Global Rapid Post-Disaster Damage Estimation (GRADE) Report

Hurricane Melissa 2025 Jamaica

(Report as of November 15, 2025)

JapanGov
The Government of Japan

GFDRR
Global Facility for Disaster Reduction and Recovery

Administered by THE WORLD BANK
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In collaboration with: IDB

Front and back cover photo: The aftermath of Hurricane Melissa in parts of Montego Bay, Jamaica, Nov. 6, 2025. Photo credit: © (U.S. Air Force Photo by Staff Sgt. Alexander Merchak)

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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, Johannes Brand, Roberth Romero, Andreas Schaefer, Bastian van den Bout, Annika Maier, Judith Claassen, Bijan Khazai 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.

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Abbreviations

PROBA-V CATDAT	Catastrophe DATA
CDEMA	Caribbean Disaster Emergency Management Agency
Copernicus EMS	Copernicus Emergency Management Service
CROPGRIDS	Global gridded crop distribution/production datasets
DaLA	Damage and Loss Assessment
DLR	Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace 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
GLOFAS	Global Flood Awareness System
GHSL	Global Human Settlement Layer
GloBFP	Global Building Footprint Database
GOES	Geostationary Operational Environmental Satellite
GoJ	Government of Jamaica
GPM-IMERG	Global Precipitation Measurement – Intg. Multi-satellite Retrievals for GPM
GRADE	Global RApid post-disaster Damage Estimation
GPURL	Urban, Disaster Risk Management, Resilience and Land Global Practice
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

IOM	International Organization for Migration
JA$	Jamaican Dollar
JIS	Jamaica Information Service
JPS	Jamaica Public Service
NOAA	National Oceanic and Atmospheric Administration
NHC	National Hurricane Center
NWC	National Water Commission
OBAT	Observed Building Attributes Tool
OCHA	Office for the Coordination of Humanitarian Affairs
OECS	Organisation of Eastern Caribbean States
ODPEM	Office of Disaster Preparedness and Emergency Management, Jamaica
OSM	Open Street Map
PDC	Pacific Disaster Center
PDNA	Post-Disaster Needs Assessments
PIOJ	Planning Institute of Jamaica
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)
STATIN	Statistical Institute (of Jamaica)
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.
Total exposed value or capital stock	The physical assets, 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 Jamaica

Statistic	Value	Source
Gross domestic product (GDP) (2024)	US$21.4 billion	Statistical Institute of Jamaica[1]
Population (2025) est.	2.84 million people	Statistical Institute of Jamaica

[1] Statistical Institute of Jamaica – Impact of Hurricane Melissa: Population, Housing, and Density Data, https://statinja.gov.jm/hurricaneMelissa.aspx

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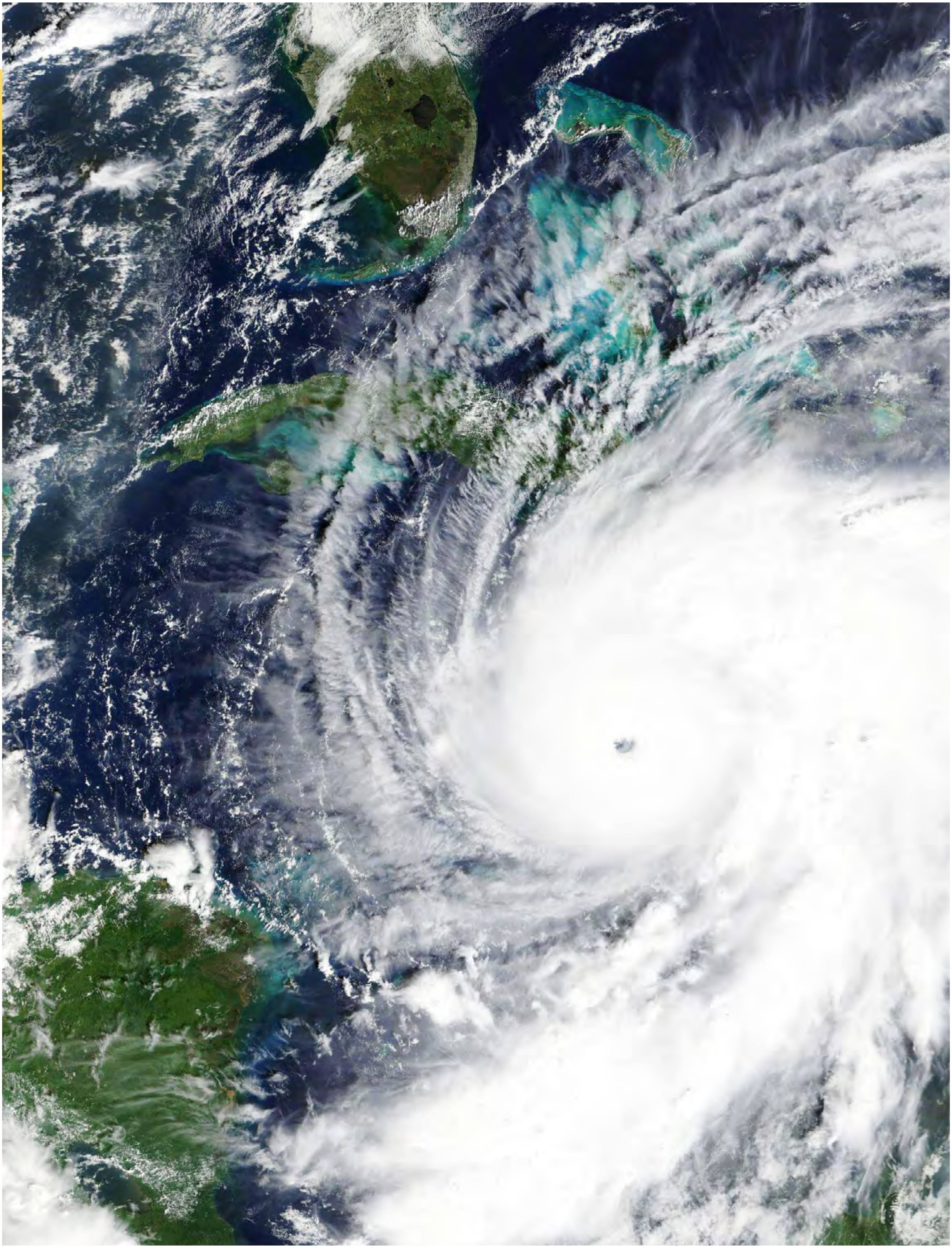


Hurricane Melissa heading towards Jamaica in October 2025. Photo credit: ©Claudia Weinmann.

Executive Summary

This Global Rapid Post-Disaster Damage Estimation (GRADE) report provides a synopsis of the estimated direct physical damage in Jamaica due to the passage of Hurricane Melissa. The report is based on a rapid and remote post-disaster damage assessment which follows the established GRADE methodology (World Bank, 2018a)[2] 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 an event. The GRADE assessment should be interpreted as a first-order estimation of direct damage, albeit with a significant degree of reliability. However, GRADE's outputs are still estimates; remote-based calculations that are influenced by, and 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 and therefore results are presented at the parish and aggregated asset class level. Furthermore, this GRADE assessment calculates the replacement costs, and does not include the costs of building back better, nor does it calculate the economic losses, and the recovery and reconstruction needs, that are also crucial for a comprehensive understanding of the impact of the disaster.

Hurricane Melissa made landfall as a strong Category 5 Hurricane on October 28, 2025, near the border of the parishes of St Elizabeth and Westmoreland in the west of Jamaica. With sustained winds of 185mph shortly before impact, this was the strongest storm recorded in Jamaica and one of the most intense Atlantic storms on record.

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

1. **Total damage is estimated at US$8.8 billion,** equivalent to approximately 41 percent of Jamaica's 2024 gross domestic product (GDP), and 6 percent of the buildings and infrastructure capital stock.

2. **The western and central parishes of St. Elizabeth, St. James, Westmoreland, Trelawny, Manchester, St. Ann, and Hannover were the worst hit parts of the country**, accounting for a total of US$7.9 billion or 90 percent of the country's total damage. Saint Elizabeth was the worst hit parish in terms of estimated damage (US$2.3 billion) caused by extreme wind speeds, storm surge, and flooding.

3. **Residential building damage,** including contents, accounted for US 3.7 billion in total, or 41 percent of the total estimated damage.

2 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[3] and contents damage**, accounted for 20 percent of the total damage estimate with a total of US$1.772 billion.

5. **Infrastructure[4] damage** was estimated at US$2.9 billion, accounting for approximately 33 percent of the total damage to Jamaica.

6. **Agricultural[5] damage** is estimated at US$389.1 million, with notable damage to the fisheries sector, livestock, and vegetables, fruit, tree, and cash crops.

Table ES.1 Summary of GRADE estimations of direct damage to physical assets in Jamaica from Hurricane Melissa in October 2025 in US$ millions

Parish	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)
Saint Elizabeth	997.2	389.5	763.6	135.7	2286.0
Saint James	704.2	506.1	587.0	24.8	1822.1
Westmoreland	690.9	220.0	434.0	64.2	1409.1
Trelawny	266.8	154.4	296.5	29.0	746.8
Manchester	305.4	102.4	252.9	28.4	689.1
Saint Ann	221.9	155.0	154.8	20.4	552.1
Hanover	158.1	66.7	141.8	20.1	386.7
Clarendon	133.1	54.2	112.0	19.3	318.6
Saint Catherine	93.2	47.8	91.4	22.3	254.8
Saint Andrew	52.5	53.8	30.6	2.7	139.5
Saint Mary	30.6	11.0	26.9	15.5	84.1
Portland	13.1	4.6	11.7	2.2	31.7
Saint Thomas	6.8	2.1	6.3	4.3	19.5
Kingston	2.6	4.4	7.0	0.0	14.0
Total	**3676.4**	**1772.2**	**2916.4**	**389.1**	**8754.2**

A bespoke exposure model was developed for Jamaica 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), resulting in a total replacement value of assets (prior to Hurricane Melissa) of US$139.7 billion. This total includes residential and non-residential buildings and their contents, and infrastructure and agriculture assets.

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

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

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

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

- Housing losses highlight persistent structural vulnerabilities and the need to “build back better”.
- Tourism assets in northern and western parishes sustained considerable damage, posing risks to short-term economic activity as the winter season approaches.
- Access constraints from damaged roads and fallen power lines continue to hinder response and service restoration.
- Agriculture damage is expected to deepen rural poverty and food insecurity in already fragile communities.
- While Jamaica’s disaster risk financing approach is among the strongest in the world, available instruments cover only a fraction of total impacts.
- Total economic impacts will be significantly higher once indirect losses and the costs of building back better improvements are included.
- The event will have intensified 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.

Hurricane aftermath. Photo credit: © Madison Muskopf.

1 Introduction

The objective of this report is to provide an estimate of the direct damage to physical assets caused by Hurricane Melissa in October 2025 in Jamaica and to provide information on the spatial and sectoral distribution of damage to help calibrate other damage estimates and support development of a roadmap for recovery and reconstruction.

1.1 Context

Jamaica is a mountainous island nation in the western Caribbean, covering about 10,991 km^2 and divided into 14 parishes. The country's total population is approximately 2.84 million, as of 2024 (up from the last official figure of 2.77 million in the 2022 census). In terms of development, Jamaica is classified as a country with high human development, ranking 117th out of 193 countries and territories with a Human Development Index (HDI) of 0.720 (United Nations Development Programme (UNDP), 2025). Life expectancy is estimated at 68.5 years for males and 72.7 years for females, while the crude birth rate is 11.4 per 1,000 population (Ministry of Health & Wellness (MOHW), 2024). The 2021 Jamaica Survey of Living Conditions reported a poverty rate of 16.7percent and a Housing Quality Index score of 78.8 (Statistical Institute of Jamaica. (2021).

Jamaica's exposure to natural hazards is high. The capital region (Kingston and St. Andrew), St. Catherine parish in the south, as well as St. James in the northwest, host the major urban centers, ports and airports, concentrating a large share of assets in low-lying coastal areas. However, significant infrastructure also traverses rural parishes, for instance Hanover, St. Mary, and Westmoreland which carry substantial portions of the national transport network which elevates exposure even in less densely populated areas (Inter-American Development Bank, 2009). A 2020 probabilistic risk assessment by the Inter-American Development Bank (IDB) indicates that tropical cyclones are the dominant threat to this exposure, contributing an Expected Annual Loss (EAL) of 0.9 percent of GDP (IDB, 2020), higher than the annual losses from earthquakes of around 0.3 percent of GDP (IDB, 2020).

Climate change is projected to intensify the hazards faced by Jamaica, increasing risks to lives, livelihoods, and critical infrastructure. Beyond hurricanes and earthquakes, Jamaica faces additional threats from extreme rainfall, drought, and sea-level rise, all of which pose serious risks to the economy and to the majority of the population who live in coastal areas.

1.2 Summary of historical disasters

Jamaica has a long history of devastating tropical cyclones. Among the deadliest were Hurricane Charlie (1951), a high-end Category 3 hurricane that killed 154 people and left 25,000 homeless; and Hurricane Gilbert (1988), a Category 4 hurricane that caused 49 deaths and over US$1 billion in damage. Earlier events, such as the 1912 hurricane and the 1722 Port Royal hurricane, claimed hundreds of lives and caused widespread destruction to coastal communities.

Since 2000, the frequency and severity of storms increased significantly, with more systems passing near or directly impacting Jamaica than in the previous two decades (Table 1). Hurricanes Ivan (2004), Dean (2007), and Gustav (2008) caused extensive flooding, landslides, and housing losses, while Tropical Storm Nicole (2010) and Hurricane Sandy (2012) brought major rainfall, causing significant infrastructure damage. The 2017 spring floods caused widespread impacts (US$32 million in damage and losses) and most recently, Category 4 Hurricane Beryl (2024) inflicted US$354 million in damage and losses, impacting nearly 23 percent of the population (Government of Jamaica, 2024).

Major meteorological events between 1912 and 2024 for which data are available are presented in Table 1, with detailed descriptions provided in Annex 1.

Table 1. Summary of recent historical disasters in Jamaica

Year	Event	**Reported Financial Impacts** (US$ value for the event year)	Sectors Impacted
2024	Hurricane Beryl	$354 million	Flooding, landslides, infrastructure disruption; At least 4 deaths, 618,496 affected (23percent of population)
2017	Mar–Jun Flood Rains	$32 million ($8 million damage, $24 million losses)	Transport, public works, utilities affected
2012	Hurricane Sandy	$100 million	Housing, buildings, infrastructure, agriculture; 2 deaths, 215,850 affected
2010	Tropical Storm Nicole	$240 million	Infrastructure ($235 million), housing ($3.2 million), agriculture; 15 deaths, 2,506 affected
2008	Hurricane Gustav	$210 million	Flooding, landslides; housing, infrastructure; 12 deaths, 4,000 affected
2007	Hurricane Dean	$329.3 million	Flooding/landslides; housing (roof loss), agriculture, roads; 4 deaths, 33,188 affected
2004	Hurricane Ivan	$595 million	Widespread flooding/damage; housing, infrastructure, agriculture; 17 deaths, 369,685 affected
1988	Hurricane Gilbert	$1.092 billion	Island-wide wind/surge/rain; housing, crops, roads, power; 49 deaths, 810,000 affected
1979	Tropical Depression One	$27 million	Extreme rainfall/floods; housing, agriculture, transport; 40 deaths, 40,000 homeless
1951	Hurricane Charlie	$56 million	Wind/rain, landslides; crops, transport, airport, housing; 154 deaths, 20,200 affected
1912	November Hurricane	$1.5 million	Severe rain/floods; bridges, rail, ports, banana crop; 142 deaths, 94,820 affected
1722	Port Royal Hurricane	Unknown	4.9 m storm surge; port/shipping destruction, housing; 400 deaths

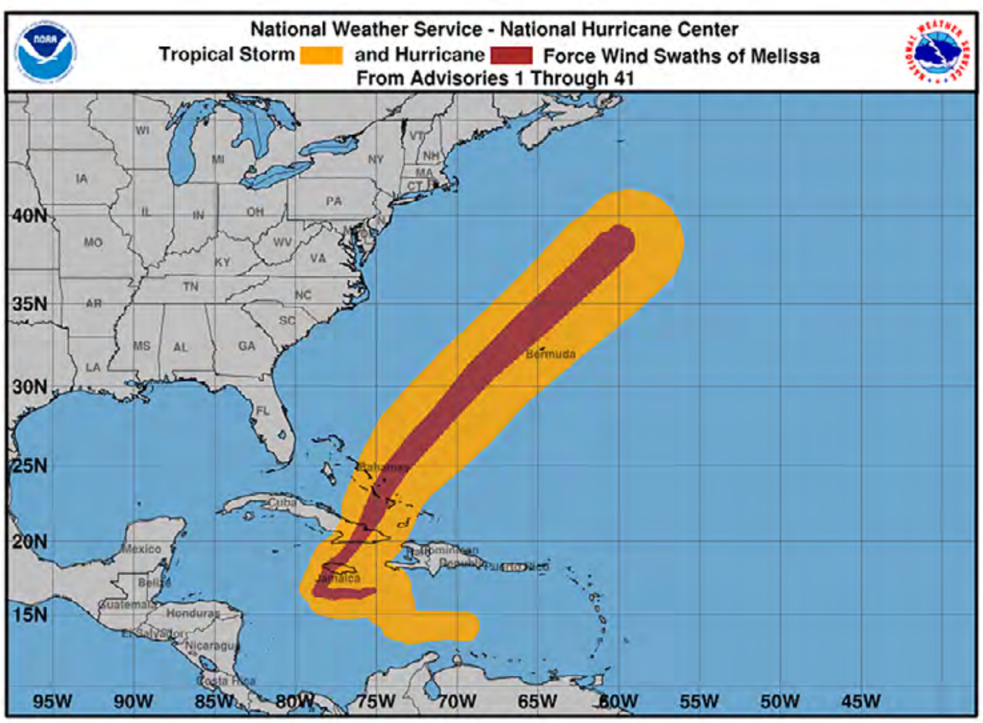
Event description

2

On October 16, 2025, the U.S. National Oceanic and Atmospheric Administration's (NOAA) National Hurricane Center (NHC) identified a westward-moving tropical wave over the central Atlantic (NHC, 2025a). The disturbance entered into the Caribbean on October 19 and then slowed markedly. It strengthened to become Tropical Storm Melissa on October 21, and a Tropical Storm Watch was issued for Jamaica. For several days, Melissa drifted slowly west-northwest under weak steering currents, and moderate vertical wind shear kept the system disorganized and capped its intensification through October 24.

By October 25, environmental conditions to the southeast and south of Jamaica became exceptionally favorable for rapid strengthening, with sea surface temperatures around 30–31 °C, among the warmest on record for late October (Yale Climate Connection, 2025). That afternoon, Melissa intensified into a hurricane and then underwent rapid intensification, with maximum sustained winds doubling from about 70 mph to 140 mph (Category 1 to Category 4) in around 18 hours. Melissa continued to strengthen and reached Category 5 status by early October 27. At 5:00 a.m. EDT, the NHC estimated sustained winds of 160 mph and a central pressure of 917 millibars as the compact, symmetric core approached Jamaica. Late on October 27, the hurricane turned sharply north-northeast towards Jamaica at peak intensity (Figure 1).

Figure 1. Wind Swaths for Hurricane Melissa passing Jamaica

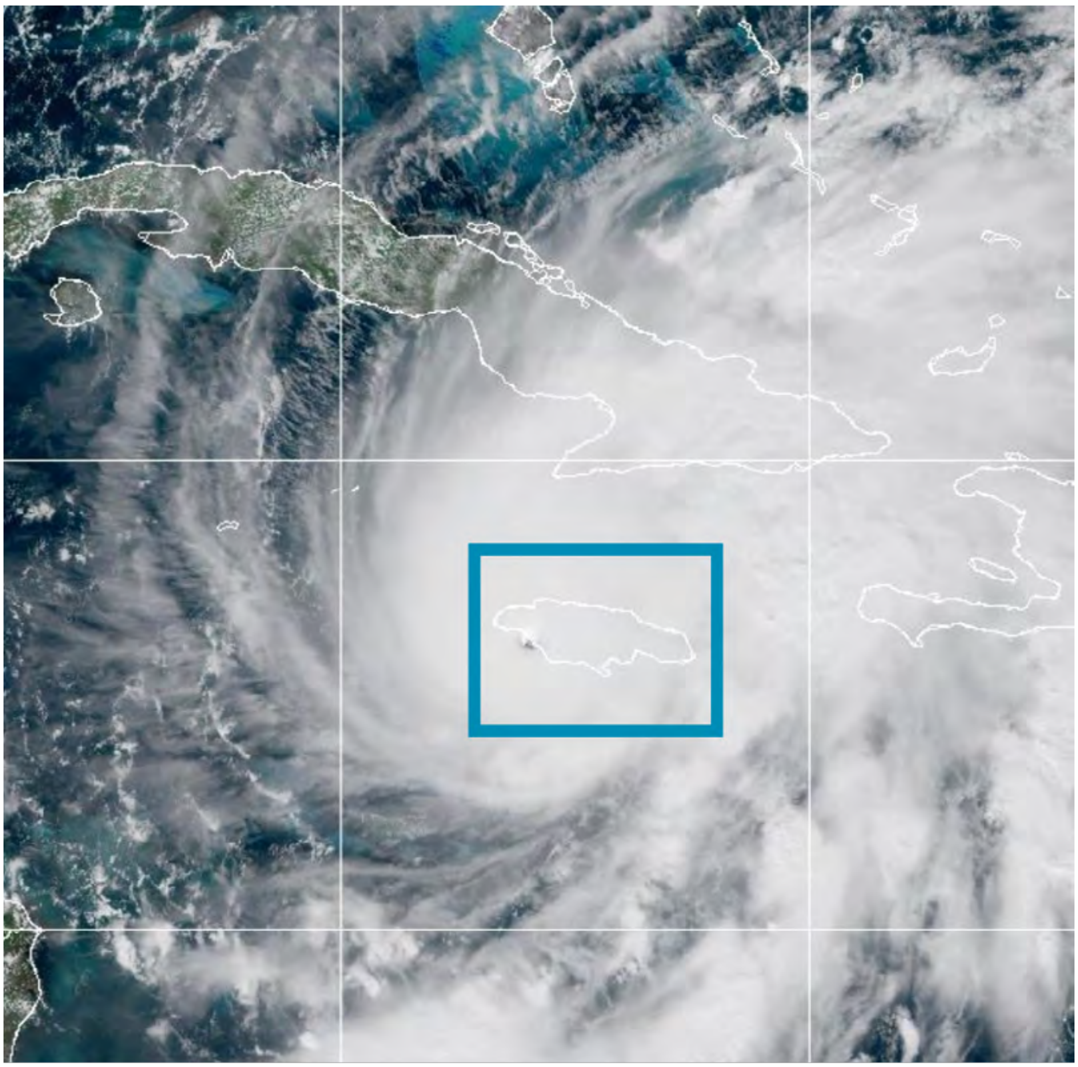


Source: National Hurricane Centre[6]

[6] https://www.nhc.noaa.gov/graphics_at3.shtml?swath

On October 28, at approximately 17:00 UTC (1:00 p.m. local time), Hurricane Melissa made landfall near the parish border between St Elizabeth and Westmoreland as a top-end Category 5 hurricane (Figure 2), with sustained winds of about 185 mph (295 km/h) (NHC, 2025b). This ranks among the most powerful Atlantic hurricane landfall on record and was the most powerful storm on record to strike Jamaica, surpassing the benchmark set by Hurricane Gilbert in 1988. Melissa produced catastrophic wind damage, storm surges of up to 4m, and extensive flooding from rainfall totals exceeding 250mm in many regions. The storm weakened slightly as it tracked north-eastward across Jamaica, emerging from Trelawny parish off the northern coast as a Category 4 hurricane.

Figure 2. Satellite imagery of the eye of Hurricane Melissa making landfall in Jamaica on October 28, 2025, around 17:00 UTC. The box highlights the location of Jamaica.



Source: NOAA[7]

7 Available at: https://cdn.star.nesdis.noaa.gov/FLOATER/AL132025/GEOCOLOR/

2.1 Reported impacts

As further context to the event, the following section summarizes the impacts of the hurricane as reported by different agencies and actors.

The latest reports suggest that 1.6 million were affected by Hurricane Melissa (UNOCHA, 2025a)**,** more than half the population of Jamaica. The most severe impacts were concentrated in the southern and western parishes, including St. Elizabeth, Westmoreland, and Manchester, where winds and flooding caused extensive damage to housing, basic services, and substantial impacts on livelihoods. At least 30,000 people were displaced from their homes initially, with large numbers initially seeking refuge in public shelters (UNOCHA, 2025b). As of November 13, it is reported that 1,100 remain in 88 emergency shelters (UNOCHA, 2025b).

A total of 45 deaths has been reported, with 15 people missing (Associated Press, 2025). Initially, access constraints impeded movement into a many affected areas, complicating response.

Damage to housing is extensive. Early assessments are varied as initial damage assessments continue. World Food Programme (WFP) report that in the hardest-hit southern and western parishes more than three-quarters of buildings sustained some level of damage, ranging from slight to complete destruction (WFP, 2025). Early Government of Jamaica estimates reported over 116,000 buildings severely damaged or stripped of roofs (Government of Jamaica, 2025). The International Organization for Migration (IOM) reported that around 120,000 residential dwellings require repair or reconstruction (IOM, 2025a). From their assessment, the most severely affected areas include St. Elizabeth (56 percent of dwellings damaged or destroyed, over 30,000 homes), Westmoreland (48 percent, nearly 26,000 homes), St. James (33 percent, over 23,000 homes), Trelawny (29 percent, almost 9,000 homes), Hanover (27 percent. 7,000 homes), Manchester (26 percent, 11,500 homes), and St Ann (24 percent, 15,000 homes). High-resolution, rapid, remote-sensing damage mapping completed by MapAction shows high damage ratios in several communities: Black River (66 percent of buildings damaged), Savanna-la-Mar (46 percent), Cambridge Town (45 percent), Bethnal Town (40 percent), Lucea (27 percent), Montego Bay (24 percent), and Santa Cruz (23 percent) (MapAction, 2025). Copernicus-EMS (Emergency Management Service) damage assessments identified 3,902 dwelling structures, of which 2,602 were possibly damaged (67 percent), 1,005 damaged (26 percent), and 295 destroyed (7 percent) (IOM, 2025b). Based on this, an estimated 5,200 residents may have lost roofs or suffered severe housing damage

Infrastructure systems have also been severely impacted. Water supply systems experienced severe nationwide disruption, with 763 National Water Commission (NWC) systems affected and only 132 operational in the immediate aftermath (NWC, 2025). Health services were heavily disrupted, particularly in the western and southern regions, where five major hospitals were classified as severely impacted (Pan-American Health Organization (PAHO)/World Health Organization (WHO), 2025). The Ministry of Health and Wellness (MOHW) further reported that more than 100 health centers across all four regional health authorities sustained damage to roofs, fencing and water systems, significantly constraining service delivery (MOHW, 2025).

The education sector experienced widespread disruption. According to the Ministry of Education, 616 institutions, including infant, primary, secondary and eight tertiary institutions, sustained impacts ranging from roof leaks to complete structural damage (JIS, 2025a).

Hurricane Melissa caused extensive disruption to Jamaica's transport networks. Initial reports stated that 151 roads had been impacted by the hurricane (The Jamaica Gleaner, 2025). At Sangster International Airport in Montego Bay, a collapsed ceiling was reported following the passage of the storm (NPR, 2025).

Damage to power and communication utilities was severe. Early assessments indicated that 77 percent (Emergency Telecommunications Cluster (ETC), 2025) of the island was without power and internet access, while only 35 percent of mobile phone sites were functioning in the immediate aftermath (NPR, 2025). Jamaica Public Service (JPS) restoration updates documented extensive damage to the transmission and distribution network, including downed poles, damaged lines, and inaccessible sites (JPS, 2025). Telecommunications providers, including Digicel and FLOW, also reported infrastructure damage and service outages, with repairs dependent on both power restoration and road clearance (Private Sector Organisation of Jamaica, 2025).

Major impacts were reported at large-scale renewable energy facilities. The Eight Rivers Solar Park (Paradise Park), Jamaica's largest photovoltaic installation, sustained catastrophic damage during Hurricane Melissa, rendering the plant non-operational (Jamaica Observer, 2025). The Wigton Wind Farm in Manchester, the site of 44 large wind turbines, reported limited damage (Wigton Energy Limited, 2025).

The agriculture sector, still recovering from damage caused by Hurricane Beryl in 2024, reported severe impacts across all major subsectors. Estimates from preliminary surveys from the Minister of Agriculture, were given as an estimated US$183.8 million in damage nationwide through partial estimates, with 41,390 hectares of farmland affected and impacts reported among over 70,000 farmers. Damage to livestock was extensive, with the loss of approximately 1,251,410 animals, including small ruminants, cattle, and poultry operations. Crop losses were widespread with 32,400 hectares of vegetable crops lost; banana and plantain production suffered losses across 2,450 hectares, while 2,450 hectares of fruit trees were damaged. Staple crops also experienced major setbacks: 70 percent of yam production was lost, while the coffee subsector sustained 40 percent damage to trees (JIS, 2025b)

Many tourism assets such as hotels and resorts reported severe impacts, and while several properties have already reopened and resumed bookings, others in heavily damaged areas like Montego Bay and the South Coast face longer timelines (Caribbean News Digital, 2025).

Storm surge inundation was localized. It was seen on the south, west and north coastlines, however, the overall impacts, save from some localized cases like Black River in St Elizabeth, were small compared to the impacts of wind, rain intrusion, and flood.

3 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 gives a high confidence estimation of damage at the aggregated level, there are many assumptions and uncertainties within the methodology driven by the inherent complex nature of disasters and how assets perform. 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 disaster's characteristics, and the complexity of the affected area.

3.1 Development of Hazard Model

A hazard profile of their wind-field was developed by collecting and assessing available cyclone track data, along with data on land properties affecting the wind-field such as land use and elevation (Figure 3). It represents the best estimation of the cyclone's track and wind-field; however, there was significant disagreement in these across multiple sources, which contributes to uncertainty in final wind-field map. Further, in larger hurricanes such at Melissa, there can be very destructive outer bands of wind and rain that cause higher damage than expected at some distance from the eye. These are extremely hard to place accurately spatially with models and wind speed stations are often too spread out to record them. This further contributes to the uncertainty in the wind hazard. Rainfall estimates from global products, including IMERG Late Run and other sources, were used. For more details on the methodology, see Annex 3.

A preliminary flood model was developed using ensemble precipitation forecasts, satellite-derived rainfall estimates, and hydrodynamic simulation to complete and initial reconstruct the spatial extent and depth of inundation (Figure 4). Storm surge modelling and coastal impacts were modelled, and compared with remote sensing imagery to examine the extents of inundation. The effects of these were relatively localized. (see Annex 4).

Figure 3. Calculated wind field map for Hurricane Melissa over Jamaica

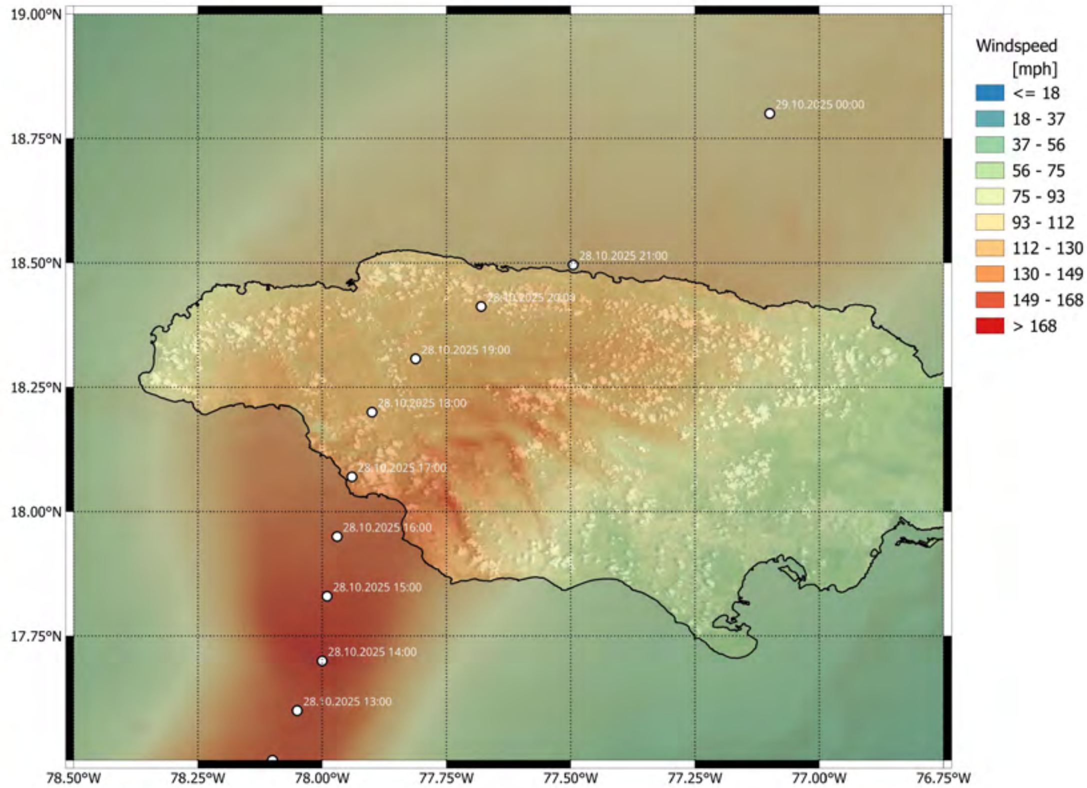
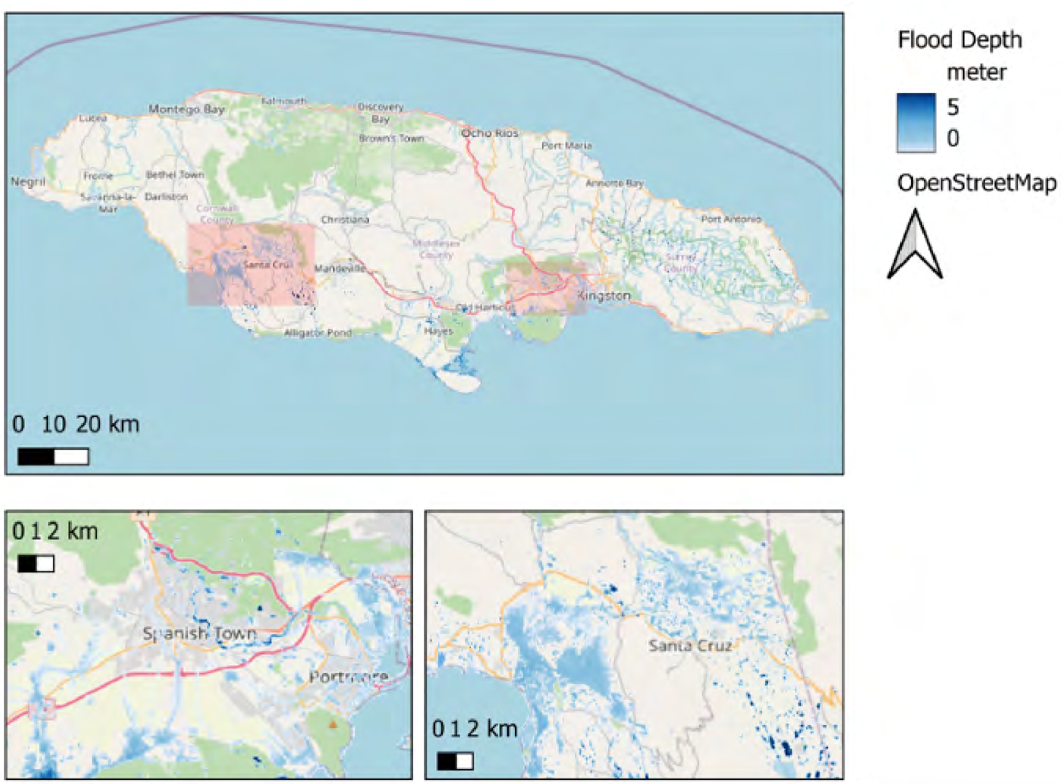


Figure 4. Preliminary flood map for Hurricane Melissa in Jamaica at 20-meter resolution, including storm surge flooding and flash flooding



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 by Gunasekera et al. (2015). The methodology draws on previous work in Jamaica (World Bank, 2016; 2018b), 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: an example of this is the considerable increase to replacement costs that the global pandemic brought, which resulted in the exposure values rising significantly. Agriculture exposure is not estimated by GRADE as accurate damage estimates are assessed through reported data instead of using modelling approaches. The exposure values representing the replacement cost estimates of built assets, including the values of contents, and are presented in Table 2 and Figure 6.

The definitions of which assets are included in each asset class are given in Figure 5.

Figure 5. Definitions of the asset classes 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

Total exposure of buildings and infrastructure is estimated to be US$139.7 billion. The majority of assets are located in Kingston, Saint Andrew, and Saint Catherine parishes, where 40 percent of the stock is present.

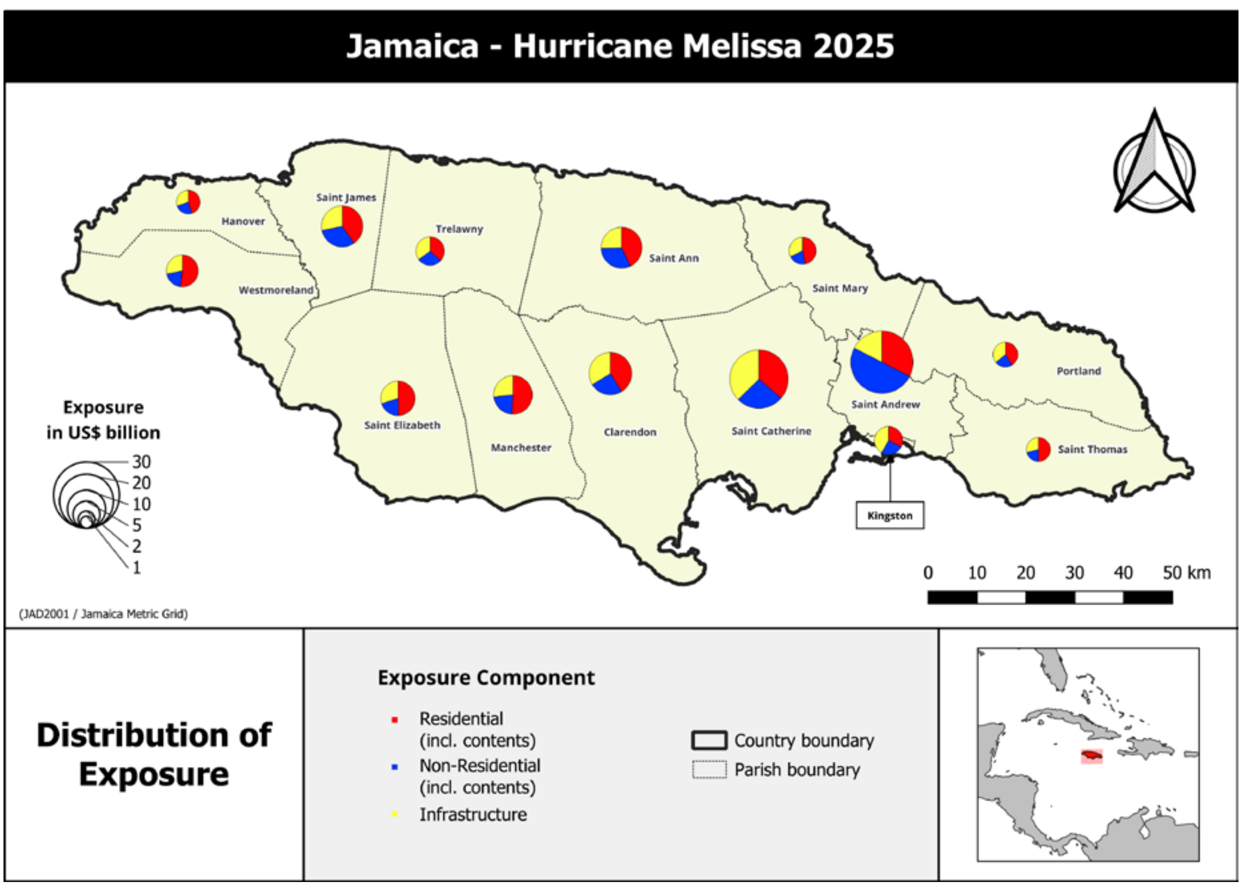
It is important to note that the unit costs of construction are often higher in Jamaica than other locations around the Caribbean due to building material prices, different building typologies, improved engineering and the economic development of Jamaica.

Vulnerability was modelled based on the construction type of the assets and the wind-field, with scaling for flooded zones based on rainfall analysis and damage data. Estimated damage in the housing sector are 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 hurricane events, as well as comparable typologies from comparable countries in the Caribbean region. This supported the derivation of damage ratios for different construction typologies. The non-residential building sector impacts were also examined as per previous Post-Disaster Needs Assessments (PDNA) and Damage and Loss Assessments (DaLA) for the Caribbean.

Table 2. 2025 exposure values calculated for Jamaica in US$ millions

Parish	Total Residential Exposure incl. Contents (US$ mn)	Total Non-Residential Exposure incl. Contents (US$ mn)	Total Infrastructure Exposure (US$ mn)	Total Exposure (US$ mn)
Clarendon	5127	3134	4201	12462
Hanover	1755	967	1177	3899
Kingston	1792	1423	2299	5514
Manchester	5224	2327	2725	10276
Portland	1745	988	1531	4264
Saint Andrew	8714	13367	4671	26753
Saint Ann	4952	3668	2926	11547
Saint Catherine	8537	6204	8771	23511
Saint Elizabeth	4066	1671	2454	8190
Saint James	4698	3715	3281	11695
Saint Mary	2364	1054	1630	5049
Saint Thomas	1991	819	1154	3964
Trelawny	2060	1577	1968	5606
Westmoreland	3634	1400	1961	6994
Total	**56659**	**42314**	**40750**	**139724**

Figure 6. Exposure map by parish and asset class for Jamaica



Infrastructure modelling was undertaken for power, transport, ICT, and water, in a hybrid approach with the data from previous tropical cyclone/hurricane PDNAs and sectoral damage assessment data around the world used to develop model inputs.

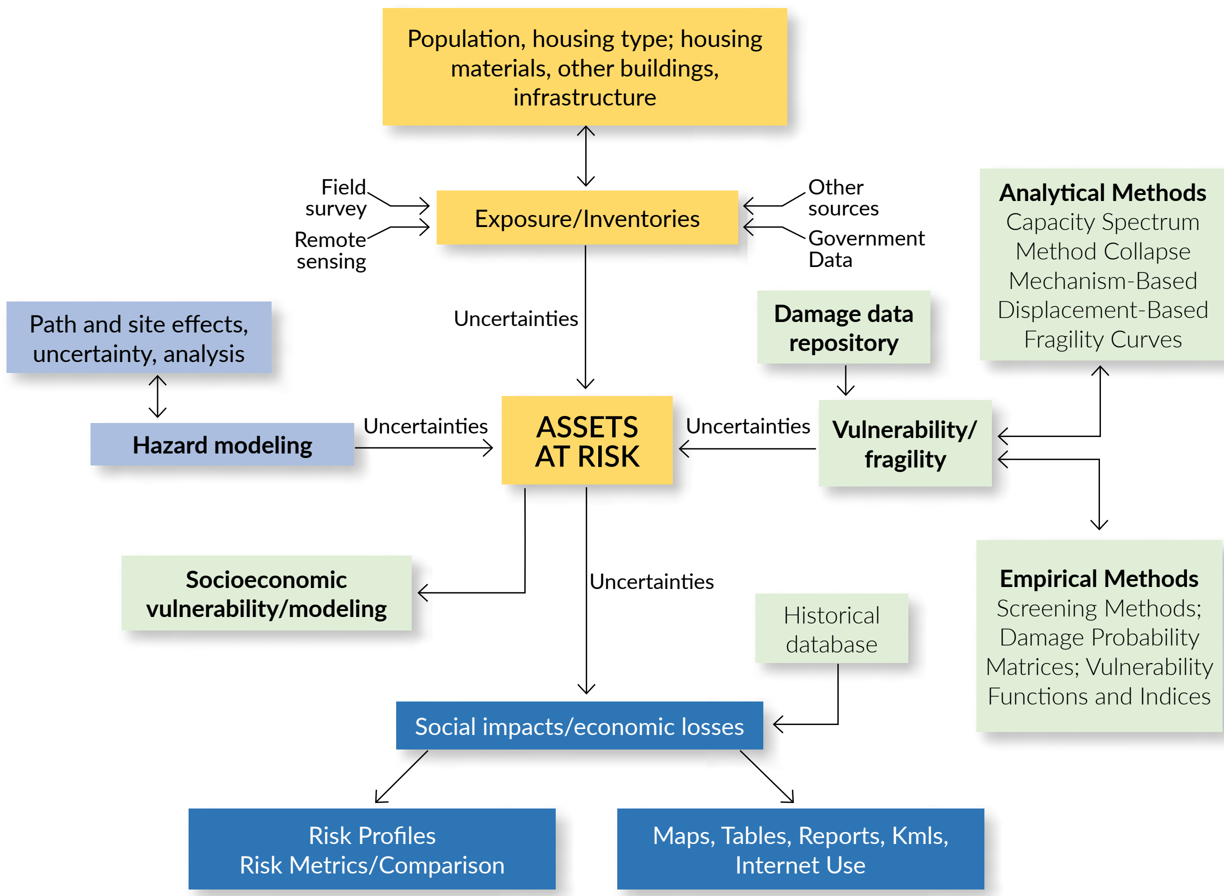
For the agriculture sector, the direct damage estimates were evaluated by reported data on damaged crops, livestock and other information combined with data from Food and Agriculture Organisation (FAO), Soil Moisture Active Passive (SMAP), global gridded crop distribution/production datasets (CROPGRIDS), Project for On-Board Autonomy - Vegetation (PROBA-V), and other sources.

An overview of the GRADE approach and datasets used in the assessment, and a general schematic flow-chart 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.

Hazard Modeling	Exposure Modeling	Vulnerability Modeling	Damage Estimation
Wind field map Map of flooding caused by excess rainfall during storms and riverine and flash flooding Storm surge inundation map	Mapping population and asset values Jamaica housing census data Gross stock data Residential buildings, according to structural type, age, height Non-residential buildings according to use and structural type Infrastructure (e.g., roads, bridges, ports, airports) urban and rural spatial considerations	Global and local database of building damage data Damage versus hazards severity according to structure type Real-time event data from social media (photos, video, drone footage) Remote sensing data Post, disaster, analytical structural vulnerability tool	Cost of direct damage to buildings and critical infrastructure Cost of direct damage to crops Human casualties due to building collapse Estimation of direct and indirect damage to other important economic sectors Potential impacts on gross domestic product and the economy
Event footprint generation	**Exposed values according to asset type and building typology**	**Vulnerability curves according to building typology**	**Report**

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



Validation and calibration against reported damage data is then carefully completed. Modelled results are cross-checked across multiple sources (Annex 2) and damage estimates are monitored over time until they stabilize. Reported damage statistics and datasets, remote-sensed and satellite imagery, local media reports, social media posts, as well as freely available walk-by, drive-through, and drone videos, which provide snapshots of damage for specific areas, were used as checks throughout the impacted areas. This iterative and lengthy calibration process refines the damage estimates but reducing the uncertainties.

Results

4

Total damage is substantial at an estimated US$8.8 billion, equivalent approximately to 41 percent of the 2024 GDP. Table 3 shows the best estimate of total direct physical damage caused by Hurricane Melissa to physical assets by asset class and parish. Table 4 presents the relative damage by parish and asset class compared to the total capital stock or total exposed value (TEV) for each parish and asset class. Figures 8 to 12 present the results in map format.

Table 3. Total damage calculated for Jamaica from the effects of Hurricane Melissa in US$ millions by asset class and parish

Parish	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)
Saint Elizabeth	997.2	389.5	763.6	135.7	2286.0
Saint James	704.2	506.1	587.0	24.8	1822.1
Westmoreland	690.9	220.0	434.0	64.2	1409.1
Trelawny	266.8	154.4	296.5	29.1	746.8
Manchester	305.4	102.4	252.9	28.4	689.1
Saint Ann	221.9	155.0	154.8	20.4	552.1
Hanover	158.1	66.7	141.8	20.1	386.7
Clarendon	133.1	54.2	112.0	19.3	318.6
Saint Catherine	93.2	47.8	91.4	22.3	254.8
Saint Andrew	52.5	53.8	30.6	2.7	139.5
Saint Mary	30.6	11.0	26.9	15.5	84.1
Portland	13.1	4.6	11.7	2.2	31.7
Saint Thomas	6.8	2.1	6.3	4.3	19.5
Kingston	2.6	4.4	7.0	0.0	14.0
Total	**3676.4**	**1772.2**	**2916.4**	**389.1**	**8754.2**

Overall, building damage (including contents) accounted for over 60 percent of the total damage. Residential damage is estimated to be US$3.676 billion including structural damage and damage to contents. Non-residential damage, including social infrastructure, tourism resorts and hotels, public buildings including health and education facilities, industrial, and commercial assets, are estimated at US$1.772 billion. The categorization of mixed-use buildings presents challenges, but these have been distributed between residential and non-residential categories using the best available data and information.

Table 4. Relative damage calculated for Jamaica from the effects of Hurricane Melissa as a percentage of the total exposed value (TEV) by asset class and parish

Parish	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)
Saint Elizabeth	24.52%	23.31%	31.12%	26.25%
Westmoreland	19.01%	15.72%	22.13%	19.23%
Saint James	14.99%	13.62%	17.89%	15.37%
Trelawny	12.95%	9.79%	15.07%	12.81%
Hanover	9.01%	6.90%	12.05%	9.40%
Manchester	5.85%	4.40%	9.28%	6.43%
Saint Ann	4.48%	4.23%	5.29%	4.60%
Clarendon	2.60%	1.73%	2.66%	2.40%
Saint Mary	1.30%	1.05%	1.65%	1.36%
Saint Catherine	1.09%	0.77%	1.04%	0.99%
Portland	0.75%	0.47%	0.77%	0.69%
Saint Andrew	0.60%	0.40%	0.65%	0.51%
Saint Thomas	0.34%	0.26%	0.55%	0.38%
Kingston	0.15%	0.31%	0.30%	0.25%
Total	**6.49%**	**4.19%**	**7.16%**	**6.27%**

Infrastructure was comparatively the worst hit in terms of percentage of the total exposed value with an estimated 7.2 percent of infrastructure capital lost at a value of US$2.916 billion. Key sectors damaged included power networks, telecommunications assets, water networks, and transport, including airports, roads, and coastal infrastructure.

Agricultural damage estimates total US$389.1 million. This includes crop and livestock damage and small-scale infrastructure such as irrigation. It also includes the impacts on beehives. The damage was caused by a combination of wind damage for trees, leaf crops, the case of some storage facilities, rain intrusion, flooding, storm surge and to a lesser extent landslides. The severe damage to the country's largest egg farm will also have significant supply-chain disruptions and highlights the vulnerability of major agri-enterprises to storm impacts.

Saint Elizabeth was worst affected of the parishes with US$2.286 billion in damage across all asset classes, equal to 26.2 percent of the exposed values. Westmoreland, Trelawney and Saint James also have over 10 percent total damage as a percentage of the exposed value.

Figure 9. Total damage maps by parish in US$ millions (upper) and by percentage of total exposed value (excluding agriculture) (lower)

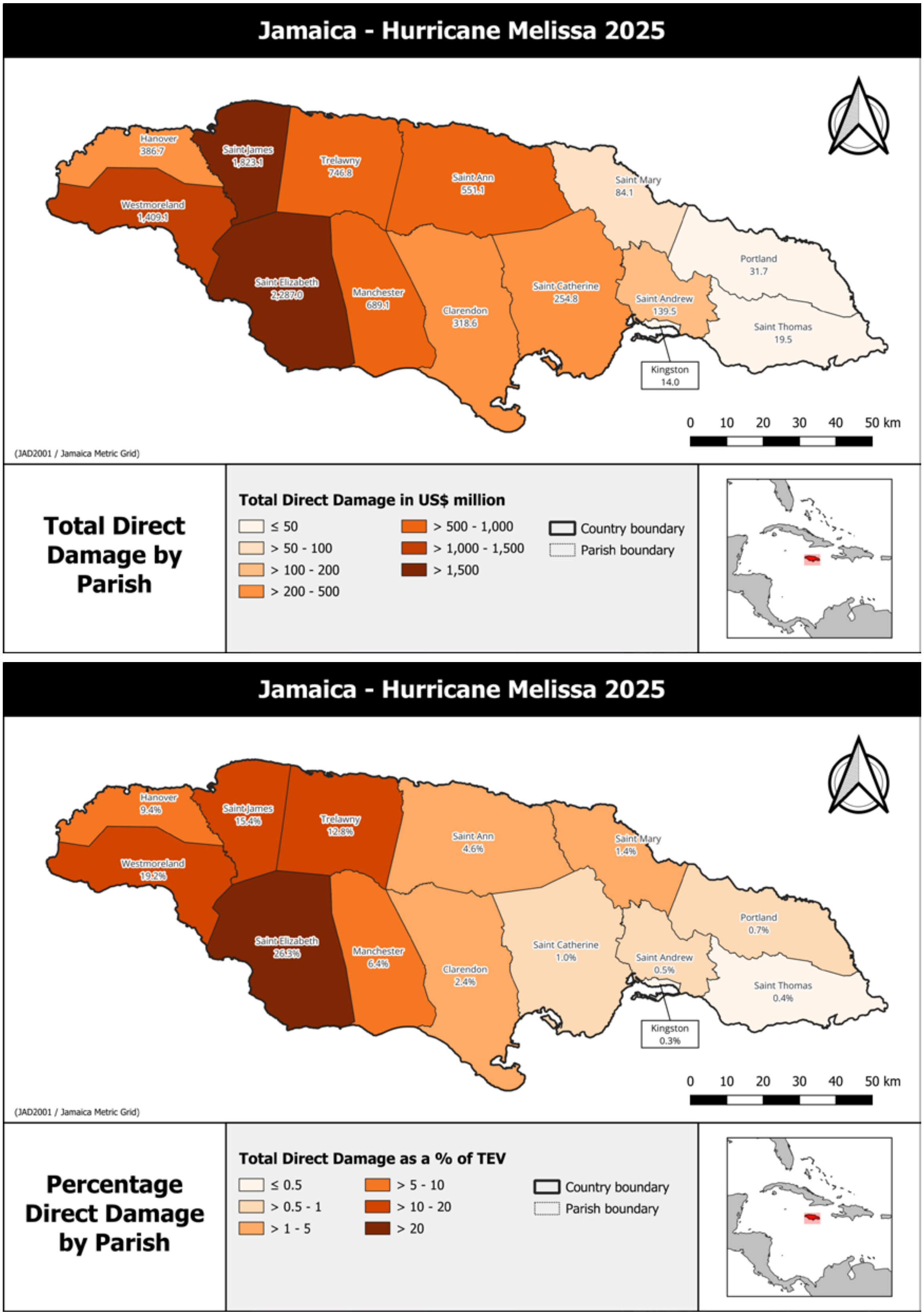


Figure 10. Residential damage maps by parish in US$ millions (upper) and by percentage of total exposed value (lower)

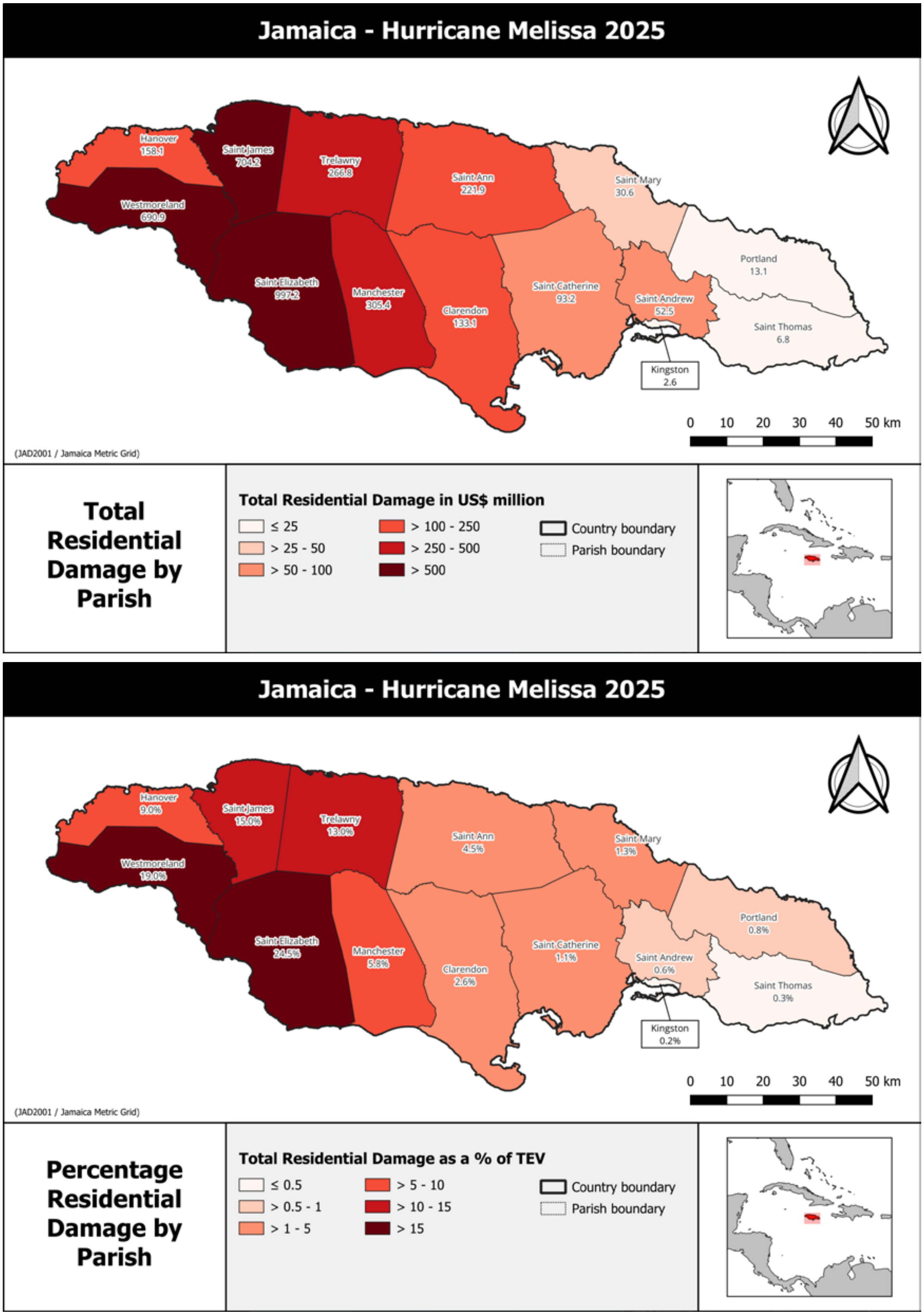


Figure 11. Non-residential damage maps by parish in US$ millions (upper) and by percentage of total exposed value (lower)

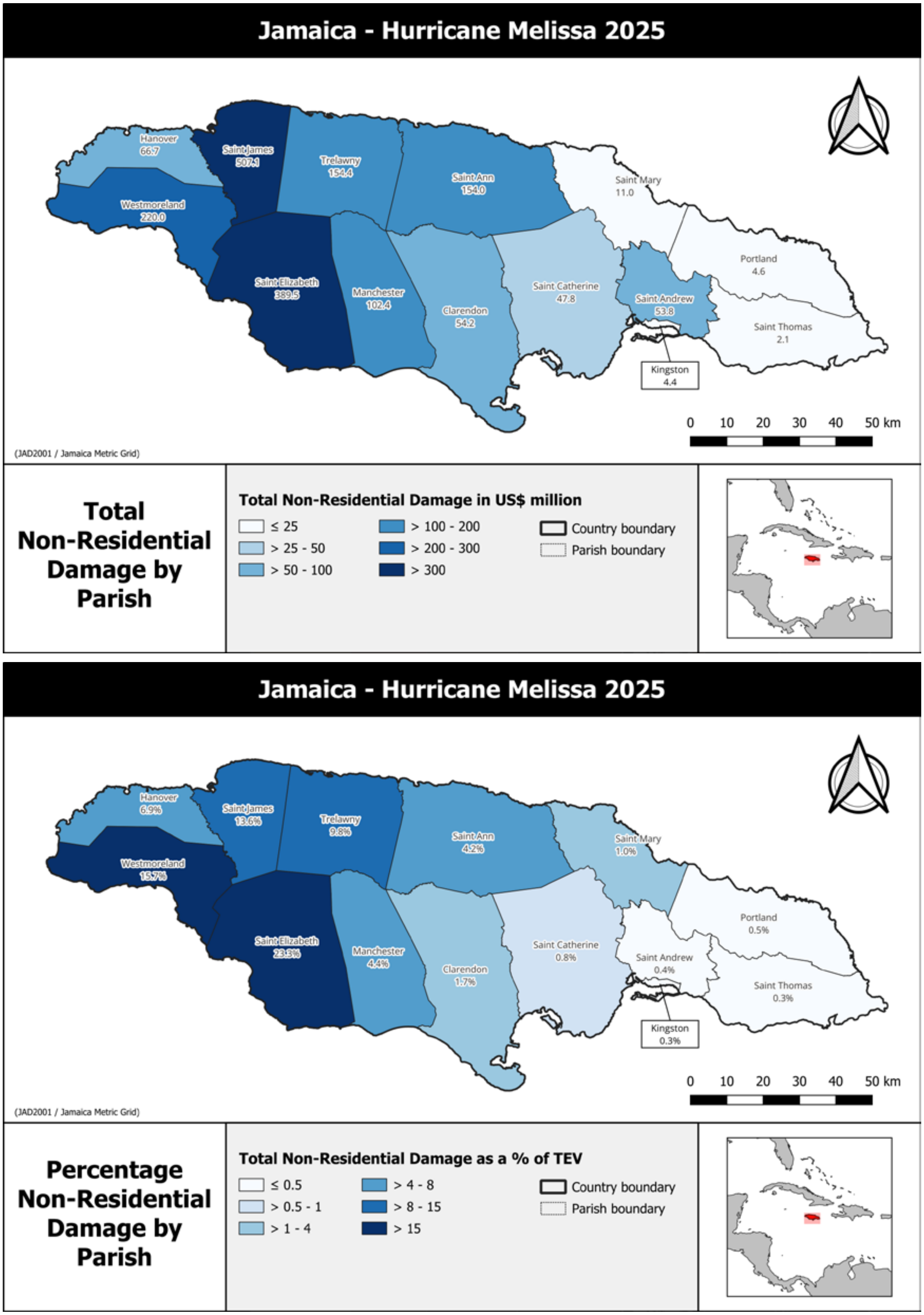
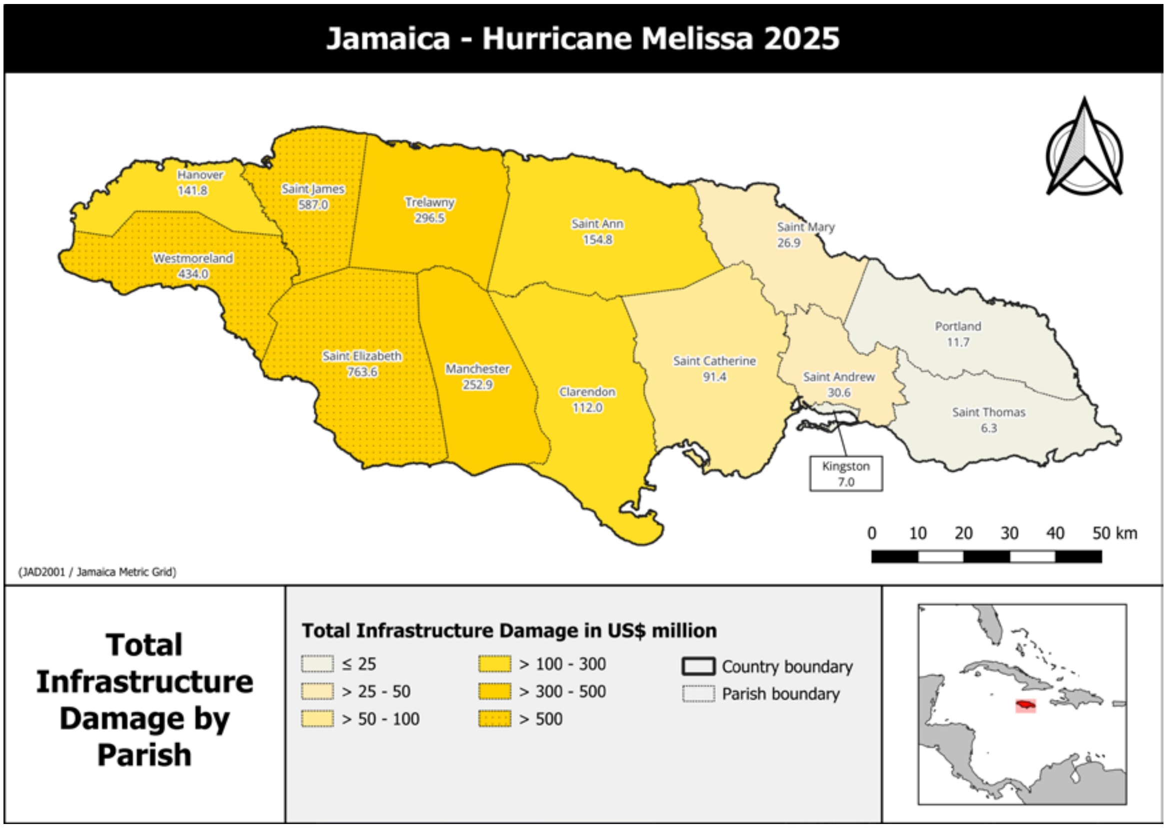


Figure 12. Infrastructure damage maps by parish in US$ millions (upper) and by percentage of total exposed value (lower)



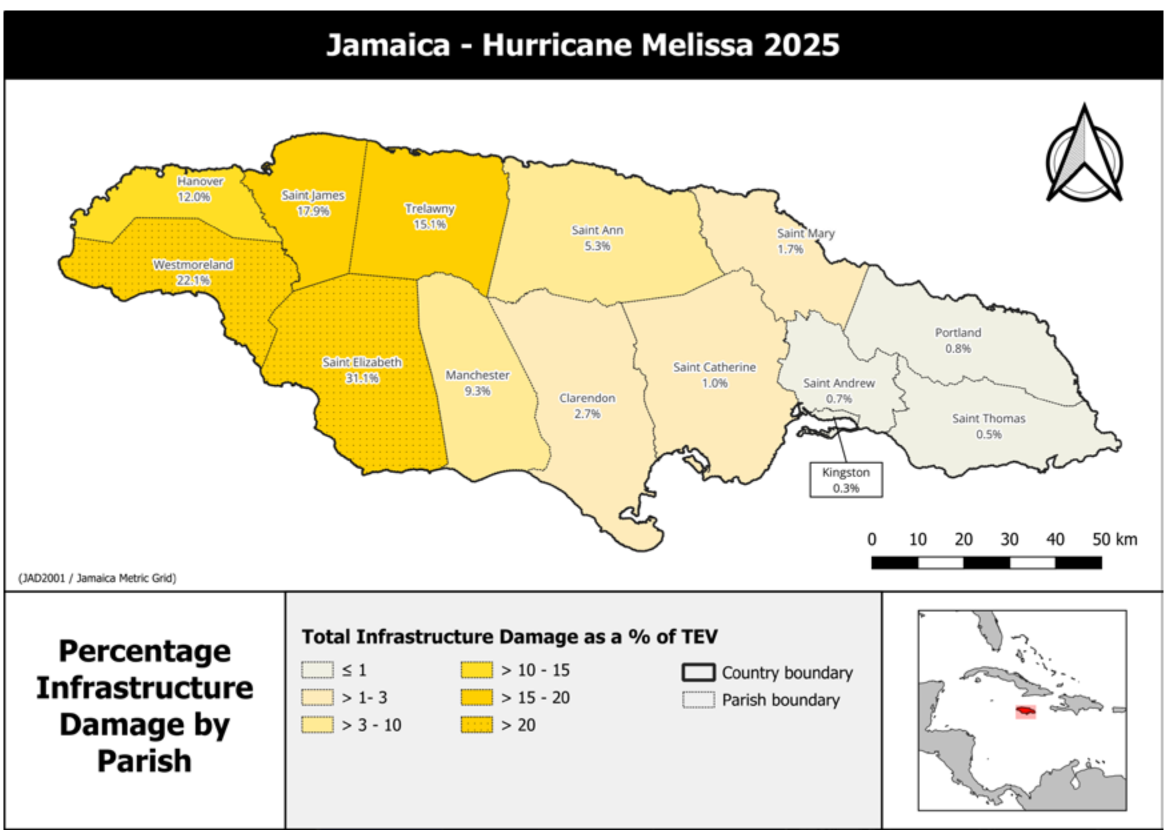
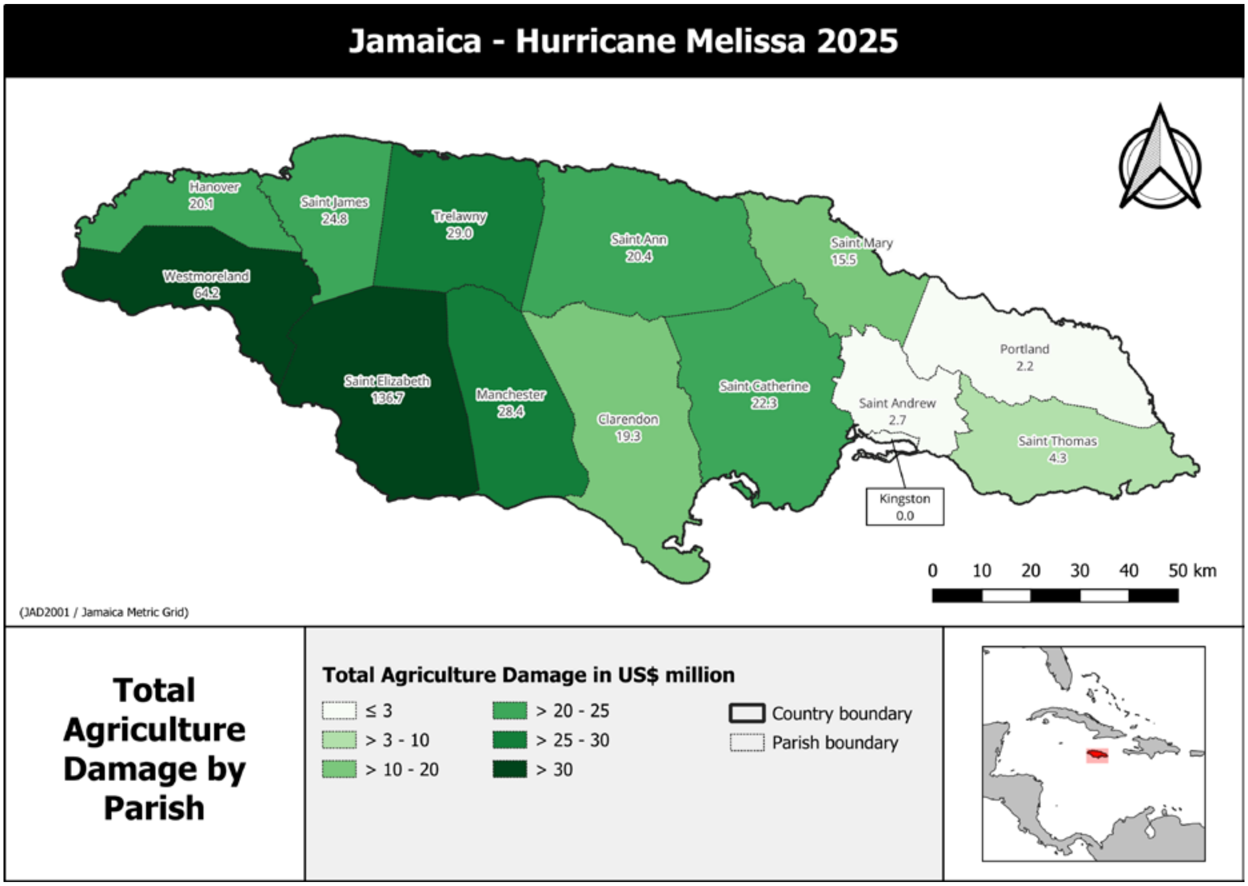


Figure 13. Agriculture damage maps by parish in US$ millions



5 Interpretation of Results and Conclusions

The GRADE assessment places the total cost of direct damage to residential, non-residential, infrastructure, and agriculture asset classes in Jamaica at US$8.75 billion, equivalent to roughly 41 percent of 2024 GDP and around 6 percent of the exposed capital stock. This makes Hurricane Melissa one of the costliest hurricanes to impact Jamaica on record. Hurricane Gilbert in 1988, when normalized to today's prices, also had an impact in the billions of USD.

The impacts on the infrastructure asset class are substantial. At approximately one-third of total damage (about US$2.9 billion) and 7.2 percent of the total exposure value, is the most heavily affected asset class relative to its capital stock. Within this category, power networks represent a large driver of damage, with widespread destruction to transmission lines, distribution networks, substations, and power generation. These impacts underscore the need to strengthen critical lifelines, particularly as Jamaica accelerates its renewable energy transition. Damage at the Eight Rivers Solar Park, Jamaica's largest photovoltaic facility, highlights the exposure of major renewable-energy investments and the need for resilient design to protect climate mitigation investments. The relatively limited impacts at Wigton Wind Farm show that well-engineered utility-scale renewables can perform robustly under extreme winds. These patterns highlight infrastructure as both a major source of direct damage and a priority asset class for resilience upgrades to safeguard service provision, reduce cascading risks, and protect Jamaica's long-term energy security.

This is a critical moment to invest in resilient housing in Jamaica. The housing damage totaling US$3.674 billion reflects the high vulnerability of Jamaica's housing stock. While these winds were extreme, it is important for focus to shift to building back better. High rates of roof damage and structural failure are generally most common in dwellings lacking adequate roof-to-wall connections. These results reinforce the importance of strong policy responses such as strengthening and enforcing building codes as well as training construction professionals. This is particularly needed in rural and low-income areas where informal structures suffered disproportionately. Cost-effective "build back better" options, such as hurricane straps, improved roof anchoring, enhanced bracing, and wind-resistant roof geometries, have repeatedly demonstrated strong cost–benefit ratios in the Caribbean. Overall, however, the building stock in Jamaica has responded better than other locations in the Caribbean in recent events, indicating more resilience compared to the region (i.e. Hurricane Beryl 2024, Hurricane Doran 2019, Hurricane Maria 2017, Hurricane Irma 2017).

Tourism is expected to see additional effects beyond direct damage. The tourism sector in the north of Jamaica has been particularly badly hit, with some large resorts such as Sandals and Iberostar incurring severe damage, and smaller scale boutique hotels and holiday villas also sustaining damage. Many of the country's tourism assets are in the western and northern parts of the island with large cruise berths in Saint Ann, Trelawny and Saint James parishes, so these impacts may be felt severely, even if some assets are insured. For a tourism-dependent economy, prolonged damage to infrastructure and accommodations in key western and northern parishes, combined with cancelled trips and disruptions, is likely to reduce tourism activity in the short-term, particularly as the peak winter season approaches.

Access constraints remain a critical barrier to response and early recovery. Extensive road damage, generally due to flooding, and fallen transmission lines and electricity poles blocking roads, continue to restrict response and recovery operations, restricting market access, and delaying the restoration of essential services that enable the recovery of livelihoods. Improvements focused on strengthening the resilience of roads, embankments, and transmission lines along roads should be made. In addition, strengthening the redundancy and climate resilience of key transport corridors is critical to reduce the impacts of future events

Agriculture, livestock and fisheries damage maes up US$389 million in the GRADE analysis (about five percent of total direct damage). A significant portion of this falls upon smallholders and rural households, making the sector's impact disproportionately severe. The loss of more than 41,000 hectares of farmland, 1.25 million animals, and major shares of vegetable, banana/plantain, fruit tree, yam and coffee production directly undermines the subsistence and market incomes of tens of thousands of farmers in the most heavily affected parishes. These are areas where household resilience is already low and where agriculture remains the primary economic anchor. With rural communities still recovering from Hurricane Beryl in 2024, the impacts of Melissa have the potential to deepening rural poverty, increase reliance on remittances and informal coping strategies, and increase short-term food insecurity.

Strong disaster risk financing (DRF) mechanisms exist, but total damage is far above available coverage. Jamaica maintains one of the Caribbean's most advanced sovereign disaster risk financing (DRF) systems, including contingency funds, parametric insurance, and a US$150 million World Bank–supported catastrophe bond intended to provide rapid post-disaster liquidity which was triggered in this event on November 7 (World Bank, 2025). Jamaica's DRF framework enhances fiscal resilience, however, the US$8.754 billion in direct damage identified by the GRADE assessment far exceeds the scale of Jamaica's ex-ante financial protections, and financial needs will extend over several years, highlighting the need for a long-term financing plan for recovery and reconstructio.

Losses and needs are not considered here but are expected to be significant. While the GRADE assessment focuses on US$8.754 billion in direct physical damage, the overall economic shock is likely to be larger once indirect losses are accounted for. It can be expected that the indirect effects of this event will be significant given the infrastructure impacts; in the past these have often been in the order of 40 to 125 percent of the direct damage in similar style events. Additionally, the cost of building back better will be often in the order of 1.5 - 2 times higher than the replacement costs (i.e. the values calculated herein) depending on the construction typologies.

Gender and social inequalities influence the populations most affected by the storm - Natural disasters in Jamaica increase the risks of diseases, illnesses, and injuries, which fall disproportionately on women due to their role in the society (World Bank, 2023). Reports on previous Hurricanes Ivan (PIOJ, ECLAC, UNDP, 2004) and Dean (PIOJ, 2007) indicate that women, children, and especially female-headed households were the most affected social groups. These households typically have less resources to repair damage to their houses (World Bank, 2023). During crises like hurricanes, unpaid care work intensifies and disproportionately falls on Jamaican women and girls. Disruption in education or childcare services often leads to increased women's caring responsibilities and levels of stress (UN Women 2025). In addition, during disasters, especially in rural areas, women may need to travel longer distances to fetch water for their family, potentially creating health problems (Pouramin et al., 2020), as well as an increased risk of harassment and violence while traveling to and from a water collection point (Sommer et.al., 2015).

The risks of gender-based violence are increased. Thousands of women and girls have been displaced and sheltered under unsafe or unstable conditions in homes without electricity or in emergency facilities (UN Women, 2025). The lack of gender-based violence (GBV) considerations in disaster settings and special measures for ensuring a safe environment in the country may affect women and children living in shelters (World Bank, 2023). Hospitals and primary health care facilities were severely damaged, leaving women and girls without access to essential health services in the most affected regions. Furthermore, nutrition and dietetic services report only a 3- to 5-day food supply in other hospitals in Jamaica, underscoring the need for urgent support for breastfeeding mothers, pregnant and lactating women, and safe infant feeding for non-breastfed children (PAHO/WHO, 2025).

This GRADE assessment is intended as a rapid, remote estimate prepared within a short timeframe to inform early decision-making. It is based on damage reporting from a range of agencies, local media updates, and modelling of buildings and infrastructure in Jamaica. Analysis and results were verified using multiple data sources, including satellite imagery, academic studies, government data and disaster agency reports. Future interventions should build upon this GRADE assessment to design targeted and inclusive recovery programs, conduct detailed sectoral needs assessments and explore instruments that enable sustained physical risk reduction.

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Annex 1: Historical disaster event descriptions

Jamaica's long hurricane history includes several landmark events that still frame today's understanding of risk. One of the earliest documented catastrophes occurred on **August 28, 1722**, when the eye of an intense hurricane crossed Port Royal. A storm surge of about 4.9 m (16 ft) destroyed roughly half of the port's buildings, with British-era structures faring worse than older Spanish ones. Around 400 people were killed, and only four crew members among 50 ships in harbour survived; the sinking of the slave ship, Kingston, alone claimed two hundred lives. Surviving colonists were left without basic necessities, and the devastation was later chronicled in John Atkins' 1723 account, *A Voyage to Guinea, Brasil, and the West-Indies*.

Another major early disaster struck in **November 1912,** when a strong hurricane moved very slowly across the island. While the system was still developing in the southern Caribbean, outer rainbands produced up to 36 in (910 mm) of rainfall between November 10-12 in parishes such as Saint Thomas, Portland, Saint Andrew and Saint Mary, causing extensive flooding and damaging roads and bridges. Strong winds destroyed banana trees (about 25 percent of the crop overall, with some plantations losing up to 60 percent) and inflicted heavy losses on the United Fruit Company. As the hurricane neared the coast, railway lines and telegraph lines were heavily damaged, communications were cut, and rough seas wrecked numerous ships. The town of Savanna-la-Mar was nearly destroyed; in Montego Bay, 42 people were killed. Across western Jamaica roughly a hundred homes were destroyed. In total, 142 fatalities and 94,820 people affected were reported, with an estimated US$1.5 million (1912) in damage. The government deployed artillerymen with tents and relief supplies to impacted regions.

In the 20th century, **Hurricane Charlie (August 17-18, 1951**) is recorded as Jamaica's deadliest disaster of that era. Making landfall near Kingston as a Category 3 hurricane, Charlie produced peak gusts near 125 mph (201 km/h) and dropped 17 inches (430 mm) of rain in the capital. Landslides occurred across eastern sections of the island, while Palisadoes Airport suffered extensive damage. Strong winds destroyed or badly damaged crops (70–80 percent of banana production and about 30 percent of other crops), and rockslides and flooding damaged roads, railways, and other tourism-related infrastructure. Overall, Charlie caused around US$56 million (1951) in crop and property damage, with 154 deaths, 2,000 injuries and 25,000 people left homeless. It remained the country's worst disaster until Hurricane Gilbert in 1988.

Severe flood events have also marked Jamaica's history. On **June 12, 1979, Tropical Depression One** stalled to the west of the island, producing 32 in (810 mm) of rain at Friendship in Westmoreland Parish. Flooding destroyed or severely damaged about 1,000 homes and rendered around 40,000 people homeless, with the town of New Market submerged for at least six months. Crops, electricity, telephone infrastructure, buildings and railways all suffered damage; agricultural losses included sugar cane, bananas and other produce. About 300 miles (480 km) of roadways were affected, several bridges collapsed and others were damaged. The event caused 40 deaths and approximately US$27 million (1979) in damage.

Hurricane Gilbert (September 12, 1988) then set a new benchmark for destruction. Making landfall as a low-end Category 4 hurricane, it was described as the most destructive storm in Jamaica's history since Charlie. Gilbert produced storm surge up to 19 ft (5.8 m) and rainfall of up to 32.4 in (823 mm) in mountainous areas, causing inland flash flooding. Winds knocked down power lines, uprooted trees, flattened fences and heavily damaged Kingston's airport and aircraft. On the north coast, waves up to 20 ft (6.1 m) battered Ocho Rios and forced hotel evacuations. Unofficial estimates suggested that at least 30 people were killed around the island, while more than 100,000 houses were destroyed or damaged and the banana crop was largely wiped out. Hundreds of miles of roads and highways were heavily damaged, and the poultry industry was effectively "wiped out." Total damage in Jamaica was reported at US$1,092 million, with 49 deaths, making Gilbert the most destructive storm on record for the country at that time.

In the 2000s, a series of intense events underscored Jamaica's multi-hazard exposure. **Hurricane Ivan (September 11, 2004)** passed very close to Portland Point and is described as one of the most intense hurricanes in the island's history, causing significant flooding and damage. Seventeen fatalities were reported and total damage reached about US$595 million, with widespread effects across Clarendon, Westmoreland, St. Catherine, St. Elizabeth, St. Thomas, St. Ann, Trelawny and Kingston. Just three years later, Hurricane Dean (August 20, 2007) passed 50–60 miles (80–95 km) south of Jamaica as a Category 4 hurricane. Heavy rainfall triggered flooding and landslides, particularly in the northeast. Over 1,500 roofs were lost; 3,127 homes were damaged, 1,582 of them left uninhabitable. Agriculture suffered severe losses, including 40 percent of the sugarcane crop, 80–100 percent of the banana crop, 75 percent of young coffee trees, and 20 percent of the top layer of cocoa. Dean affected 248 roads, 186 of which were blocked, and caused roughly US$329 million in damage with 4 deaths.

Hurricane Gustav (August 29, 2008) made landfall on the eastern tip of Jamaica as a high-end tropical storm, moving slowly along the south and west coasts. Twelve deaths were reported and total damage reached about US$210 million. Most affected communities were in Kingston and St. Andrew, with flooding the main driver of impact, alongside some storm surge, wind damage and landslides. Housing damage was particularly severe in the Hope River Valley, especially in Tavern and Kintyre.

Two years later, the precursor disturbance and subsequent **Tropical Storm Nicole (late September 2010)** produced extraordinary rainfall over several days. Belleisle in Westmoreland recorded 37.42 in (940 mm) from September 26-30, with most other parishes receiving over 12 in (300 mm). These amounts tripled the normal monthly average in some locations. Although large-scale winds remained gentle, convective bands generated three damaging microbursts. Flooding and landslides affected numerous communities, particularly in southern parishes, trapping hundreds of residents and isolating communities as roads and bridges were washed out. Nationwide, 16 deaths and 42 injuries were recorded, and 507,831 people were affected. Infrastructure damage was extensive: more than 288,000 residences lost power, over 40 percent of the water supply was disrupted, dozens of bridges collapsed, and 543 principal roads sustained some damage. Infrastructure losses approached US$235.4 million (J$20 billion). Housing losses reached US$3.2 million (J$274.3 million), with 2,169 houses damaged (54 destroyed), and agriculture sustained US$6.8 million (J$576.5 million) in losses.

In **October 2012, Hurricane Sandy** made landfall near Kingston with 85 mph (137 km/h) winds, the first hurricane landfall on the island since Gilbert. Two fatalities were reported and damage in Jamaica was assessed at US$100 million. The storm affected multiple parishes, including Kingston and St. Andrew, Clarendon, Portland, St. Thomas, St. Mary, St. Catherine, St. Ann, Portmore, St. Elizabeth, Manchester, Trelawny, Westmoreland and Hanover.

Not all major disasters have been associated with named hurricanes. The **March–June 2017 rainfall** events caused extensive flooding across 11 parishes, impacting 2,474,535 people—around 90.6 percent of the national population. Total damage and loss were estimated at J$4.0 billion, or 0.2 percent of 2016 GDP, of which J$1.0 billion (24.7 percent) was direct damage and J$3.0 billion (75.3 percent) were losses and additional costs. More than J$3.3 billion (over 80 percent) of the total was borne by the public sector, with losses concentrated in infrastructure, particularly transport, where reported losses reached J$2.9 billion.

Most recently, **Hurricane Beryl (July 3, 2024**) passed just south of Jamaica as a Category 4 hurricane, hammering the island with heavy winds and rain. At least four fatalities were reported. Damage and losses were estimated at J$56.7 billion, equivalent to 1.9 percent of 2023 GDP. Approximately 22.9 percent of the island's population—618,496 people across 119 communities—were directly affected by flooding, landslides and infrastructure damage. Beryl thus stands with Gilbert, Ivan and Charlie among the benchmark events shaping Jamaica's contemporary disaster risk landscape.

Annex 2: Datasets and data sources used

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

Hazard

- NOAA-IBTrACS data.
- FastFlood using data from global
- HWRF, HMON, NCEP, ECMWF, GFS, HAFS-A, HAFS-B datasets and models for track determination, wind field heterogeneity etc.
- Wind station data.
- Satellite Products (UNOSAT, COPERNICUS via Sentinel 1 and Sentinel 2)
- CATDAT (historical info).
- IMERG Rainfall Data from NASA
- HYBAS Basin Datasets from HydroBASINS

Exposure

- Socioeconomic data and enterprise surveys, integrated business enterprise surveys, and other statistical datasets in Jamaica including parish GDP, checks against CATDAT data, investment data, building types, religious structures from the Statistical Institute of Jamaica (STATIN).
- Ministry websites and social media reporting.
- Livestock data from Global Products, FAO - agriculture exposure in terms of food production.
- Global ML and Google Buildings Dataset, as well as VIDA
- Infrastructure: JPS data on transmission lines, PIOJ databases as well as Government of Jamaica data, OSM data from 2025, including HOTOSM updates, for roads, bridges, and other elements, augmented via various datasets, Geonodes, and annual yearbook statistics.
- 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.
- WSF3D at 90 m from DLR.
- Capital Stock Modeling methods using national account data,
- Global Program for Safer Schools study, ministry data, health statistics, and other energy statistics.
- 2025 FAO/WFP Crop and Food Security Assessment Mission
- ESA 10m WorldCover Product
- PROBA-V product
- Meta Relative Wealth Index, High-Resolution Settlement Layer (HRSL), WorldPop for population checks.
- Gridfinder, Enipedia, power data. GoJ and UNOCHA administrative boundaries and other World Bank boundaries.

- Vulnerability/Risk
- Country Disaster Risk Profile 2016 for Jamaica (World Bank)
- Country Disaster Risk Profiles
- CATDAT
- IDB Risk Profile 2020
- CCRIF and other Caribbean modelling
- Historical event data (DaLA, PDNA, CATDAT) from many past (hurricane) events in Jamaica and the Caribbean

Damage Data and Observations

- GoJ Reported Damage Data, Updates and Observations
- GoJ – Hurricane Incident Dashboard: https://goj.maps.arcgis.com/apps/dashboards/f7b4531571904a0589962b8c241a6a65
- OPDEM - Bulletins and other updates. Published online on their website (https://www.odpem.org.jm/weather-alert-melissa/) and on social media (e.g. https://www.facebook.com/ODPEM.JA/).
- Various satellite-, aircraft and UAV-based post-event imagery data
- Special Press Briefings on Hurricane Melissa preparations, damages and recovery
- Jamaica Information Service (JIS) - https://jis.gov.jm/.
- Updates from the Prime Minister of Jamaica Andrew Holness - Published on website (https://opm.gov.jm/) and social media (e.g. https://x.com/AndrewHolnessJM).
- Ministry of Health and Wellness (MOHW) - Updates posted on website (https://www.moh.gov.jm/) and social media (e.g. https://x.com/themohwgovjm).
- Ministry of Education, Skills, Youth & Information (MOEY) - Updates posted on website (https://moey.gov.jm/) and social media (e.g. https://www.facebook.com/MOEYIJamaica/).
- Ministry of Agriculture and Fisheries (MoAF) - Updates posted on website (https://www.moa.gov.jm/) and social media (e.g. https://www.facebook.com/moafjamaica).
- Water Resources Authority (WRA) - Updates posted on website (https://www.wra.gov.jm/) and social media (e.g. https://www.facebook.com/wra.gov.jm/).
- National Works Agency (NWA) - Updates posted on website (https://www.nwa.gov.jm/) and social media (e.g. https://x.com/nwa_ja).
- National Water Commission (NWC) - Facilities Status Tracker (https://goj.maps.arcgis.com/apps/dashboards/45689b3d66884462baf2b64d62337961), updates posted on website (https://www.nwcjamaica.com/) and social media (e.g. https://www.facebook.com/NWCjam/).
- Various social media updates from several ministers
- Floyd Green (Minister of Agriculture, Fisheries, and Mining of Jamaica): https://x.com/floydgreenja
- Dana Dixon (Minister of Education, Skills, Youth and Information): https://x.com/IamDanaDixon
- Robert Nesta Morgan (Minister without Portfolio in the Ministry of Economic Growth and Job Creation with the responsibility for Works): https://x.com/NestaJA
- Energy and ITC company updates
- Jamaica Public Service (JPS): https://www.jpsco.com/; https://www.facebook.com/myjpsonline/
- Digicel: https://www.digicelgroup.com/jm/en/hurricane-melissa; https://x.com/DigicelJamaica; https://www.arcgis.com/apps/dashboards/4015b01c8acb4f2997db6d9175ca5d7f
- FLOW: https://x.com/FLOWJamaica
- National and international news and media sources
- Jamaica Observer. Retrieved from https://www.jamaicaobserver.com/.

- Jamaica Gleaner. Retrieved from https://jamaica-gleaner.com/.
- IrieFM. Retrieved from: https://iriefm.net/.
- Radio Jamaica News. Retrieved from https://radiojamaicanewsonline.com/.
- AP News. Retrieved from https://apnews.com/.
- The Guardian: Retrieved from https://www.theguardian.com/
- ReliefWeb: https://reliefweb.int/updates?advanced-search=%28PC127%29_%28D52461%29&page=0.
- Humanitarian Response Data: https://data.humdata.org/group/jam.
- Pacific Disaster Center (PDC):
- https://disasteraware.pdc.org/
- CDEMA, UNOCHA, MapAction, WFP, IOM, UNICEF, DG ECHO, LogCluster, Emergency Telecommunications Cluster (etc), and PAHO Situation Reports and Updates
- CDEMA - https://cdema.org/.
- UNOCHA - https://reliefweb.int/updates?advanced-search=%28C127%29_%28S1503%29.
- MapAction - https://maps.mapaction.org/event/2025-jam-001.
- WFP - https://reliefweb.int/updates?advanced-search=%28C127%29_%28S1741%29.
- IOM - https://reliefweb.int/updates?advanced-search=%28C127%29_%28S1255%29.
- UNICEF-https://reliefweb.int/updates?advanced-search=%28PC127%29_%28S1979%29_%28D52461%29.
- DG ECHO - https://erccportal.jrc.ec.europa.eu/.
- LogCluster - https://www.logcluster.org/en/relief-and-logistics-thematic-working-group-rltwg; https://logie.logcluster.org/?op=jam.
- ETC - https://www.etcluster.org/emergency/caribbean-hurricane-melissa.
- PAHO - https://www.paho.org/en/hurricane-melissa.
- NOAA - https://storms.ngs.noaa.gov/storms/melissa/ index.html.
- Vantor (formerly Maxar) - https://xpress.maxar.com/.
- Umbra Synthetic Aperture Radar (SAR) Open Data - http://umbra-open-data-catalog.s3-website.us-west-2.amazonaws.com/?prefix=sar-data/tasks/Jamaica-2025-10/.
- Drone/streetview imagery and videos shared on social media.
- UNOSAT Satellite Derived Damage Assessments: https://experience.arcgis.com/experience/c4a17cbf128c422ea6e07f92defe7395/page/UNOSAT
- COPERNICUS Satellite Derived Damage Assessment (EMSR847):
- https://mapping.emergency.copernicus.eu/activations/EMSR847/
- Microsoft AI for Good Lab building damage assessments:
- https://data.humdata.org/dataset/hurricane-melissa-building-damage-assessment-in-jamaica
- Earth Observatory of Singapore - Remote Sensing (EOS-RS) & Advanced Rapid Imaging and Analysis Singapore (ARIA-SG) Products
- https://eos-rs-products.earthobservatory.sg/EOS-RS_202510_Jamaica_Hurricane_Melissa/
- UNDP Rapid Digital Assessment (RAPIDA) of Hurricane Melissa in Jamaica: https://geosmart.undp.org/arcgis/apps/experiencebuilder/experience/?_gl=1%2A1juvli2%2A_ga%2AMTgyNDUyMjYyNy4xNzUyMTUwMjMw%2A_ga_PBF14M9C6G%2AczE3NjI1MDM2MjkkbzkkZzAkdDE3NjI1MDM2MjkkajYwJGwwJGgw&id=0804dbcb11994e9d8a566d2c300c36b0&page=Page.
- Updates and data on estimated (insured) damages and payouts by various companies and research groups.
- Various other social media data (X/Twitter, Telegram, Facebook sites).

Annex 3: Overview of Windfield Modelling Methodology – used in conjunction with other wind damage data and observations

To accurately estimate the windfield associated with Hurricane Melissa during its landfall on Jamaica, a refined track and intensity reconstruction was developed. Standard best-track datasets, such as the International Best Track Archive for Climate Stewardship (IBTrACS, Knapp et al., 2010), provided an essential starting point for this process. However, their temporal resolution of three-hour intervals was not sufficient to fully capture the rapid structural and directional changes that Melissa underwent while interacting with the island's terrain. In particular, the storm's center crossed the coastline between two IBTrACS timestamps, causing one position to fall offshore and the next over land, with the intermediate evolution left unresolved. Given the storm's documented shift from a north-northeast to a more north-east trajectory during landfall, additional detail was required for credible impact modelling.

To address this, the storm track was reconstructed at hourly intervals. Geostationary Operational Environmental Satellite (GOES) imagery (National Oceanic and Atmospheric Administration, n.d.) was used to manually identify and follow the location of the hurricane's eye on an hour-by-hour basis. This produced a significantly smoother and more realistic track that better reflected the short-term motion of the storm. By increasing the temporal resolution, the model was able to capture subtle but important directional changes that influence the distribution and intensity of winds experienced on the ground.

Alongside track refinement, central pressure estimates from IBTrACS were non-linearly interpolated to align with both the higher-resolution track and the damage evidence collected on the ground. This calibration step ensured that the modelled windfield more closely matched observed impacts, particularly in locations where topography or storm asymmetry played a decisive role in shaping local wind conditions.

The windfield itself was generated using a Willoughby wind-profile (Willoughby et al., 2006) implemented within a modified McConochie wind model framework (McConochie, 2018). The Willoughby profile allowed for a physically informed representation of the radial wind structure, while the McConochie model provided the broader dynamical environment needed for large-scale windfield reconstruction. Several targeted adjustments were incorporated to strengthen the model's ability to represent the asymmetric nature of Hurricane Melissa's windfield and wind direction. This included refinements to better reflect the storm's interaction with Jamaica's mountainous terrain.

Together, these methodological enhancements resulted in a windfield simulation that is both physically consistent and aligned with observed on-the-ground damage patterns. By combining improved temporal resolution, satellite-supported track verification, calibrated intensity estimates, and a physically robust wind model, the approach provides a reliable foundation for subsequent loss and needs assessments under the GRADE framework. The resulting windfield estimates therefore support evidence-based decision-making for recovery planning, financial response mechanisms, and long-term resilience investments.

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

The flood analysis combined Ensemble precipitation forecasts from the European Centre for Medium-Range Weather Forecasts (ECMWF), GPM-IMERG[8] satellite rainfall estimates, and a high-resolution hydrodynamic model (FastFlood) to reconstruct Hurricane Melissa's inundation profile. ECMWF ensemble forecasts one day before landfall indicated widespread extreme rainfall potential, while post-event GPM-IMERG estimates showed localized accumulations exceeding 1,000 mm, surpassing 200-year return-period thresholds.

Figure 4-1. ECMWF forecast precipitation ensemble, cumulative precipitation, 1 day before landfall

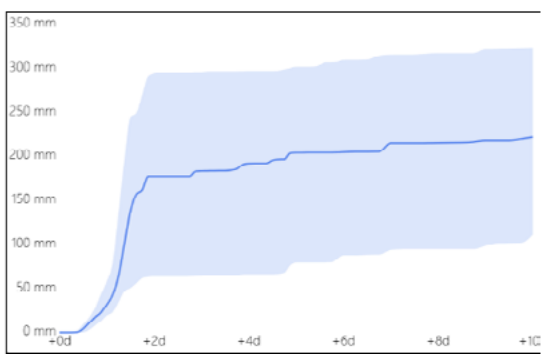
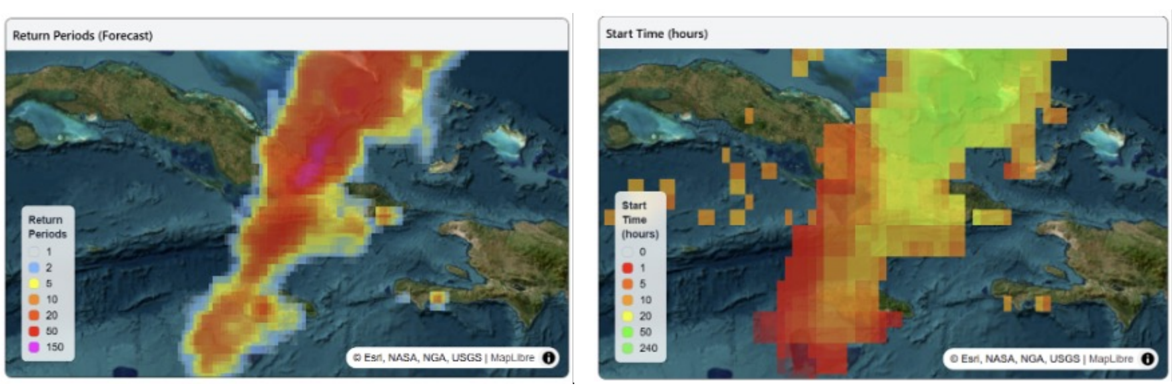


Figure 4-2. Analysis of the ECMWF forecast ensemble 1 day before landfall, (Left) Return period of the precipitation, (Right) Start time.



[8] Global Precipitation Measurement – Integrated Multi-satellite Retrievals for GPM

Figure 4-3. Cumulative precipitation patterns between 27-10 and 30-10 from GPM-IMERG

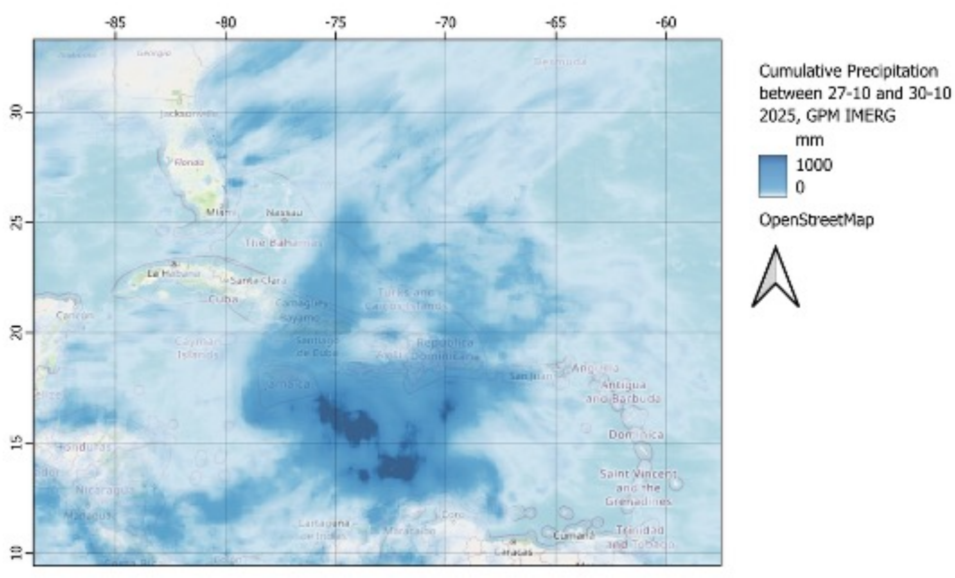


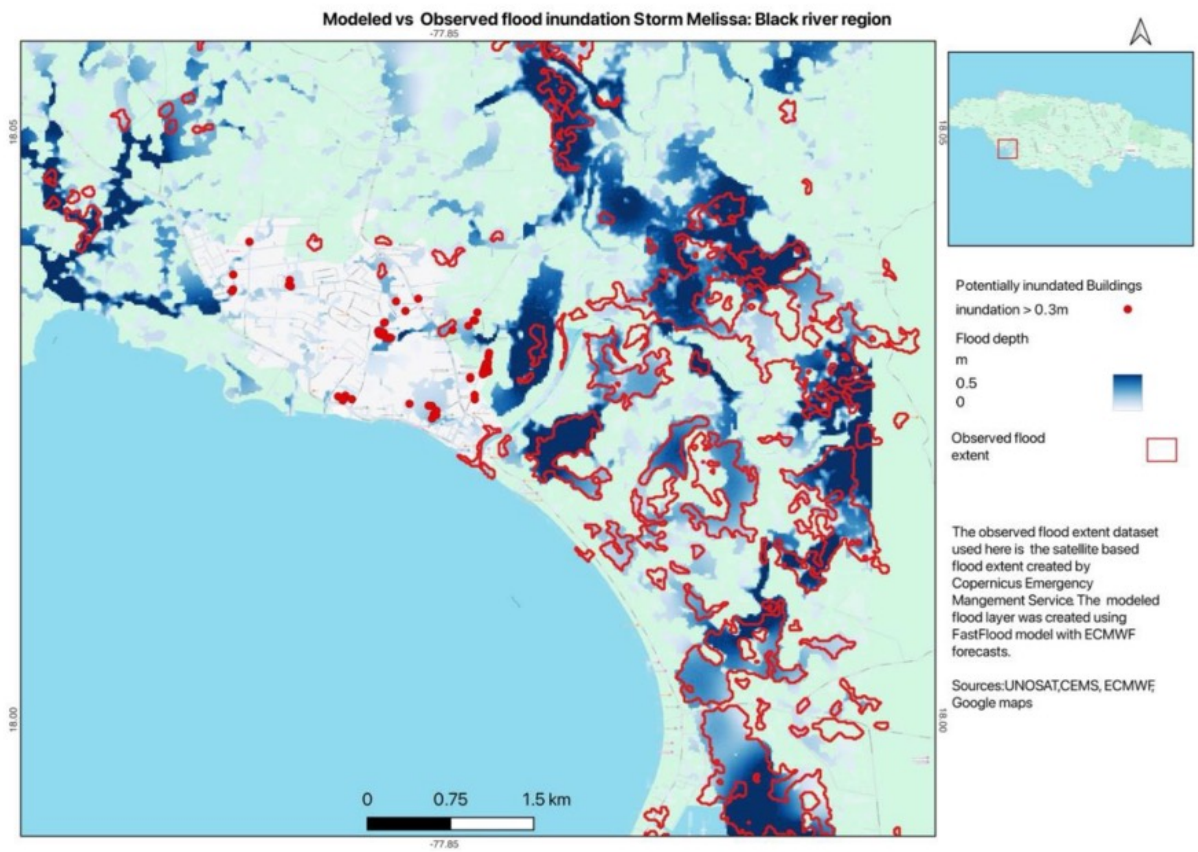
Figure 4-4. Preliminary flood map for the Melissa event in Jamaica at 20 meter resolution, including storm surge flooding and flash flooding. The red boxes are the insets below.

Model Performance

Comparison between the FastFlood simulation and the CEMS-observed flood extent demonstrated strong spatial agreement, particularly across the lower floodplain and coastal zones (Figure 4-5). Minor deviations were observed in localized areas, likely attributable to the coarser digital elevation model (DEM) resolution and simplified surface roughness representation. Despite limited calibration due to the time-critical nature of the assessment, the overall correspondence between modelled and observed extents was high. Further calibration is expected to enhance model accuracy and performance. Additionally, the flood extents observed from the Radar satellite platforms utilized by CEMS, show limited coverage of streams and rivers, and mostly emphasize regions of pooling water. This is a common shortcoming of the space-based observations, where fly-over time and spatial resolution prevent resolving detail of small streams in sloping landscapes.

The flood depth mapping was based on preliminary FastFlood model outputs and available satellite-derived datasets. The model was not calibrated for discharge or flood height due to the absence of observed hydrological data at the time of analysis. Consequently, the results presented here should be considered preliminary and subject to refinement as additional data and calibration opportunities become available.

Figure 4-5. Comparison between the flood simulations and the CEMS flood extent observations.



Localized Flood and Damage Validation – Black River Region

Figures 4-6 and 4-7 present a localized assessment of building damage and inundation within the Black River region, derived from the UNOSAT rapid mapping product. This dataset, based on very high-resolution satellite imagery, was used to support validation of the FastFlood model outputs following Hurricane Melissa. The analysis focuses solely on this region and should not be interpreted as representative of national-level impacts. Broader and more comprehensive loss and damage estimates are detailed separately in the World Bank's national impact assessment.

Figure 4-6 illustrates the spatial distribution of buildings identified by UNOSAT as damaged or destroyed, overlaid with the flood depth layer generated by the FastFlood model using GPM IMERG precipitation data. The results show clear clustering of structural damage along the low-lying coastal areas and floodplains. While the majority of destruction is attributed to extreme wind forces, the overlap between the modelled inundation zones and damaged buildings demonstrates a strong spatial correlation, supporting the reliability of the simulated flood extent.

Figure 4-7 refines this analysis by highlighting potentially inundated buildings, defined as those exposed to water depths exceeding 0.3 meters. The pattern of inundation corresponds closely with flood-prone areas identified in Figure 4-6, particularly along the southern coastal fringe and river outflows. This subset analysis identified 158 buildings that were potentially flooded, including 81 with water depths greater than 0.3 meters. Among these, 27 were completely destroyed, underscoring the compounding effects of wind and flood hazards in these low-lying settlements.

Together, the two figures attempt further validation of the flood modelling output using the UNOSAT dataset. The strong spatial coherence between observed damage and simulated inundation patterns increases confidence in the model's predictive capability. At the same time, this localized comparison emphasizes that the findings are specific to the Black River region, serving primarily as a validation exercise rather than a full damage accounting for Hurricane Melissa across Jamaica.

Figure 4-6. Localized validation with impact for Black river region

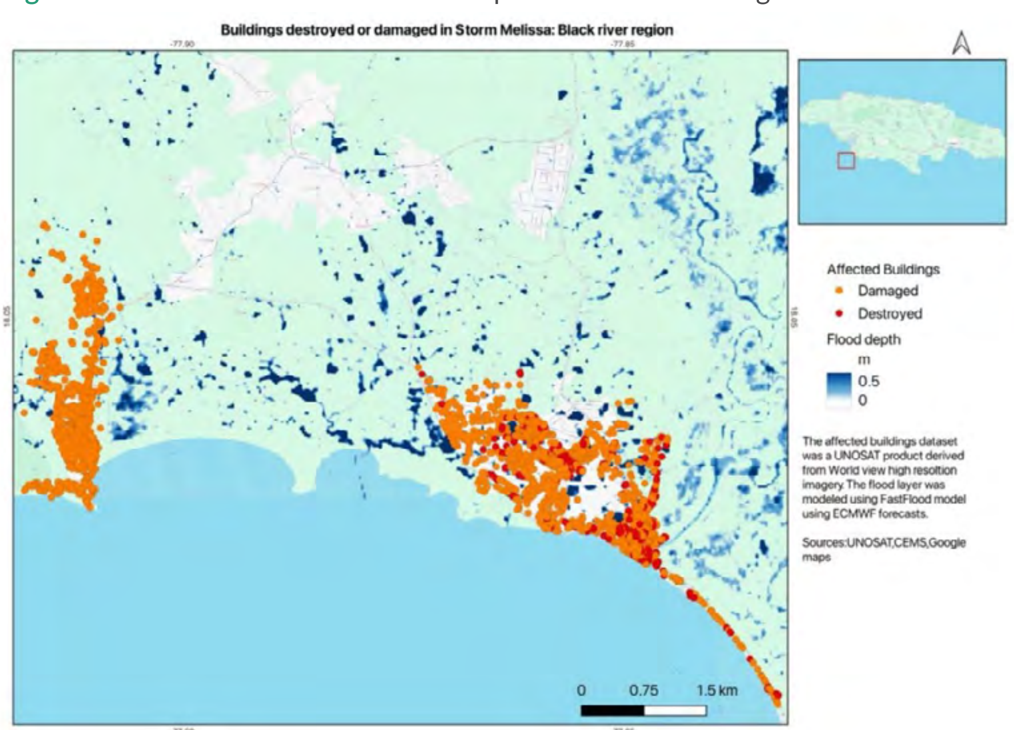
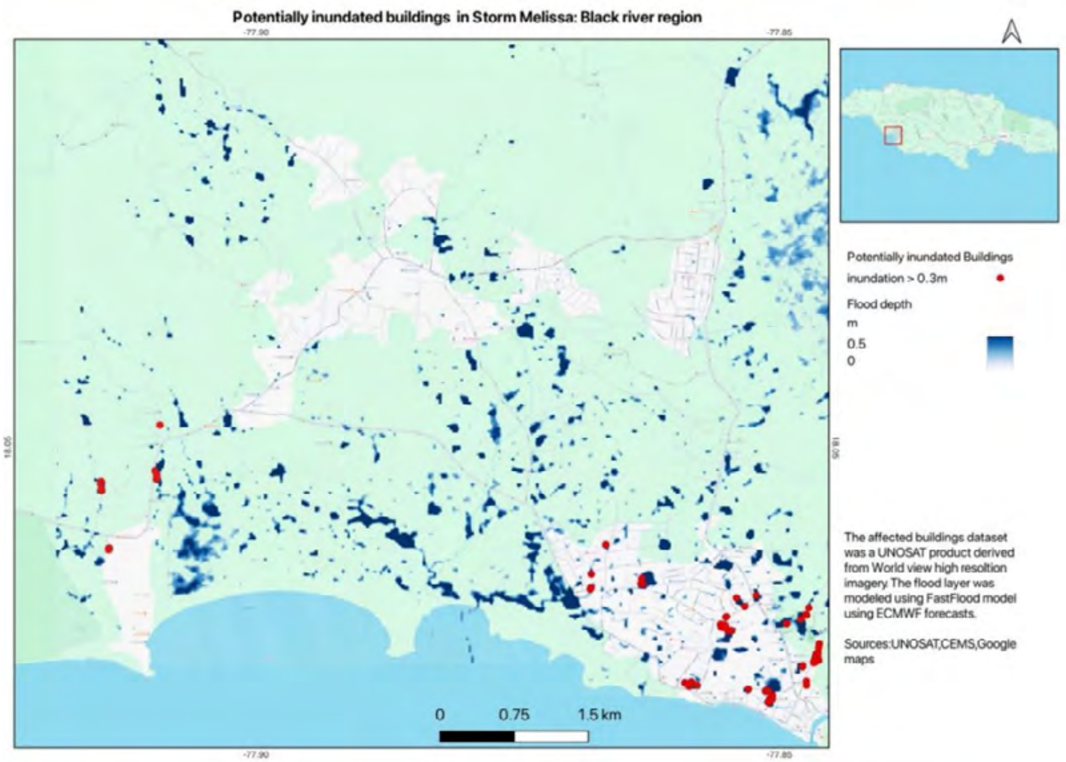


Figure 4-7. Localized validation with impact for Black River region

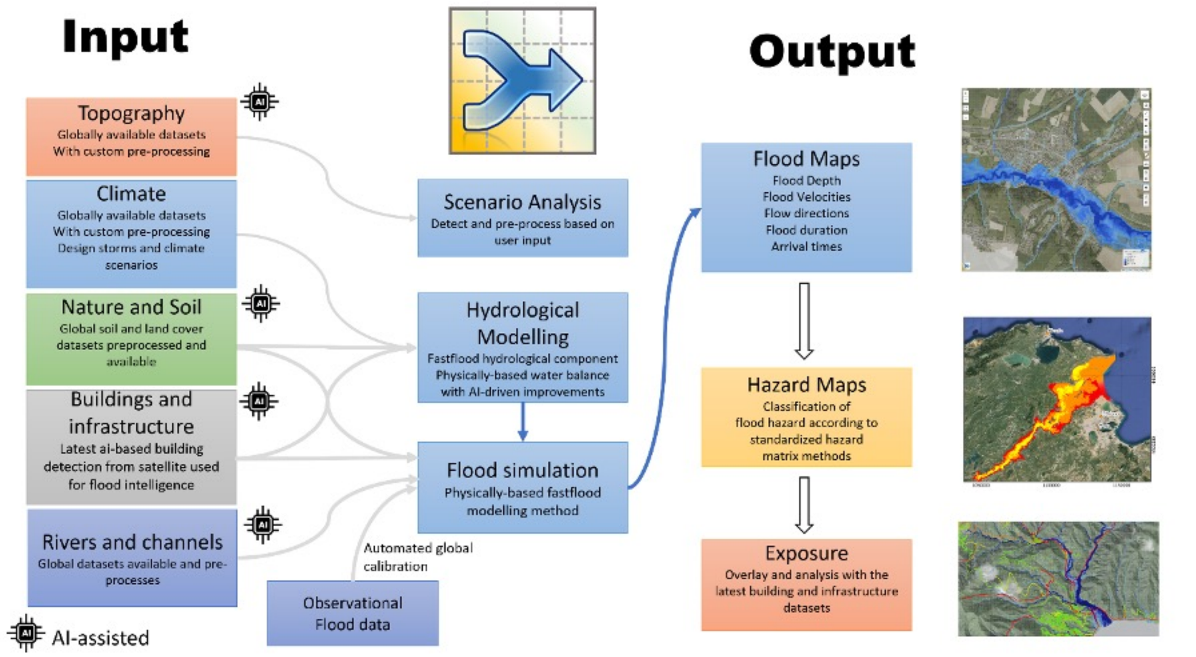


High-Resolution Interactive Flood Modelling for Forecast, Hindcast and Scenario Analysis

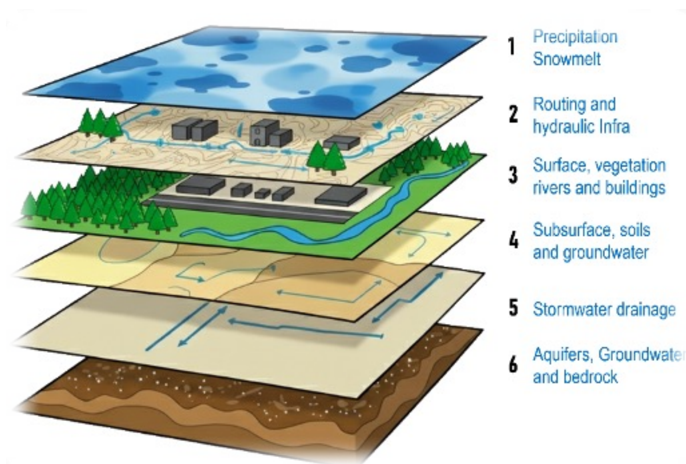
FastFlood Global represents a new generation of hydrodynamic flood modelling technology designed for high-resolution, interactive analysis at global scale. The system integrates a physically based flood simulation engine with automated global parameterization derived from bias-corrected Earth Observation and reanalysis datasets. It enables rapid generation of flood hazard maps for historic, real-time, and future climate scenarios without the need for manual setup or local calibration.

At its core, the model combines a hybrid approach linking a rapid physically-based "peak of intensity" solver with a fully dynamic multi-threaded Saint-Venant scheme. This structure allows simulation of flood wave propagation and inundation processes with several orders of magnitude improvement in computational efficiency compared to conventional models, while maintaining strong agreement with reference hydraulic simulations. The model employs adaptive cascading grids that dynamically adjust resolution according to process complexity, ensuring computational speed without compromising hydrodynamic accuracy.

The global parameterization framework builds on a suite of space-based datasets including Copernicus30 and EnsembleDEM for terrain, ERA5 and GPM IMERG for atmospheric forcing, SoilGrids and SMAP for soil and moisture characterization, and GLOFAS and GRDC for river discharge and calibration. Land cover and surface roughness are derived from Sentinel-2 WorldCover, while urban drainage and protection capacities are informed through FLOPROS and OpenStreetMap. Together, these datasets provide a



coherent, spatially uniform input base for model setup anywhere in the world.



FastFlood Global can be applied in three temporal modes: (i) hindcast, producing continuous daily flood reconstructions since 2000; (ii) forecast, generating near-real-time inundation predictions using bias-corrected GLOFAS discharge and precipitation forecasts; and (iii) design-event simulation, using globally derived Intensity-Duration-Frequency-Space (IDFS) statistics to evaluate hazard under present and future climate conditions. The framework supports user-defined alterations such as new levees, drainage upgrades, or land-use changes, which can be implemented interactively through simple geospatial inputs.

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.

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