Global Rapid Post-Disaster Damage Estimation (GRADE) Report

Cyclone Ditwah 2025

Sri Lanka

Report as of December 17, 2025

JAPANGov The Government of Japan
GFDRR Global Facility for Disaster Reduction and Recovery
Administered by THE WORLD BANK IBRD • IDA | WORLD BANK GROUP

Disclaimer

1818 H Street NW
Washington DC 20433
Telephone: 202-473-1000
Internet: www.worldbank.org

Cover photo: https://commons.wikimedia.org/wiki/File:Ditwah_2025-11-29_0905Z.jpg

Global Rapid Post-Disaster Damage Estimation (GRADE) Report

Cyclone Ditwah 2025

Sri Lanka

Acknowledgments

This report was prepared by a team led by Rashmin Gunasekera (World Bank's Disaster Climate Risk Management, IDURM and the Global Facility for Disaster Reduction and Recovery, GFDRR). The team comprises James Daniell, Harriette Stone, Bramka Jafino, Aaron Opdyke, Johannes Brand, Roberth Romero, Annika Maier, Andreas Schaefer, Bastian van den Bout, Judith Claassen, Mikhail Sirenko and Kerri Cox of the GFDRR's Global Program for Disaster Risk Analytics and the World Bank's Disaster Resilience Analytics and Solutions (D-RAS) team.

The GRADE team would like to thank the Government of Japan for its continued generous support to the GRADE assessments through GFDRR and its Japan-World Bank program for Mainstreaming Disaster Risk Management in Developing Countries.

The team gratefully acknowledges the contribution and guidance of peer reviewers: Jian Vun (Senior Disaster Risk Management Specialist, IEAU1) and Natasha Chapplow (Disaster Risk Management Specialist, ISAU1).

The GRADE team is also grateful for the support of Adelaide University (University of Adelaide and University of South Australia), including Tharindi Wijekoon, Chamaka Karunanayake, Helani Mahapatunage, Pasindu Karunatilaka and Guna Hewa.

The team acknowledges the support, contributions, and guidance of the World Bank's Sri Lanka Country Mangment Unit and the South Asia Disaster Risk Mangment Team.

The team gratefully acknowledges the contribution and guidance of Niels Holm-Nielsen (GFDRR/World Bank). Contributions on gender are from Zoe Trohanis, Mirtha Escobar and Carolina de los Angeles Ferrer Rincon (GFDRR/World Bank) World Bank's Map Clearance team. The World Bank acknowledges the Government of Sri Lanka's leadership in completing this assessment. The assessment benefited from close collaboration with the External Resources Department, the Treasury, the Disaster Management Centre, and the Department of National Planning, General Treasury, and many local and international organisations as listed in the data sources and throughout the report.

Abbreviations

CATDAT	Catastrophe DATA
Copernicus EMS	Copernicus Emergency Management Service
CROPGRIDS	Global gridded crop distribution/production datasets
DLR	Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Center)
DMC	Disaster Management Center
D-RAS	Disaster-Resilience Analytics & Solutions, GPURL, World Bank Group
DRM	Disaster Risk Management
ERA5	ECMWF Reanalysis 5th Generation
ECLAC	Economic Commission for Latin America and the Caribbean
ECMWF	European Centre for Medium-Range Weather Forecasts
FAO	Food and Agriculture Organization
FY	Financial Year
GDP	Gross Domestic Product
GFDRR	Global Facility for Disaster Reduction and Recovery
GHSL	Global Human Settlement Layer
GLOFAS	Global Flood Awareness System
GloBFP	Global Building Footprint Database
GOES	Geostationary Operational Environmental Satellite
GoSL	Government of Sri Lanka
GPM-IMERG	Global Precipitation Measurement – Intg. Multi-satellite Retrievals for GPM
GPURL	Urban, Disaster Risk Management, Resilience and Land Global Practice
GRADE	Global RApid post-disaster Damage Estimation
HOTOSM	Humanitarian OpenStreetMap Team
HRSL	High-Resolution Settlement Layer
IBTrACS	International Best Track Archive for Climate Stewardship
ICT	Information and Communication Technology
IDFS	Intensity-Duration-Frequency-Space (statistics)
IFRC	International Federation of Red Cross and Red Crescent Societies
IMD	Indian Meteorological Department
IOM	International Organization for Migration
NBRO	National Building Research Organization
NWC	National Water Commission
OBAT	Observed Building Attributes Tool
OCHA	Office for the Coordination of Humanitarian Affairs
OSM	Open Street Map
PDC	Pacific Disaster Center
PDNA	Post-Disaster Needs Assessments
PML	Probable Maximum Loss
PROBA-V	Project for On-Board Autonomy - Vegetation (ESA vegetation-monitoring satellite)
RAPIDA	Rapid Digital Assessment
SMAP	Soil Moisture Active Passive (NASA)
TEV	Total Exposure Value
UCC	Unit Cost of Construction
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
UNOCHA	United Nations Office for the Coordination of Humanitarian Affairs
UNOSAT	United Nations Satellite Centre
US$	United States Dollar

WASH	Water, Sanitation, and Hygiene
WFP	World Food Programme
WHO	World Health Organization
WRA	Water Resource Authority
WSF3D	World Settlement Footprint 3D

Glossary

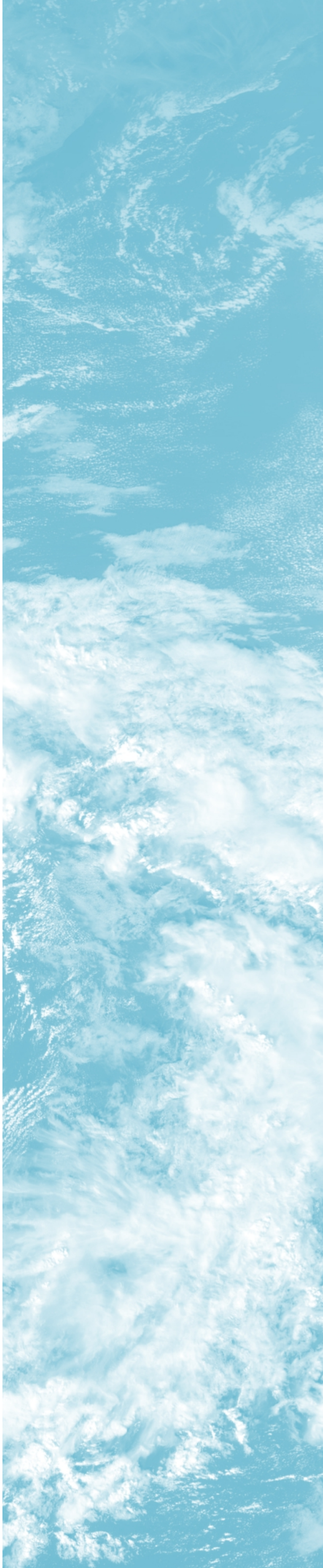
Building typology	The classification of buildings based on their characteristics, such as their function, structure, style, age, or other defined characteristics.
Damage	The destruction of physical assets.
Exposure	The people, property, and systems that could be affected by a disaster including the value of these assets.
Losses	The value of lost production or income.
Needs	The short-, medium-, and long-term needs for reconstruction and recovery.
Replacement cost	The cost to construct or replace an asset with equal quality and construction to its pre-disaster state using pre-disaster prices.
Reconstruction cost	The cost to replicate the asset, at current construction prices, to current construction standards and quality.

Key Statistics for Sri Lanka

Statistic	Value	Source
Gross domestic product (GDP) (2024)	US$98.96 billion	World Bank[1]
Population (2025) est.	21.9 million people	World Bank[2]

[1] https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=LK
[2] ibid.

Contents



Executive Summary

This Global Rapid Post-Disaster Damage Estimation (GRADE) report provides a synopsis of the estimated direct physical damage in Sri Lanka due to the passage of Cyclone Ditwah. The report is based on a rapid and remote post-disaster damage assessment which follows the established GRADE methodology (World Bank, 2018a)[3] and is prepared within a short timeframe to inform early decision-making. It is not intended as a substitute for the detailed, sectoral, on-the-ground analysis which may be conducted in the weeks and months after a disaster.

Cyclone Ditwah passed over the east of Sri Lanka between November 27 and 29 before moving into the Bay of Bengal. Sustained winds of 65 km/h were recorded, and rainfall was intense, causing devastating flooding.

The damage estimates are summarized in Table ES1, and the key findings are summarized below:

1. **Total damage is estimated at US$4.1 billion,** equivalent to approximately 4 percent of Sri Lanka's 2024 gross domestic product (GDP), and 0.48 percent of the estimated capital stock of buildings and infrastructure.
2. **Sri Lanka's 25 districts were all impacted by flooding and extreme rainfall.** Kandy was the worst hit district in terms of estimated damage (US$689 million), which was primarily caused by flooding and to a lesser extent by landslides.
3. **Residential building damage, including contents, accounted for US$985 million,** or 24 percent of the total estimated damage.
4. **Non-residential buildings[4] and contents damage accounted for a total of US$562 million,** or 14 percent of the total estimated damage. Much of the damage was spread across education, health, commercial, and large industrial facilities and factories located along some of the large rivers and creeks which flooded.
5. **Infrastructure[5] damage was estimated at US$1.735 billion,** accounting for approximately 42 percent of the total damage in Sri Lanka, with substantial damage to transport, water, and energy systems. Roads, bridges, railways, and water infrastructure suffered significant damage.
6. **Agricultural[6] damage is estimated at US$814 million,** or nearly 20 percent of the total estimated damage, with notable damage to rice paddies, vegetable crops, subsistence farming, maize, livestock, and agricultural infrastructure as well as some damage to inland fisheries.

---

[3] Global Rapid post-disaster Damage Estimation (GRADE) approach developed at the World Bank and conducted by the Global Practice for Urban, Resilience and Land (GPURL) Disaster-Resilience Analytics & Solutions (D-RAS) Knowledge Silo Breaker (KSB). The methodology aims to address specific damage information needs in the first few weeks after a major disaster.
See: https://www.gfdrr.org/sites/default/files/publication/DRAS_web_04172018.pdf for details of the methodology.

[4] Non-residential buildings includes commercial, tourism, public (including health and education), mixed-used categorized as non-residential, and industrial buildings.

[5] Infrastructure includes power, telecommunications and water networks, and seaports, airports, jetties, coastal structures, roads, bridges and related equipment.

[6] Agriculture including crops and livestock, small-scale agricultural infrastructure such as irrigation networks, and infrastructure related to fisheries sector.

Table ES1: Summary of GRADE estimations of direct damage to physical assets in Sri Lanka from Cyclone Ditwah in November 2025 in US$ millions.

District	Total Residential Damage incl. Contents (US$ mn)	Total Non-Residential Damage incl. Contents (US$ mn)	Total Infrastructure Damage (US$ mn)	Total Agriculture Damage (US$ mn)	Total Damage (US$ mn)
Kandy	210	117	318	44	689
Puttalam	144	67	207	67	486
Badulla	80	42	165	92	379
Kagalle	77	37	176	77	367
Kurunegala	60	30	127	84	302
Gampaha	81	72	108	7	268
Nuwara Eliya	57	39	82	31	209
Ratnapura	45	21	79	35	180
Anuradhapura	29	15	70	57	172
Polonnaruwa	28	15	45	68	155
Colombo	44	37	66	2	149
Trincomalee	14	11	33	60	117
Matale	31	11	52	13	106
Batticaloa	9	4	25	52	90
Ampara	9	5	19	50	84
Vavuniya	12	11	34	19	75
Moneragala	12	4	24	20	61
Kalutara	14	11	20	4	49
Galle	7	3	26	7	42
Matara	5	1	19	3	27
Mannar	5	1	9	8	23
Mallaitivu	5	2	9	5	22
Jaffna	4	3	8	2	17
Hambantota	2		9	2	13
Kilinochchi	2	1	4	4	12
Total	**985**	**562**	**1,735**	**814**	**4,096**

A bespoke exposure model was developed for Sri Lanka as part of this GRADE assessment using established methods (Gunasekera et al., 2015) and building on previous exposure modelling for the country (World Bank, 2016; World Bank, 2018b). Model results indicate a total replacement value of assets and equipment (prior to Cyclone Ditwah) of US$688 billion.[7] This total includes residential and non-residential buildings and their contents, as well as infrastructure assets.

Given the scale and distribution of damages, several critical insights emerge:

- The scale of housing and non-residential damage highlights persistent structural vulnerabilities and the need to "build back better" through more resilient design, improved land use planning, and enhanced flood control structures. As of December 17th, access constraints from damaged roads, railways and power infrastructure continue to hinder response and service restoration, especially with significant landslides in the Central highlands.
- Agriculture damage is expected to deepen rural poverty and food insecurity in already fragile communities.
- Total economic impacts will be significantly higher once indirect losses and the costs of building back better, including improving the resilience of assets, are included.
- There are significant impacts on infrastructure and economic sectors such as transport, energy, water, and tourism which will need focused resilient recovery plans.
- The event will likely intensify gender and social inequalities, with women, girls, and female-headed households facing heightened exposure to health risks, unpaid care burdens, limited access to essential services, and increased risks of gender-based violence.
- The social vulnerability analysis highlights the districts of Badulla, Nuwara Eliya, Kandy, Kegalle, and Puttalam as facing some of the highest housing losses, and coincidentally, having relatively high rates of multidimensional poverty.[8] This may result in long recovery trajectories for the affected households.

The GRADE assessment should be interpreted only as an initial, early estimation of direct damage in selected sectors, albeit with a significant degree of reliability. The GRADE estimates provide the Government and its stakeholders with an early quantification and spatial distribution of damages to inform immediate response actions and more detailed post-disaster recovery planning and identification of potential funding sources, including the use of Contingent Emergency Response Components (CERCs) and possible Crisis Response Window (CRW) supported operations. However, the GRADE outputs are still estimates, based on remote-based calculations that are influenced by, and should be updated with, available ground-based data. While there is confidence in the overall damage estimates and distribution of damage, the confidence level at the individual asset level is low. Results are therefore presented at the district level and at an aggregated sector level. Furthermore, this GRADE assessment calculates only the replacement costs and does not include the costs of building back better. It does not estimate economic losses or the broader and longer-term recovery and reconstruction needs, that are also crucial for a comprehensive understanding of the impact of the disaster.

[7] The total replacement value is defined as the physical assets, property, and systems that could be affected by a disaster.
[8] Multidimensional poverty is determined by lack of sufficient access to education (e.g., not completing the compulsory level of schooling), health (e.g., chronic illness), and living standards (e.g., sanitation facility is shared with other households).

1.0 Introduction

The objective of this report is to provide an estimate of the direct physical damage caused by Cyclone Ditwah in November 2025 in Sri Lanka. The assessment provides information on the spatial and sectoral distribution of damage to help calibrate other damage estimates and support the development of a roadmap for recovery and reconstruction.

1.1 Context

Sri Lanka is an island nation located in the northern Indian Ocean, less than 100 kilometers to the south of India, covering about 65,610 km^2 and administered through 25 districts organized into nine provinces. The country's total population is approximately 21.9 million, as of 2024. In terms of development, Sri Lanka is classified as a country with high human development, with a Human Development Index (HDI) of 0.776 (United Nations Development Programme (UNDP), 2025). The 2021 Sri Lanka poverty rate (against the National Poverty Line) is estimated at 14.3 percent.[9]

Sri Lanka's exposure to natural hazards is high with seasonal rainfall causing flooding and landslides. The country also faces risks from tropical cyclones which cause high winds, excessive rainfall, and storm surges. The majority of the population and economic activity are located in low-lying, flood-prone areas, including the largest city, Colombo.

1.2 Summary of historical disasters

Sri Lanka's flood history, as reflected in the table below, shows a long and continuous pattern of flooding caused by a combination of cyclone-related flooding, monsoon rains, and flash flood events. Sri Lanka has experienced flood-related damage every year over the past 40 years, with impacts ranging from localized minor floods to nationwide disasters.

Major meteorological and flooding events between 1936 and 2024 for which data are available are presented in Table 1, with detailed descriptions provided in Annex 1.

[9] When other poverty metrics are used, there are different estimated poverty rates, e.g.,. https://openknowledge.worldbank.org/server/api/core/bitstreams/78f84883-fb3b-4f73-bb42-1b124aaf39bc/content

Table 1: *Summary of selected recent historical disasters in Sri Lanka.*

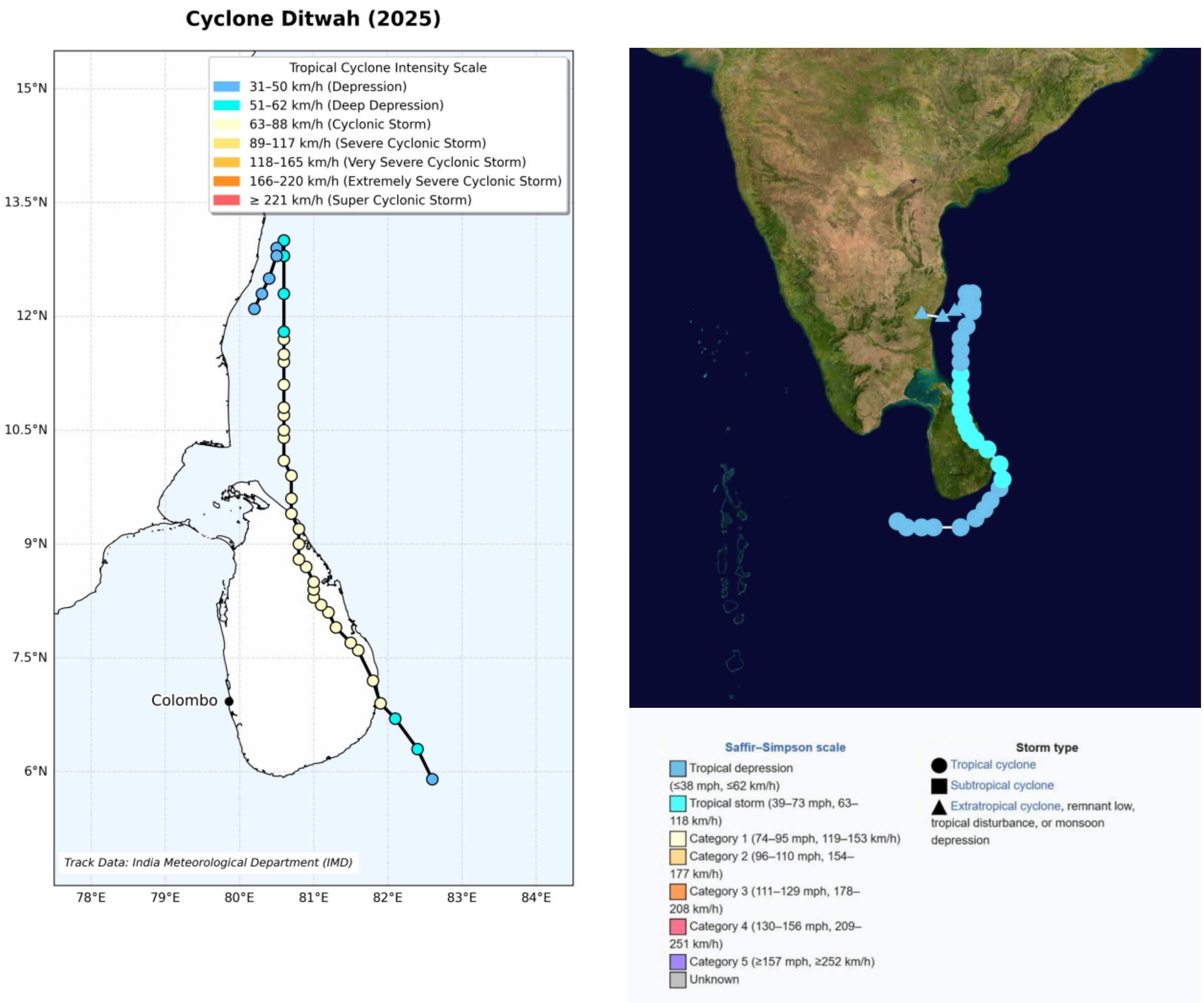
Year/Period	Event	Reported Financial Impact in US$ (at time of event)	Damaged/ Destroyed Buildings	Deaths	Other Impacts
May/June 2024	Floods		12,000+ damaged	42	20 districts affected; ~800,000 people affected
2022–2023	Minor Floods		200+ damaged	6+	
May/June 2021	Floods & Landslides		800+ destroyed	35	
Year 2020	Floods & Landslides		50 destroyed; 2,148 damaged	6	44,848 people affected
Sept. 2019	Floods & Landslides		282 destroyed	29	13 districts; 116,000 people affected
May 2018	Floods & Landslides		105 destroyed; 4,832 damaged		~400,000 people affected
May 2017	Floods & Landslides	$398 million (incl. ~$190 million housing) + $70.2 million losses	3,008 destroyed; 74,301 damaged	224	15 districts affected
May-16	Floods & Landslides	$600.2 million (incl. ~$400 million housing) + $123.2 million losses	6,382 destroyed; 52,543 damaged	93 (117 missing)	24 districts affected
Oct. 2014	Floods & Landslides			95	
2013	Floods & Landslides			110	
Oct. 2012	Cyclone-related Flood	$57 million		75	~500,000 people affected
2011	Floods & Landslides	$500 million		65	1,206,000 people affected
Nov. 2010	Floods		11 destroyed; 257 damaged	1	164,000 people affected; Colombo impacted
May 2010	Floods & Landslides	$105 million		28	606,000 people affected
2009	Minor Floods			3	
Nov. 2008	Cyclone Nisha			15	100,000+ people affected
2007	Major Flooding			33	400,000 people affected

Monsoon 2006	Major Flooding			25	333,000 people affected
2003	Major Flooding	$135 million	24,750 destroyed; 32,426 damaged	246	
Dec. 2000	Floods & Landslides		83,000++ damaged	17	
June 1992	Floods	$250 million		14	250,000 people affected
June 1991	Floods	$30 million		27	297,000 people affected
Nov. 1978	Cyclone		250,000+ destroyed	915	90% coconut crop lost; ~28,000 of 31,500 acres destroyed; 240 schools, 11 paddy granaries, 130 miles of electric cables destroyed; 1/5 fishing fleet lost
May 1965	Rameswaram Cyclone	200 million Rs (approximately US$42 million)		600+	
Dec. 1957	Floods			200+	300,000+ people affected
Aug. 1947	Gambola Floods	Severe hill-country flooding; Mahaweli & Gelioya overflowed; transport links severed.			
1936	Floods	Significant flooding reported			

2.0 Event Description

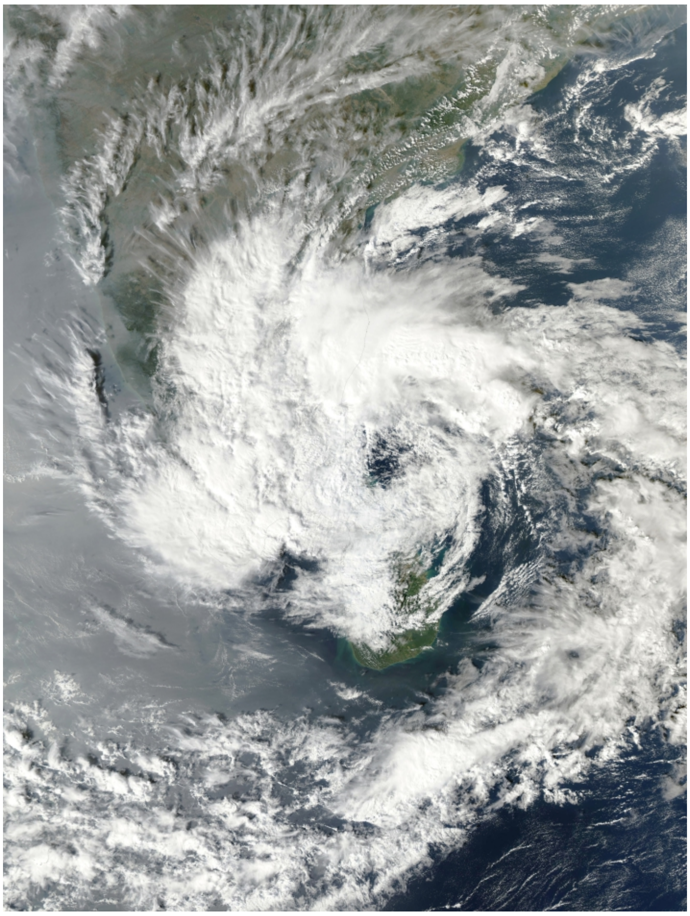
On November 26, 2025, the Indian Meteorological Department (IMD) identified and started tracking a depression just to the southwest of Sri Lanka. The system continued to intensify and by 06.00 UTC on November 27, 2025, it was classified as a Cyclonic Storm and named Cyclone Ditwah. Cyclone Ditwah further intensified, moving in a northeasterly direction and passing over Sri Lanka into the Bay of Bengal on November 29, 2025. Maximum wind speeds between 65 and 90 km/h were reported. Torrential rainfall was widespread, with a maximum recorded rainfall of over 300 mm in 24 hours in Vavuniya and Mullaitivu. The excess rainfall and flooding triggered landslides in the mountainous areas.

Figure 1: *Track of Cyclone Ditwah.*



Source: https://en.wikipedia.org/wiki/Cyclone_Ditwah#/media/File:Ditwah_2025_path.png

Figure 2: *Satellite imagery of the eye of Cyclone Ditwah over Sri Lanka on November 28, 2025.*



Source: NASA available at: https://commons.wikimedia.org/wiki/File:Ditwah_2025-11-29_0905Z.jpg

2.1 Reported impacts

As further context for the event, the following section summarizes the impacts of the cyclone as reported by different agencies and actors. In the highlands in central Sri Lanka, areas within Nuwara Eliya, Badulla, and Kegalle Districts experienced torrential rainfall, triggering landslides, isolating rural communities and damaging access roads (UNDP, 2025). Flooding occurred in all districts.

Early estimates suggested the number of landslides was in the thousands (UNDP, 2025). The highest number of landslides was in the Ududumbara Divisional Secretariat in Kandy District which registered 135 landslides. Laggala (Matale District), Kothmale East (Nuwara Eliya District), and Lunugala and Passara (Badulla District) each registered over 60 landslides each (UNDP, 2025a).

Reports from December 12 suggested that nearly 1.6 million people were affected by Cyclone Ditwah, around 7 percent of the national population of Sri Lanka (DMC, 2025); however, this number varies between sources. The worst affected districts by people affected are Colombo and Puttalam. As of December 11, the Disaster Management Center's (DMC) reported 640 fatalities and 211 missing (DMC, 2025).

Damage to residential structures is extensive. Over 6,000 homes were reported as fully damaged, with a further 112,000 reported as partially damaged. Kandy and Puttalam districts reported the most damage with more than 2,000 and 627 fully damaged, respectively, and 14,111 and 20,813, partially damaged, respectively (DMC, 2025).

Infrastructure systems have also been severely impacted. The transport sector has been hit particularly hard. Approximately 247 km of A- and B- roads[10] were reported as damaged by flooding, with 40 road bridges destroyed. Many more local roads and private roads were affected, as well as many bridges (News.lk, 2025a).

Seventy percent of the railway networks were reported as unusable. A smaller share of lines sustained physical damage, and within those, some sections were significantly damaged. The General Manager of Railways estimated the damage in the hundreds of millions of dollars (Newswire, 2025).

Education infrastructure was also badly affected, with over 1,000 schools reported damaged by the Ministry of Education (Adaderana, 2025). The preliminary estimate for damage to the Peradeniya University is reported by the university as at least Rs. 3 billion (US$ 9.7 million). **Notable impacts were reported to health clinics and hospitals, including flooding damage to over 100 small hospitals,** and three larger hospitals (Daily Mirror, 2025).

The water networks were reportedly substantially damaged, with 156 supply systems out of 342 completely broken, and a further seven difficult to access. Restoration works were reportedly progressing rapidly.

The agriculture sector employs nearly 30 percent of Sri Lankans, primarily in the production of rice. Vegetables, maize, subsistence farming and cash crops were also significantly affected. At least 100,000 hectares of paddy were destroyed, with 150,000 hectares also affected/damaged. The Department of Animal Husbandry and Health reported that tens of thousands of heads of livestock (e.g. cattle, buffaloes, goats and pigs) have perished (Economy Next, 2025). Additionally, media outlets reported nearly three million chickens have perished (Gossip Lanka News, 2025a).

Telecommunications networks were impacted by landslides and power outages but were reported restored within days (Ministry of Digital Economy, 2025). The **electricity network** was also impacted with around 55 percent of customers losing connection; however, restoration was reported to be fairly rapid (news.lk, 2025b).

The impact on cultural heritage assets was significant, with around 855 sites across 19 districts reported to have incurred damage (Gossip Lanka News, 2025b).

[10] A and B roads are primary national highways managed by the Road Development Authority, with **A-roads** being major trunk routes connecting large areas and **B-roads** serving as distributor roads connecting smaller towns and feeding into A-roads.

3.0 Direct Damage Estimation Methodology

The GRADE methodology adopted here is a rapid, first-order approximation that provides a rapid, high-level estimate of damage to physical assets.

The GRADE methodology was conducted in four stages:

1. Data collection, monitoring, and checking;
2. Risk modelling and initial characterization;
3. Comparison with damage estimates for historical events;
4. Calibration, model updating, cross-checking, and validation.

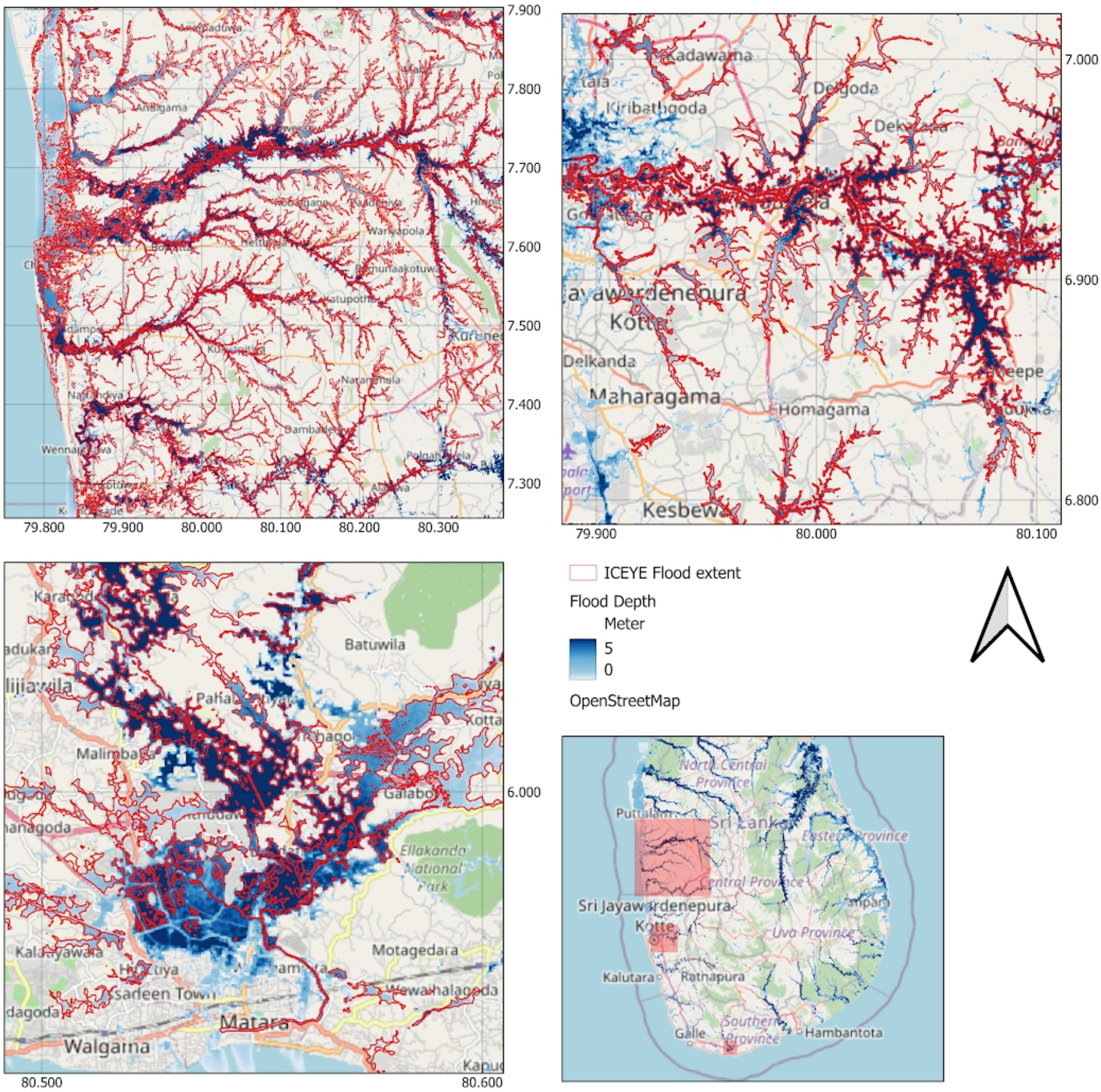
While GRADE provide robust estimation of damage at the aggregate level, there are many assumptions and uncertainties within the methodology driven by the inherent complex nature of disasters, and in this case the layering of hazards including rainfall, flooding, wind, and landslides. There are numerous sources of uncertainty, some of which are discussed in detail in World Bank (2025b). These uncertainties include how assets respond to the different perils, and their economic values. The GRADE methodology does not have a stated margin of error, as it is a rapid assessment tool and not a statistical survey. Instead, its accuracy depends on the data available at the time of assessment. Its strength lies in providing a quick, initial estimate, but the accuracy can vary depending on factors like the resolution of available satellite imagery, the specific characteristics of the disaster, and the complexity of the affected area. Annex 2 provides an extensive list of data sources used during the assessment.

3.1 Development of Hazard Model

A preliminary flood model was developed using ensemble precipitation forecasts, satellite-derived rainfall estimates, and hydrodynamic simulation. This supported the development of an initial reconstruction of the spatial extent and depth of inundation (Figure 4). Flood extents, depths, and velocities were modelled and compared with remote sensing imagery to examine the extents of inundation. ICEYE[11] created an approximate satellite data flood footprint in conjunction with social media modelling and adaption of the flood footprint, which was updated 10 times as more data was received and analyzed. Modelling of flood depth at the resolution and scale required to support detailed contingency planning is not possible within the GRADE timelines. Annex 4 gives a more detailed description of the methodology used to develop the flood hazard model.

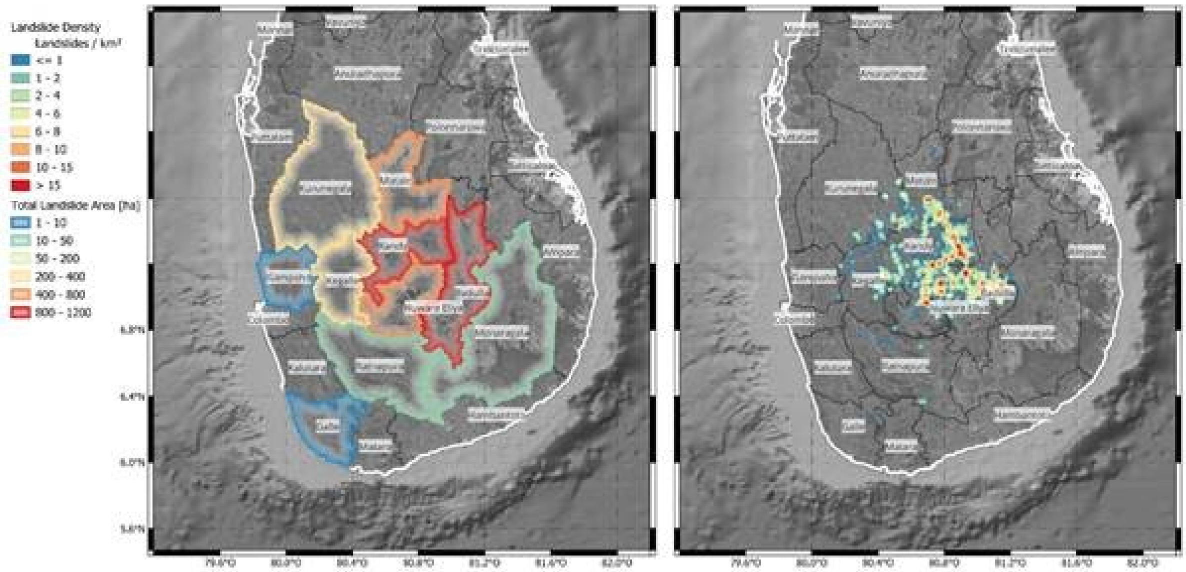
[11] https://www.iceye.com/

Figure 3: *Preliminary flood map for Cyclone Ditwah in Sri Lanka at 20-meter resolution, including hydrodynamic modelling. Red indicates ICEYE modelling with the blue indicating one version of the hydrodynamic modelling.*



An aggregation of the landslide data from the National Building Research Organization (NBRO) and other sources was also undertaken. Landslide and debris flow footprints were identified using red-green-blue (RGB) imagery of the Sentinel-2 L2A satellite which was acquired immediately before and after the cyclone impact. Cloud- and shadow-masked images were co-registered, and short temporal composites were used in parallel to minimize cloud contamination typical of tropical conditions in Sri Lanka. Overall, satellite imagery from November 30 to December 7 was used to achieve as much spatial completeness as possible. Sentinel-2 L2A provides a pixel resolution of 10m, which is sufficient to detect most large-scale ground movements. A more detailed description of the methodology can be found in Annex 3.

Figure 4: *Left Map of total landslide affected area by district (admin-level 2) in hectares (ha). Right: Map of landslide density as a heatmap showing landslides per km^2.*



3.2 Development of the Exposure and Vulnerability Models

The development of an exposure model, which encompasses the total capital stock in the country, was also completed using the methodology developed by Gunasekera et al. (2015). The methodology draws on census and living condition surveys, global exposure datasets, and other government sources. Where data were out of date, updates and projections were included to achieve a current exposure model. For example the global pandemic and economic crisis led to a considerable increase in replacement costs, resulting in a significant rise in exposure values. Impact of disaster on agriculture yield is not estimated by GRADE as damage estimates are assessed through reported data rather than through modelling approaches. Definitions of the assets included in each aggregated sector are given in .

Figure 5: *Definitions of the aggregated sectors assessed in GRADE.*

Residential	Non-Residential	Infrastructure	Agriculture
Houses and mixed-use characterized as residential, and contents	Commercial, tourism, public (including health facilities and education), mixed-use categorized as non-residential, and industrial buildings, and contents	Power networks, telecommunications networks, water networks, seaports, jetties, coastal structures, airports, roads, bridges, equipment	Crops, livestock, dairy, small-scale infrastructure, fisheries infrastructure

The exposure values representing the replacement cost estimates of built assets, including the values of contents, are presented in Table 2 and Table 6. Different typologies of residential and non-residential structures were used with unit costs of construction (UCCs) broken down by story height and typology. Brick and cement block are the most common typologies in Sri Lanka with kabook (laterite) also being a common building material.

The total exposure value of buildings and infrastructure across all of Sri Lanka is estimated to be US$688 billion. The majority of assets are located in the districts of Colombo, Gampaha, and Kalutara, where over 40 percent of the stock is present. It is important to note that the residential unit costs of construction (UCCs) differ significantly, ranging from US$130 per square meter for tin/metal and light materials to over US$900 per square meter for taller structures constructed with reinforced concrete. Similarly, non-residential structures show a large difference in UCCs. Finishings and location also play a significant role in the UCCs, as well as the current cost of materials.

Figure 6: *Exposure map by district and aggregated sector for Sri Lanka.*

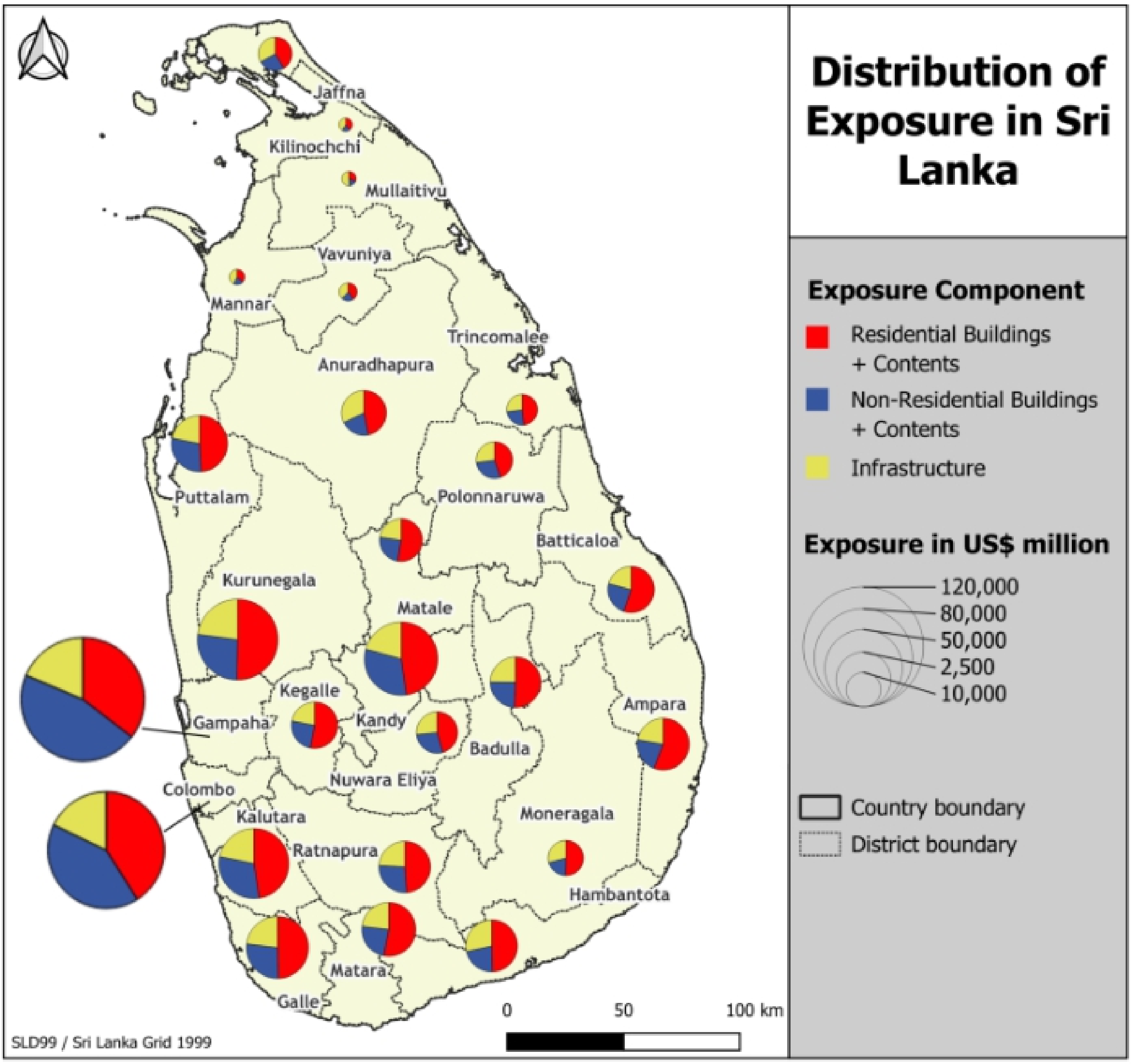


Table 2: *2025 exposure values calculated for Sri Lanka in US$ millions.*

District	Total Residential Exposure incl. Contents (US$ mn)	Total Non-Residential Exposure incl. Contents (US$ mn)	Total Infrastructure Exposure (US$ mn)	Total Exposure (US$ mn)
Colombo	49,773	49,813	21,590	121,176
Gampaha	45,393	58,912	23,790	128,095
Kalutara	19,408	12,461	8,823	40,692
Kandy	21,360	14,074	9,260	44,695
Matale	7,991	3,746	3,471	15,209
Nuwara Eliya	6,466	4,008	3,768	14,243
Galle	16,005	8,793	7,450	32,248
Matara	12,808	5,772	5,593	24,173
Hambantota	11,118	4,896	6,387	22,401
Jaffna	3,922	2,387	3,131	9,440
Mannar	701	406	830	1,937
Vavuniya	1,099	605	1,038	2,742
Mallaitivu	543	302	868	1,713
Kilinochchi	591	279	619	1,489
Batticaloa	9,871	4,312	3,710	17,893
Ampara	12,534	4,916	4,985	22,435
Trincomalee	3,848	1,965	2,151	7,964
Karunegala	27,200	14,551	12,365	54,117
Puttalam	12,919	7,654	5,703	26,277
Anuradhapura	7,890	3,532	5,422	16,844
Polonnaruwa	4,975	3,142	3,014	11,130
Badulla	10,821	5,227	5,311	21,359
Moneragala	5,244	2,137	3,036	10,417
Ratnapura	10,766	5,957	5,292	22,015
Kagalle	9,436	4,466	3,925	17,828
Total	**312,684**	**224,312**	**151,534**	**688,530**

Vulnerability was modelled based on the construction type of the assets and the level of flooding, with flood-ed zone scalings based on rainfall analysis and damage data. Estimated damage in the housing sector was derived using knowledge of the replacement value of the housing stock in the affected region. Analysis of vulnerability was conducted based on detailed assessment information from previous events, as well as comparable typologies from comparable countries in the region. This analysis supported the derivation of damage ratios for different construction typologies. The non-residential building sector impacts were also examined, consistent with previous Post-Disaster Needs Assessments (PDNA) and similar studies for nearby countries.

Infrastructure modeling was undertaken for power, transport, ICT, and water, using a hybrid approach, with data from flood sectoral damage assessments around the world used to develop model inputs. Districts of Colombo and Gampaha has the highest value of infrastructure assets totaling almost 30% of the country's infrastructure value.

For the agriculture sector, the direct damage estimates were evaluated using reported data on damaged crops, livestock and other information from the Ministry of Agriculture, the Food and Agriculture Organisation (FAO) of the United Nations, global gridded crop distribution/production datasets (CROPGRIDS), the Project for On-Board Autonomy - Vegetation (PROBA-V), and other sources. Current costs for different livestock such as broiler chickens, eggs and cattle were taken from market and farm prices recorded over the last year in Sri Lanka.

An overview of the GRADE approach and datasets used in the assessment, and a general schematic flowchart of disaster modeling using the GRADE approach, are shown in Figure 7 and Figure 8, respectively. Additional details of datasets used can be found in Annex 2.

Figure 7: *Overview of the GRADE approach and datasets used in an assessment.*

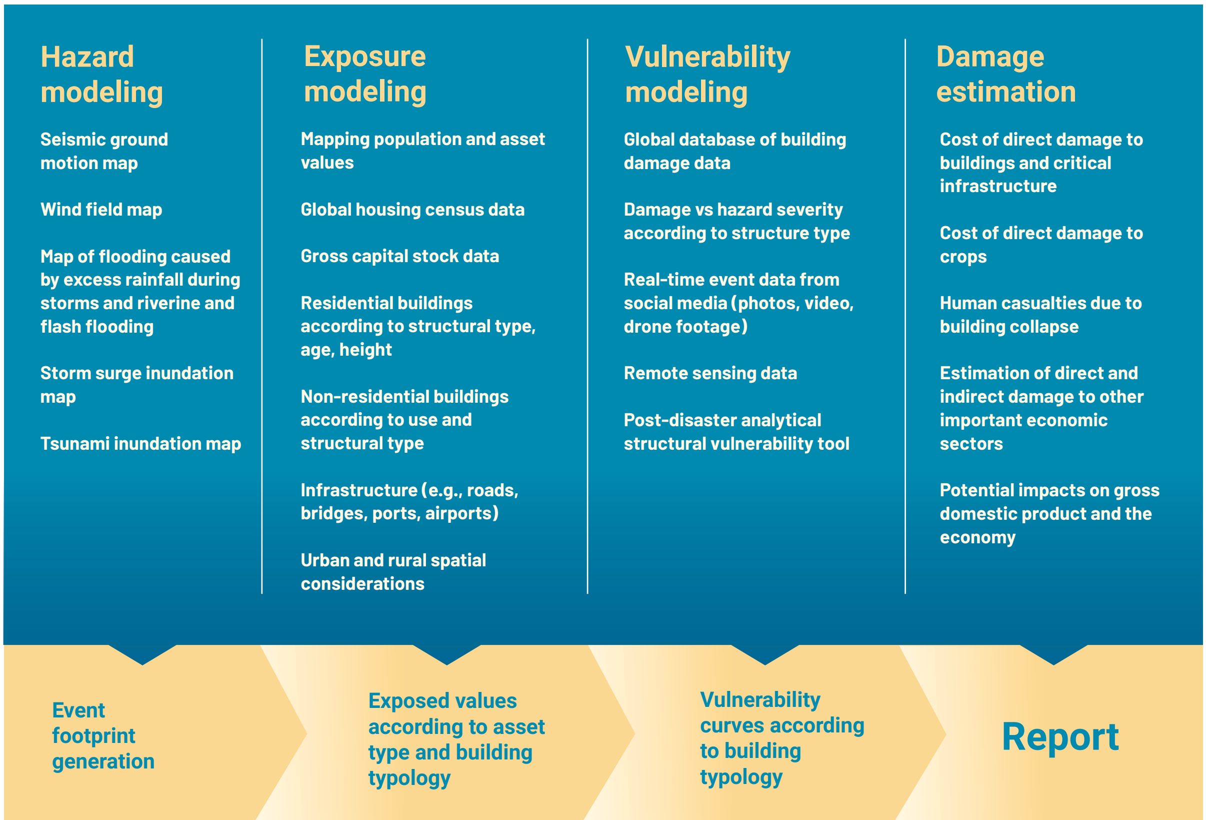
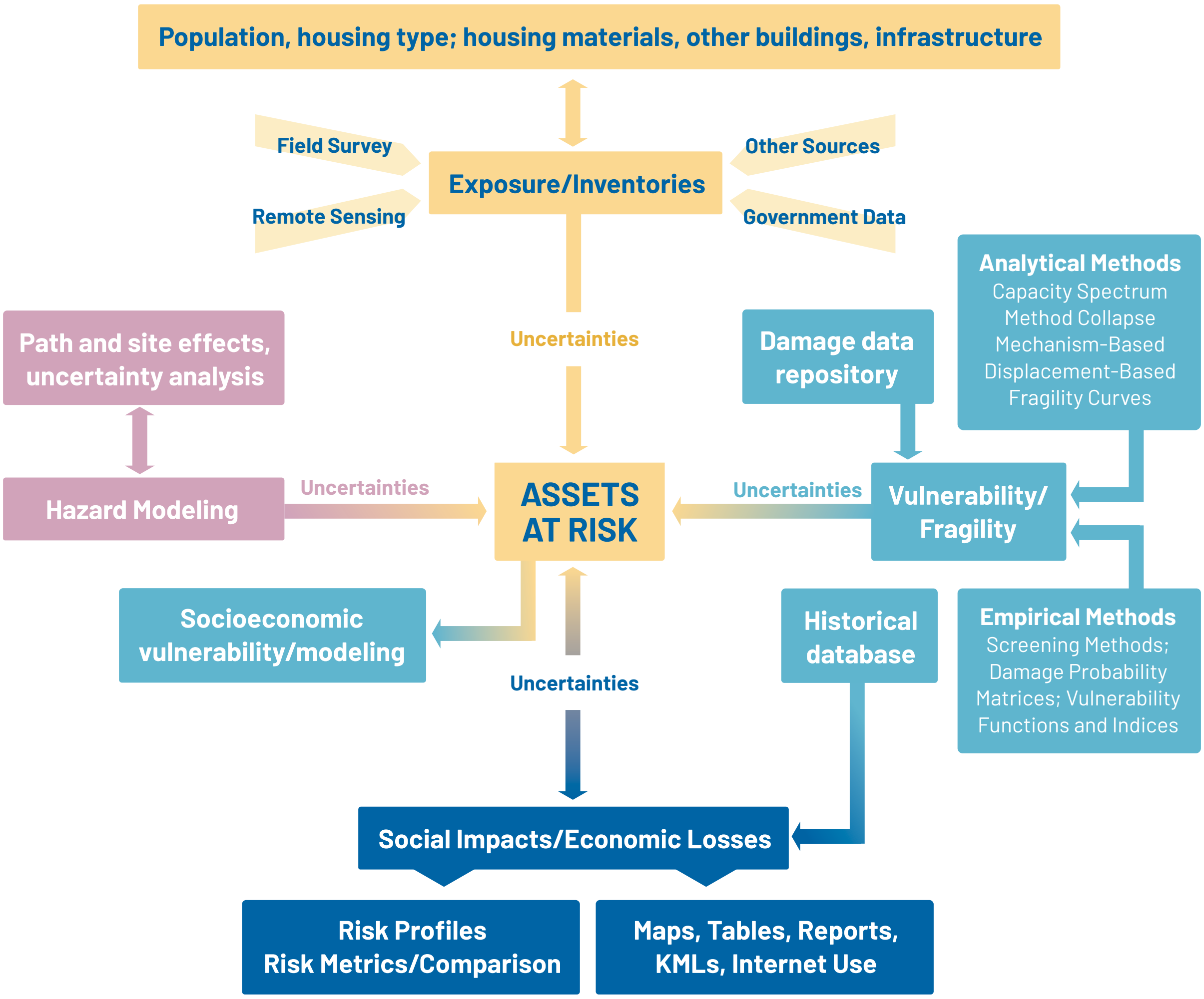


Figure 8: *Schematic flowchart of disaster modeling using the GRADE approach.*



Validation and calibration against reported damage data are then carefully completed. Modelled results are cross-checked across multiple sources (Annex 2) and damage estimates are monitored over time until the estimates stabilize. Reported damage statistics and datasets, remote sensing and satellite imagery, local media reports, social media posts, as well as freely available videos and damage statistics, which provide snapshots of damage for specific areas, were used as checks throughout the impacted areas. This iterative and lengthy calibration process refines the quantification of estimated damages and reduces uncertainty. In this case, multiple other studies also include remote sensing data products.

4.0 Results

Total damage is substantial at an estimated US$4.1 billion, equivalent to 4 percent of the 2024 GDP. Table 3 shows the best estimate of total direct physical damage caused by Cyclone Ditwah by sector and district. Table 4 presents the relative damage by district and sector compared to the total capital stock or total exposed value (TEV) for each district and sector. Table 4 therefore can be useful for recovery planning and prioritization. Agricultural exposure is not calculated. Figures 9 to 13 present the results in map format.

Overall, building damage (including contents) accounted for over 37 percent of the total damage. Residential building damage is estimated to be US$985 million including structural damage and damage to contents. Non-residential building damage, including social infrastructure, tourism resorts and hotels, public buildings including health and education facilities, industrial, and commercial assets, is estimated at US$562 million. The categorization of mixed-use buildings presents challenges, but these were distributed between residential and non-residential categories using the best available data and information.

Infrastructure was comparatively the worst hit in terms of percentage of the total exposed value[12] with an estimated 1.1 percent of infrastructure capital lost at a value of US$1.735 billion or 42 percent of the capital damage. Key sectors damaged included power networks, telecommunications assets, water networks, and transport, including airports, roads, and coastal infrastructure.

[12] N.B. Agricultural assets are not included in this comparison as agricultural exposure is not calculated.

Table 3: *Total damage calculated for Sri Lanka from the effects of Cyclone Ditwah in US$ millions by aggregated sectors and district.*

District	Total Residential Damage incl. Contents (US$ mn)	Total Non-Residential Damage incl. Contents (US$ mn)	Total Infrastructure Damage (US$ mn)	Total Agriculture Damage (US$ mn)	Total Damage (US$ mn)
Kandy	210	117	318	44	689
Puttalam	144	67	207	67	486
Badulla	80	42	165	92	379
Kagalle	77	37	176	77	367
Kurunegala	60	30	127	84	302
Gampaha	81	72	108	7	268
Nuwara Eliya	57	39	82	31	209
Ratnapura	45	21	79	35	180
Anuradhapura	29	15	70	57	172
Polonnaruwa	28	15	45	68	155
Colombo	44	37	66	2	149
Trincomalee	14	11	33	60	117
Matale	31	11	52	13	106
Batticaloa	9	4	25	52	90
Ampara	9	5	19	50	84
Vavuniya	12	11	34	19	75
Moneragala	12	4	24	20	61
Kalutara	14	11	20	4	49
Galle	7	3	26	7	42
Matara	5	1	19	3	27
Mannar	5	1	9	8	23
Mallaitivu	5	2	9	5	22
Jaffna	4	3	8	2	17
Hambantota	2		9	2	13
Kilinochchi	2	1	4	4	12
Total	**985**	**562**	**1,735**	**814**	**4,096**

Table 4: *Relative damage calculated for Sri Lanka from the effects of Cyclone Ditwah as a percentage of the total exposed value (TEV) by aggregated sectors and district. N.B. Agriculture exposure is not calculated.*

District	Total Residential Damage incl. Contents (as a % of TEV)	Total Non-Residential Damage incl. Contents (as a % of TEV)	Total Infrastructure Damage (as a % of TEV)	Total Damage (as a % of TEV)
Vavuniya	1.12%	1.75%	3.28%	2.08%
Kagalle	0.82%	0.82%	4.50%	1.63%
Puttalam	1.12%	0.88%	3.63%	1.59%
Kandy	0.98%	0.83%	3.44%	1.44%
Badulla	0.74%	0.80%	3.10%	1.34%
Nuwara Eliya	0.88%	0.98%	2.19%	1.25%
Mallaitivu	0.95%	0.79%	1.09%	0.99%
Polonnaruwa	0.56%	0.46%	1.48%	0.78%
Mannar	0.67%	0.36%	1.07%	0.77%
Trincomalee	0.37%	0.56%	1.53%	0.73%
Anuradhapura	0.37%	0.42%	1.30%	0.68%
Ratnapura	0.41%	0.35%	1.50%	0.66%
Matale	0.38%	0.29%	1.50%	0.61%
Kilinochchi	0.40%	0.36%	0.71%	0.52%
Karunegala	0.22%	0.21%	1.03%	0.40%
Moneragala	0.23%	0.19%	0.80%	0.39%
Batticaloa	0.09%	0.09%	0.68%	0.21%
Gampaha	0.18%	0.12%	0.45%	0.20%
Jaffna	0.11%	0.12%	0.26%	0.16%
Ampara	0.08%	0.11%	0.39%	0.15%
Colombo	0.09%	0.08%	0.30%	0.12%
Galle	0.04%	0.04%	0.34%	0.11%
Kalutara	0.07%	0.09%	0.22%	0.11%
Matara	0.04%	0.02%	0.34%	0.10%
Hambantota	0.02%	0.01%	0.13%	0.05%
Total	**0.32%**	**0.25%**	**1.14%**	**0.48%**

Agricultural damage estimates total US$814 million, or around 20 percent of the total damage estimate. This includes crop and livestock damage, and small-scale infrastructure such as irrigation. The damage was caused mostly by flood water and mud, as well as landslides. In the case of some storage facilities, rain intrusion was also recorded as a driver of damage.

Kandy was the worst affected district with US$689 million in damage across all sectors due to extensive flooding and rainfall effects, equal to 17 percent of the total damage. Puttalam and Badulla together account for 21 percent of the total damage. Together, these three districts make up nearly 40 percent of district-level damage.

Figure 9: *Total damage maps by district in US$ millions (top) and by percentage of total exposed value (excluding agriculture) (bottom).*

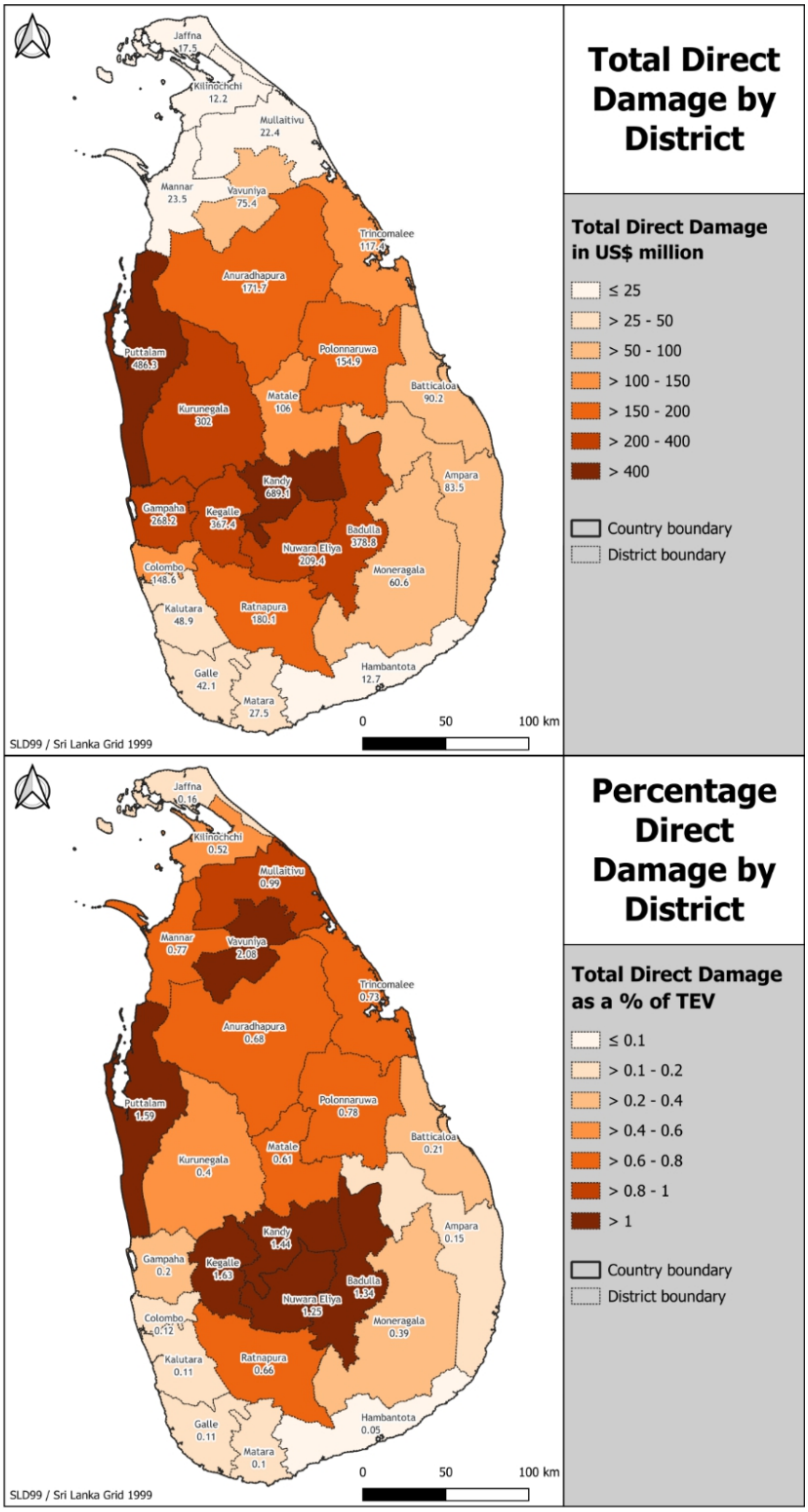


Figure 10: *Residential damage maps by district in US$ millions (top) and by percentage of total exposed value (bottom).*

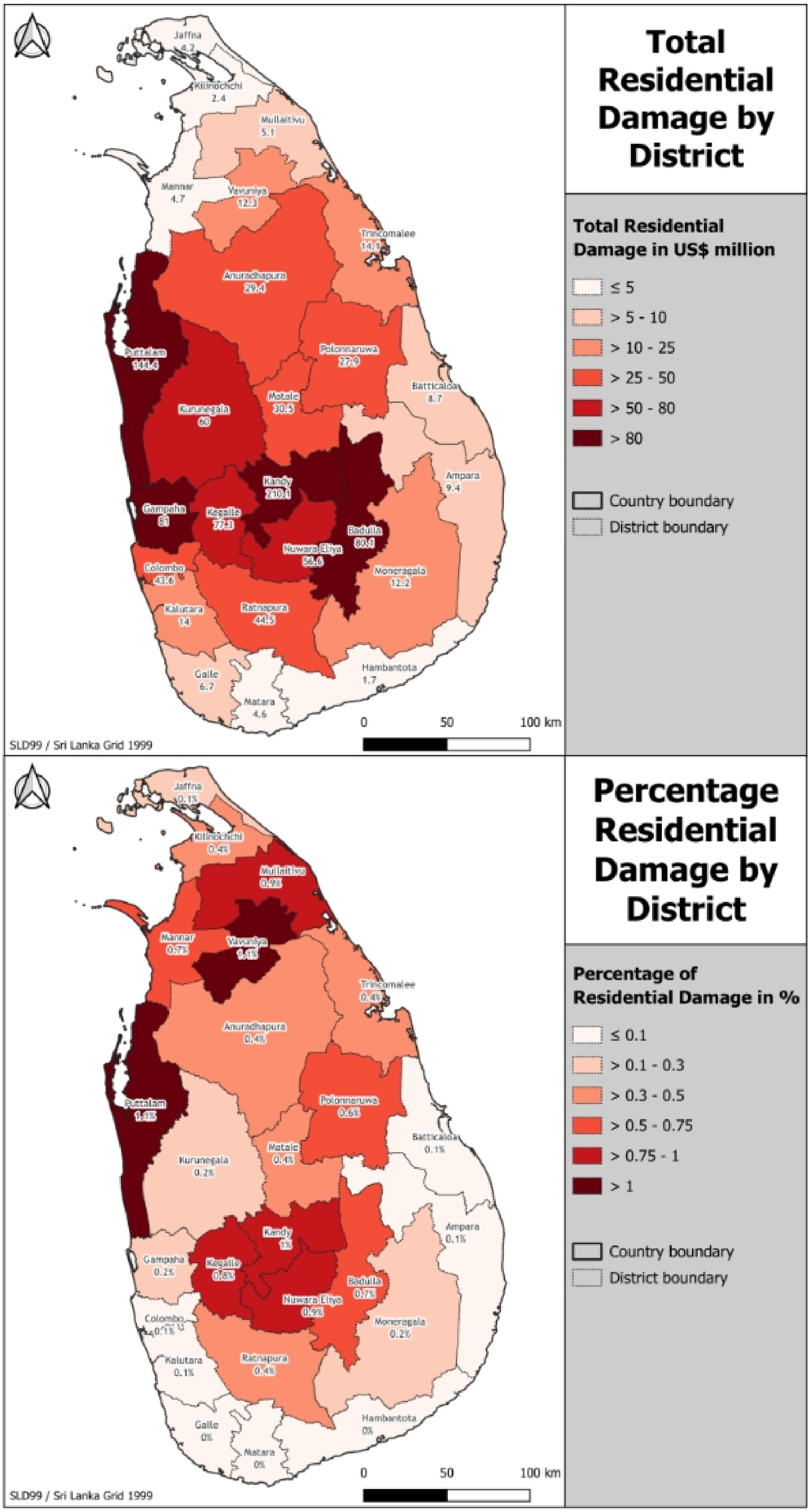


Figure 11: *Non-residential damage maps by district in US$ millions (upper) and by percentage of total exposed value (lower).*

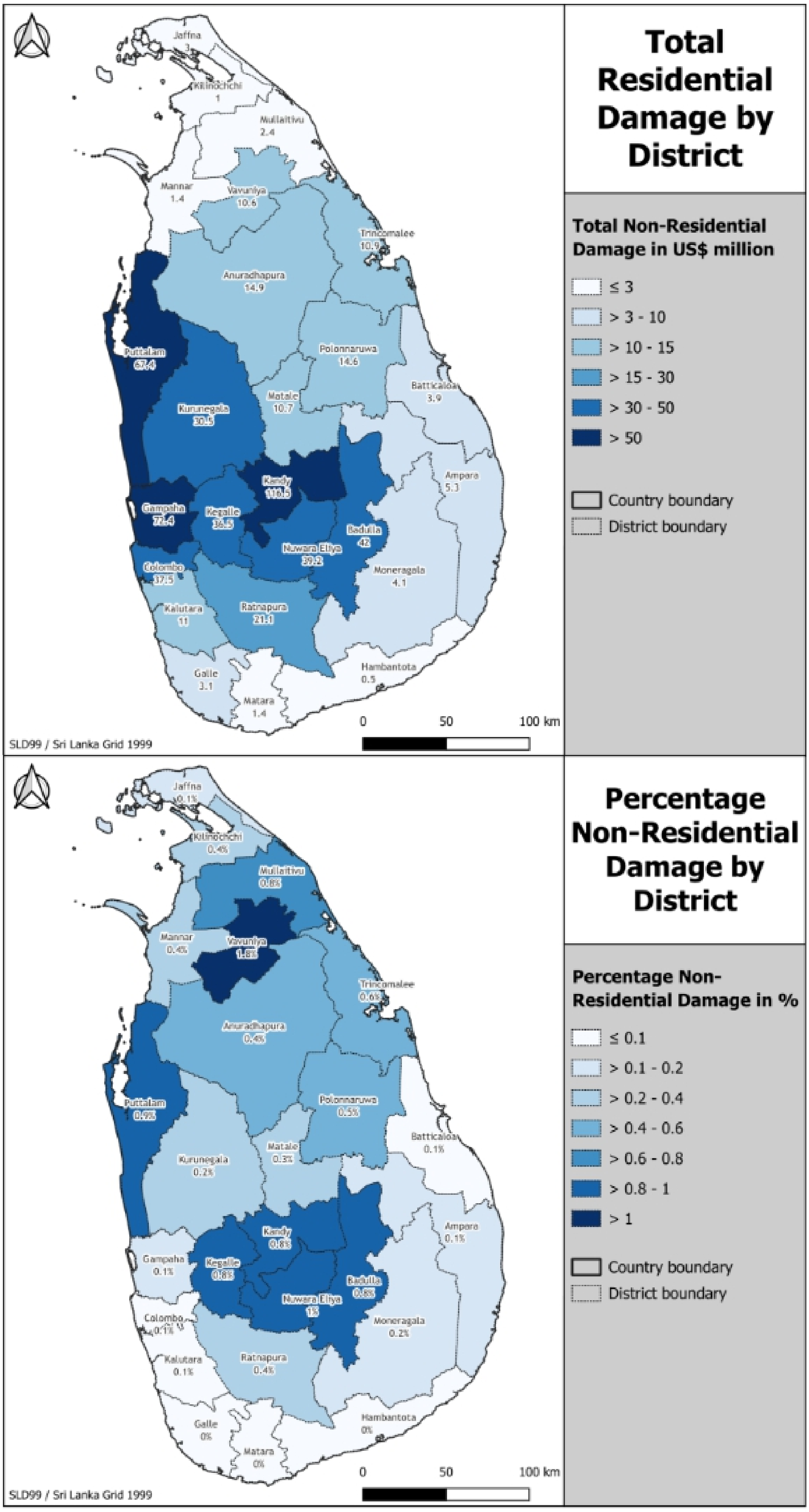


Figure 12: *Infrastructure damage maps by district in US$ millions (upper) and by percentage of total exposed value (lower).*

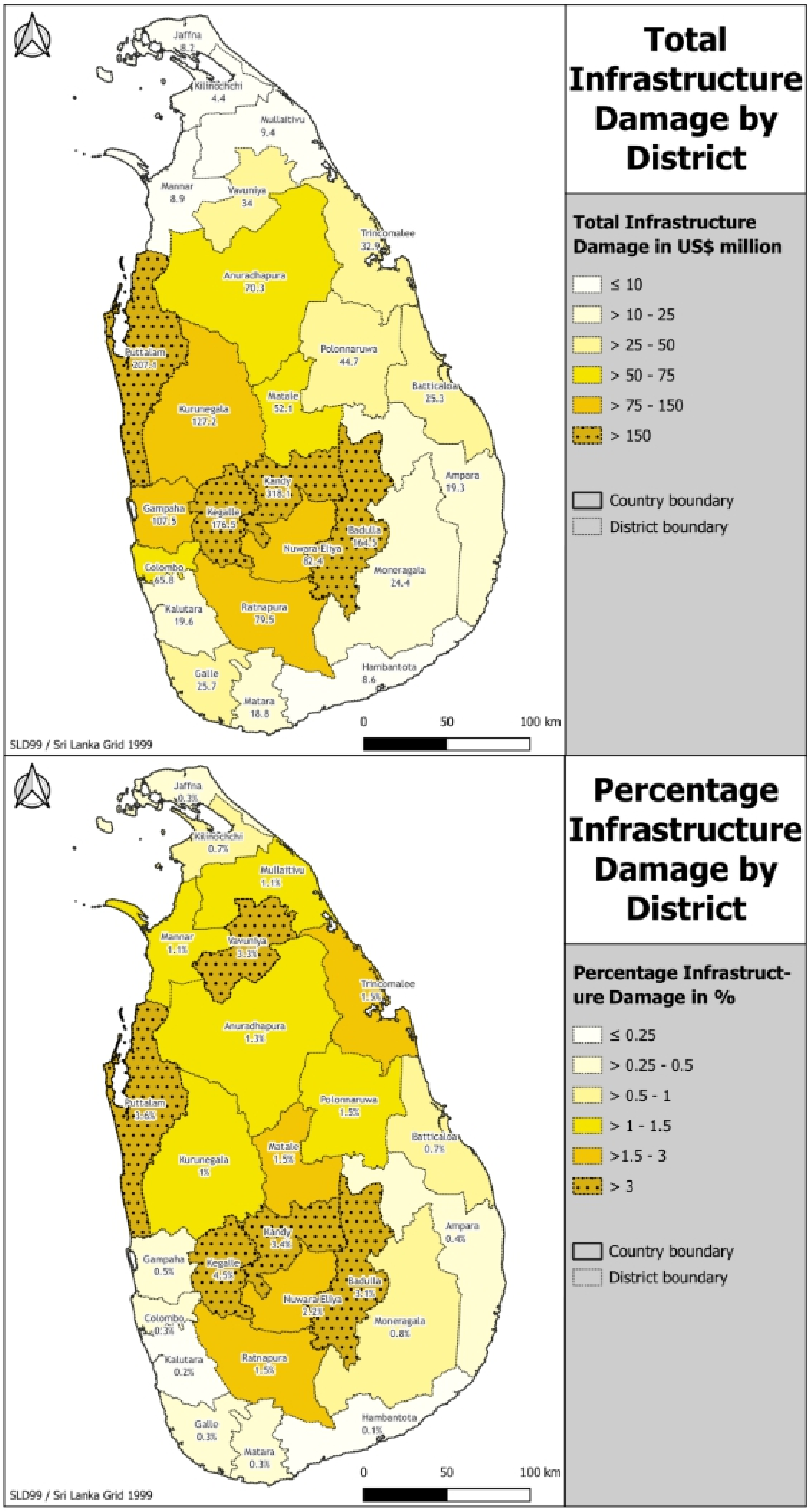
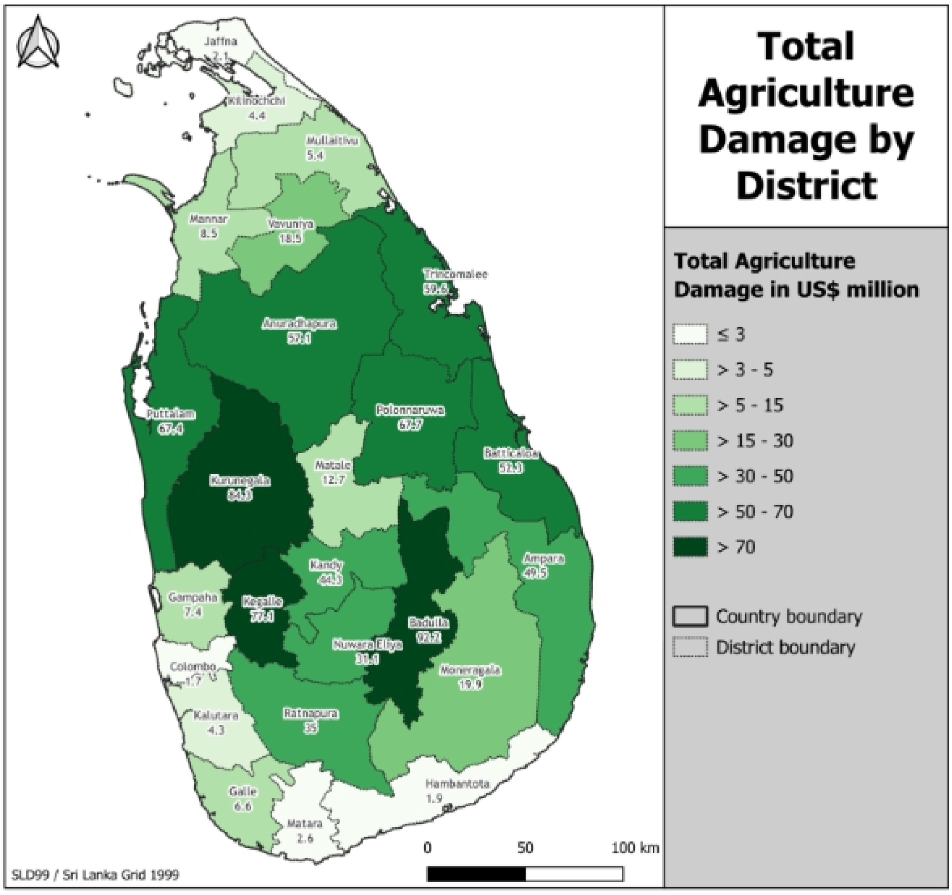


Figure 13: *Agriculture damage maps by district in US$ millions.*



Some districts experienced significant damage while also having a high multidimensional poverty headcount (i.e., Badulla, Nuwara Eliya, and Ratnapura). This combination is likely to make recovery slower and more difficult for the affected households (see section 5 for more details).

5.0 Implications of Results and Conclusions

The GRADE assessment estimates the total cost of direct damage to residential, non-residential, infrastructure, and agriculture sectors in Sri Lanka at US$4.1 billion, equivalent to roughly 4 percent of 2024 GDP. This makes Cyclone Ditwah one of the costliest cyclones to impact Sri Lanka on record.

The August 1947 Gampola floods stand out as a historical hydrological analogue for extreme flooding in Sri Lanka and provide contextual insight for understanding the magnitude and spatial characteristics of 2025 Ditwah flooding. The 1947 event, driven by intense monsoon rainfall, caused the Mahaweli River and its tributary, the Gelioya, to overflow, inundating villages between Peradeniya and Gampola and submerging areas up to several feet above the railway line. Multiple districts were severely affected, including Ratnapura, Kandy, Matale, and parts of Colombo, with Gampola experiencing some of the worst impacts recorded at the time. Similar to the 2025 Ditwah flooding, the 1947 Gampola floods were characterized by rapid river rise, widespread inundation, and severe disruption to transport and livelihoods, particularly in the central highlands. While the 2025 Ditwah event occurred in a more densely populated and economically interconnected Sri Lanka, the 1947 Gampola floods remain comparable in terms of hydrological severity and geographic spread. Looking back at past events is important for planning a more resilient future.

The damage profile of Cyclone Ditwah indicates that post-event recovery cannot be limited to asset replacement at pre-event standards. Observed failure mechanisms point to the need for targeted improvements in transport hydraulic design, bridge scour protection, slope stabilization, dam safety, drainage improvements, sediment management, and infrastructure siting. Incorporating these measures within recovery and reconstruction programs is critical to reducing repeat losses under similar or more extreme future events, particularly in upland and downstream flood-prone systems. In addition, build back better approaches are likely needed with regards to buildings and infrastructure, as well as agricultural assets and irrigation systems. Globally, in past events of similar nature, reconstruction costs of 1.75 to 2.5 times the direct damage have been incurred.

The GRADE assessment focuses on estimating direct physical damages only; economic losses and needs are not assessed here but are expected to be significant. For similar events in the past, the losses and needs have been in the order of 20 to 125 percent of the total direct damage. In particular, infrastructure damage is significant and spatially concentrated along major transport and utility corridors, particularly where assets intersect floodplains, river crossings, and steep upland terrain. The magnitude of infrastructure damage has cascading effects on accessibility, service provision, and sectoral recovery, amplifying indirect impacts. Reconstruction strategies with resilient infrastructure should be a priority.

5.1 Implications for Sectors

Transport infrastructure represents the largest contributor to infrastructure damages. Damage to the road and rail networks includes embankment failure, pavement scour, ballast washout, track deformation, and bridge abutment undermining. Bridge damage is especially critical, as structural failure or load restrictions at river crossings result in network-level disconnection rather than isolated asset damage. The scale of observed damage impacts indicates exceedance of design flood levels, insufficient freeboard at crossings, and limited resilience to debris-laden flows, particularly in the Central Highlands and downstream catchments.

The tourism sector is expected to feel the effects beyond direct damage. The tourism sector in coastal areas and along affected railway sections of Sri Lanka has been particularly hard hit, with large losses expected. For a tourism-dependent economy, prolonged damage to infrastructure, combined with cancelled trips and disruptions, is likely to reduce tourism activity in the short term.

Energy and water infrastructure sustained significant impacts linked to sediment transport and prolonged inundation. Hydropower facilities in upland catchments experienced damage associated with high sediment loads, debris impact, and intake clogging, leading to operational outages and increased maintenance requirements. Water supply systems were affected by widespread mud infiltration, resulting in contamination of treatment facilities and distribution networks. Irrigation channels have also seen major damage. These impacts demonstrate the sensitivity of infrastructure performance to upstream erosion processes and highlight the need to address catchment-scale drivers of sediment mobilization as part of recovery planning. These impacts underscore the need to strengthen critical lifelines, particularly as Sri Lanka accelerates its renewable energy transition.

Agricultural damage is extensive, particularly in rice paddies, maize and mixed vegetable systems, where damage is driven not only by flood depth and duration but also the deposition of mud and sand. Sediment accumulation reduces soil fertility, impairs drainage, and delays replanting, leading to multi-season productivity losses. These impacts are not adequately captured by short-term crop damage estimates and require longer-term soil rehabilitation and land restoration interventions to restore agricultural output, often with significant associated losses. A portion of these impacts are felt directly by smallholders and rural households, making the impacts disproportionately severe. The loss of a substantial number of hectares of farmland, over two million farm animals, and major shares of vegetable, fruit, maize and cash crop production directly undermines the subsistence and market incomes of tens of thousands of farmers in the most heavily affected districts. Food security in the short term may also be a concern.

At the building and community level, mud contamination significantly increases recovery time and cost for residential, commercial, and public facilities. Compared with clean-water flooding, sediment-laden inundation results in greater structural degradation, prolonged uninhabitability, and higher demands for debris removal and sanitation. This disproportionately affects low-income households and small enterprises, where recovery resources are limited and repair timelines are extended. The capital, Colombo, has a high concentration of people and assets and therefore prioritizing urban risk reduction measures will be important to build resilience.

5.2 Gender Implications

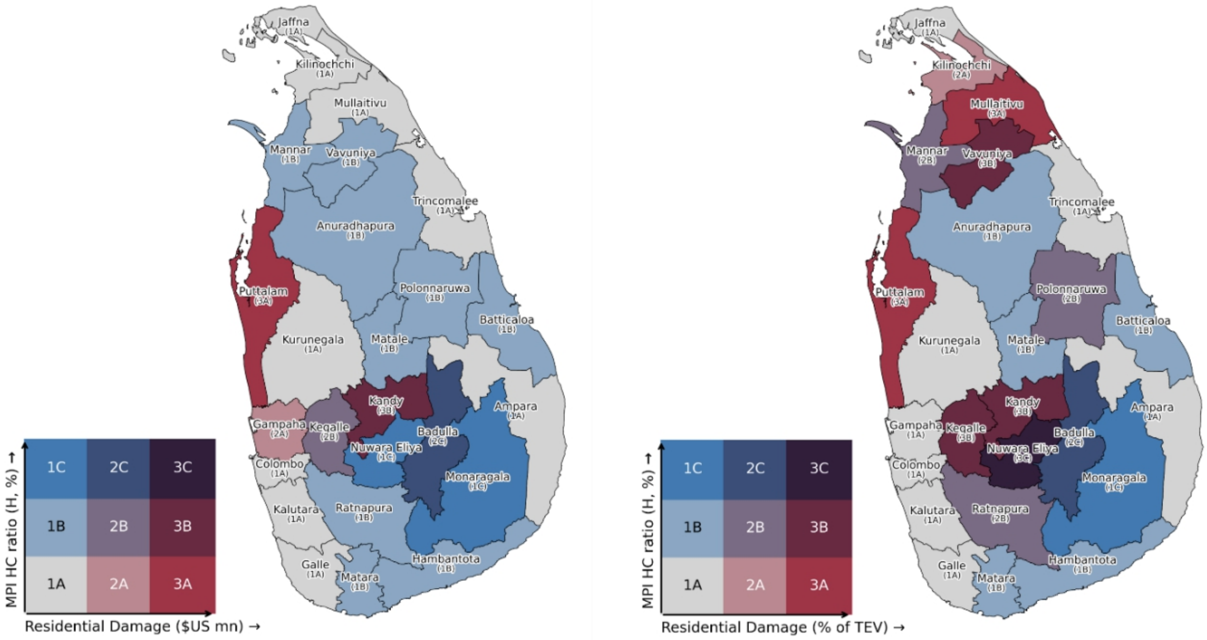
Gendered impacts are visible across affected districts, particularly among women, adolescent girls and female-headed households. The exposed population includes approximately 1.2 million women, 522,000 children and 263,000 older persons (UNDP 2025). Early reports from national women´s organizations indicate disruptions in WASH access, rapid loss of income for women dependent on daily wages, home-based and microenterprise work. Increased indebtedness and negative coping are likely as women turn to high interest borrowing to rebuild homes, buy food, and re-establish livelihoods, on top of existing microfinance burdens (UN Women 2025). Approximately more than 22,500 pregnant women and 520,500 women of reproductive age have been affected by Cyclone Ditwah. With several hospitals and health clinics damaged, many women are left without reliable access to life-saving sexual and reproductive health service, increasing risks of unassisted births, pregnancy complications and unmet family planning needs (UNFPA 2025).

Female headed households also face a disproportionate burden after the destruction or heavy damage to homes as well as severe food insecurity as they struggle to secure rations, leaving them and their children without adequate meals (UN Women 2025). More than 150,000 people are residing in temporary evacuation shelters. Overcrowding, limited lighting, lack of privacy, stress and shared sanitation facilities are heightening gender-based violence risks, particularly for women (UN Women 2025). Under current emergency conditions, pre-existing gender inequalities are likely to compound, increasing the risk of domestic violence, sexual exploitation and bribery, economic insecurity, hunger, and exclusion from humanitarian assistance, particularly for women who are not in formal camps (UN Women 2025).

5.3 Implications on Equity - Social Vulnerability Analysis

Disasters do not affect all people equally. Beyond the visible damage to roads, bridges, and buildings, there is a critical socio-economic dimension: who is hit hardest and how quickly people can recover. This analysis combines information on physical damage with the multi-dimensional poverty indicators (MPI) reported in the 2019 Household Income and Expenditure Survey (HIES), using the district-level MPI headcount ratio (H, %) as a first approximation of socio-economic vulnerability and resilience. Specifically, it examines the share of people in each district living in multidimensional poverty and overlay it with the estimated damage. Figure 14 presents the relationship between residential damage and multidimensional poverty by district. Residential damage is expressed both in absolute monetary terms and in relative terms as a share of total economic value (TEV), and is compared with the MPI headcount ratio. Several districts emerge as critical. Badulla, Nuwara Eliya, Kandy, Kegalle, and Puttalam show relatively large residential damages in absolute terms or as a share of TEV alongside sizeable MPI headcount ratios. In these districts, many households were already multidimensionally poor before the disaster and now face some of the highest housing losses, which can translate into long and difficult recovery trajectories. Districts such as Monaragala, Mannar, and Mullaitivu record more modest residential losses but have comparatively high poverty rates (over 25 percent in Mannar and around one-third in Monaragala). In such contexts, even medium-scale damage can push already vulnerable households into prolonged hardship. By contrast, Colombo and Gampaha incur considerable residential damage in absolute terms but have relatively low MPI headcount ratios (3.5 and 5.1 percent, respectively). While the physical losses there are large and must be addressed, the average household in these districts is generally better positioned to absorb shocks and recover compared to the poorer districts highlighted above.

Figure 13: *District-level relationship between residential damage and multidimensional poverty. Each district is classified into a bivariate category based on residential damage (in USD million or as a share of total economic value) and the MPI headcount ratio (H, %), highlighting potential hotspots where high losses coincide with higher levels of multidimensional poverty.*



These descriptive patterns suggest that the disaster has a differentiated socio-economic impact across Sri Lanka. Some districts might be considered more disadvantaged, facing both high damage and high pre-existing poverty, while others experience major losses in more affluent settings. To move beyond static maps and simple overlays, a more robust approach to assessing resilience is to utilize dynamic simulation models, such as the Unbreakable model. This approach links physical damage to household income, consumption, savings and dwelling vulnerability over time, estimating how long it takes different groups to recover to their pre-disaster living standards, how many households fall back into poverty, and how much consumption is lost during the recovery period. It is critical to note that the results are based on pre-disaster data; they should be treated as a diagnostic signal rather than a definitive answer. They must be updated and validated as soon as more recent MPI information becomes available and should not be used alone to make detailed policy decisions.

5.4 Conclusions

This Global Rapid Post-Disaster Damage Estimation (GRADE) report provides a synopsis of the estimated direct physical damage in Sri Lanka due to the passage of Cyclone Ditwah. The Total damage is estimated at US$4.1 billion, equivalent to approximately 4 percent of Sri Lanka's 2024 gross domestic product (GDP). Sri Lanka's 25 districts were all impacted by flooding and extreme rainfall. Kandy was the worst hit district in terms of estimated damage (US$689 million), caused by flooding primarily and to a lesser extent by landslides.

Sectoral impacts of the cyclone are significant. Infrastructure is the most affected sector with estimated damages of **US$1.735 billion,** accounting for approximately 42 percent of the total damage in Sri Lanka. There are substantial damage to transport, water and energy systems. Roads, bridges, railways and water infrastructure also suffered significant damage. Housing and non-residential damage also highlight persistent structural vulnerabilities and the need to "build back better" through more resilient design, improved land use planning, and enhanced flood control structures. Agriculture damage is expected to deepen rural poverty and food insecurity in already fragile communities. However, total economic impacts will be significantly higher once indirect losses and the costs of building back better, including improving the resilience of assets, are also included.

The report is prepared within a short timeframe with reasonably degree of confidence to inform early decision-making. Building on the GRADE assessment, the World Bank's support to Sri Lanka's recovery from Cyclone Ditwah could be delivered through a combination of complementary financing instruments. In the immediate term, the assessment will help guide the activation of Contingent Emergency Response Components (CERCs) to address urgent response needs. It will also inform consideration of access to the Crisis Response Window (CRW), including a potential increase in financing under the Development Policy Operation (DPO) series currently under preparation, with additional resources flowing directly to the budget to provide flexible support for the Government's recovery and reconstruction needs. In parallel, the GRADE will inform the preparation of a CRW-supported investment operation focused on longer-term recovery and resilience, including reducing flood and landslide risks in priority river basins such as the Kelani River, and strengthening emergency preparedness and response through improved early warning systems, Emergency Operations Centers, coordination arrangements, and first responder capacity at national and sub-national levels.

6.0 Bibliography

Adaderana. (2025). Nearly 100,000 schoolchildren affected by adverse weather. Available at: https://www.adaderana.lk/news.php?nid=115709

Ceylon Today (2025). PM pledges support as Peradeniya Uni flood damage hits Rs 6B. Available at: https://ceylontoday.lk/2025/12/09/pm-pledges-support-as-peradeniya-uni-flood-damage-hits-rs-6b/

Daily Mirror. (2025). Three hospitals extensively damaged. Available at: https://www.dailymirror.lk/breaking-news/Three-hospitals-extensively-damaged/108-327090

Disaster Management Center (DMC). (2025). Current Situation Report 12.12.2025 at 1800 hrs. Available at: https://www.dmc.gov.lk/images/dmcreports/Situation_Report_at_1800hrs_on_2025__1765544355.pdf

Economy Next. (2025). Cyclone Ditwah kills 35,000 cattle in Sri Lanka, 2,000 pigs. Available at: https://economynext.com/cyclone-ditwah-kills-35000-cattle-in-sri-lanka-2000-pigs-252356/

Gossip Lanka News. (2025a). More than 28 lakh egg-laying hens died in the flood. (translated from Sinhala). Available at: https://www.gossiplankanews.com/2025/12/over-28-million-egg-laying-hens-have-died-in-the-floods.html

Gossip Lanka News. (2025b). Cyclone Aftermath: 855 Sacred Sites Damaged Across Sri Lanka. Available at: https://english.gossiplankanews.com/2025/12/cyclone-aftermath-855-sacred-sites.html

Gunasekera, R., Ishizawa, O., Aubrecht, C., Blankespoor, B., Murray, S., Pomonis, A,. & Daniell, J. D. (2015). Developing an adaptive global exposure model to support the generation of country disaster risk profiles. Earth-Science Reviews, 150, 594-608.

Huru News. (2025). 500 million rupee loss to water supply due to disaster [translated from Sinhala]. Available at: https://hirunews.lk/434548/500-million-rupees-loss-to-water-supply-due-to-disaster

Ministry of Digital Economy. (2025). Facebook video. Available at: https://www.facebook.com/reel/868351205726875.

News.lk. (2025a). Prioritize Restoration of Damaged Road Networks. Available at: https://www.news.lk/current-affairs/prioritize-restoration-of-damaged-road-networks-2

News.lk. (2025b). 85% of Power Connections Damaged by the Cyclone, Restored. Available at: https://www.news.lk/current-affairs/85-of-power-connections-damaged-by-the-cyclone-restored

Newswire. (2025). Just 30% of Railways Survive Cyclone: Sri Lanka Reveals Shocking Damage. Available at: https://www.newswire.lk/2025/12/04/just-30-of-railways-survive-cyclone-sri-lanka-reveals-shocking-damage/

IOM. (2025). Cyclone Ditwah Response Summary of Displacement – Displacement Snapshot 1. Available at: https://reliefweb.int/report/sri-lanka/sri-lanka-cyclone-ditwah-response-9-december-2025

UNDP. (2025a). Mapping the Initial Impact of Cyclone Ditwah in Sri Lanka. Available at: https://geosmart.undp.org/arcgis/apps/storymaps/stories/25866fbc805c4d70b6bf35c23f896daf

UNDP. (2025b). One-fifth of Sri Lanka inundated by cyclone Ditwah. Available at: https://www.undp.org/asia-pacific/press-releases/one-fifth-sri-lanka-inundated-cyclone-ditwah-undp-analysis

UNFPA. (2025). UNFPA Sri Lanka Cyclone Ditwah Appeal. Available at: https://asiapacific.unfpa.org/en/publications/unfpa-sri-lanka-cyclone-ditwah-appeal

UN Women. (2025). Gender Alert No. 1 Early Gendered Risks: Sri Lanka Tropical Cyclone Ditwah (As of 3 December 2025). Available at: https://reliefweb.int/report/sri-lanka/gender-alert-no-1-early-gendered-risks-sri-lanka-tropical-cyclone-ditwah-3-december-2025

World Bank. (2018). Global Rapid Post-Disaster Damage Estimation (GRADE) methodology. Available at: https://www.gfdrr.org/sites/default/files/publication/DRAS_web_04172018.pdf

World Bank. (2025a). GDP (current US$) – Sri Lanka (NY.GDP.MKTP.CD). Available at: https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=LK

World Bank. (2025b). A Review of the Global Rapid Post-Disaster Damage Estimation Assessments: The Frontier in Rapid Post-Disaster Damage Estimations for Developing Countries 2015-2024. Available at: https://openknowledge.worldbank.org/entities/publication/1180a3f4-b5bf-41fa-b601-11dfda7bdae3

Annex 1: Historical events description

- In May and June 2024, floods affected 20 districts, impacted about 800,000 people, caused 42 deaths, and damaged more than 12,000 buildings. During 2022 and 2023, a series of minor floods resulted in over six deaths and damage to more than 200 buildings, highlighting that even lower-intensity events have recurring consequences.

- In May and June 2021, floods and landslides caused 35 deaths and destroyed 800+ buildings. In 2020, floods and landslides affected 44,848 people, led to six deaths, destroyed 50 buildings, and damaged 2,148 buildings. The September 2019 floods and landslides affected 13 districts, impacted 116,000 people, caused 29 deaths, and destroyed 282 buildings.

- The May 2018 floods and landslides affected about 400,000 people, with 105 buildings destroyed and 4,832 buildings damaged.

- The events of May 2017 were particularly severe. Floods and landslides affected 15 districts, caused 224 deaths, destroyed 3,008 buildings, damaged 74,301 buildings, and resulted in economic damage of $398 million at the time of the event, including about $190 million in housing, with an additional $70.2 million in losses at the time of the event.

- In May 2016, floods and landslides affected 24 districts, caused 93 deaths with 117 people missing, destroyed 6,382 buildings, damaged 52,543 buildings, and resulted in economic damage of $600.2 million, including about $400 million in housing, plus $123.2 million in additional losses.

- Earlier in the decade, October 2014 floods and landslides caused 95 deaths, while 2013 floods and landslides caused 110 deaths.

- In October 2012, cyclone-related flooding affected 500,000 people, caused 75 deaths, and resulted in $57 million in economic damage at the time of the event.

- The 2011 floods and landslides affected 1,206,000 people, caused 65 deaths, and resulted in $500 million in economic damage at the time of the event

- In November 2010, floods affected 164,000 people, caused one death, destroyed 11 buildings, damaged 257 buildings, and notably affected Colombo. In May 2010, floods and landslides affected 606,000 people, caused 28 deaths, and resulted in $105 million in economic damage at the time of the event.

- Minor floods in 2009 caused three deaths, while Cyclone Nisha in November 2008 affected more than 100,000 people and caused 15 deaths.

- Earlier major events include 2007, when major flooding affected 400,000 people and caused 33 deaths, and the 2006 monsoon floods, which affected 333,000 people and caused 25 deaths.

- In 2003, major flooding caused 246 deaths, destroyed 24,750 buildings, damaged 32,426 buildings, and resulted in $135 million in economic damage at the time of the event. December 2000 floods and landslides caused 17 deaths and damaged over 83,000 buildings.

- In the early 1990s, June 1992 floods affected 250,000 people, caused 14 deaths, and resulted in $250 million in economic damage at the time of the event, while June 1991 floods affected 297,000 people, caused 27 deaths, and resulted in $30 million in economic damage at the time of the event.

- One of the deadliest disasters was the November 1978 cyclone, which caused 915 deaths, destroyed 250,000+ buildings, devastated 90 percent of the coconut crop, damaged about 28,000 acres out of 31,500 coconut plantations, destroyed 240 school buildings, one-fifth of Batticaloa's fishing fleet, 11 paddy granaries, and 130 miles of electric cables.

- Earlier historical events include the May 1965 Rameswaram Cyclone, which caused over 600 deaths and resulted in economic losses of 200 million rupees at the time of the event, and December 1957, when floods affected over 300,000 people and caused more than 200 deaths.

- The August 1947 Gampola floods caused widespread inundation across the hill country, severely affecting areas between Peradeniya and Gampola.

- Records also note that 1936 experienced significant floods, reinforcing that destructive flooding, driven by cyclones, monsoons, and flash floods, has been a persistent and annual feature of Sri Lanka's environmental history.

Annex 2: Hazard Analysis

The main datasets and data sources used in this GRADE assessment are summarized below:

Hazard:

1. ICEYE R1-R10 versions
2. FastFlood flood data
3. HWRF, HMON, NCEP, ECMWF, GFS, HAFS-A, HAFS-B datasets and models for track determination, wind field heterogeneity etc.
4. Wind and rainfall station data.
5. Satellite Products (UNOSAT, COPERNICUS via Sentinel 1 and Sentinel 2)
6. Landslide data from https://lrip.nbro.gov.lk/portal/apps/webappviewer/index.html?id=7524ad70c98e4124a6f4dfed6ea615fe, NBRI and other sources
7. CATDAT (historical info).
8. IMERG Rainfall Data from NASA
9. HYBAS Basin Datasets from HydroBASINS
10. River water levels, https://github.com/nuuuwan/lk_dmc_vis
11. DesInventar Sri Lanka, http://www.desinventar.lk:8081/DesInventar/main.jsp
12. Sentinel Asia, https://storymaps.arcgis.com/collections/8acb5761eefd4816bbb99f1e7146e6a2?item=2

Exposure:

13. Socioeconomic data and enterprise surveys, integrated business enterprise surveys, and other statistical datasets in Sri Lanka including district GDP, checks against CATDAT data, investment data, building types, religious structures from the Department of Census and Statistics.
14. Ministry websites and social media reporting.
15. Livestock data from local data, MoA, global Products, FAO - agriculture exposure in terms of food production.
16. Global ML and Google Buildings Dataset, as well as VIDA.
17. Infrastructure: Roads data, CEB databases as well as Government of Sri Lanka data, OSM data from 2025, including HOTOSM updates, for roads, bridges, and other elements, augmented via various datasets, Geonodes, and annual yearbook statistics.
18. Population and Building Footprints: GHSL 2024 250 m adjusted to present day using multiple census datasets; GHS-BUILT V, BUILT S, BUILT C MSZ at 100 m and 10 m; GHS-BUILT products (volume, surface, population, height, building characterization); observed building attributes tool (OBAT); and others.
19. WSF3D at 90 m from DLR.
20. Capital Stock Modeling methods using national account data, including GFCF data, budget and investment data.
21. Global Program for Safer Schools study, ministry data, health statistics, and other energy statistics.
22. FAO/WFP Crop and Food Security Assessment Mission
23. ESA 10m WorldCover Product, PROBA-V product
24. Meta Relative Wealth Index, High-Resolution Settlement Layer (HRSL), WorldPop for population checks.
25. Gridfinder, Enipedia, power data, CEB, GoJ and UNOCHA administrative boundaries and other World Bank boundaries.

Vulnerability/ Risk:

26. Fiscal Disaster Risk Assessment and Risk Financing Options SRI LANKA" - 2016 for Sri Lanka (World Bank)
27. Country Disaster Risk Profiles
28. Historical event data (DaLA, PDNA, CATDAT) from many past (flood) events in Sri Lanka and the surrounding countries

Damage Data and Observations:

29. Government Reported Damage Data, Updates and Observations
30. NDRSC Portal and reports (National Disaster Relief Services Centre) - http://www.ndrsc.lk/; http://www.ndrsc.gov.lk/web/index.php?option=com_content&view=article&id=58&Itemid=65&lang=en
31. Disaster Management Center, https://www.dmc.gov.lk/index.php?lang=en
32. National Spatial Data Infrastructure (NSDI) Sri Lanka, https://nsdi.gov.lk/spatial-data-services
33. Ministry of Disaster Management, http://www.disastermin.gov.lk/
34. DEPARTMENT OF METEOROLOGY, https://meteo.gov.lk/
35. National Building Research Organisation, https://nbro.gov.lk/index.php?option=com_content&view=featured&Itemid=101&lang=en#
36. Department of Census and Statistics, https://www.statistics.gov.lk/
37. Department of Agriculture Sri Lanka, https://doa.gov.lk/
38. Ministry of Agriculture, https://www.agrimin.gov.lk/web/index.php/en
39. Irrigation department, https://www.irrigation.gov.lk/web/index.php?lang=en
40. Ministry of Agriculture, Livestock, Lands and Irrigation, https://landmin.gov.lk/web/en/home/
41. Ministry of Health, https://www.health.gov.lk/
42. Road Development Authority, https://rda.gov.lk/index.php?lang=en
43. Department of Agrarian Development, https://agrariandept.gov.lk/web/index.php?lang=en
44. Sri Lanka Railways, https://www.railway.gov.lk/web/?Name=Value
45. Ministry of Transport, Highways and Urban Development, https://www.transport.gov.lk/web/index.php?lang=en
46. National Water Supply and Drainage Board, https://www.waterboard.lk/
47. Disaster Data Collection System (DDCS), https://apps.powerapps.com/play/e/e40a4482-808c-ef02-aa1c-a56541c5109c/a/85ec7407-2f20-4a2c-a68b-d3d790086a6c?tenantId=c9fcb722-803d-47ff-b825-ce230851adbb&hint=b2c8eb50-aa5c-45c6-affc-5c19b693eac2&sourcetime=1764856687009
48. Various satellite-, aircraft and UAV-based post-event imagery data
49. Special Press Briefings on Cyclone Ditwah preparations, damages and recovery
50. Various social media updates from several ministers
51. Energy (CEB) and company updates
52. Dailymirror LK, https://www.dailymirror.lk/
53. Hiru News LK, https://hirunews.lk/
54. News Wire, https://www.newswire.lk/
55. ADA derana, https://www.adaderana.lk/
56. News LK, https://www.news.lk/
57. Dinamina LK, https://www.dinamina.lk/
58. Reliefweb, https://reliefweb.int/disaster/fl-2025-000213-lka
59. UN Sri Lanka, https://srilanka.un.org/en/resources/publications
60. UNDP Sri Lanka, https://www.undp.org/srilanka?fbclid=IwY2xjawOeMs5leHRuA2FlbQIxMABicmlkETE1SXRKMlFiR1hMZXZNMVlIc3J0YwZhcHBfaWQQMjIyMDM5MTc4ODIwMDg5MgABHjN0Rhj8c3HXM_qHG5VTGtf17LtwfZ0YI8qSrk6T9XM3w9DJBWp6TFIn7GdX_aem_wkcFz2ktH1RZeSxiDpcNaw

61. LogCluster, https://logcluster.org/en/countries/LKA
62. UNOSAT, https://unosat.org/products/4223
63. DIEM, https://data-in-emergencies.fao.org/pages/impact
64. Sheltercluster, https://sheltercluster.org/pages/operations
65. IOM -DTM, https://srilanka.iom.int/
66. Asia Pacific Alliance for Disaster Management Sri Lanka (A-PAD SL), https://apad.lk/
67. Humanitarian Response Data: https://data.humdata.org/group/lka
68. Drone/streetview imagery and videos shared on social media.
69. EMERGENCY RESPONSE Sri Lanka Flood Relief, https://floodsupport.org/
70. Flood Infra Impact, https://lookerstudio.google.com/u/0/reporting/b254c1c9-8e03-40ef-bd4e-b8814a3d5c73/page/sOLhF
71. UNOSAT Satellite Derived Damage Assessments: https://experience.arcgis.com/experience/c4a17cbf128c422ea6e07f92defe7395/page/UNOSA
72. COPERNICUS Satellite Derived Damage Assessment (EMSR851): https://mapping.emergency.copernicus.eu/activations/EMSR851/
73. Microsoft AI for Good Lab building damage assessments.
74. Earth Observatory of Singapore - Remote Sensing (EOS-RS) & Advanced Rapid Imaging and Analysis Singapore (ARIA-SG) Products
75. UNDP Rapid Digital Assessment (RAPIDA) of Cyclone Ditwah in Sri Lanka: https://geosmart.undp.org/arcgis/apps/experiencebuilder/experience/?_gl=1%2A1juvli2%2A_ga%2AMTgyNDUyMjYyNy4xNzUyMTUwMjMw%2A_ga_PBF14M9C6G%2AczE3NjI1MDM2MjkkbzkkZzAkdDE3NjI1MDM2MjkkajYwJGwwJGgw&id=0804dbcb11994e9d8a566d2c300c36b0&page=Page.
76. Damage and Needs Assessment – Nov-Dec 2025 https://experience.arcgis.com/experience/d87eac39f1dd45dcb381f4b87dba8f87
77. Updates and data on estimated (insured) damages and payouts by various companies and research groups.
78. Various other social media data (X/Twitter, Telegram, Facebook sites).

Annex 3: Overview of Landslide Data Collection – used in conjunction with other flood damage data and observations

Methodology

Visual comparison of pre- and post-event imagery reveals distinct changes in surface appearance, primarily related to the removal of vegetation and exposure of fresh soil and rock. Areas affected by slope failures are shown by a clear shift from green vegetated surfaces to brown, grey, or dark wet-soil tones, indicating newly exposed material. In several locations, debris deposits appear darker shortly after the event due to high moisture content and become brighter in later acquisitions as surfaces dry.

Debris flows were identified by their characteristic downslope-aligned morphology. These features typically originated from small upslope failure areas and extended downslope as narrow, linear to sinuous tracks, frequently following existing topography like stream channels and small valleys. The tracks terminate usually in fan-shaped deposits at slope breaks or valley floors, often showing heterogeneous textures caused by a mixture of soil, rocks, and uprooted vegetation.

Landslides on open slopes display more compact and patch-like geometries. Many failures show a distinct head scarp at the crown, sharply separating intact vegetation from exposed ground. The displaced material forms elongated or teardrop-shaped bodies downslope, sometimes with a slightly bulging toe. Topographic consistency was used as a key confirmation criterion. Mapped features have to consistently align with downhill gradients and drainage pathways, supporting their interpretation as landslide or debris-flow footprints rather than land-use changes. Such manual georeferencing focuses on clearly expressed systems consisting of source, track and deposition area, ensuring that only cyclone-related mass-movement features were included.

Detection is more challenging in built-up areas and settlements, where landslide signatures are frequently obscured by paved surfaces, buildings, and complex land-cover patterns. In these environments, slope failures are often partially hidden beneath roofs or mixed with debris from damaged infrastructure, making the typical soil-color change less distinct in RGB imagery. Very small landslides along road cuts or behind houses were particularly difficult to identify at Sentinel-2 spatial resolution, as their footprints were often smaller than a single pixel or spectrally mixed with surrounding urban materials. As a result, landslide occurrence in densely settled areas is likely underestimated.

Additional uncertainty comes from agricultural landscapes, where recent land preparation, harvesting, or terracing produces soil exposures similar in color and texture to fresh landslide scars. Recently ploughed fields and plantation maintenance areas sometimes show abrupt vegetation loss and bare soil in the post-event imagery, mimicking cyclone-related slope failures. These features were distinguished from actual landslides primarily by their regular shapes, field boundaries, and lack of clear downslope movement, as well as their persistence in pre-event imagery. Nevertheless, in intensively farmed regions, especially on steep terrain, agricultural soil disturbance remains a key source of false positives in RGB-based landslide mapping.

Results

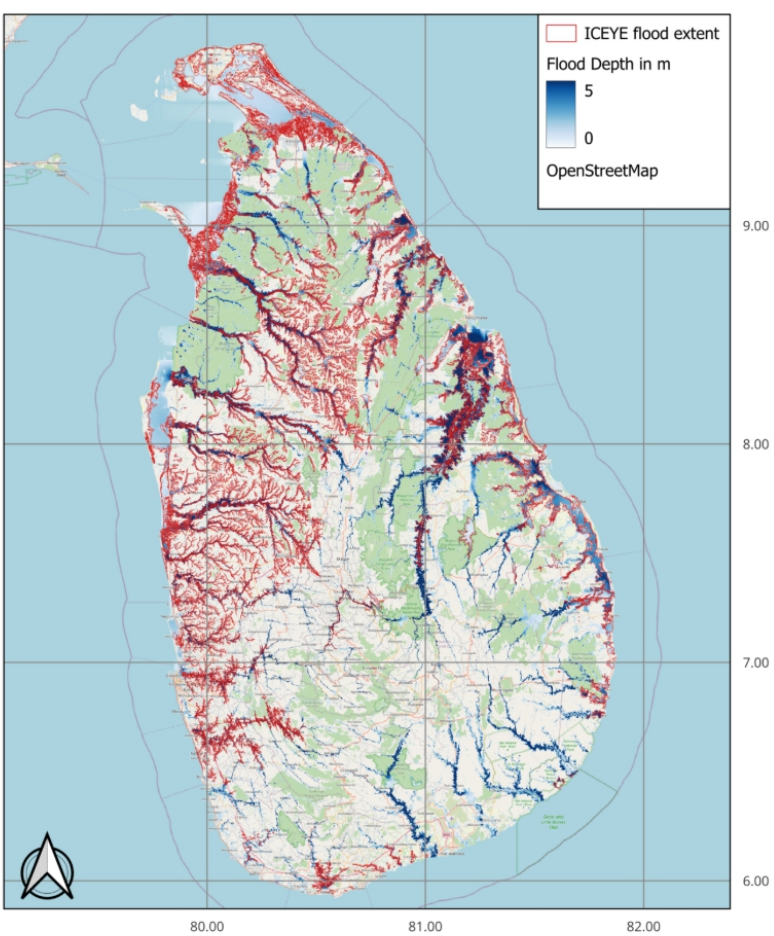
To support the mapping, previous mapping results provided by UNOSAT and NBRO mapping have been merged and extended with additional detections. In total, almost 1,600 individual landslide footprints have been identified by the GRADE analysis with a majority in the districts of Kandy (447), Nuwara Eliya (372) and Badulla (364). The total affected area by landslides accumulates to about 38 km^2. Major contributors to the affected area are especially a small number (65) of large-scale debris flows which affect areas from 0.1 – 0.7 km^2 individually. Most landslides area smaller than 2 ha. These numbers may deviate from other sources as some landslides have been merged into a single footprint, while extra landslides have been appended as additional entries or some landslides of other sources have been dropped due to assumed false detection.

Annex 4: Overview of Flood Modelling Methodology – used in conjunction with the flood damage data, and footprints

Model Description and Implementation

The hydrological simulation for this event was executed using the FastFlood rapid modelling technology, a simulation platform capable of handling complex hydraulic processes at scale. For this specific deployment, the model ingested initial boundary conditions derived from SMAP satellite soil moisture data to accurately represent antecedent saturation levels, coupled with meteorological forcing from the ECMWF ensemble forecast. This configuration allowed for a comprehensive, high-resolution hydraulic analysis of the entire country, processed at a 20 -meter spatial resolution. The integration of these datasets within the global landscape datasets(e.g. Copernicus30 elevation data with DTM filter, global river datasets) framework enables the rapid generation of flood depth and extent outputs that account for catchment-wide hydrological connectivity. The output for the country of Sri Lanka is visualized in Figure 4.1 along with the ICEYE R10 version.

Figure 4.1: *Flood modelling output (depth in meters, blue) compared with ICEYE flood extent data which were then used and compared.*



Validation Against ICEYE Satellite Data

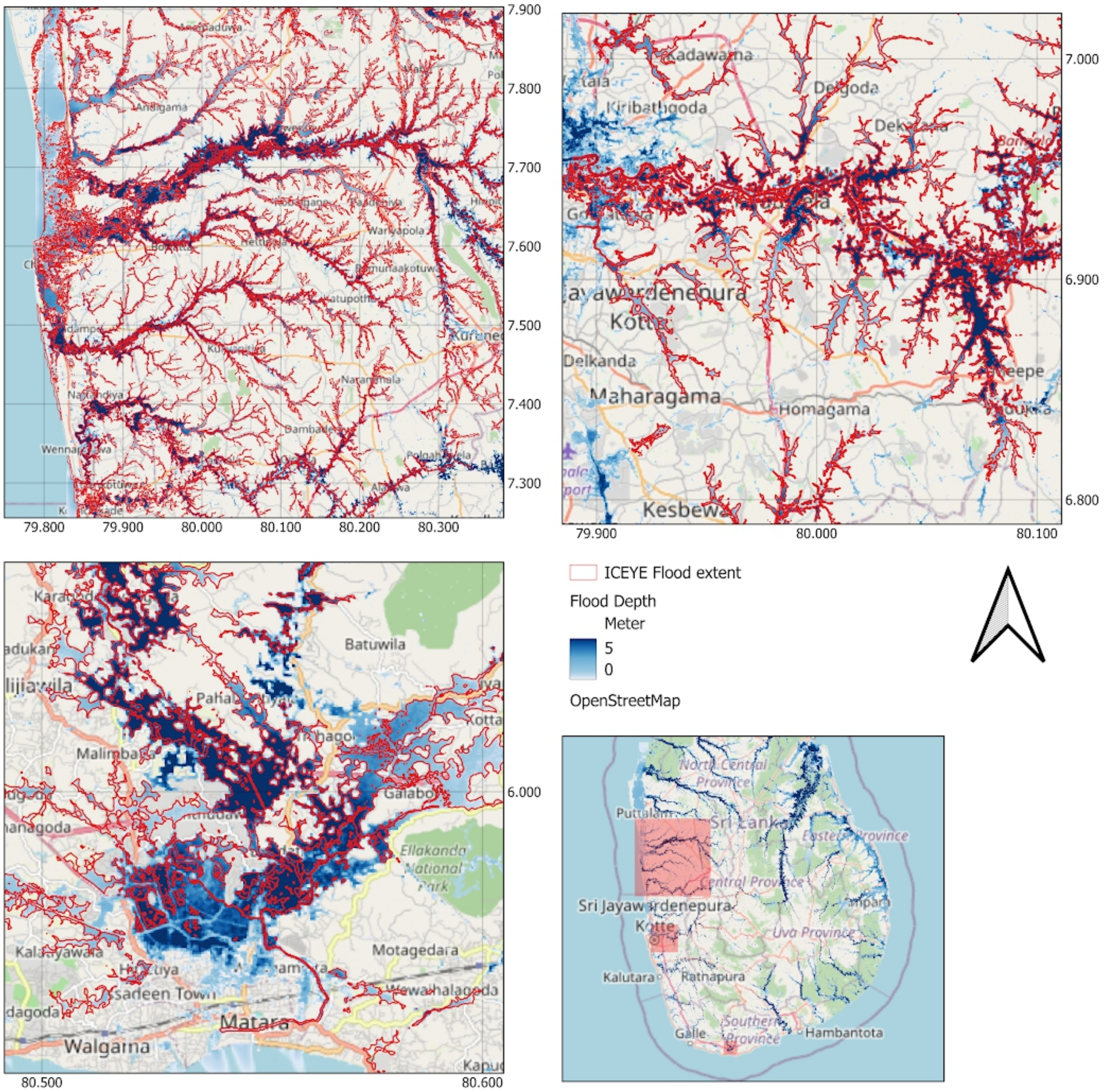
The performance of the model was validated against observed flood extents provided by ICEYE synthetic aperture radar (SAR) satellite data. The comparative analysis demonstrates an exceptionally high degree of similarity between the simulated inundation zones and the satellite-observed footprint. In regions where valid satellite observations were available, the model achieved a high spatial match for flood extent. Notably, this level of accuracy was attained using an uncalibrated model setup, underscoring the physical robustness of the underlying hydraulic routing algorithms and the quality of the global input datasets. The detailed visual comparisons reveal that the model correctly captures intricate floodplain dynamics and riverine overbanking events that align precisely with the remotely sensed water masks.

Discrepancy Analysis and Cross-Validation

While the agreement is strong across the majority of the domain, spatial discrepancies are evident in the southern territories where the model predicts significant inundation that is absent in the ICEYE dataset. Analysis suggests these deviations are likely attributable to gaps in the observational coverage of the ICEYE pass rather than model over-prediction. This interpretation is corroborated by cross-referencing with Global Flood Monitoring (GFM) data from the Copernicus Emergency Management Service (Appendix), which confirms the presence of extensive flooding in the southern regions consistent with the FastFlood simulation results, as well as the GPM-IMERG precipitation estimates, showing an abundance of rainfall in the South. Consequently, the model output appears to provide a more complete representation of the event's total footprint, filling in critical observational blind spots inherent in the available SAR imagery.

Figure 4.2: *GPM IMERG precipitation estimates for the 2025 fall floods in Sri Lanka.*

Figure 4.3: *Detailed flood map output and validation comparison within the country.*



About GRADE

GRADE reports provide an estimate of the costs associated with the economic damage to physical assets of housing, non-residential buildings, agriculture, and critical infrastructure using a methodology that considers the disaster's three components: hazard, exposure, and vulnerability. To conduct GRADE reports, the World Bank's D-RAS team compiles physical damage information by employing hazard and engineering modelling, checks the information carefully against observations and historical precedent, and presents the data, figures, and estimated costs in the first weeks after a major disaster such as cyclones, earthquakes, floods, hurricanes, typhoons, and conflicts. GRADE reports continue to provide a useful initial estimate of the damage and economic impact and help contribute and complement additional damage and loss assessments conducted, which all are key to plan and design disaster recovery and reconstruction. To date, the D-RAS team has conducted more than 70 GRADE assessments. So far, on average, GRADE's estimated overall damage are above 90 percent accurate relative to the detailed, on the ground assessments that follow in the weeks and months after a disaster.

JapanGov The Government of Japan
GFDRR Global Facility for Disaster Reduction and Recovery
Administered by THE WORLD BANK IBRD • IDA | WORLD BANK GROUP