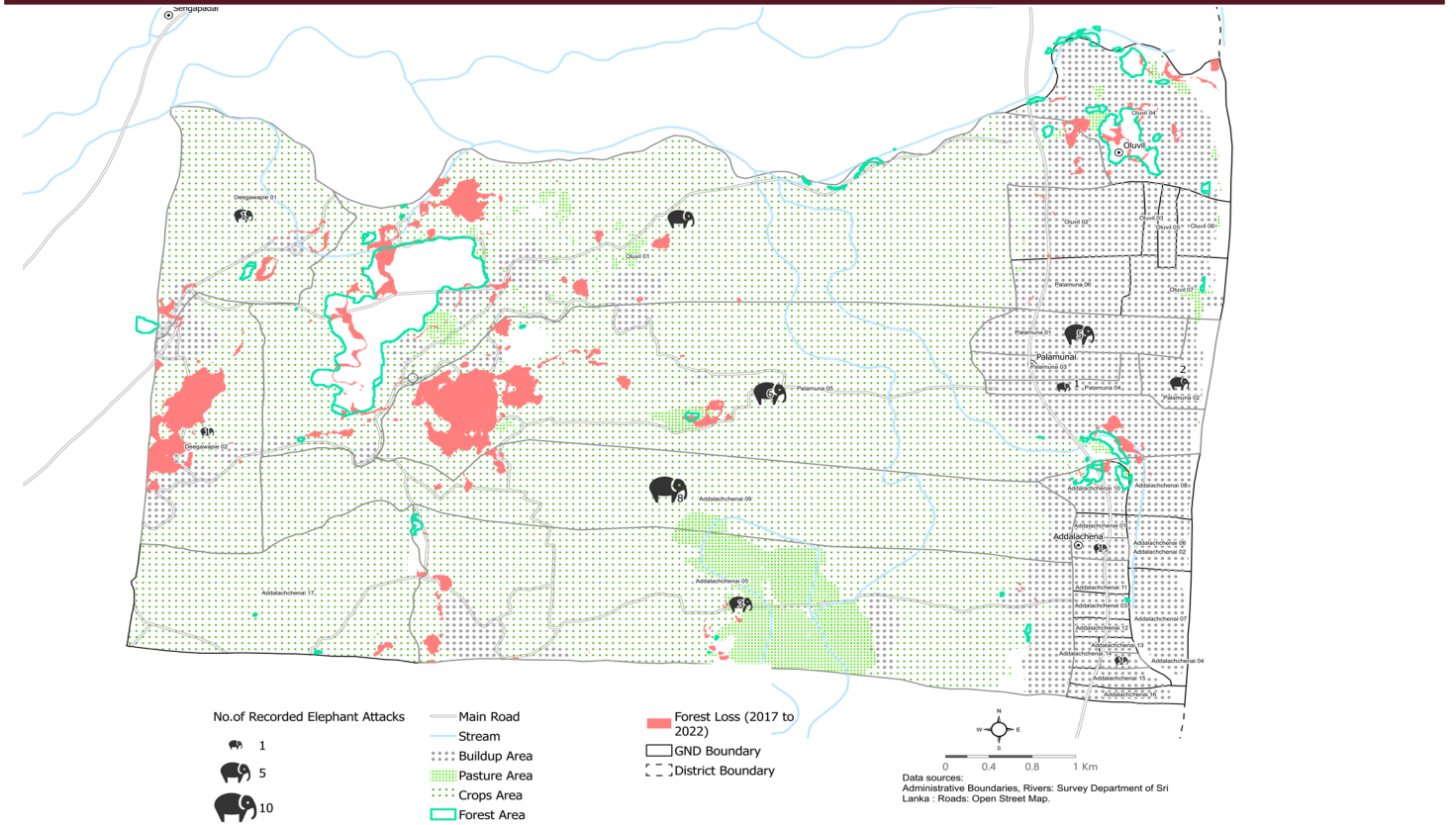


Figure 7. Human and elephant deaths in Sri Lanka[23]

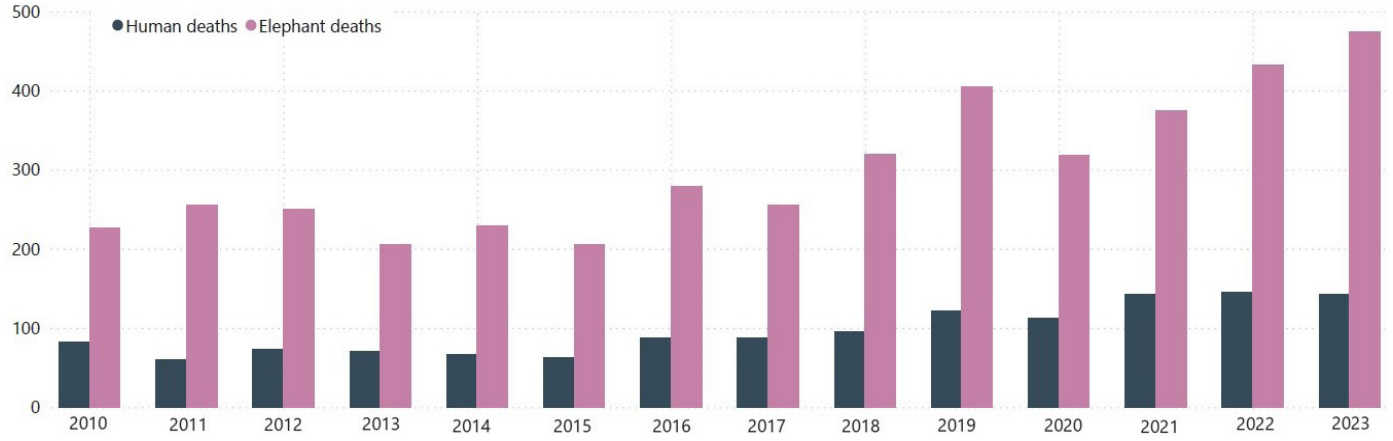


Table 3. HEC risk index

GND	Hazard	Exposure	Vulnerability	Risk
Deegawapiya - 01	**0.21**	**0.38**	**0.44**	**0.036**
Oluvil - 01	**0.56**	**0.36**	**0.15**	**0.030**
Addalaichenai - 09	**0.29**	**0.53**	**0.19**	**0.029**
Palamunai - 05	0.41	0.57	0.10	0.025
Deegawapiya - 02	0.23	0.22	0.37	0.018
Oluvil - 02	0.07	0.84	0.13	0.007
Addalaichenai - 05	0.18	0.26	0.14	0.007
Addalaichenai - 10	0.08	0.49	0.17	0.006
Oluvil - 03	0.33	0.03	0.61	0.006
Oluvil - 05	0.07	0.21	0.33	0.005
Addalaichenai - 02	0.07	0.36	0.13	0.003
Oluvil - 04	0.11	0.49	0.05	0.002
Addalaichenai - 08	0.01	1.00	0.18	0.001
Addalaichenai - 17	0.01	0.31	0.18	0.000
Palamunai - 01	0.00	0.75	0.13	0.000
Oluvil - 06	0.00	0.38	0.30	0.000
Addalaichenai - 06	0.00	0.79	0.34	0.000
Oluvil - 07	0.00	0.47	0.05	0.000
Addalaichenai - 07	0.00	0.38	0.13	0.000
Palamunai - 06	0.07	0.00	0.41	0.000
Addalaichenai - 01	0.00	0.42	0.18	0.000
Addalaichenai - 03	0.00	0.27	0.17	0.000

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

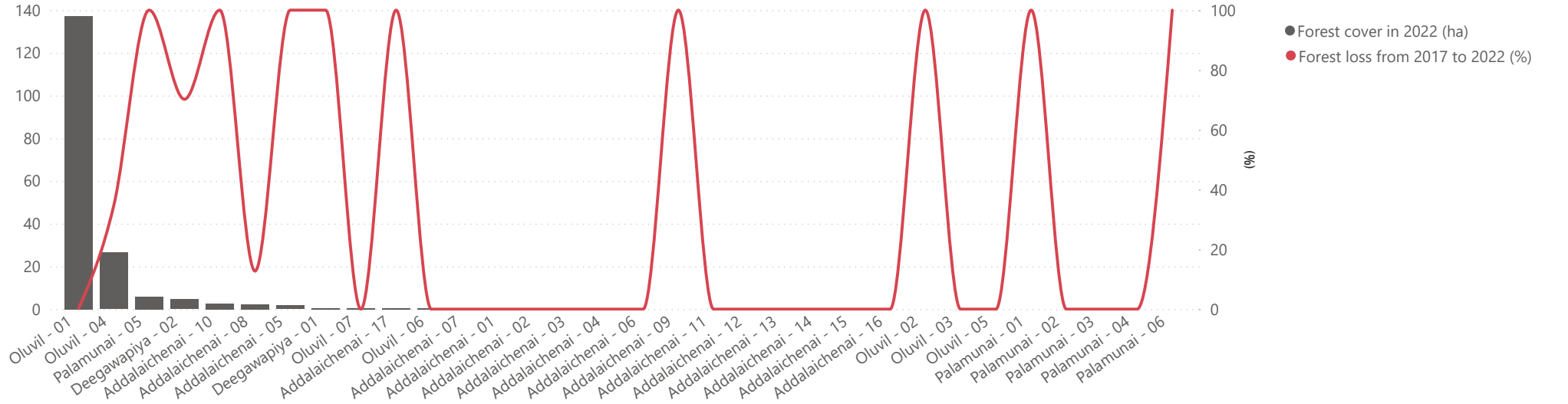
agricultural fields and human-occupied areas. Farmers may view elephants as threats to their livelihoods, increasing the likelihood of retaliatory measures. Between 2015 and 2021, 54% of incidences in Sri Lanka happened in open forests, while 62% were within 2 km of the forest edge[22].

Table 3 shows Deegawapiya - 01 as the GND most at risk with three registered elephant attacks. The high risk is driven by the high share of female-headed households, number of families with members with a disability, child and elderly density, resulting in high vulnerability, the GND has almost 30% of families engaged in agriculture. Oluvil - 01 comes second, with the highest hazard index, driven by the largest forest area and second forest disturbance, followed by Addalaichenai - 09, with four elephant attacks and above avarage population density.

According to local authorities' data, 10 GNDs registered elephant attacks, with Oluvil - 03 with the most events, five times. The impact of deforestation is evident in Addalaichenai, 20 GNDs have no forest cover left, and the DSD registered over 200 ha of forest loss in the past five years (Figure 8). The high population density across the DSD and low forest cover presents a threat to conservation efforts and the potential to sustainably host human and elephant populations.

In Addalaichenai, seventeen GNDs present no risk to HEC, most cases driven by no hazard indexes, with no registered attacks, no or low forest cover and disturbance. Palamunai - 06 is the only that registered one attack but having low population density, the exposure index is reduced. Palamunai - 02, 03, and 04 come last with low vulnerability indexes.

Figure 8. Forest disturbance in the last 5 years[25]



MULTI-HAZARD RISK

Addalaichenai'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 (≥0.08 out of 1) is Addalaichenai - 09, Oluvil - 01, and Palamunai - 05. The multi-hazard risk across Addalaichenai's is low, with 23 GNDs with risk lower than 0.01. This is due to low hazard index on all three hazards, mostly in the GNDs located on the coast (map 5). The families across the DSD have low dependency on agriculture and inland fishery.

Addalaichenai - 09 presents the highest flood risk and second highest HEC risk. Beyond the high exposure, with 33% of drought exposed crop lands, the DSD has 25% child density and 11% elderly and almost 50% of families have daily wages between 2.000 and 3.000 LKR, contributing to its vulnerability.

Oluvil - 01 has the highest drought risk, with large affected areas, with almost 60% of low income families, high share of female-headed households, and child density, the vulnerability contributes to high risk for the other hazards. Palamunai - 05 has the second highest risk for flood and drought, the GND has 38% of low-income families.

The higher exposure to natural hazards 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. Addalaichenai has an average of 74% of families earning daily wages between 2000 and 3000 LKR, this further impacts their ability to prepare for, respond to, and recover from shocks.

Deegawapiya - 02 has 100% of families engaged in agriculture, and Addalaichenai - 06, 60% of families engaged in inland fisheries. The lack of livelihood diversification might pose a threat in the future. 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.

In Addalaichenai 13 GNDs have zero risk for all analysed hazards, resulting in no multi-hazard 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 Addalaichenai present opportunities for a multi-pronged approach to mitigating disaster risks and their impact on communities.

Map 5. Multi-hazard map

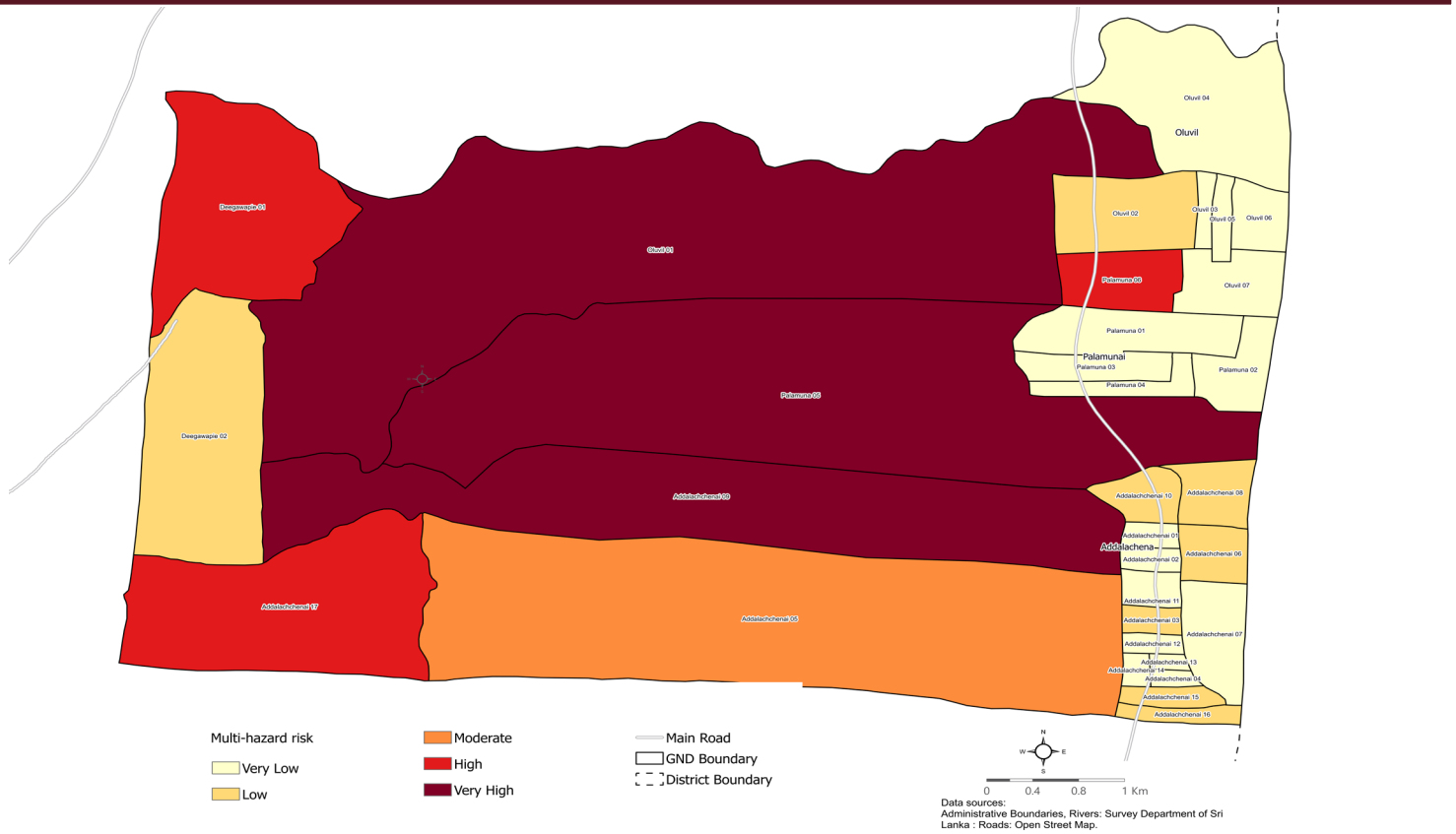


Table 4. Multi-hazard risk index

GND	Flood	Drought	HEC	Multi-hazard risk
Addalaichenai - 09	**0.27**	**0.01**	**0.03**	**0.102**
Oluvil - 01	**0.15**	**0.11**	**0.03**	**0.096**
Palamunai - 05	**0.19**	**0.04**	**0.02**	**0.087**
Deegawapiya - 01	0.11	0.03	0.04	0.057
Addalaichenai - 17	0.13	0.00	0.00	0.042
Addalaichenai - 16	0.11	0.00	0.00	0.038
Palamunai - 06	0.10	0.00	0.00	0.033
Addalaichenai - 05	0.05	0.01	0.01	0.020
Addalaichenai - 10	0.03	0.00	0.01	0.011
Addalaichenai - 15	0.02	0.00	0.00	0.007
Deegawapiya - 02	0.00	0.00	0.02	0.006
Addalaichenai - 08	0.02	0.00	0.00	0.006
Addalaichenai - 06	0.01	0.00	0.00	0.004
Oluvil - 02	0.00	0.00	0.01	0.004
Addalaichenai - 03	0.01	0.00	0.00	0.003
Oluvil - 03	0.00	0.00	0.01	0.002
Oluvil - 05	0.00	0.00	0.00	0.002
Oluvil - 04	0.00	0.00	0.00	0.001
Addalaichenai - 02	0.00	0.00	0.00	0.001
Palamunai - 01	0.00	0.00	0.00	0.000
Oluvil - 06	0.00	0.00	0.00	0.000
Addalaichenai - 07	0.00	0.00	0.00	0.000
Oluvil - 07	0.00	0.00	0.00	0.000
Palamunai - 02	0.00	0.00	0.00	0.000
Palamunai - 03	0.00	0.00	0.00	0.000
Addalaichenai - 01	0.00	0.00	0.00	0.000
Addalaichenai - 04	0.00	0.00	0.00	0.000
Addalaichenai - 11	0.00	0.00	0.00	0.000
Addalaichenai - 12	0.00	0.00	0.00	0.000
Addalaichenai - 13	0.00	0.00	0.00	0.000
Addalaichenai - 14	0.00	0.00	0.00	0.000
Palamunai - 04	0.00	0.00	0.00	0.000

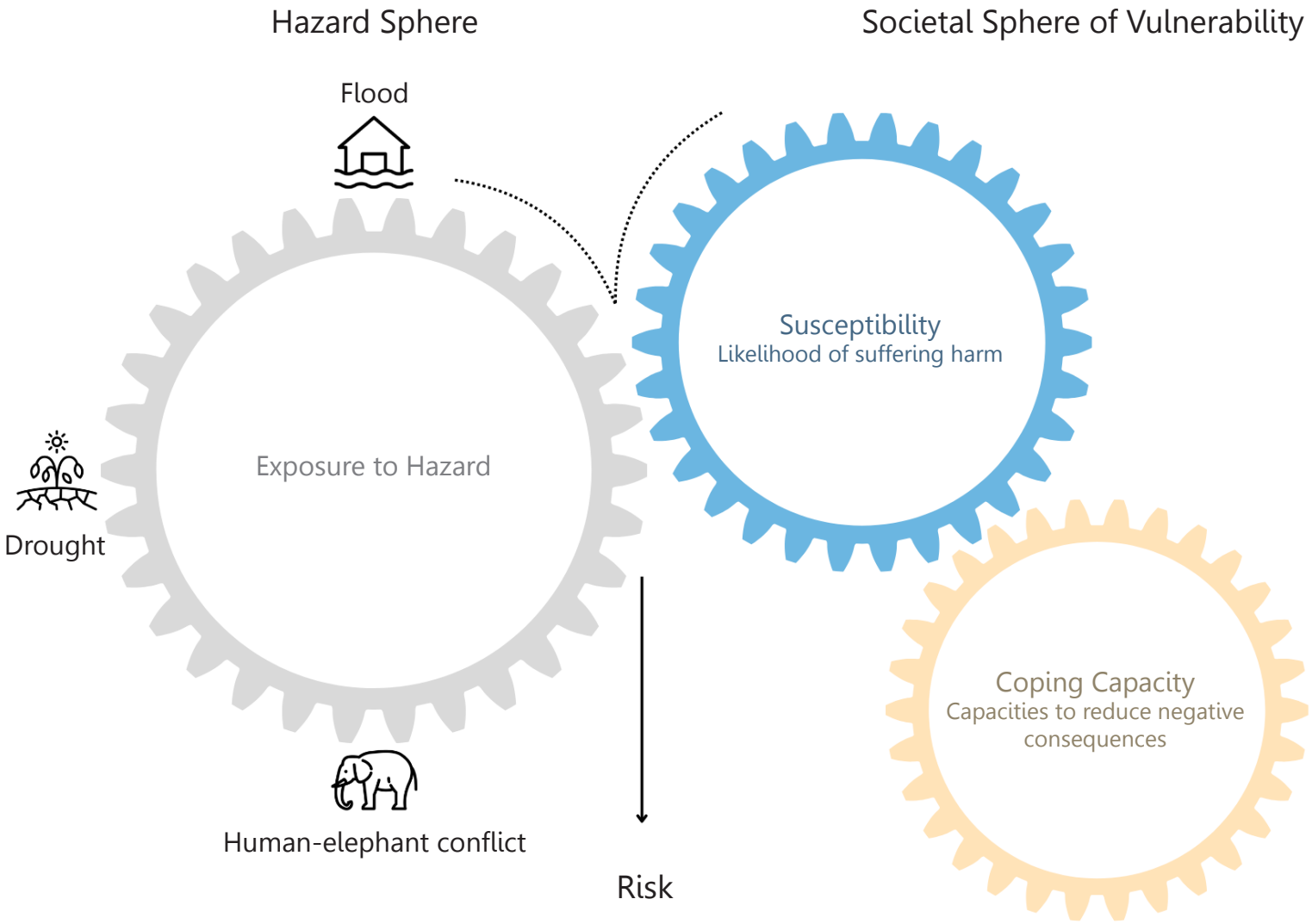
OTHER POTENTIAL HAZARDS

Other hazards also affect the population in Addalaichenai, 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

Table 1. Drought risk index

GND	Hazard	Exposure	Vulnerability	Risk
Oluvil - 01	1.00	0.72	0.15	0.107
Palamunai - 05	0.52	0.72	0.12	0.044
Deegawapiya - 01	0.15	0.46	0.41	0.028
Addalaichenai - 09	0.08	0.51	0.19	0.008
Addalaichenai - 05	0.11	0.42	0.14	0.007
Oluvil - 02	0.10	0.31	0.12	0.004
Oluvil - 04	0.12	0.27	0.04	0.001
Palamunai - 01	0.04	0.25	0.10	0.001
Oluvil - 06	0.02	0.13	0.36	0.001
Oluvil - 05	0.02	0.07	0.34	0.000
Oluvil - 07	0.05	0.17	0.04	0.000
Palamunai - 06	0.06	0.01	0.34	0.000
Oluvil - 03	0.01	0.01	0.69	0.000
Palamunai - 02	0.00	0.16	0.08	0.000
Palamunai - 03	0.00	0.20	0.12	0.000
Addalaichenai - 08	0.00	0.33	0.16	0.000
Addalaichenai - 06	0.00	0.26	0.23	0.000
Addalaichenai - 15	0.00	0.24	0.21	0.000
Palamunai - 04	0.00	0.22	0.13	0.000
Addalaichenai - 04	0.00	0.19	0.13	0.000
Addalaichenai - 16	0.00	0.18	0.16	0.000
Addalaichenai - 10	0.00	0.16	0.15	0.000
Addalaichenai - 13	0.00	0.15	0.18	0.000
Addalaichenai - 01	0.00	0.14	0.17	0.000
Addalaichenai - 07	0.00	0.13	0.12	0.000
Addalaichenai - 02	0.00	0.12	0.24	0.000
Addalaichenai - 14	0.00	0.11	0.18	0.000
Addalaichenai - 11	0.00	0.11	0.19	0.000
Addalaichenai - 17	0.00	0.10	0.17	0.000
Addalaichenai - 03	0.00	0.09	0.15	0.000
Addalaichenai - 12	0.00	0.08	0.22	0.000
Deegawapiya - 02	0.00	0.07	0.38	0.000

Table 2. Flood risk index

GND	Hazard-Exposure	Vulnerability	Risk
Addalaichenai - 09	0.45	0.60	0.269
Palamunai - 05	0.35	0.55	0.193
Oluvil - 01	0.26	0.57	0.151
Addalaichenai - 17	0.21	0.59	0.126
Deegawapiya - 01	0.15	0.72	0.109
Palamunai - 06	0.14	0.70	0.099
Addalaichenai - 16	0.10	0.58	0.058
Addalaichenai - 05	0.65	0.07	0.046
Addalaichenai - 10	0.32	0.08	0.027
Addalaichenai - 15	0.28	0.08	0.022
Addalaichenai - 08	0.17	0.09	0.016
Addalaichenai - 06	0.07	0.17	0.012
Addalaichenai - 03	0.01	0.58	0.008
Addalaichenai - 07	0.01	0.06	0.000
Oluvil - 03	0.00	0.80	0.000
Oluvil - 05	0.00	0.66	0.000
Deegawapiya - 02	0.00	0.69	0.000
Addalaichenai - 14	0.00	0.60	0.000
Addalaichenai - 12	0.00	0.61	0.000
Oluvil - 06	0.00	0.65	0.000
Addalaichenai - 11	0.00	0.60	0.000
Addalaichenai - 01	0.00	0.58	0.000
Addalaichenai - 13	0.00	0.59	0.000
Oluvil - 02	0.00	0.07	0.000
Palamunai - 03	0.00	0.57	0.000
Addalaichenai - 02	0.00	0.56	0.000
Addalaichenai - 04	0.00	0.57	0.000
Palamunai - 01	0.00	0.56	0.000
Palamunai - 04	0.00	0.56	0.000
Palamunai - 02	0.00	0.04	0.000
Oluvil - 07	0.00	0.02	0.000
Oluvil - 04	0.00	0.52	0.000

Table 3. HEC risk index

GND	Hazard	Exposure	Vulnerability	Risk
Deegawapiya - 01	0.21	0.38	0.44	0.036
Oluvil - 01	0.56	0.36	0.15	0.030
Addalaichenai - 09	0.29	0.53	0.19	0.029
Palamunai - 05	0.41	0.57	0.10	0.025
Deegawapiya - 02	0.23	0.22	0.37	0.018
Oluvil - 02	0.07	0.84	0.13	0.007
Addalaichenai - 05	0.18	0.26	0.14	0.007
Addalaichenai - 10	0.08	0.49	0.17	0.006
Oluvil - 03	0.33	0.03	0.61	0.006
Oluvil - 05	0.07	0.21	0.33	0.005
Addalaichenai - 02	0.07	0.36	0.13	0.003
Oluvil - 04	0.11	0.49	0.05	0.002
Addalaichenai - 08	0.01	1.00	0.18	0.001
Addalaichenai - 17	0.01	0.31	0.18	0.000
Palamunai - 01	0.00	0.75	0.13	0.000
Oluvil - 06	0.00	0.38	0.30	0.000
Addalaichenai - 06	0.00	0.79	0.34	0.000
Oluvil - 07	0.00	0.47	0.05	0.000
Addalaichenai - 07	0.00	0.38	0.13	0.000
Palamunai - 06	0.07	0.00	0.41	0.000
Addalaichenai - 01	0.00	0.42	0.18	0.000
Addalaichenai - 03	0.00	0.27	0.17	0.000
Addalaichenai - 04	0.00	0.57	0.13	0.000
Addalaichenai - 11	0.00	0.33	0.20	0.000
Addalaichenai - 12	0.00	0.25	0.22	0.000
Addalaichenai - 13	0.00	0.46	0.18	0.000
Addalaichenai - 14	0.00	0.33	0.20	0.000
Addalaichenai - 15	0.00	0.71	0.16	0.000
Addalaichenai - 16	0.00	0.55	0.16	0.000
Palamunai - 02	0.00	0.47	0.08	0.000
Palamunai - 03	0.00	0.40	0.14	0.000
Palamunai - 04	0.00	0.66	0.12	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 calculated 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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