SRI LANKA

Area-Based Risk Assessment in Karachchi Divisional Secretariat Division

Kilinochchi District

June 2024

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Who are we?

About IMPACT

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 Karachchi 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 Karachchi 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 Karachchi.

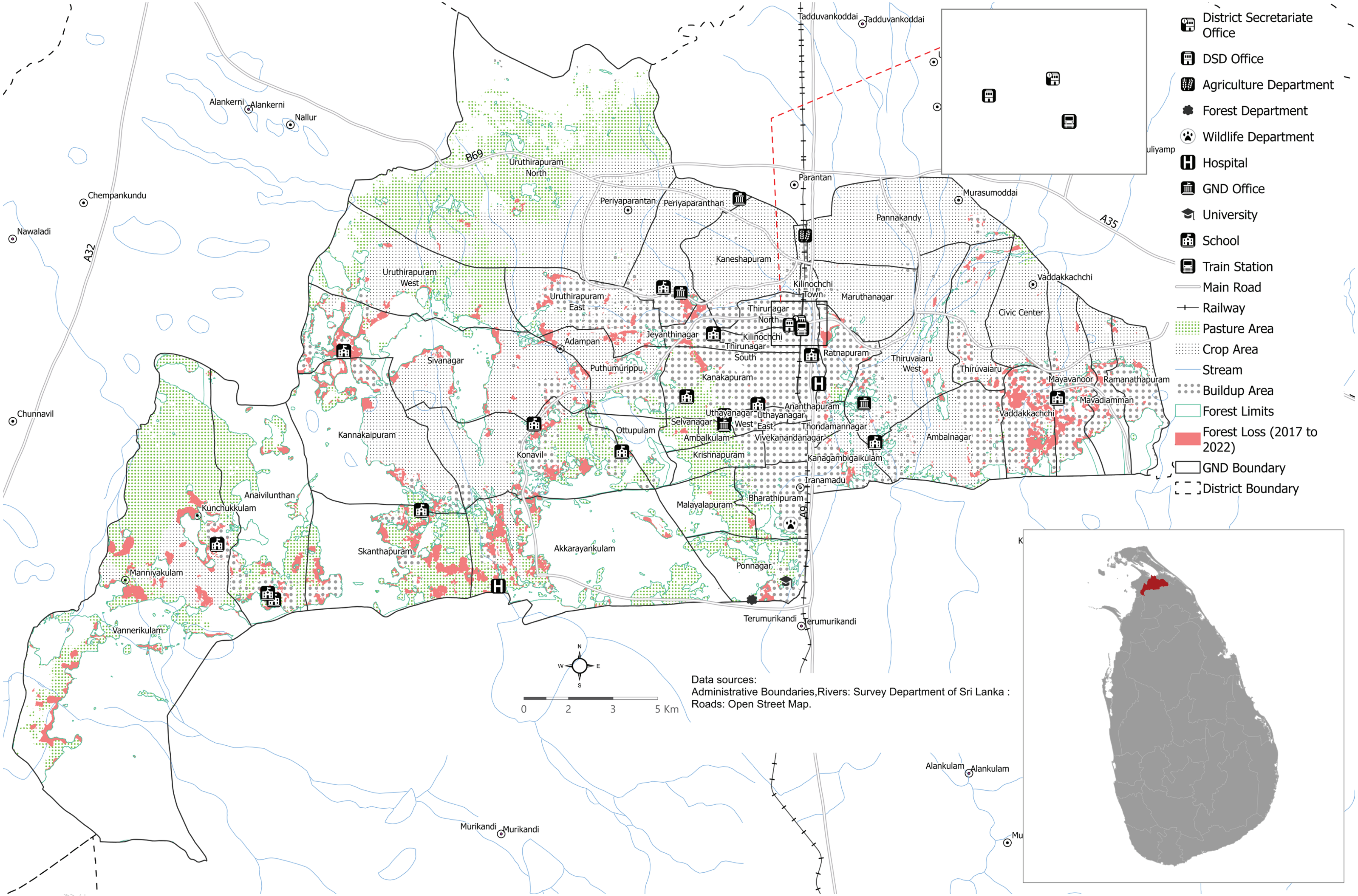
Through the study, IMPACT identified three GNDs, namely Vannerikulam, Kilinochchi Town, and Uruthirapuram West as the most at risk for multiple hazards. Uruthirapuram West and Vannerikulam have the largest drought prone areas in the DSD with 85% and 92% of pasture land affected, respectively. The average affected cropland and pasture land are 37% and 46%, respectively. Kilinochchi Town is the most at risk from floods, with a large affected population density, cropland and buildup areas. Twelve GNDs have over 20% of flood-affected areas, and an average of 25% of cropland is flood-prone.

In Uthayanagar East, the population has the highest level of vulnerability regarding social dependency, with a high share of low-income families and the highest child and elderly density. Social dependency is when an individual or group relies on another individual or group for resources, support, or guidance.

According to local authorities, 16 out of the 42 GNDs have registered elephant attacks. The DSD had 1853 ha of forest loss between 1990 and 2022, accounting to 16% of its original area. Vannerikulam was identified as the GND most at risk for having the largest forest disturbance combined with vulnerabilty indicators such as high dependency in agriculture and share of low income families. The unemployment and low-income rates are social insecurity indicators, that present the low 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 Karachchi against single and multi-hazard scenarios.

Map 1. Overview map of Karachchi DSD



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

BACKGROUND

Located in the Northern province, Kilinochci district, Karachchi DSD covers an area of 438.2 km², with a population of 73,150 individuals, of whom 50,3% are female, living across 42 Grama Nilhadari Divisions (GNDs). It is estimated that the dependency ratio reaches 42%, which is the population below 15 and above 60 years old[3]. The average population density is 49,85/ km². The terrain in Karachchi 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].

Overall, Karachchi's geography significantly shapes its economy, with livelihood activities primarily revolving around agriculture. In addition to the agricultural sector, the industries and services are newly emerging economic sectors. The residential area has been expanded towards Uruthirapuram, Kanagapuram, Ratnapuram, and Malayapuram. Many new technologies-based enterprises have emerged in Ariviyal Nagar. Most of the commercial activities are along the major A9 road[5]. In Karachchi, paddy cultivation stands out as the predominant agricultural activity, with the highest level of employment. According to local authorities, 3797 families are engaged in agriculture, 3403 employed by the government, 1800 in the private sector, 668 in fishing, and 619 in local businesses. This highlights the dependency on rice cultivation.

During heavy monsoon rains, low-lying areas in Karachchi 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. Karachchi 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. For example, the Iranamadu tank is a large irrigation tank in the Northern Province and the backbone of the economics and the livelihood of the people of Kilinochchi District in Karaichchi. Due to heavy rain experienced in the districts of Kilinochchi, the increased inflow of water can go beyond the tank's capacity level, resulting in a heavy overflow, flooding downstream areas and causing extensive damages and losses to public and private properties and risking the tank's structure[6]. Karachchi'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 42 GNDs in Karachchi, 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 Karachchi 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)[7]. 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[8]).
- **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 Karachchi, 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 Karachchi.

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[9] (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[10]). MODIS Normalized differentiated vegetation index (NDVI[11]) and MODIS Land Surface Temperature (LST[12]) 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[13]. 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[14] 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 Karachchi (Map 2), the exposure index is considerably high across the DSD with 52% of the total area and an average of 37% of cropland affected by drought and 46% of pasture land. In total terms, Uruthirapuram West presents the highest risks, with the largest drought area, over 4000 ha, covering 74% of the GND area and 85% of pasture land exposed to drought. Civic Centre, Uruthirapuram North, and Maruthanagar have over 90% of their territory affected by drought. Six GNDs have over 90% of their cropland affected by drought, and seven their pasture land. Only eight out of all GNDs have less than 20% drought

Map 2. Drought exposure

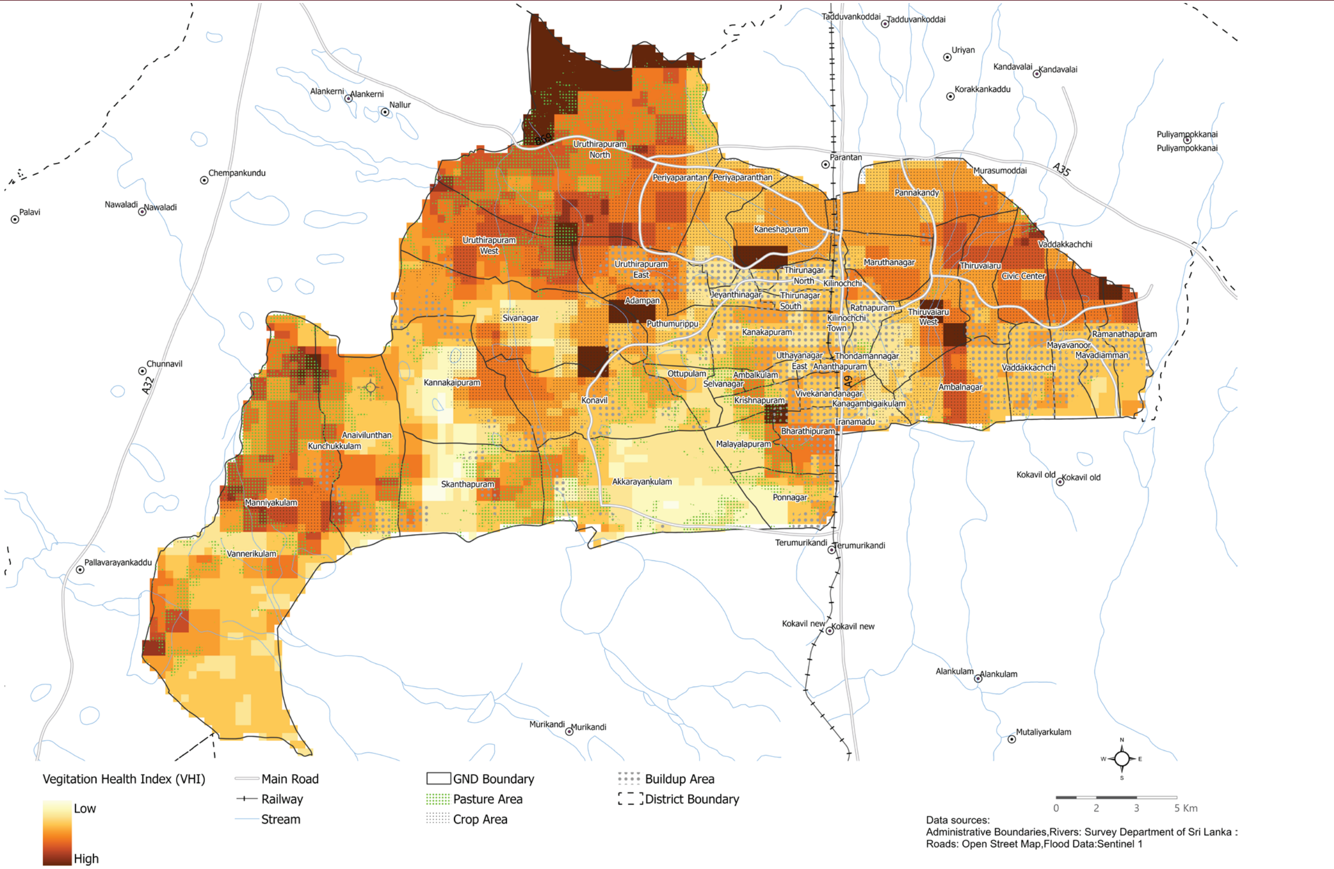


Figure 1. Drought area (ha) per GND[15]

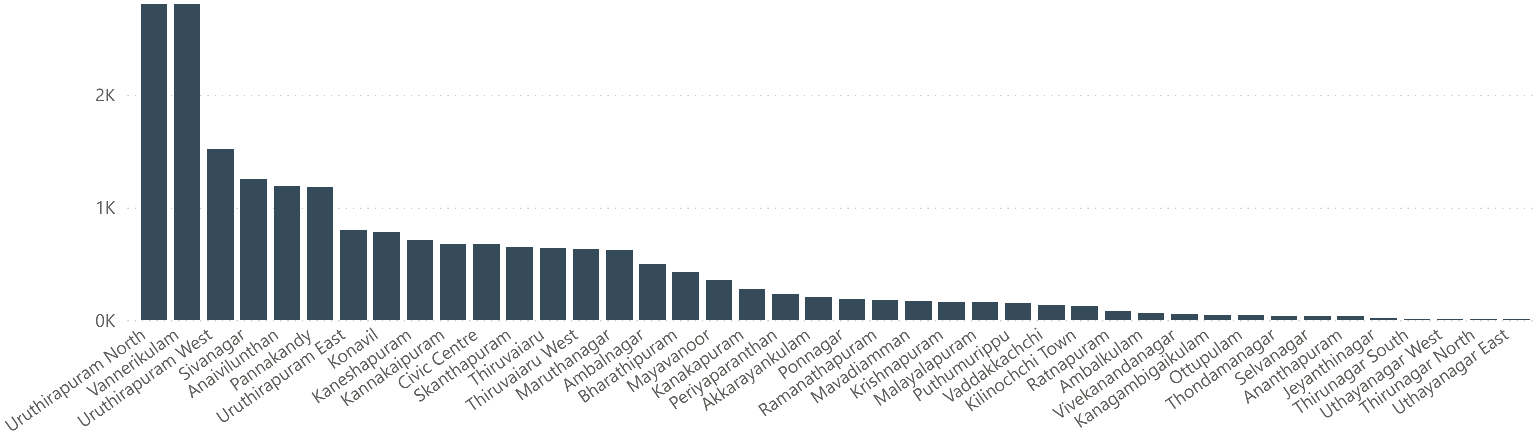


Table 1. Drought risk index				
GND	Hazard	Exposure	Vulnerability	Risk
Uruthirapuram West	**1.00**	**0.43**	**0.44**	**0.191**
Vannerikulam	**0.88**	**0.40**	**0.47**	**0.163**
Uthayanagar East	**0.37**	**0.45**	**0.56**	**0.093**
Skanthapuram	0.30	0.43	0.40	0.052
Periyaparanthan	0.28	0.69	0.24	0.047
Uruthirapuram North	0.19	0.51	0.43	0.042
Anaivilunthan	0.28	0.28	0.49	0.040
Civic Centre	0.16	0.66	0.37	0.039
Thiruvaiaru West	0.15	0.63	0.35	0.034
Thondamanagar	0.15	0.63	0.33	0.031
Mayavanoor	0.09	0.73	0.38	0.024
Konavil	0.19	0.45	0.26	0.022
Ambalkulam	0.12	0.45	0.33	0.018
Kannakaipuram	0.16	0.26	0.41	0.017
Maruthanagar	0.15	0.36	0.30	0.016
Bharathipuram	0.10	0.44	0.35	0.016
Kanakapuram	0.17	0.40	0.13	0.009
Ponnagar	0.06	0.48	0.31	0.008
Thirunagar North	0.16	0.26	0.20	0.008
Ratnapuram	0.04	0.38	0.44	0.007

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

affected area.

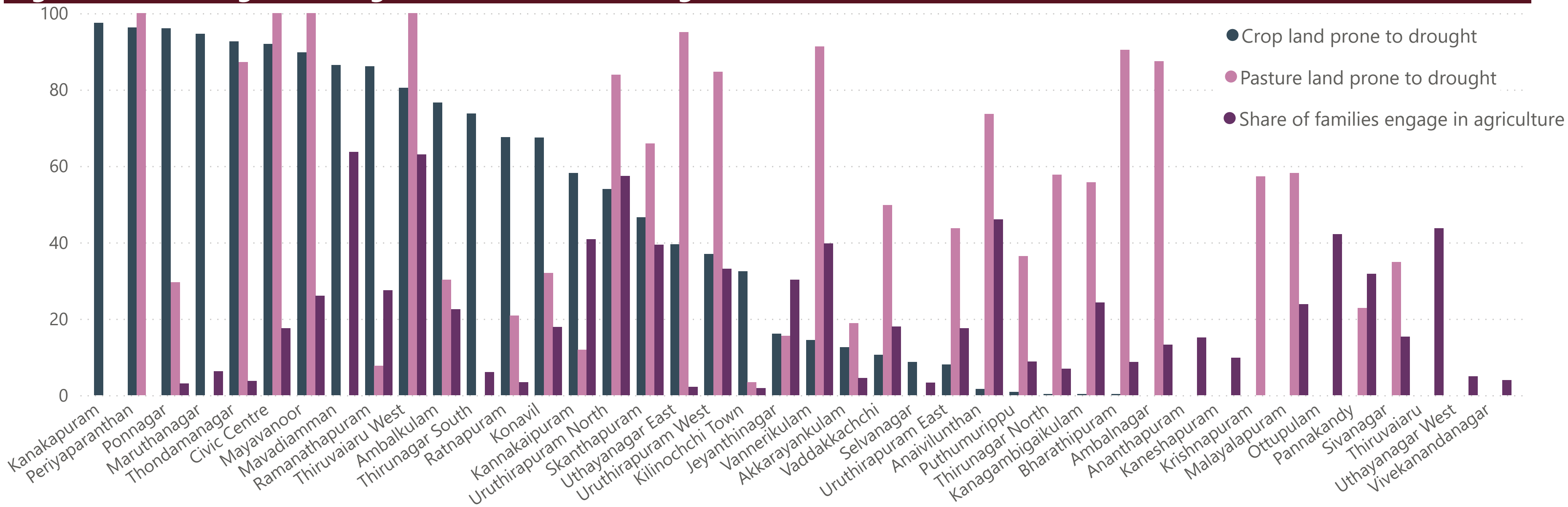
The high share of female headed households (28%), families earning daily wage between 2,000 and 3,000 LKR (82%), and share of families engaged in agriculture (33%) contribute to the livelihood and social dependency of Uruthirapuram West.

The second largest drought area leads Vannerikulam to high risk. The GND has 91% of drought prone farming land and 81% of low income families. The third GND most at risk is Uthayanagar East with 95% of drought prone pasture land, 23% of female headed households, 68% of low income families, and the largest density of children and elderly.

GNDs characterized by high population density, such as Kanagambigaikulam, Krishnapuram, and Vivekanandanagar 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 and livestock production decline in Karachchi. Mavadiamman, Thiruvaiaru West, and Uruthirapuram North have around 60% of families engaged in agriculture, the first two with over 80% of 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[16]



AGORA

FLOODS

The rainy season in Karachchi 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. The Iranamadu tank overflowing also poses a threat to the government and local communities[18].

Between 2018 and 2020, satellite images showed that 6366 hectares of Karachchi were flooded. The largest flooded areas were registered in Uruthirapuram North, Pannakandy, and Vannerikulam, with 853 ha, 727 ha, and 678 ha respectively. The flooded areas in the three GNDs represented over 30% of flood cover in Karachchi. Pannakandy and Maruthanagar had over 50% 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 and railways within flooded zones.

Table 2 indicates that Kilinochchi Town is at the highest risk due to its high exposure and vulnerability. It has the largest percentage of cropland within a flood zone, 78%, and 52% of

Map 3. Flood exposure

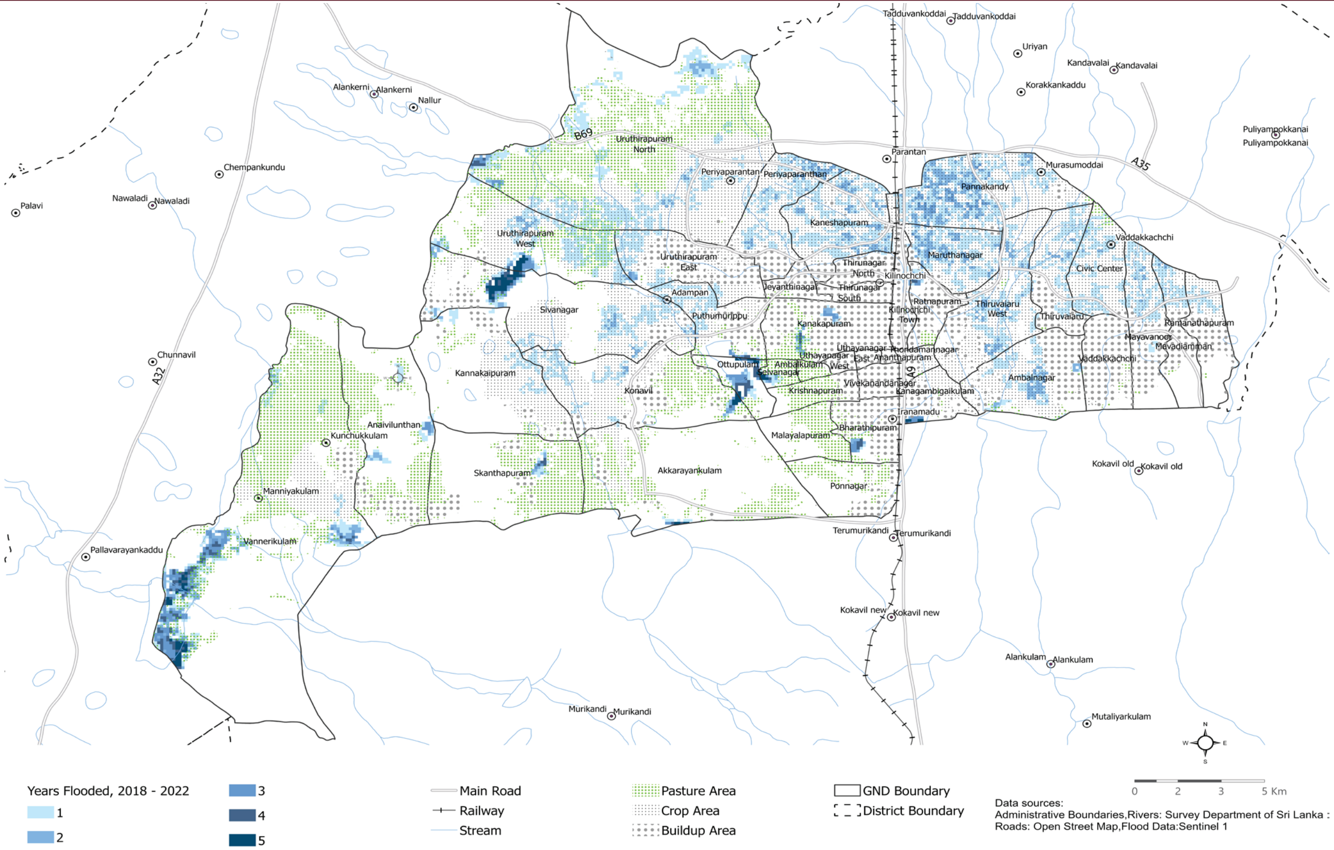


Figure 3. Flood-affected areas and inland fishery and agricultural families[17]

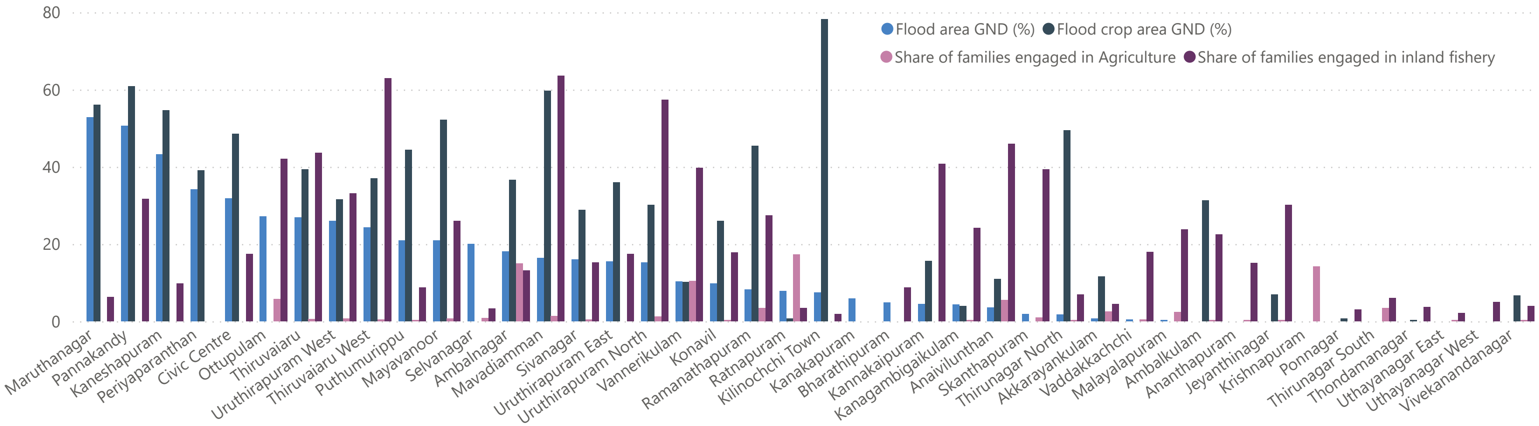


Table 2. Flood risk index

GND	Hazard-Exposure	Vulnerability	Risk
Kilinochchi Town	**0.59**	**0.62**	**0.364**
Periyaparanthan	**0.47**	**0.62**	**0.296**
Maruthanagar	**0.47**	**0.63**	**0.295**
Kanakapuram	0.48	0.58	0.281
Mayavanoor	0.40	0.69	0.272
Ambalkulam	0.40	0.67	0.266
Pannakandy	0.38	0.68	0.257
Thiruvaiaru West	0.35	0.67	0.233
Mavadiamman	0.33	0.69	0.230
Sivanagar	0.33	0.63	0.209
Civic Centre	0.29	0.69	0.198
Uruthirapuram West	0.23	0.74	0.170
Vannerikulam	0.23	0.72	0.166
Akkarayankulam	0.25	0.64	0.159
Ramanathapuram	0.22	0.72	0.155
Ratnapuram	0.20	0.72	0.144
Anaivilunthan	0.17	0.74	0.126
Konavil	0.31	0.40	0.125
Thirunagar North	0.18	0.60	0.110
Skanthapuram	0.24	0.45	0.107
Thondamanagar	0.16	0.65	0.103
Kaneshapuram	0.16	0.65	0.101
Uruthirapuram East	0.15	0.64	0.098

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

buildup area in the same conditions. Beyond having a large affected population density, it has 27% of female headed households and 80% of its families earn daily wages between 2000 and 3000 LKR. Periyaparanthan and Maruthanagar follow, both with large affected population density and flood-affected cropland, and around 20% of female headed households.

Ottupulam, Malayalapuram, Uthayanagar West, and Krishnapuram have the lowest risk. This scenario is due to having low hazards exposure, with no flooded areas during the assessed period. However, their vulnerability indexes are high, indicating that their risk might change in the near future in case the extreme rain events get more frequent.

The distribution of flood risks in Karachchi underscores the need for flood management plans, especially during agricultural seasons, to mitigate adverse effects. Six GNDs have over 50% of cropland within flood zones, indicating a significant impact on agricultural activities. This is critical for the livelihood and food security of families. The paddy seasons in Karachchi 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 Karachchi[20]

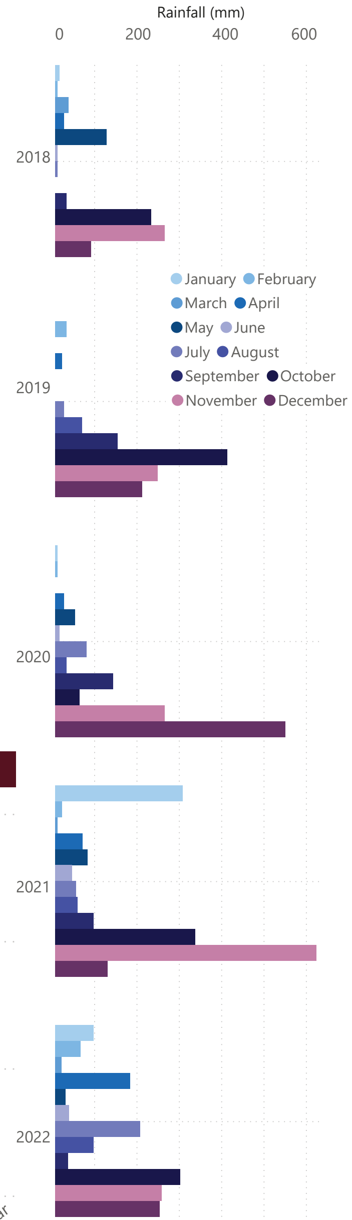
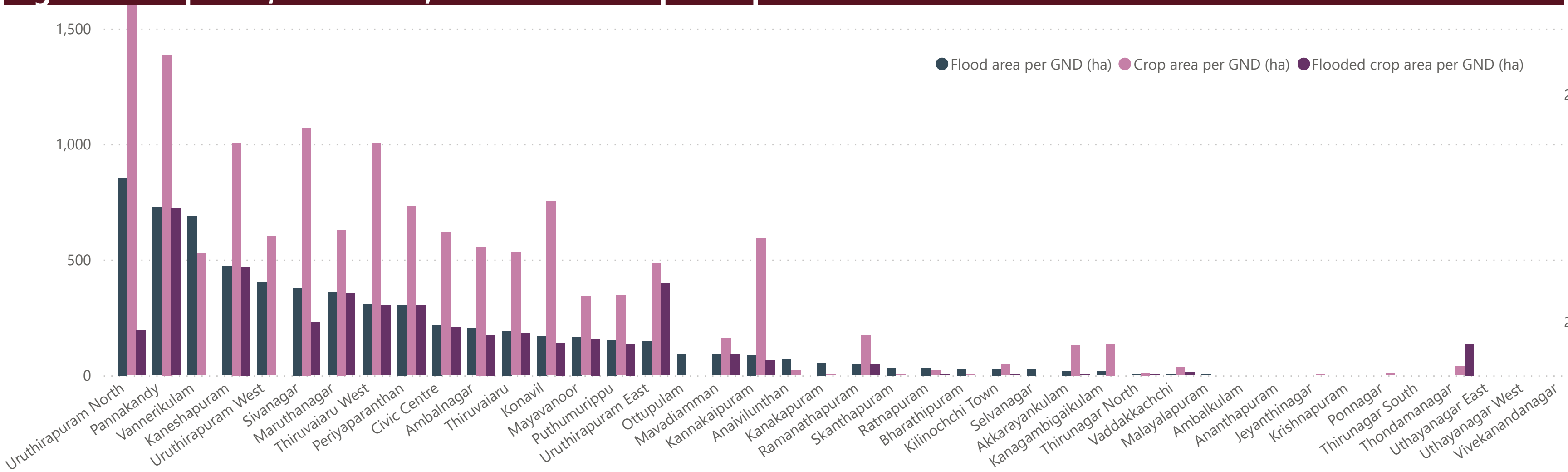


Figure 4. Crop area, flood area, and flooded crop area per GND[19]



AGORA

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

Map 4. Human-elephant conflict exposure

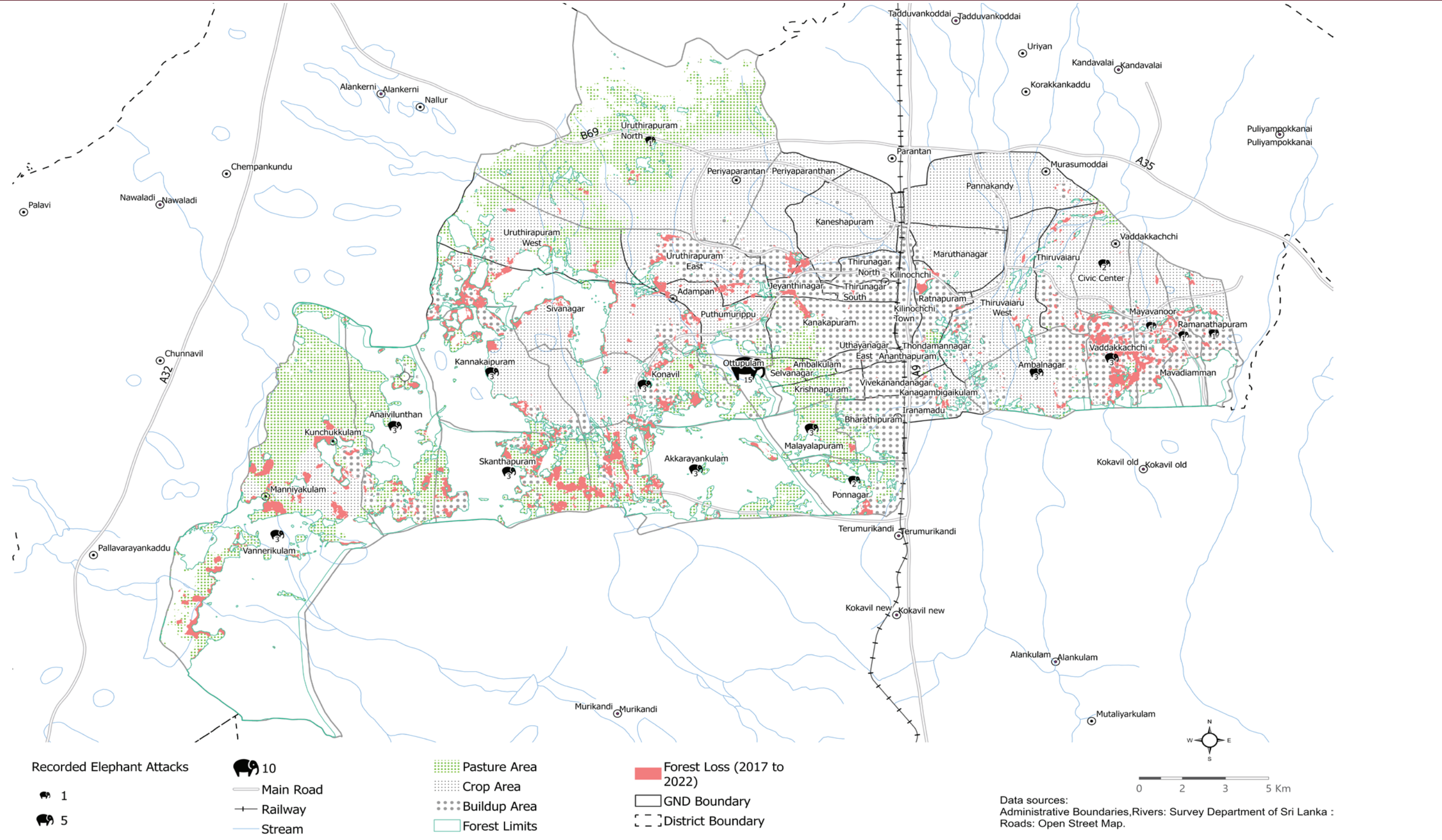


Figure 6. Human death and property damage caused by elephants/Elephant death and human density[24]

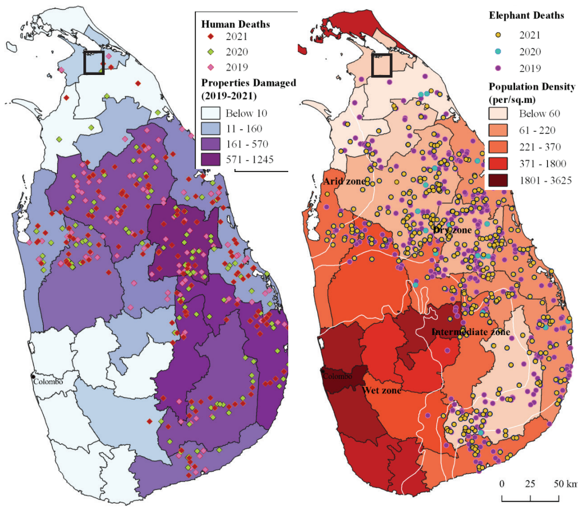


Figure 7. Human and elephant deaths in Sri Lanka[23]

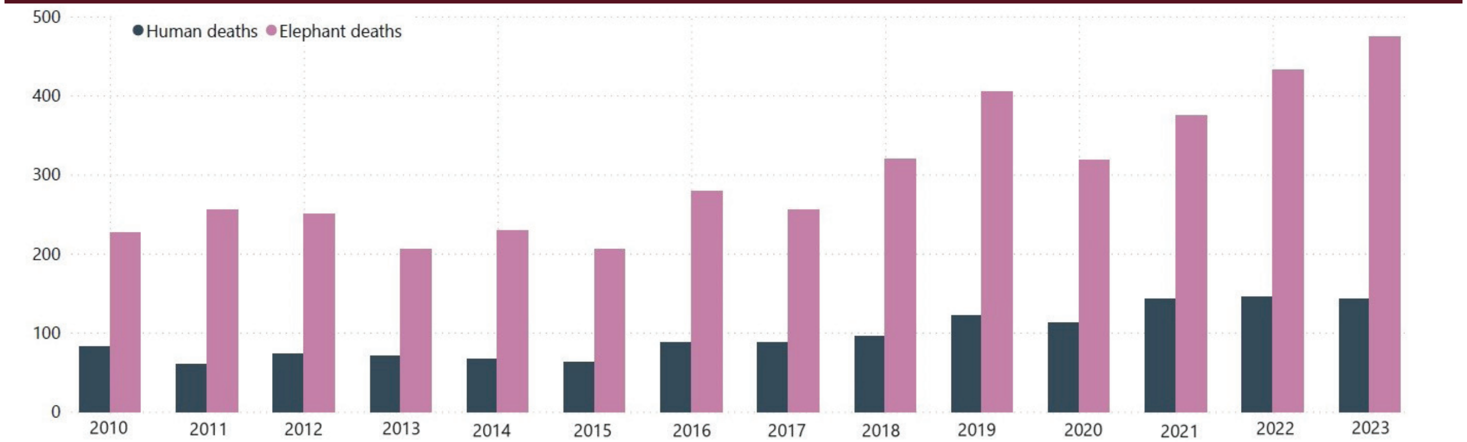


Table 3. HEC risk index

GND	Hazard	Exposure	Vulnerability	Risk
Vannerikulam	**0.73**	**0.13**	**0.43**	**0.042**
Ottupulam	**0.33**	**0.24**	**0.43**	**0.035**
Akkarayankulam	**0.44**	**0.23**	**0.29**	**0.028**
Skanthapuram	0.35	0.15	0.40	0.022
Konavil	0.21	0.33	0.31	0.021
Vaddakkachchi	0.22	0.26	0.34	0.020
Thirunagar North	0.31	0.20	0.21	0.013
Anaivilunthan	0.25	0.10	0.48	0.012
Mayavanoor	0.12	0.26	0.37	0.012
Malayalapuram	0.10	0.25	0.41	0.010
Ambalnagar	0.07	0.30	0.48	0.010
Kannakaipuram	0.29	0.06	0.39	0.007
Mavadiamman	0.08	0.21	0.38	0.007
Uruthirapuram North	0.09	0.14	0.45	0.006
Ramanathapuram	0.07	0.17	0.44	0.005
Ratnapuram	0.05	0.24	0.44	0.005
Ponnagar	0.06	0.15	0.37	0.003
Ambalkulam	0.03	0.26	0.34	0.003
Kanagambigaikulam	0.02	1.00	0.11	0.002
Selvanagar	0.02	0.30	0.32	0.002
Bharathipuram	0.01	0.42	0.34	0.002
Kaneshapuram	0.03	0.17	0.30	0.002

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

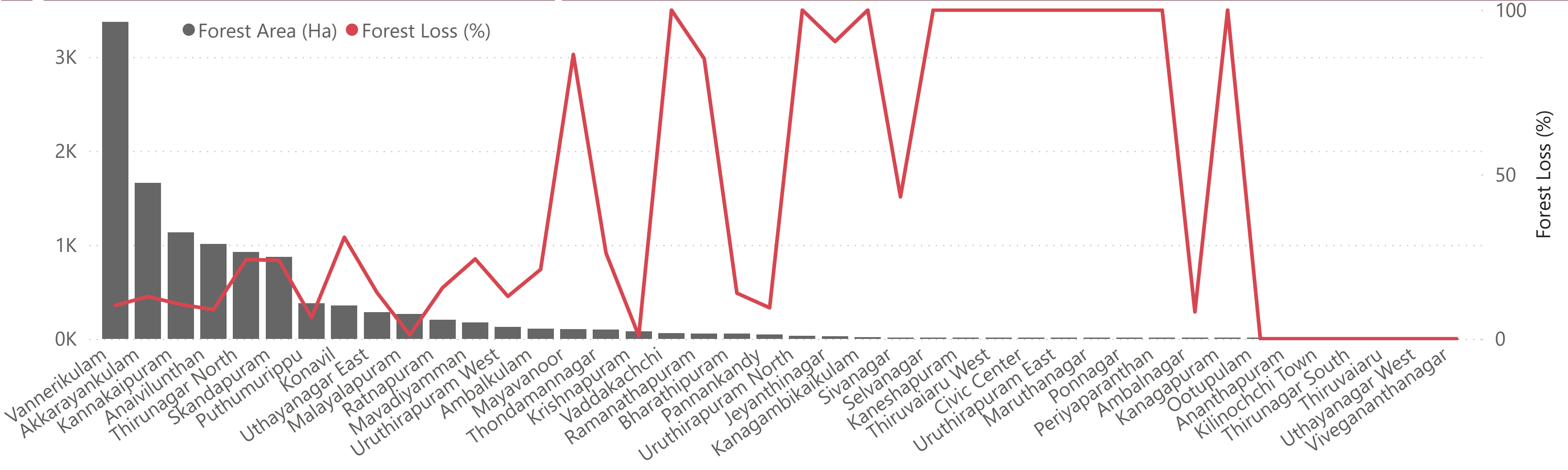
agricultural fields and human-occupied areas. Farmers may view elephants as threats to their livelihoods, increasing the likelihood of retaliatory measures. Between 2015 and 2021, 54% of incidences in Sri Lanka happened in open forests, while 62% were within 2 km of the forest edge[22].

Table 3 shows Vannerikulam as the GND most at risk with 3 registered elephant attacks. The high risk is driven by the highest forest disturbances, 40% of families engaged in agriculture and 11% in fishing, and 80% of families earning daily wages between 2000 and 3000 LKR. Ottupulam and Akkarayankulam follow, both with over 80% of low-income families and around 20% of female-headed households. Ottupulam registered 15 elephant attacks, has over 40% of families engaged in agriculture, and has the largest share of families with members with disabilities. Akkarayankulam registered the third larged forest disturbed area.

According to local authorities' data, 15 GNDs registered between 1 and 3 elephant attacks. The impact of deforestation is evident in Karachchi, the GND had 16% of total forest disturbance. Twelve GNDs registered 100% of forest disturbance, all with original forest smaller than 60 ha. Other three GNDs had over 85% of forest disturbance (Figure 8).

Vannerikulam, Akkarayankulam, Kannakaipuram, and Anaivilunthan have the largest forest areas and relatively low population density. With the correct protection and conservation efforts application, they have the potential to sustainably host human and elephant populations. Kilinochchi Town, Ananthapuram, and Uthayanagar East present the lowest risk to HEC, resulting from low hazard exposure indicators. The three GNDs have low family dependance on agriculture and fishery. Six GNDs present no risk to HEC, driven mostly by the absence of forest cover and disturbance, with no recorded elephant attacks.

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



AGORA

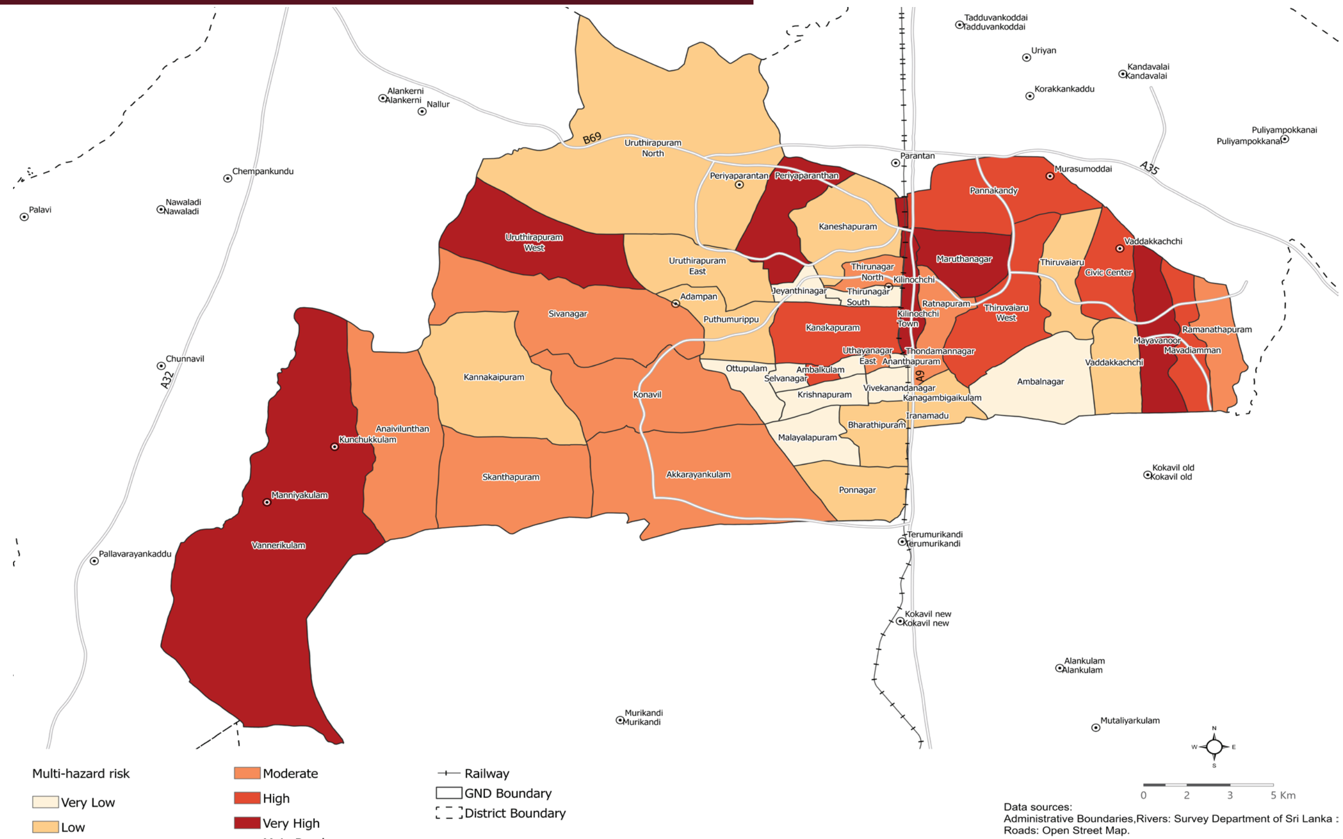
MULTI-HAZARD RISK

Karachchi'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 high risk (≥0.12 out of 1) are Vannerikulam, Kilinochchi Town, and Uruthirapuram West.

Vannerikulam presents the highest HEC and second highest flood risk indexes. Beyond the high exposure, with 90% of drought exposed crop lands, it has 40% of families dependent on agriculture and 10% on fishery. Kilinochchi Town is at the top on flood risk, and Uruthirapuram West on drought, both with almost 30% of female headed households. All GNDs have above 80% of families earning daily wages between 2,000 and 3,000 LKR per day.

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. Karachchi has an average of 75% of families earning daily wages between 2000 and 3000 LKR, this further impacts their ability to prepare for, respond to, and recover from shocks.

Map 5. Multi-hazard map



Mavadiamman, Thiruvaiaru West, and Uruthirapuram North have over 57% of families engaged in agriculture. 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.

Uthayanagar West, Krishnapuram and Malayalapuram present the lowest multi-hazard risk, having low flood risk, low drought exposure, and in Uthayanagar West and Krishnapuram, no registration of elephant attacks. They show a low share of families engaged in agriculture and inland fishery and elder density.

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 Karachchi 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
Vannerikulam	**0.17**	**0.16**	**0.04**	**0.124**
Kilinochchi Town	**0.36**	**0.00**	**0.00**	**0.122**
Uruthirapuram West	**0.17**	**0.19**	**0.00**	**0.121**
Periyaparanthan	0.30	0.05	0.00	0.114
Maruthanagar	0.29	0.02	0.00	0.104
Mayavanoor	0.27	0.02	0.01	0.102
Kanakapuram	0.28	0.01	0.00	0.097
Ambalkulam	0.27	0.02	0.00	0.096
Thiruvaiaru West	0.23	0.03	0.00	0.089
Pannakandy	0.26	0.00	0.00	0.086
Mavadiamman	0.23	0.01	0.01	0.081
Civic Centre	0.20	0.04	0.00	0.079
Sivanagar	0.21	0.00	0.00	0.070
Akkarayankulam	0.16	0.00	0.03	0.063
Skanthapuram	0.11	0.05	0.02	0.060
Anaivilunthan	0.13	0.04	0.01	0.059
Konavil	0.12	0.02	0.02	0.056
Ramanathapuram	0.15	0.01	0.01	0.055
Ratnapuram	0.14	0.01	0.01	0.052
Uthayanagar East	0.04	0.09	0.00	0.046
Thondamanagar	0.10	0.03	0.00	0.045
Thirunagar North	0.11	0.01	0.01	0.044
Uruthirapuram North	0.07	0.04	0.01	0.038
Kaneshapuram	0.10	0.00	0.00	0.034
Ponnagar	0.09	0.01	0.00	0.034
Uruthirapuram East	0.10	0.00	0.00	0.033
Puthumurippu	0.09	0.00	0.00	0.033
Kannakaipuram	0.07	0.02	0.01	0.031
Thiruvaiaru	0.09	0.00	0.00	0.031
Kanagambigaikulam	0.08	0.00	0.00	0.030
Vaddakkachchi	0.06	0.00	0.02	0.029
Bharathipuram	0.05	0.02	0.00	0.022
Ambalnagar	0.04	0.00	0.01	0.019
Selvanagar	0.04	0.00	0.00	0.015
Thirunagar South	0.04	0.00	0.00	0.015
Ottupulam	0.00	0.00	0.03	0.012
Vivekanandanagar	0.03	0.00	0.00	0.011
Ananthapuram	0.03	0.00	0.00	0.010
Jeyanthinagar	0.02	0.00	0.00	0.007
Malayalapuram	0.00	0.00	0.01	0.006
Krishnapuram	0.01	0.00	0.00	0.004
Uthayanagar West	0.00	0.00	0.00	0.001

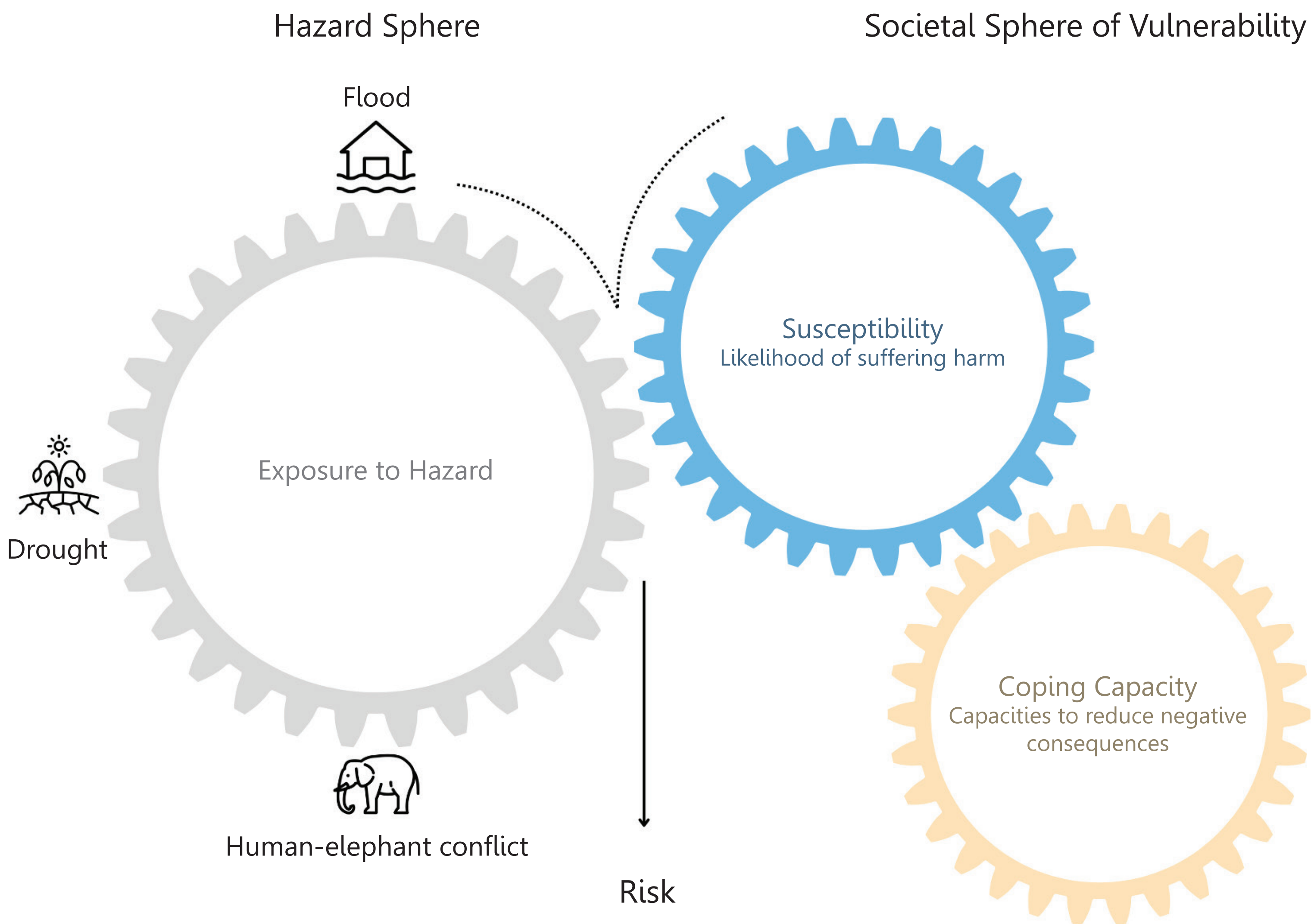
OTHER POTENTIAL HAZARDS

Other hazards also affect the population in Karachchi, 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
Uruthirapuram West	1.00	0.43	0.44	0.191
Vannerikulam	0.88	0.40	0.47	0.163
Uthayanagar East	0.37	0.45	0.56	0.093
Skanthapuram	0.30	0.43	0.40	0.052
Periyaparanthan	0.28	0.69	0.24	0.047
Uruthirapuram North	0.19	0.51	0.43	0.042
Anaivilunthan	0.28	0.28	0.49	0.040
Civic Centre	0.16	0.66	0.37	0.039
Thiruvaiaru West	0.15	0.63	0.35	0.034
Thondamanagar	0.15	0.63	0.33	0.031
Mayavanoor	0.09	0.73	0.38	0.024
Konavil	0.19	0.45	0.26	0.022
Ambalkulam	0.12	0.45	0.33	0.018
Kannakaipuram	0.16	0.26	0.41	0.017
Maruthanagar	0.15	0.36	0.30	0.016
Bharathipuram	0.10	0.44	0.35	0.016
Kanakapuram	0.17	0.40	0.13	0.009
Ponnagar	0.06	0.48	0.31	0.008
Thirunagar North	0.16	0.26	0.20	0.008
Ratnapuram	0.04	0.38	0.44	0.007
Ramanathapuram	0.03	0.38	0.44	0.006
Mavadiamman	0.04	0.37	0.37	0.005
Malayalapuram	0.04	0.28	0.40	0.004
Krishnapuram	0.04	0.39	0.24	0.004
Kanagambigaikulam	0.07	0.52	0.10	0.003
Vaddakkachchi	0.03	0.29	0.33	0.003
Puthumurippu	0.04	0.13	0.47	0.003
Ambalnagar	0.01	0.39	0.48	0.003
Akkarayankulam	0.05	0.18	0.29	0.003
Kilinochchi Town	0.03	0.25	0.25	0.002
Selvanagar	0.02	0.13	0.36	0.001
Jeyanthinagar	0.01	0.16	0.32	0.001
Uruthirapuram East	0.01	0.23	0.30	0.001
Pannakandy	0.01	0.14	0.37	0.001
Vivekanandanagar	0.01	0.18	0.23	0.000
Sivanagar	0.01	0.20	0.27	0.000
Ananthapuram	0.01	0.10	0.25	0.000
Kaneshapuram	0.00	0.06	0.26	0.000
Ottupulam	0.00	0.08	0.36	0.000
Thiruvaiaru	0.00	0.05	0.32	0.000
Thirunagar South	0.00	0.31	0.21	0.000
Uthayanagar West	0.00	0.10	0.29	0.000

Table 2. Flood risk index

GND	Hazard-Exposure	Vulnerability	Risk
Kilinochchi Town	0.59	0.62	0.364
Periyaparanthan	0.47	0.62	0.296
Maruthanagar	0.47	0.63	0.295
Kanakapuram	0.48	0.58	0.281
Mayavanoor	0.40	0.69	0.272
Ambalkulam	0.40	0.67	0.266
Pannakandy	0.38	0.68	0.257
Thiruvaiaru West	0.35	0.67	0.233
Mavadiamman	0.33	0.69	0.230
Sivanagar	0.33	0.63	0.209
Civic Centre	0.29	0.69	0.198
Uruthirapuram West	0.23	0.74	0.170
Vannerikulam	0.23	0.72	0.166
Akkarayankulam	0.25	0.64	0.159
Ramanathapuram	0.22	0.72	0.155
Ratnapuram	0.20	0.72	0.144
Anaivilunthan	0.17	0.74	0.126
Konavil	0.31	0.40	0.125
Thirunagar North	0.18	0.60	0.110
Skanthapuram	0.24	0.45	0.107
Thondamanagar	0.16	0.65	0.103
Kaneshapuram	0.16	0.65	0.101
Uruthirapuram East	0.15	0.64	0.098
Puthumurippu	0.13	0.73	0.095
Thiruvaiaru	0.13	0.68	0.091
Ponnagar	0.21	0.43	0.089
Kanagambigaikulam	0.15	0.56	0.084
Kannakaipuram	0.10	0.70	0.068
Uruthirapuram North	0.14	0.48	0.066
Vaddakkachchi	0.09	0.67	0.063
Bharathipuram	0.07	0.67	0.048
Ambalnagar	0.19	0.24	0.044
Uthayanagar East	0.06	0.77	0.044
Thirunagar South	0.07	0.60	0.044
Selvanagar	0.06	0.66	0.043
Vivekanandanagar	0.05	0.62	0.031
Ananthapuram	0.05	0.63	0.030
Jeyanthinagar	0.05	0.41	0.020
Krishnapuram	0.01	0.61	0.007
Uthayanagar West	0.01	0.65	0.004
Malayalapuram	0.00	0.71	0.003
Ottupulam	0.00	0.71	0.001

Table 3. HEC risk index

GND	Hazard	Exposure	Vulnerability	Risk
Vannerikulam	0.73	0.13	0.43	0.042
Ottupulam	0.33	0.24	0.43	0.035
Akkarayankulam	0.44	0.23	0.29	0.028
Skanthapuram	0.35	0.15	0.40	0.022
Konavil	0.21	0.33	0.31	0.021
Vaddakkachchi	0.22	0.26	0.34	0.020
Thirunagar North	0.31	0.20	0.21	0.013
Anaivilunthan	0.25	0.10	0.48	0.012
Mayavanoor	0.12	0.26	0.37	0.012
Malayalapuram	0.10	0.25	0.41	0.010
Ambalnagar	0.07	0.30	0.48	0.010
Kannakaipuram	0.29	0.06	0.39	0.007
Mavadiamman	0.08	0.21	0.38	0.007
Uruthirapuram North	0.09	0.14	0.45	0.006
Ramanathapuram	0.07	0.17	0.44	0.005
Ratnapuram	0.05	0.24	0.44	0.005
Ponnagar	0.06	0.15	0.37	0.003
Ambalkulam	0.03	0.26	0.34	0.003
Kanagambigaikulam	0.02	1.00	0.11	0.002
Selvanagar	0.02	0.30	0.32	0.002
Bharathipuram	0.01	0.42	0.34	0.002
Kaneshapuram	0.03	0.17	0.30	0.002
Jeyanthinagar	0.02	0.17	0.32	0.001
Krishnapuram	0.01	0.59	0.22	0.001
Uruthirapuram West	0.03	0.06	0.47	0.001
Puthumurippu	0.06	0.03	0.46	0.001
Thondamanagar	0.03	0.07	0.30	0.001
Thiruvaiaru West	0.03	0.07	0.35	0.001
Pannakandy	0.01	0.20	0.35	0.001
Civic Centre	0.06	0.02	0.38	0.001
Sivanagar	0.01	0.24	0.27	0.000
Uruthirapuram East	0.01	0.16	0.28	0.000
Kanakapuram	0.01	0.21	0.16	0.000
Thiruvaiaru	0.00	0.16	0.36	0.000
Maruthanagar	0.01	0.12	0.27	0.000
Periyaparanthan	0.00	0.08	0.25	0.000
Uthayanagar West	0.00	0.29	0.29	0.000
Vivekanandanagar	0.00	0.54	0.24	0.000
Thirunagar South	0.00	0.18	0.20	0.000
Uthayanagar East	0.07	0.00	0.55	0.000
Ananthapuram	0.00	0.30	0.25	0.000
Kilinochchi Town	0.00	0.39	0.24	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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