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Extremely Severe Cyclonic Storm Mocha, May 2023, Myanmar:

Global Rapid Post-Disaster Damage Estimation (GRADE) Report

Disclaimer

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Abbreviations

NDMC:	National Disaster Management Committee
D-RAS:	Disaster-Resilience Analytics & Solutions Team, World Bank Group
FAO:	Food and Agriculture Organisation of the United Nations
GAD:	General Administrative Department
GPURL:	Urban, Disaster Risk Management, Resilience and Land Global Practice
GRADE:	Global RApid post-disaster Damage Estimation
MIMU:	Myanmar Information Management Unit
MOALI:	Myanmar Ministry of Agriculture Livestock and Irrigation
PDNA:	Post-Disaster Needs Assessment

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Executive Summary

Given the fragile and conflict-affected situation with limited access in Myanmar, the World Bank has adopted the Global RApid post-disaster Damage Estimation (GRADE) methodology to estimate damages arising from Cyclone Mocha. GRADE is a remote, desktop analysis to estimate damage to capital stock. This report summarizes the results of the GRADE[1] conducted to assess damages following the impact of Extremely severe cyclonic storm[2] Mocha in Myanmar during May 2023.

Key Findings

- **Total Damages:** The median estimate of total direct damages caused by Cyclone Mocha is US$ 2.24 billion, equivalent to 3.4% of Myanmar's GDP in 2021. This includes damages to residential and non-residential buildings and contents, agriculture, and infrastructure.

- **Output Definition:** Economic impacts are reported in terms of capital damages, estimated via the GRADE methodology.

- **Affected Sectors:** Based on damages estimated from reported impacts, the residential housing sector is the hardest hit, followed by non-residential buildings and infrastructure, and then agriculture.

- **Spatial Distribution:** Over 80% of the damages occurred in Rakhine and Sagaing. Rakhine was the worst affected, with approximately 1.2 million people across seven districts and 17 townships impacted. Internally Displaced Persons (IDPs) camps across Rakhine State, were devastated by the storm, leading to many deaths.

- **Points of Interest:** (a) The cyclone caused significant damages to five States/Regions in the west and northwestern part of the country: Rakhine, Sagaing, Magway, Mandalay, and Chin; (b) The primary source of damage from Cyclone Mocha in Rakhine State was wind while in Magway and Sagaing regions there was also significant flooding; (c) Infrastructure across the affected regions suffered extensive damage, including health facilities, schools, communication networks, and transportation systems; (d) The ongoing conflict in several regions, particularly in Rakhine State, has exacerbated the impacts of the cyclone and is likely to impact the response and recovery process.

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

[2] This terminology follows the classification of tropical cyclones in the WMO regional tropical cyclone bodies. Available from: https://community.wmo.int/en/classification-tropical-cyclones [accessed 18/06/2023]

This post-disaster damage estimation effort provides a useful initial estimate of the damages and economic impact caused by Cyclone Mocha in Myanmar and could contribute and complement additional damage and loss assessments involving ground evaluations to plan and design recovery planning and reconstruction.

Residential buildings, non-residential buildings and infrastructure damages are estimated via the GRADE methodology. Published national-level and state/township-level damage reports from local sources have been used for the model (see Annex 2 for detailed references). Data has been cross-checked with georeferenced images and footage from mainstream and social media, and reports from other agencies and organizations.

For residential buildings, non-residential buildings and infrastructure, the analyses at this point evaluate only physical damage to capital stock and do not cover the economic flow losses (e.g., costs of business interruption).

Agricultural damages and losses are estimated based on the disaggregation, quantification, and values of crops from the 2021 Statistical Yearbook and previous agricultural censuses; combined with current yield estimates from state and district agricultural departments. Agricultural losses include damage and production losses.

Estimated Damages

The cost of direct damages to buildings, infrastructure, and agriculture from Cyclone Mocha are estimated at US$2.24 billion. This is equivalent to approximately 3.4% of Myanmar's 2021 GDP. The estimation includes damages due to wind, flooding, storm surge and landslides to residential and non-residential buildings (including building contents), as well as damages to agriculture and infrastructure sector.

Table 1 shows the breakdown of the best estimate of direct economic damages in Myanmar by sector and by State or Region, and as a whole for the event. There is some uncertainty around the estimates, due to incomplete damage statistics which were compensated for by using modelling methods. The analyses at this point evaluate only physical damage to capital stock and do not cover the losses as per PDNA[3] definition (e.g., business interruption), except for agriculture. The damages to buildings (residential and non-residential) include building contents. It is estimated that more than 70% of the total damages occurred in Rakhine State. Damages to housing and non-residential buildings and their contents account for over 49% and 18% of the total respectively, while damages to infrastructure and agriculture account for under 22% and 11% of the total respectively.

[3] The Post-Disaster Needs Assessment (PDNA) is an internationally accepted methodology for determining the physical damages, economic losses, and costs of meeting recovery needs after a natural disaster through a government-led process.

Table 1 Estimate of the breakdown of the capital damages in absolute values (in US$ millions). The colored bars indicate the relative severity of the sector's damages in each state/region.

States/Regions	Residential	Non-Residential	Infrastructure	Agriculture	Total
Rakhine	898	331	294	99	**1,622**
Sagaing	74	28	83	68	**254**
Magway	78	31	57	33	**198**
Mandalay	18	5	30	9	**63**
Chin	24	10	10	5	**50**
Bago	8	3	8	11	**30**
Ayeyarwady	3	1	4	7	**14**
Shan	1	0	2	3	**6**
Other States	2	1	2	3	**7**
Total	**1,107**	**410**	**490**	**237**	**2,244**

To derive the capital damages, the analysis has taken into consideration observational and historical information in the region. Published damage reports from May 12th to June 8th have been used from, among others, the National Disaster Management Committee (NDMC) and Ministry of Humanitarian Affairs and Disaster Management (MOHADM) agencies, as well as other state and township level data from news reports and public agencies' reporting[4]. This has been cross-checked with georeferenced images and footage from mainstream and social media, and flood footprints derived from satellite imagery and flow gauge data from Myanmar's Department of Meteorology and Hydrology (DMH).

The spatial distribution of total capital damages is shown in Figure 5 and Figure 6 (Section 2.3). **The greatest damages have occurred in Rakhine State and Sagaing Region, which together account for nearly 84% of the total accumulated damages**. Rakhine, as the State that was hit the hardest, experienced a total damage that amounted to almost 30% of its total capital stock.

[4] The complete list of sources is presented in Annex 2.

1 Introduction

1.1 Event description

Extremely severe cyclonic storm *Mocha* made landfall as a Category 4-equivalent cyclone in the Saffir–Simpson hurricane wind scale on Sunday May 14, 2023, at 07:07 UTC (14:07 local time) around Sittwe city, the capital of Rakhine State, Myanmar (see Figure 1). It was one of the strongest cyclones ever recorded in Myanmar, approaching the coast with 3-minute sustained winds of 215 km/h and gusts of up to 305 km/h, before continuing inland and affecting communities with winds and heavy rain on May 15th. Strong winds, heavy rainfall and storm surge associated with the cyclone affected Myanmar and parts of Bangladesh.

Whilst in the Bay of Bengal off the northwestern Myanmar shores and around 250 km southwest of Sittwe, **Cyclone Mocha was the strongest cyclone in the 2023 North Indian Ocean cyclone season so far. Simultaneously, Cyclone Mocha, along with Extremely Severe Cyclonic Storm Fani of April 2019** (which affected the Indian states of Odisha and Andhra Pradesh)**, was the strongest storm ever recorded in the North Indian Ocean in terms of 1-minute sustained winds.**

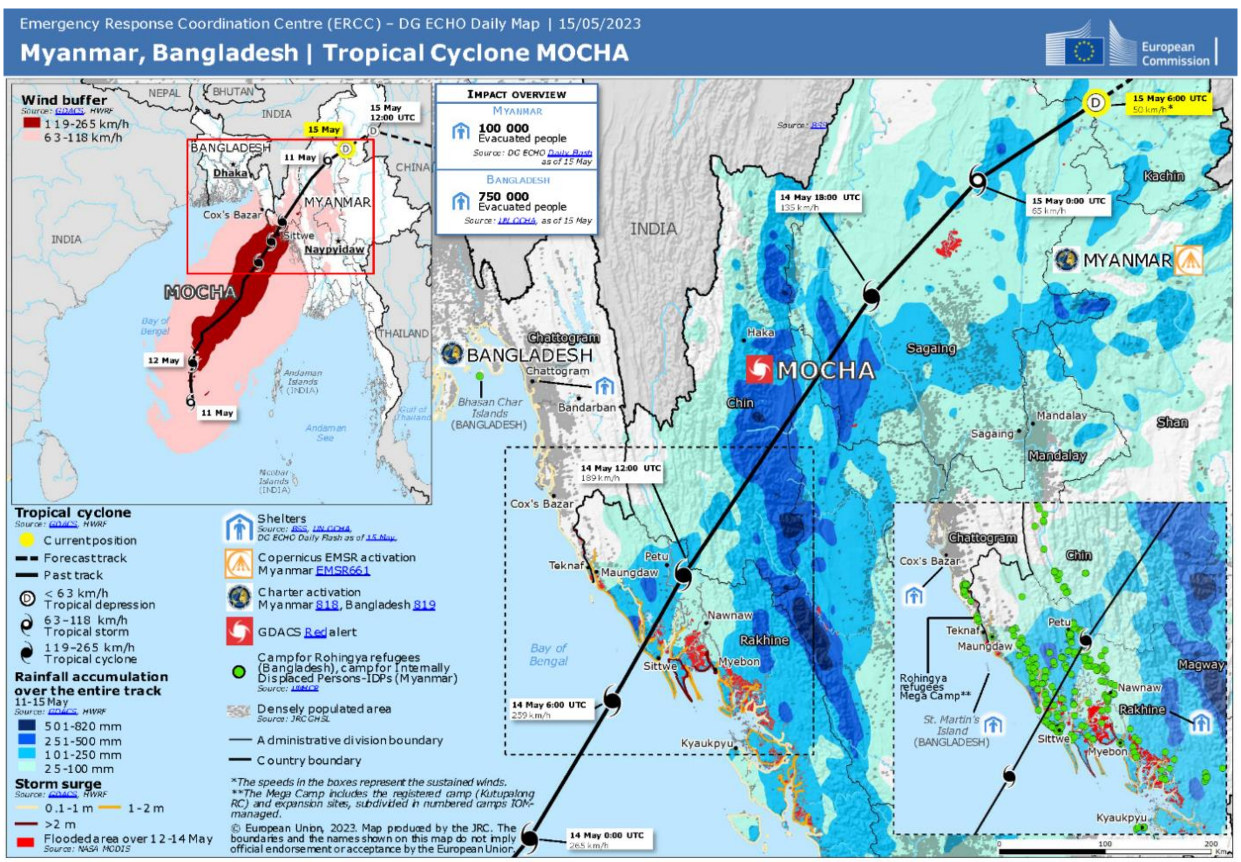

Figure 1: The storm track of Cyclone Mocha showing its landfall in Myanmar on 14 May 2023 (Source: DG Echo).

Cyclone Mocha originated from a low-pressure area that was first noted on May 8th just west of the southernmost part of the Nicobar Islands. After consolidating into a depression, the storm tracked slowly north to northwestward across the Bay of Bengal. After reaching the middle of the bay, it made a turn north-northeastwards, rapidly intensifying and moving faster towards northwestern Myanmar reaching Category 5-equivalent intensity in the early morning of May 14th with winds of 280 km/h. At that point, Cyclone Mocha was a large storm with a symmetrical eye about 37 km wide. As it approached the shores of northwest Myanmar and moved inland, Mocha weakened very rapidly and was no longer considered a tropical storm system on May 15th.

Along with strong winds, Cyclone Mocha's passage led to heavy rainfall that caused severe floods and landslides. According to the DMH, several meteorological stations received record rainfalls on May 14th. Chauk Town in Magway Region registered 218 mm (8.58 in). The previous record was only 97 mm (3.82 in). Sinbyugyun town, also located in the Magway Region, reported record rainfall totals of 177 mm (6.97 in), also well above the previous record total of 98 mm (3.86 in). The continuous heavy rain caused the Ayeyarwady River to overflow and flood several townships in Magway.

Before landfall thousands of volunteers assisted people living in the Cyclone Mocha path in evacuating as the cyclone approached land. Evacuations were ordered for low-lying areas in Rakhine: Sittwe, Pauktaw, Myebon, Maungdaw, and Buthidaung. According to reports of the Myanmar Red Cross Society (MRCS), more than 137,000 people were evacuated from at-risk areas prior to Mocha making land fall, including 18,800 internally displaced persons (IDPs) in Rakhine. Roughly 4,000 evacuated from Sittwe (2014 census population of nearly 101,000 in the city proper, nearly 148,000 in Sittwe township and nearly 536,000 in Sittwe district - increased in recent times by 140,000 IDPs living in camps around the city) while 20,000 other residents sought refuge in local shelters. Monasteries, pagodas, and schools, some of which were partially damaged by the cyclone, have sheltered thousands of people. The authorities' preparations for shelter stockpiled to accommodate 100,000 people. Large-scale search and rescue teams were placed on standby, consisting of 3,207 personnel equipped with 1,009 land and 242 water vehicles. Dozens of medical personnel and rapid response teams were deployed to Rakhine and Chin. Non-food items for more than 10,000 people were provisioned.

1.2 Impacts

After landfall, as of May 15th, the State Administration Council (SAC) declared all **17 townships** of **Rakhine state** as disaster affected areas under section 11 of the National Disaster Management Law.[5] A similar announcement was made for **four townships in Chin State** (Tiddim, Matupi, Paletwa and Hakha) on May 16th. In addition, almost 150,000 people in the Northwest (Chin State, Magway and Sagaing Regions) were heavily affected, as well as a smaller number in Kachin and Shan States. The damage reports below from the affected States/Regions districts and township provide a partial overview of the damage effects of Cyclone Mocha.

The main sources for this compilation are the UNOCHA Flash Updates # 4 to # 10 (from May 15 - 23, 2023) and UNOCHA Situation Reports # 1 to # 3 (from May 25 - June 1, 2023), the AHA Centre

[5] https://www.mlis.gov.mm/mLsView.do;jsessionid=71BF528AED0CC8733B678F5C85E94AF2?lawordSn=289

Situation Updates # 2 to # 9 (from May 14 -30, 2023) as well as the Federal Republic of Myanmar, National Disaster Management Committee (NDMC) infographics from May 29 to June 2, 2023 posted on the website of the Ministry of Social Welfare, Relief and Resettlement (MoSWRR).

1.2.1 Damage reports in Rakhine State

Approximately 1.2 million people in all seven districts and 17 townships in Rakhine State were affected, but the worst effects were seen in eight townships (Sittwe, Rathedaung, Ponnangyun, Pauktaw, Mrauk-U, Kyauktaw, Munaung and Buthidaung) with the southern townships of Thandwe district seeing less damage. Figure 2 shows a map of the districts and townships of Rakhine State (MIMU, 2020 - https://reliefweb.int/map/myanmar/myanmar-district-map-rakhine-state-24-april-2020-enmy). **In total, more than 200,000 buildings, including individual houses, were damaged** or destroyed. Hardest-hit townships were **Sittwe and Rathedaung** (combined population nearly 258,000 in the 2014 census). Another seven townships were also affected: Buthidaung, Kyauktaw, Maungdaw, Minbya, Mrauk-U, Pauktaw, and Ponnagyun. Kyaukpyu, Ramree, Munaung, Myebon, and Ann townships experienced less damage, while damage was limited in Toungap, Thandwe, Gwa and Maungdaw townships.

Eight out of 16 township hospitals were damaged but remained operational. Over 1,380 basic education schools in Rakhine have experienced substantial damage (in total, there are 3,193 basic education schools). Additionally, nearly all Temporary Learning Spaces in IDP camps/sites have been destroyed, posing a significant challenge with the start of the school term in June. In Minbya, Mrauk-U, Myebon, Pauktaw, Ponnagyun, Rathedaung, and Sittwe townships, a total of 208 water ponds in 105 villages were flooded by saltwater. This has impacted 19,152 households, comprising more than 100,000 people. In addition, approximately 80 percent of paddy seeds stored by farmers in Sittwe, Pauktaw, Rathedaung, Kyauktaw, Mrauk-U, Ponnagyun, and Maungdaw townships were destroyed by the cyclonic storm. According to the Ministry of Information (MOI), 605 acres of bananas, 1,345 acres of areca catechus, 58 acres of betel plants, 231 acres of thatch palm, 5 acres of pará rubber tree and 1,709 acres of orchards were damaged in Rakhine state. Moreover, 4,209 buffaloes, 7,593 cows, 2,283 pigs, 738 goats and 489,205 chickens from ten townships were killed. More than 3,500 lamp posts and 7 electricity towers were destroyed and among the 1,233 mobile stations operated by four telecommunication companies in Rakhine state, a total of 904 mobile stations were disconnected due to the impact caused by Cyclone Mocha. As of June 8th, 97% of the communication services have been restored.

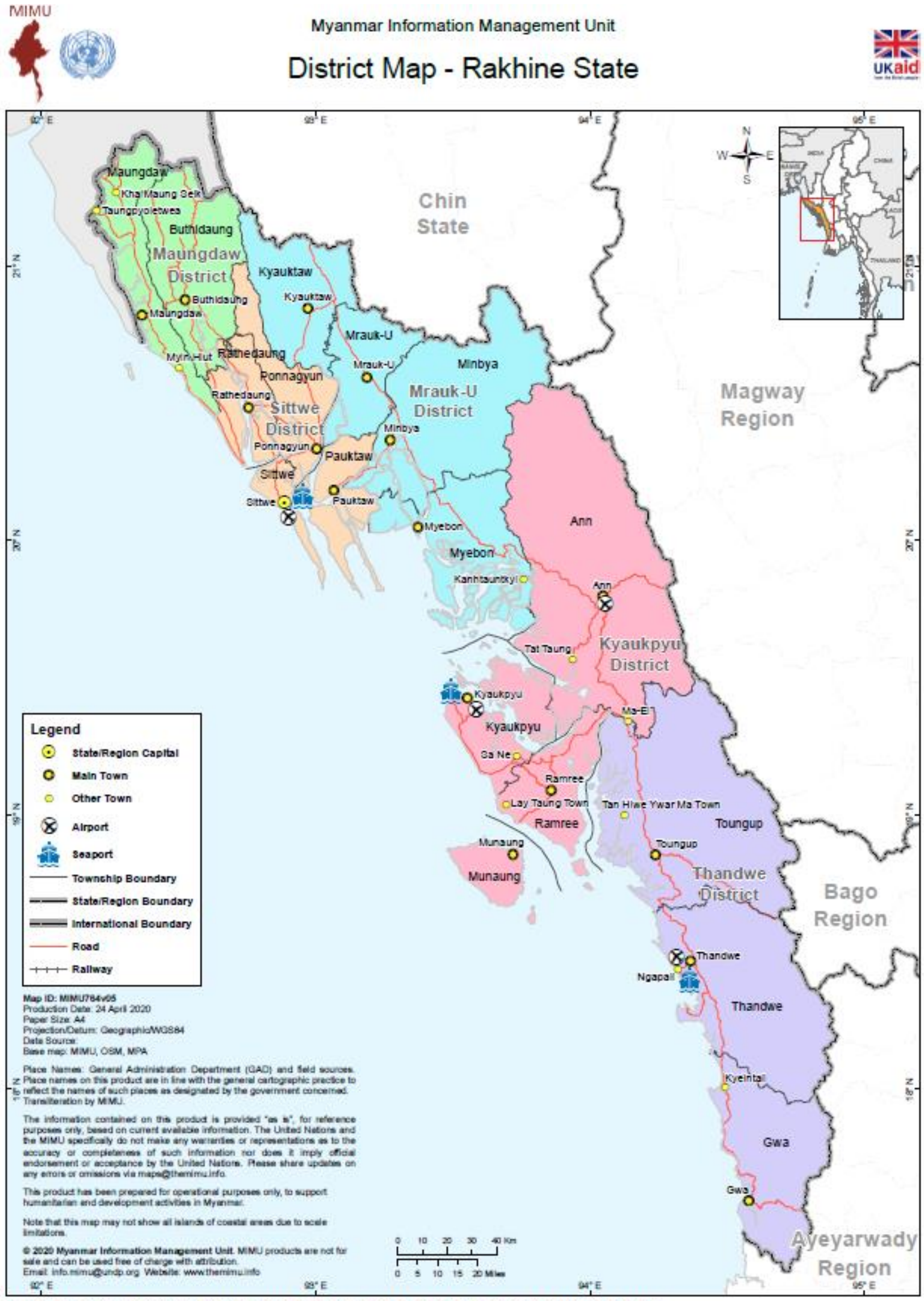

Figure 2: District-Township map of Rakhine State (Source: MIMU, 2020).

In **Sittwe township**, nearly all houses (an estimated 97 percent) were damaged. Bridges allowing access into the Sittwe IDP camps were heavily demolished and two out of the three access routes were barely functional (three bridges near *Dar Pai, Thae Chaung*, and *Thet Kae Pyin* IDP camps collapsed). According to the Camp Management Committee (CMC); in Basara Camp, which accommodates around 2,530 IDPs, three out of 52 longhouses were completely destroyed, while the remaining structures suffered varying degrees of damage. Field observations[6] conducted in Ohn Taw Gyi South Rohingya IDP camp revealed that nearly 2,300 households have endured significant damage to their shelters. In Thet Kae Pyin village, approximately 2,700 households lost their homes. Banks were also damaged and while some might be repaired in the near future, other banks may be closed for a month or so. There are limits on cash withdrawals. The Sittwe airport remained closed for several days after the passage of the storm.

In **Rathedaung township** (Sittwe district), nearly all households have been affected by the cyclone, most villages have reportedly sustained severe damage. The Station Hospital in In Ku Taung village was destroyed. In Mo Zé island, about 40 percent of the houses were reportedly destroyed and another 50 percent were damaged. Almost all infrastructure, including schools, religious, public buildings, hospitals was heavily damaged. In Nyaung Pin Gyi Rohingya village, the community reported that the flooding reached 1.5 meters. In Kyin Pin village, half of the 300 latrines were damaged and most of the paddy fields were flooded. In Kat Chaung village, the embankment, which protected the village from saltwater from the river, was damaged.

In **Ponnagyun township** (Sittwe district), an estimated 80 percent of the public schools were damaged and in six IDP camp sites, all the shelters were reportedly destroyed, most houses were collapsed and damaged in Kun Taung, Pa Day Thar, Sin Inn Gyi, and Ywar Thar Yar, including heavy damage to roofs, while in Ponnagyun town, less damage was reported. In addition, the Ngapihtaung dam, which the government built in Thin Pone Tan village in 2016, using roughly 300,000,000 kyat (US$ 142,542), was destroyed by Cyclone Mocha, resulting in damage to more than 500 acres of agriculture and affected many farmers.

Furthermore, Cyclone Mocha destroyed 11 solar-powered fish drying facilities in **Sittwe, Pauktaw, Ponnagyun townships.** Depending on the size, the facilities are worth between 15 million and 60 million kyats. The establishment of facilities utilizing solar power to dry fish was made possible with the technical and financial support provided by the United Nations Development Programme (UNDP) and Sustainable Coastal Fisheries.

In **Pauktaw township** (Sittwe district), there was less damage compared to Sittwe. Among the most affected was Sin Tet Maw village, where most of the houses suffered damage, and in the neighboring *Sin Tet Maw* Rohingya IDP camp (around 40 houses out of 1,136 houses destroyed and approximately 40 per cent of the houses damaged in *Nget Chaung-1* IDP Rohingya camp

[6] Based on the UN Ocha Flash Update 10: https://reliefweb.int/report/myanmar/myanmar-cyclone-mocha-flash-update-10-1400-23-may-2023-enmy

(5,157 resident IDPs) and around 25% of the houses destroyed in *Nget Chaung 2* IDP camp (5,288 resident IDPs)).

Further inland more than half of all houses in **Mrauk-U township** and over one-third of all houses in **Minbya township** (Mrauk-U district), were damaged or destroyed and around 40 houses in Tha Yet Oke village were destroyed. According to local media reports, the Thein Nyo displacement site hosting around 2,860 IDPs in Mrauk-U was reportedly destroyed, along with 80 houses in the host community.

In **Kyauktaw township** (Mrauk-U district - approximately 100 km north of Sittwe), nearly 90 percent of the houses were reportedly destroyed while in IDP camps, nearly all the bamboo shelters and tarpaulins were destroyed, and many latrines and bathing stations were damaged, two school buildings providing free education to more than 600 students were reportedly destroyed, while in Oke Kyut village 260 houses were reportedly exhibiting near total damage.

On **Munaung (Cheduba) Island**-**Township** (Kyaukpyu district - 170 km south of Sittwe) 1,000 houses were destroyed, including 400 in Pyaeng Taung village.

Information from **Buthidaung township** and **Maungdaw township** in the north of Rakhine State was initially limited due to the telecommunications being down. In these two townships more than half of the shelters are either temporary or semi-permanent. Later it was reported that 70 to 90 percent of the houses and 80 percent of schools in Buthidaung township have been damaged, while in Maungdaw township the ratio of damaged houses was lower (10%) and there was no flooding in Maungdaw town. However, in southern Maungdaw, residents reported being heavily impacted by the cyclone. According to field observations,[7] schools in five villages were significantly damaged, with roofs, wells, furniture, and water sources destroyed.

Heavy rainfall, storm surge and strong winds associated with the cyclone caused widespread damage in low-lying areas of Rakhine, particularly in and around Sittwe, as well as the townships of Kyauktaw, Maungdaw, Pauktaw, Ponnagyun, and Rathedaung. Significant damage has also been reported in IDP camps around Sittwe. Around 205 pre-existing displacement sites and camps in Rakhine have been severely damaged. A storm surge estimated at 3 to 3.5 m impacted coastal communities in Rakhine State. Parts of Sittwe were flooded by the surge, while severe winds knocked down electricity towers and communication networks across Rakhine State were damaged. Most health facilities, including Sittwe General Hospital, have been damaged and many laboratories and operating theatres are non-functional. Medical clinics in displacement camps are damaged (only one building functional). Thet Kal Pyin Station Hospital – a 16-bed hospital providing health services for stateless people – is functioning at half its capacity. Rural health centers, as well as IDP camp and community clinics have also been damaged. Three rural

[7] UN Ocha Flash Update 9: https://reliefweb.int/report/myanmar/myanmar-cyclone-mocha-flash-update-9-1400-21-may-2023-enmy

hospitals in Kyauktaw, Minbya, and Rathedaung townships, as well as the Station Hospital in Tein Nyo village in Mrauk-U township were damaged.

1.2.2 Damage reports in other states/regions

Field observations[8] indicate that at least **43,468 houses were damaged or destroyed** in the Northwest and the Northeast (Kachin and Shan States) of Myanmar. In the Northwest (Magway, Sagaing and Chin Regions/States), the UN estimates that more than 150,000 people were affected.

In **Magway Region**, heavy rain caused flooding and the Ayeyarwady River overflowed, **49,950 people (11,100 households)** from 8 townships were affected by flooding. Houses were washed away by floodwaters and electricity poles are down, with networks cut off in some townships. According to initial field reports, one rural health center was damaged. Ten villages were flooded in **Salin township** affecting more than 15,570 people and resulting in the destruction of 83 houses, while 100 people, including elderlies, from 20 villages around Kyun Yin village were unable to evacuate to higher ground due to their remote location along ravines near the Salin River. Five villages were flooded in the **Myaing township**. In **Pakokku township,** 19 villages (495 displaced people) were flooded, and 1,200 households were affected and 600 people in the Sin Pauk Hla village are being assisted. While 1,400 households were affected and an IDP camp hosting some 3,000 people was destroyed by the winds in **Pauk township**, 10 villages seriously flooded in **Seikphyu township,** and 182 houses damaged in **Gangaw township**. In **Saw township,** houses and other infrastructure were damaged or destroyed, including a dam, and agricultural land and equipment was washed/blown away, animals lost, and 600 households are affected. According to local people,[9] Cyclone Mocha damaged or destroyed thousands of homes as well as several rural bridges across 96 villages in **Htilin township.** For the Magway Region, the Ministry of Information (MOI) stated that 109 acres of spring rice, 49,569 acres of spring sesame, 8 acres of winter sunflowers, 22 acres of rainy sunflowers and 6,766 acres of green bean were damaged; three buffaloes, 73 cows and 12 pigs died.

In **Sagaing Region**, **85,000 people** from five townships (Kale, Khin-U, Pale, Wetlet, and Yinmarbin township) were affected by strong winds and flooding. Electricity poles were down, with networks cut off in some townships. Seventy-one houses and one school in **Kale town** were destroyed and 44 shelters in four informal IDP sites in **Kale township** were severely damaged. In **Monywa district**, landslides and floods occurred in areas where landmines and improvised explosive devices existed.

In Magway and Sagaing Regions, the already challenging situation has been exacerbated by the presence of troops in the region and ongoing conflict, making it even more difficult for affected people to find safe shelter. There are reports of communities being displaced by conflict as the

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[8] UN Ocha MYANMAR: Cyclone Mocha Situation Report No.3: https://themimu.info/sites/themimu.info/files/documents/Sitrep_Situation_Report_3_on_Cyclone_Mocha_OCHA_01Jun2023.pdf

[9] https://www.dmediag.com/news/drevimg.html

cyclone was approaching (more than 23,000 people from Kani, Khin-U, and Monywa townships of Sagaing were displaced).

In Chin State, multiple landslides were reported in different townships. The Interim Chin National Consultative Council (ICNCC) compiled a list of the damage caused by collating information from humanitarian and disaster management officers in Chin State townships (Table 2). As of May 23rd, 3,338 buildings were destroyed by the cyclone winds, heavy rain, and triggered landslides, including 2,774 residential houses, 185 schools, 102 religious buildings, 12 places where people could receive medical treatment, 259 barns and six auditoriums.

Table 2 Compiled list of damages caused by Cyclone Mocha in Chin State.[10]

List of damages caused by Cyclone Mocha in Chin State							
No	Townships	Home	School	Religious Building	Hospital and Clinic	Barn	Event Hall & Others
1	Kanpetlet	211	21	14	0	31	0
2	Mindat	654	114	32	2	179	1
3	Matupi	1211	25	41	8	44	2
4	Paletwa	400	11	7	1	5	0
5	Tedim	52	7	1	0	0	1
6	Tonzang	0	0	0	0	0	0
7	Thantlang	41	0	2	1	0	1
8	Falam	100	5	4	0	0	1
9	Hakha	105	2	1	0	0	0
Total		2774	185	102	12	259	6
		3338					

In **<u>Kachin State</u>**, **Waingmaw township and Mansi township** were primarily affected by strong winds. This resulted in the damage of more than 380 structures in 5 IDP camps in Waingmaw township. Among the structures affected are several houses, latrines, kitchens, schools, and a clinic. Approximately 4,300 IDPs have been impacted by the cyclone's aftermath. Damage was also reported in **Tanai township** (at least 42 shelters in the Roman Catholic Church IDP camp were affected). In **Mansi township** (Bhamo district), Mai Kone, Wa Htang, Hkyet Ma, and Aung Nan villages were seriously affected (130 structures in 8 villages were damaged, affecting about 500 people).

In **<u>Shan State</u>**, 140 houses in the **Kutkai, Kyaukme, Manton, Muse**, and **Namhsan townships** sustained damage due to the heavy rains and strong winds.

[10] Interim Chin National Consultative Council Facebook Update May 22nd 2023: https://www.facebook.com/icncc/posts/pfbid0grbz6HLrpVCg2Mimv97dM2PtLVWvDPA85QzMaiwhDNHkeBA3QL1trYgz5tPub8KRl

In **Yangon Region**, situated more than 500 km south of Sittwe, roofs were blown off houses, and billboards flew off buildings. On May 14th, the Myanmar Fire Services Department (MFSD) reported falling trees that caused significant damage to houses, roads, and power lines in 25 townships.

In **Mandalay Region**, more than 200 people were displaced as their houses were swept away by strong winds and flooding.

1.2.3 Additional information

In terms of **flooding**, a satellite estimate released on May 16th [11] determined that at least 895 km^2 of land was inundated, exposing over 141,000 people in Rakhine State. In **Magway** and **Sagaing Regions**, floodwaters reportedly damaged infrastructure and agricultural fields and washed away livestock and personal belongings, affecting 100,000 people, causing destruction of educational materials and health facilities across 150 villages in 10 townships in these two regions. Electricity poles collapsed, with networks cut off in some townships. Bridges were damaged. Most of the crops and agricultural fields affected by these floods were destroyed. Personal belongings, animals, and agriculture materials were also washed away. In general, due to Cyclone Mocha, extensive areas of farming land and coastal areas have been affected, with severe losses of assets that are crucial for the agriculture and fishery sectors including destroyed crops and trees and destruction of fishing vessels.

In total, the number of people living in the highest impact zone is 3.4 million with 1.6 million (34% children, 53% female) being targeted under the multi-sectoral Myanmar Cyclone Mocha Flash Appeal. An estimated 5.4 million people (depending on different assessments) lived in areas that experienced winds in excess of 90 km/h during the cyclone of **which 3.4 million faced destructive winds of more than 120 km/h**.

Information on the total number of damaged homes and other buildings, facilities and infrastructure fluctuate but as of June 2nd, according to the National Disaster Management Committee (NDMC), **262,954 houses (mostly in Rakhine State), 3,057 religious buildings, 1,892 school units, 444 medical facilities were damaged, while the number of animal deaths was 299,337 and the number of damaged communication towers and power distribution poles was 17 and 8,693 respectively** (https://www.moswrr.gov.mm/news/ministry-news/details/c7223922-e7fb-4981-a942-904d4339c3ce).

Water systems, sanitation facilities, water supply infrastructure and latrines were affected, reducing access to safe drinking water and basic hygiene services. Bridges were damaged or destroyed. The road between Yangon and Sittwe was blocked but re-opened three days later.

[11] Myanmar: Probable Flood Inundated Area in Rakhine State (as of May 15, 2023), by MIMU: https://reliefweb.int/map/myanmar/myanmar-probable-flood-inundated-area-rakhine-state-15-may-2023

Sittwe Airport was closed for four days, and Thandwe airport in southern Rakhine is partly damaged.

There are differences in the reported number of casualties stemming from this disaster. The NDMC on June 2nd, reported 148 deaths and 132 injuries, but the Ministry of Housing Affairs and Disaster Management (MoHADM) on May 17th, said that the death toll **reached 435 people** and there was an unspecified number of people missing, in their Situation Report #3 (https://www.cnbctv18.com/environment/cyclone-mocha-myanmar-government-claims-435-dead-appeals-for-international-aid-16688751.htm/). Reports from humanitarian workers on the ground suggested that many Rohingya villagers had died due to lack of information on the arrival of the cyclone or because they could not access the emergency shelter centers; by the time they received the warning, the shelters were already overcrowded. Some 130,000 Rohingya have lived for more than a decade in IDP camps in the Sittwe area. In one instance a survivor from the *Thet Kae Pyin camp* said that the bodies of 110 Rohingya villagers were buried on May 15th and 16th. In the *Bay Dar camp* located on an island on the coast the sea level suddenly rose nearly 10 meters and of the 380 houses only six remained and hundreds of people were missing.

In addition, heavy rainfall events are also concentrated in the hot, humid months of the **monsoon season** (May to October), with flooding due to excess rainfall affecting Myanmar almost every year. The compound impact of the **fragility, conflict, and violence (FCV)** context and cyclone to the humanitarian situation is particularly concerning given the onset of the monsoon season.[12] UNOCHA reports that heavy rains and some flooding were observed in areas that were already heavily impacted, making recovery more difficult for those whose coping capacities are already overstretched.[13]

1.3 Conflict exacerbated disaster risk and impacts

In Rakhine State and the northwest region of Myanmar affected by Cyclone Mocha, FCV conditions prevail. As of March 2023, the UN estimates 1.8 million IDPs in Myanmar, including 1.4 million newly displaced by conflict and insecurity since the February 2021 military takeover.[14] While the exact number of IDPs is difficult to ascertain due to limited access and data challenges, it is estimated that 75% of these IDPs reside in states and regions affected by Cyclone Mocha.[15]

Cyclone Mocha is exacerbating Myanmar's pre-existing crises. In addition to the widespread damage to physical assets caused by the cyclone, control of Myanmar's territory is extremely fragmented, making it difficult for international humanitarian and development agencies to

[12] AHA Center, 2023. Flash Update No. 1 – Tropical Cyclone Three in Myanmar. 09 June.
[13] UNOCHA, 2023, Myanmar: Cyclone Mocha Situation Report No. 4 (as of 14:00 8 June 2023).
[14] Source: UN Myanmar, 2023. Myanmar Humanitarian Update No. 28, 06 April. Available from: https://myanmar.un.org/en/226483-myanmar-humanitarian-update-no-28
[15] Sources: Flooding areas, UNOSAT https://unosat-rm.cern.ch/FloodAI/apps/MMR/ compared with locations with IDPs as reported by UNHCR in March 2023, https://data.unhcr.org/en/country/mmr.

deliver the needed relief.[16] Food insecurity is expected to worsen due to the damages to crops and infrastructure,[17] aggravating existing tensions between different ethnic groups over access to basic needs, possibly leading to further surges of violence.

Together with the **Mines Advisory Group, (MAG), the Danish Refugee Council and UNICEF, Mine Action Area of Responsibility (MA AoR) conducted a rapid analysis of contamination based on incident data from Cyclone Mocha's worst hit areas** (see Figure 3). They found that over 60% of landmine incidents reported in the first quarter of 2023 are from areas recently affected by Cyclone Mocha and of these, 90% are reported from zones where winds of over 120 km/h have been recorded (from an earlier windfield from GDACS). Almost half of the villages that have reported contamination with high confidence (47%) are located within this wind zone. In addition, 48 % of the villages surveyed that have reported contamination with lower confidence (people suspicious of landmine contamination) are also located in the 120 km/h wind zone. Additionally, heavy rains, floods and landslides occurring due to Cyclone Mocha may carry these devices in locations that were previously deemed safe.[18]

[16] Shidore, S. (2023). Cyclone Mocha in conflict-ridden Myanmar is another warning to take climate security seriously: Regional and global cooperation that respects sovereignty is the only way forward. Asia Research Institute: Singapore. Available from: https://ari.nus.edu.sg/app-essay-sarang-shidore-2/ [accessed 22/05/2023]

[17] OCHA (2023). Myanmar: Cyclone Mocha - Flash Update #7. May 18, 2023. Available from: https://reliefweb.int/report/myanmar/myanmar-cyclone-mocha-flash-update-7-1400-18-may-2023 [accessed 22/05/2023]

[18] ACAPS (May 2023) Bangladesh and Myanmar. Impact of Cyclone Mocha.

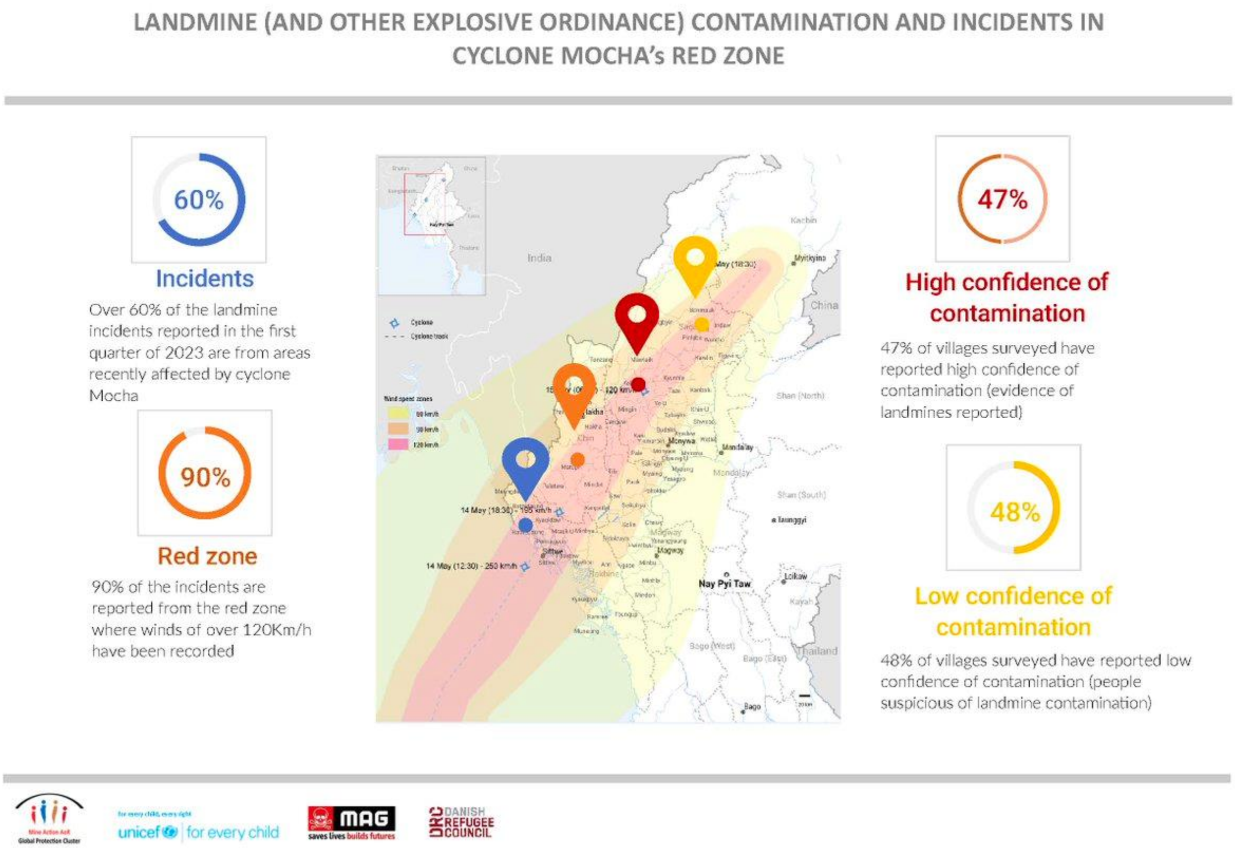


Figure 3: Analysis of unexploded ordnance contamination in the path of Cyclone Mocha.

The findings of the rapid assessment underline the high risks of landmine and unexploded ordnance contamination in cyclone-affected areas, creating a potential threat to the population, in particular children who are less likely to recognize a landmine/unexploded ordnance (UXO), and to recovery and relief efforts.

The IDP camps across Rakhine State, mostly situated near the coastlines of Sittwe and Pauktaw townships, were devastated by the storm. More specifically, the coastal State of Rakhine is home to 600,000 Rohingyas, a minority group in Myanmar. Rohingyas in Rakhine, most of them confined in camps in the town of Sittwe, rely almost entirely on humanitarian assistance. As of June 2023, access restrictions have escalated, with existing Travel Authorizations (TA) that had been facilitating assistance delivery in Rakhine suspended, and initial approval for humanitarian distribution and transport plans across 11 townships rescinded pending additional deliberations in the capital, Nay Pyi Taw. These TAs have hitherto facilitated the provision of shelter materials and other relief items to over 113,200 people in the affected areas, and food assistance to over 293,800 people in Rakhine alone.

1.4 The historical context of tropical cyclones in Myanmar

According to the Climate Risk Index, Myanmar ranks as the second most disaster-affected country over the last two decades globally (after Puerto Rico), taking into account number of deaths and also deaths per capita as well as sum of losses and loss per GDP from climate-related disasters in the twenty-year period between 2000 and 2019 (*Eckstein et al., 2021: Global Climate Risk Index 2021 Report*).

In Myanmar, the tropical cyclone season occurs between April and December with **cyclones forming in the Bay of Bengal and on average making landfall around once a year (since the year 2000)**. Most frequent are cyclones in the months of April-May, followed by the months of October-November. Damage can occur due to high winds, storm surge, flooding, and associated landslides.

In the recent past and particularly **in 2008 (cyclone *Nargis*)**, meteorological disasters have taken a heavy toll on Myanmar, with **the occurrence of damaging tropical cyclones showing an increasing trend** (one event in the 1980's, five in the 1990's, eight in the decade 2000-2009, and 11 in the decade of the 2010's).

The Bay of Bengal, the largest bay in the world – with more than 500 million people living on the coastal areas that surround it - is the site of most of the deadliest tropical cyclones in world history. **Since 1950, 12 out of 15 of the deadliest cyclones worldwide (loss of 10,000 lives or more) have taken place in the Bay of Bengal**, including the deadliest in history (cyclone *Bhola* in November 1970, causing the loss of more than 300,000 lives in Bangladesh) and **the 21st century's deadliest cyclone so far (cyclone *Nargis)* in May 2008 with up to 146,000 deaths affecting Myanmar's low-lying Irrawaddy delta region**.

Tropical cyclones in the Bay of Bengal are precipitated by high sea surface temperatures, combined with a large expanse of shallow water as well as the constant inflow of fresh warm water from major rivers like the Bramhmaputra, Ganges, Irrawaddy and others that keep the waters in the bay warm throughout the year. **With the increasing frequency of intense cyclones, the economic consequences have also been increasing. In the last quarter of a century (since 1988) the 10 costliest Bay of Bengal cyclones caused a combined US$52.4 billion in impacts,** equivalent to US$70 billion in today's terms (not accounting for the ever-increasing exposures over time) **with US$1.754 billion in damages and US$2.324 in losses (equivalent to US$5.75 billion in today's terms) associated with the May 2008 cyclone *Nargis* in Myanmar**.

Myanmar's coastline on the eastern side of the Bay of Bengal is about 2,300 km long and consists of three distinct parts (north to south):

- the western Rakhine (Arakan) coast,
- the southern Irrawaddy (Ayeyarwady) deltaic coast, and
- the north south Tenasserim (Tanintharyi) strip.

The **Rakhine coast** is about 1000-km long and runs from the Myanmar-Bangladesh border south to the Cape Negrais peninsula (in the Ayeyarwady Region), parallel to the Arakan Mountains (Rakhine Yoma) range. The Arakan Mountains act as a barrier to the southwestern monsoon rains and thus shield the central Myanmar area, making their western slopes extraordinarily wet during the monsoon with typically over one metre of rain per month, and the eastern slopes much drier. The Irrawaddy River runs east of this range and west of the Pegu Mountains (Pegu Yoma or Bago Yoma) range.

The **Irrawaddy deltaic coast** covers the area from Cape Negrais in the east to Moulmein in the west and includes the deltaic plains of the Irrawaddy River and the coastal areas of the Gulf of Martaban (Mottama) up to the Sittaung River in the east.

The **Tenasserim (Tanintharyi) coastal strip** runs north to south from Moulmein down to Mergui and the Isthmus of Kra in the Myanmar-Thailand border and is generally steep, bordering the Tenasserim Mountain ranges.

Since 1968, eight destructive cyclones and cyclonic storms have affected the two northern coastal regions (seven in or near the Rakhine coast and one in the Irrawaddy deltaic coast) as listed in Table 3. It is noted that all but one of these disasters occurred between 1992 and 2015. Cyclone Mocha is the first severe tropical cyclone event to affect Myanmar in eight years. Details about the impacts of these eight events can be seen in Annex 3.

Table 3 List of the most severe tropical cyclones and cyclonic storms in Myanmar between 1968 and 2022.

Date	Landfall Area	Name	Category upon landfall (Saffir Simpson scale)	People Killed	Houses Destroyed	Damage (US$, mn)
1968-05-09	Rakhine Coast	n/a	4	1,037	57,660	3.25
1992-05-19	Rakhine Coast	n/a	Tropical Depression	27	433	
1994-05-02	SE Bangladesh	n/a	2	17	~1,550	10
2004-05-19	Rakhine Coast	n/a	1	236	up to 1,000	99.2
2006-04-29	Rakhine Coast	Mala	1	37	at least 220	6.7
2008-05-02	Irrawady Delta	Nargis	3	up to 146,000	450,000	1754
2010-10-22	Rakhine Coast	Giri	3	157	15,000	>359
2015-07-30	SE Bangladesh	Komen	Tropical Storm	103	17,000	

It is seen that cyclones affecting the Rakhine coast are the most frequent, but the economic and human loss effects of the May 2008 cyclone Nargis in the Irrawaddy delta region by far outweigh the combined effects of all the other cyclones that occurred in the Rakhine coast during the cyclone seasons between 1968 and 2022. This is because the Irrawaddy delta region is low-lying, vulnerable to wind driven storm surges and is at the same time densely occupied (around 28% of Myanmar's population in the 2014 census lived in the Ayeyarwady and Yangon Regions) while around half of Myanmar's GDP originates from these two regions. In contrast, Rakhine State accounts for 6% of the country's population (2014 census) with over 69% of its population living in poverty.

In addition, in recent years monsoon season floods have been recurring annually in Myanmar. It has been noted that a significant increase in the effects of these floods can be detected from 2011 onwards (Table 4) with the monsoon floods of mid-July to early August 2015 exacerbated by the effects of the concurrent cyclone Komen being the most severe.

Table 4: Recent historical monsoon flood events in Myanmar. Comparison shows that this year's event is less severe than those experienced every year for the past four years (data from DIDM, CATDAT, PDNAs).

Year	# People Died	# People Affected	# Houses Destroyed	# Houses Damaged	# Acres Dest. or Dmg.
2011		177,188	12,217	17,230	65,084
2012		66,382	12,075	17,617	120,683
2013	4	91,708	6,239	18,830	36,491
2014	7	27,856	1,076	9,171	90,295
2015	172	1,692,837	54,369	457,452	1,415,723
2016	77	947,101	3,184	140,506	174,775
2017	35	332,003	471	3,028	162,559
2018	70	378,877	3,282	1,860	300,000
2019	97	***300,000***			***134,000***

2 Methodology and results

2.1 Exposure

As part of the analysis, an updated Building exposure model was developed and adapted from previous GRADEs. This included the Myanmar 2019 model which was produced using the 2014 Census as well as other Township profile data. This has since been updated for new exposure as well as adjusted capital through the impacts of past events and replaced capital, as well as the conflict situation as well as the investment in capital over the last 4 years. The main agglomeration of residential and non-residential capital stock (Yangon) is largely unaffected through this event, with the path impacting in the order of 8-10 million people.

The value of buildings per capita outside of the major urban centers is generally much lower due to traditional materials (bamboo etc.) being used versus concrete and other permanent materials in locations like Sittwe. Approximately 20 percent of capital stock in Myanmar is present in the worst affected provinces of Rakhine (in which Sittwe is situated), Chin, Sagaing and Magway (Figure 4). The residential and non-residential building exposure has been estimated in the order of US$145 billion (Table 5). In terms of infrastructure, Myanmar has significant road, port, and railway infrastructure due to the number of cities, topography, and different regions. In addition, there are growing significant power, ICT and especially WASH services with the total assessed exposure for infrastructure in the order of US$50.9 billion.

Table 5: Exposure value by State/Region and by Sector.

States/Regions	Total Residential	Total Non-Residential	Total Infrastructure	Total Value
Kachin	2712	1204	1354	**5270**
Kayah	503	240	276	**1019**
Kayin	1507	767	899	**3173**
Chin	313	158	185	**655**
Sagaing	7975	4158	4907	**17040**
Tanintharyi	3028	1388	1577	**5993**
Magway	6911	3443	4013	**14367**
Mandalay	14078	6075	6767	**26920**
Mon	3532	1596	1806	**6934**
Rakhine	2691	1266	1450	**5407**
Yangon	32747	13187	14322	**60257**
Ayeyarwady	7353	3785	4453	**15591**
Nay Pyi Taw	2485	1061	1178	**4725**
Bago	6423	3237	3786	**13446**
Shan	7530	3485	3973	**14988**
Total	**99788**	**45051**	**50946**	**195785**

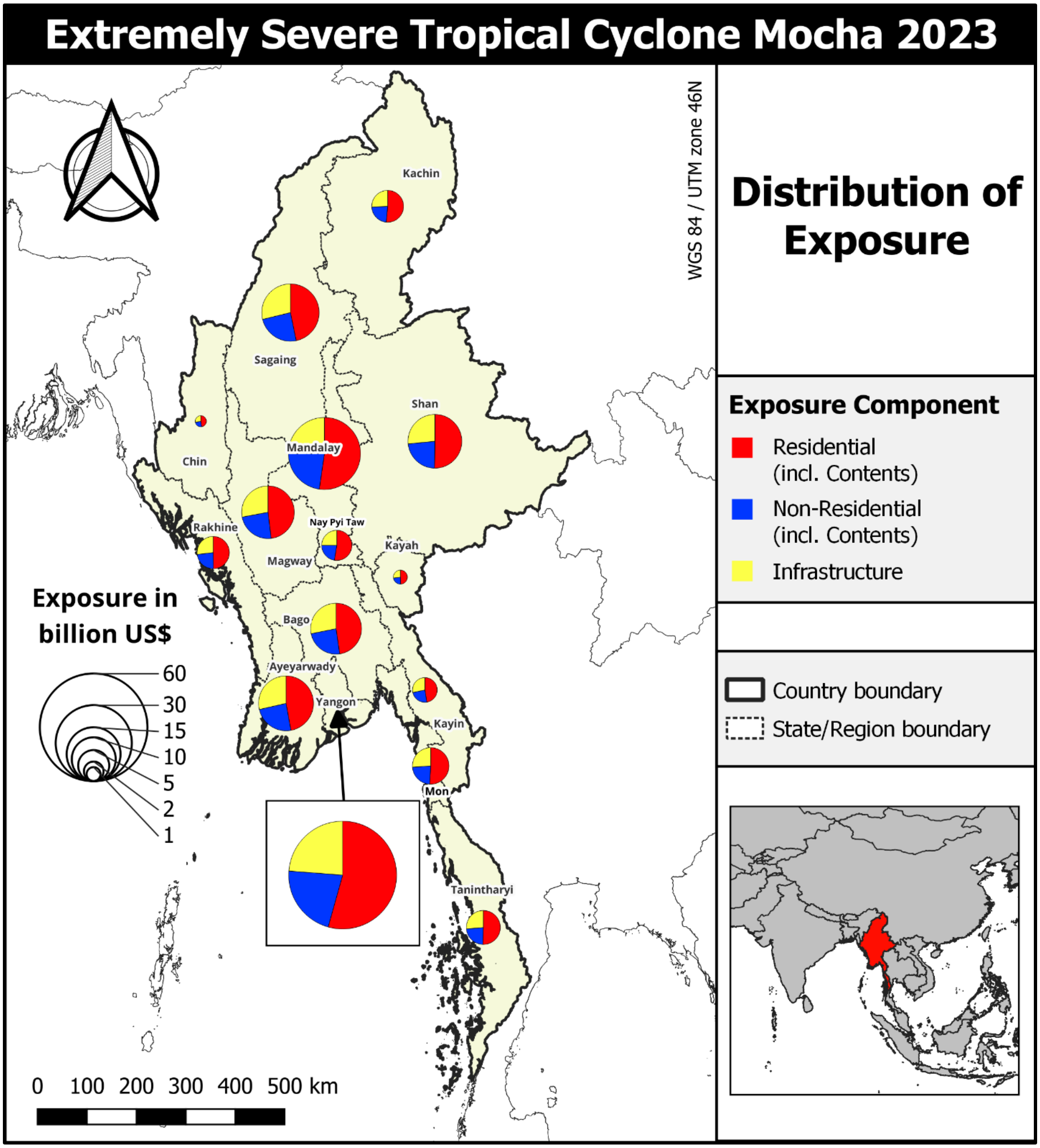


Figure 4: Distribution of exposure.

2.2 Methodology adopted

The analysis of damages is undertaken using the three components of exposure, vulnerability, and damage reports; with modelled wind speeds from Reask adapted to ground information; and storm surge flood depths in various locations estimated from georeferenced satellite imagery, on the ground reports, local reports and river flow gauges.[19] The exposure was built based on Unit Cost of Construction (UCC) and capital stock modelling[20] for the residential and non-residential buildings and infrastructure, as well as agricultural crop value modelling. Further in-depth methodology information can be seen in Annex 1.

The national NDMC data was cross-checked with reports from state/region and township agencies and the media. Note that **numbers of affected people, destroyed and damaged houses reported by the NDMC appear to be less than those reported in alternative sources** in many locations as well as older sources, as of June 7th, 2023. This is likely due to the time-lag in local-level data being accumulated at a national level. This is now explained due to it only being for 2 states (Rakhine, Chin) as well as there being significant difficulties in data collection due to the ongoing disaster situation as well as data flows in conflict areas. **Therefore, the modelling and calculation of estimated damages has taken into account and is informed by the numbers of affected people, damaged buildings per zone and other metrics reported by the NDMC, as well as reports from state/region and township agencies. However, the modelled version is the one eventually used for the final assessment in this report.** These modelled estimates have then been re-checked against reported numbers of destroyed and damaged houses, where possible, from other sources.

The evolution of flooding between May 13th to May 18th has been ascertained using estimated flood extents obtained from satellite imagery, as well as flow gauge data obtained from Myanmar's Department of Meteorology and Hydrology. This data has not been used directly for damage estimation, as the available satellite imagery only covers a portion of all flooded areas each day; so given the rapid evolution of the flooding, the imagery could not be guaranteed to have picked up all flooded locations throughout the duration of the event. Instead, the **satellite imagery and the flow gauge data were analyzed to corroborate and identify gaps in the damage reports and areas for closer investigation**.

Damage reports and flood extents have been further corroborated with georeferenced images and photos, enabling checks of flood depths and damage at specific locations.

[19] Hazard refers to the likelihood and intensity of a potentially destructive natural phenomenon. Exposure refers to the location, attributes, and value of assets that are important to the various communities, such as people, buildings, factories, farmland, and infrastructure. Vulnerability is the damageability or fragility of the exposure (assets) when exposed to different intensities of a specific hazard event.

[20] Capital stock modelling is forming a monetary estimate of the current value of fiscal capital based on investment over a long time-series using a fixed depreciation rate. For further details see *Gunasekera et al. 2015, Developing an adaptive global exposure model to support the generation of country disaster risk profiles, Earth-Science Reviews, Vol 150*.

The agricultural damage and crop value have been estimated by using the unit sale prices per item, ton, viss, tin, basket[21] and so on, over 48 crop types in order to estimate the respective value of crops in each township. State level data of yields were used for each crop to determine the total sum of agricultural crops. In addition, seed prices and net margins were examined in order to factor the final loss depending on the stage of crop in each location. As such, each state/region has a different unit cost per lost acre depending on the crop combination.

2.3 Estimated damages

The GRADE analysis estimates that wind and flood-related economic damage amount to US$ 2.244 billion. Table 6 shows the breakdown of this best estimate of direct economic damages in Myanmar by sector. Damages to the residential sector are around US$1.106 billion (median estimate), and the non-residential damage totals around US$410 million (Table 6). The infrastructure sector (US$490 million) and the agriculture sector (US$237 million) have significant damages, but the associated losses are expected to be even more significant. There is some uncertainty around the estimates, due to incomplete damage statistics and the need for modelling fill-ins.

Table 6: Total Damages by Sector

Country	Residential	Non-Residential	Infrastructure	Agriculture	Total Value
Myanmar	1106.6	410.4	490.0	237.3	2244.2

The most significant damages occurred in Rakhine, Sagaing, and Magway, accounting for more than 90 percent of the total damages. These states and regions are home to more than 12 million people (24 percent of the total population, based on the 2014 census) and almost 20 percent of the country's total asset stock. The total damage in Rakhine, as the state that is hardest hit, amounts to more than one fourth (27.2 percent) of its total capital stock. Chin is the second hardest hit state with a total damage of 6.6 percent of its total capital stock. Other states and regions experience relatively minor damages of less than two percent of their capital stocks.

Vulnerability functions have been derived for the three sectors using past regional projects and photo and video evidence. Exposure values have been reduced for agriculture and infrastructure to account for the effects of conflict.

Residential damage also includes household-based infrastructure including water, power, irrigation, and ICT components feeding in, which in other countries is often included under "infrastructure" damages.

Infrastructure includes physical infrastructure; irrigation; flood management; water, sanitation, and hygiene (WASH); energy, transport, communication, motors, and social protection. The

[21] Tin, basket and viss are Myanmar units of measurement: https://en.wikipedia.org/wiki/Myanmar_units_of_measurement

buildings which are not residential housing however are included within the non-residential buildings, where there is of course also significant damage.

The wind impact caused significant damage across the residential, non-residential and infrastructure sectors, but has been further exacerbated by flooding to all these sectors (buildings and infrastructure), especially in Sagaing and Magway.

The estimated damage costs for the agriculture sector include subsistence and cash crops. The agriculture sector accounts for 30 percent of GDP, however due to the conflict there has been significant reductions in agricultural production. This suggests an overall aggregated economic damage of US$237 million that is equivalent to about one percent of the agricultural GDP.

The estimated absolute and relative to exposure damages by province and sector are shown in Table 7 and Table 8, respectively for all sectors.

Table 7: Total Damages by State/Region and by Sector.

States/Regions	Residential	Non-Residential	Infrastructure	Agriculture	Total
Rakhine	898	331	294	99	**1,622**
Sagaing	74	28	83	68	**254**
Magway	78	31	57	33	**198**
Mandalay	18	5	30	9	**63**
Chin	24	10	10	5	**50**
Bago	8	3	8	11	**30**
Ayeyarwady	3	1	4	7	**14**
Shan	1	0	2	3	**6**
Other States	2	1	2	3	**7**
Total	**1,107**	**410**	**490**	**237**	**2,244**

Table 8: Relative Damages (Damage per State/Region, as a proportion of Capital Stock for that State/Region) by Sector.

States/ Regions	Residential	Non-Residential	Infrastructure	Agriculture	Total
Rakhine	33.4%	26.1%	20.3%	17.6%	**27.2%**
Chin	7.7%	6.6%	5.6%	5.4%	**6.6%**
Sagaing	0.9%	0.7%	1.7%	2.4%	**1.3%**
Magway	1.1%	0.9%	1.4%	1.6%	**1.2%**
Others	<1%	<1%	<1%	<1%	**<1%**
Total	**1.1%**	**1.0%**	**0.8%**	**1.5%**	**1.1%**

A summary of the datasets used is in Annex 2.

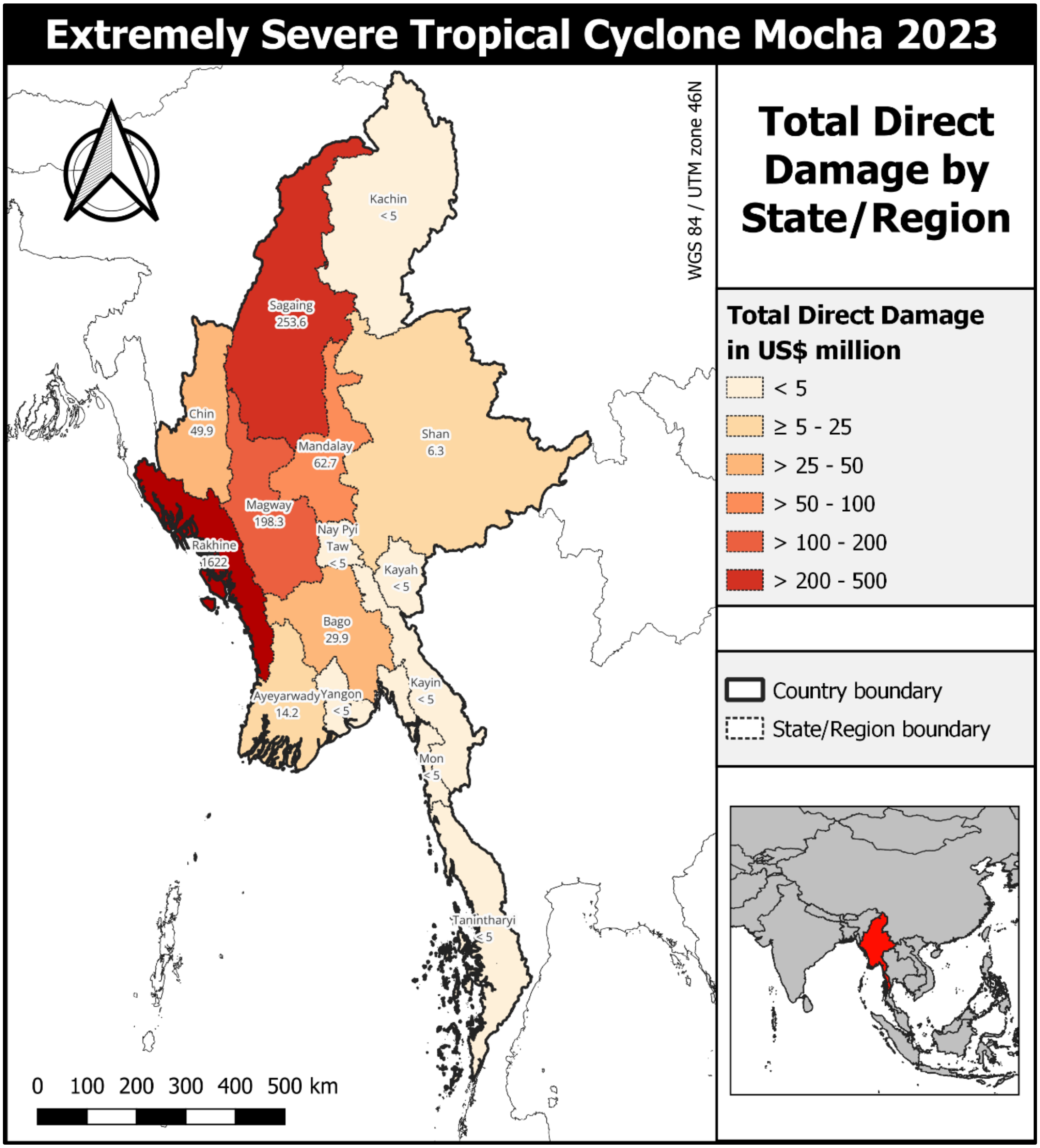


Figure 5: Total Direct Damages by State/Region.

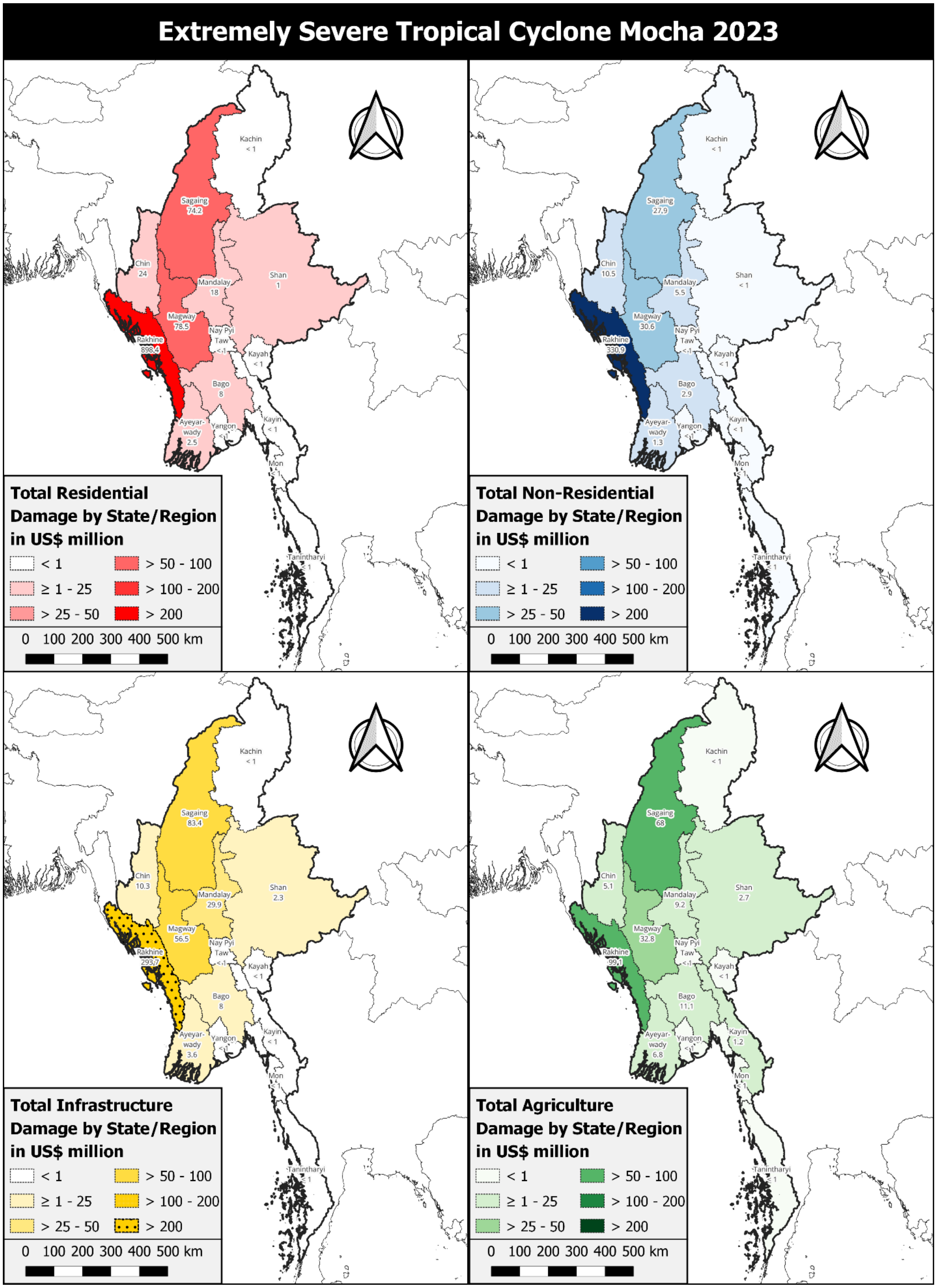


Figure 6: Direct Damages by State/Region by Sector

2.4 Socio-economic vulnerability considerations

Recovery from disasters is influenced by not only total asset damages, but also coping capacity of the affected population. When poorer people are affected, they may suffer higher welfare losses, thus requiring longer time to recover back to their pre-disaster welfare level. Socio-economic vulnerability is therefore a strong predictor of people's coping and recovery capacity. **The focus of this section is on estimating the extent of socio-economically vulnerable population who were exposed to significant gust wind speeds during the Cyclone Mocha event**.

2.4.1 Multidimensional poverty and structural vulnerability of Myanmar households

Social vulnerability to disaster can be proxied through the degree of multidimensional poverty of a household. Following on the World Bank's Multidimensional Poverty Measure (MPM), the degree of multidimensional poverty is calculated through a combination of monetary poverty (1/3), children school enrollment (1/6), education attainment of adult members (1/6), access to improved sources of drinking water (1/9), access to improved sanitation facility (1/9), and access to electricity (1/9).[22]

A recent Myanmar Subnational Phone Survey carried out by the World Bank between November 2022 and March 2023[23] was used to estimate multidimensional poverty. Nationally, around 11 percent of the population is found to be multidimensionally poor. The rates vary by States and Regions. **In States/Regions significantly affected by Cyclone Mocha (Rakhine, Sagaing, Magway, Mandalay, and Chin) almost 3 million people are living in multidimensional poverty.**

The multidimensional poverty information was further combined with disaster vulnerability aspects, proxied by the dwelling types of the households. **More than 50 percent of the population in each affected state/region are living in either wooden or bamboo houses** (Figure 7)**.** Less than 20 percent of the population in each state/region live in less structurally vulnerable dwellings (e.g., apartments, condominium, brick houses).

[22] World Bank, 2022, Multidimensional Poverty Measure. Available from: https://elibrary.worldbank.org/doi/abs/10.1596/38203

[23] Sinha Roy, Sutirtha. Myanmar Subnational Phone Surveys (MSPS) of the World Bank: Coverage, Reliability, and Representativeness (English). Washington, D.C.: World Bank Group. http://documents.worldbank.org/curated/en/099060523053037887/P179106053122a04508fcd015baf80eadf5

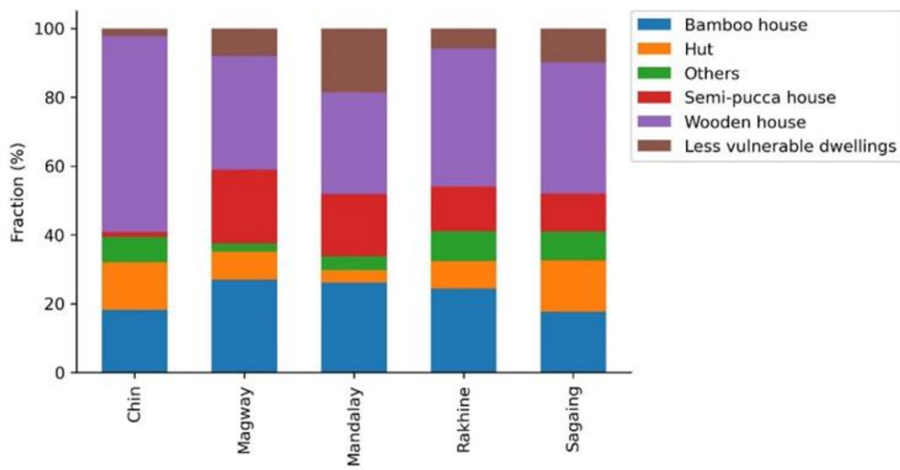


Figure 7 Housing Typology Proportions by State/Region

Overlaying these two variables, it is found that **almost all people who are in multidimensional poverty live in structurally vulnerable dwellings – amounting to 2.944 million people**. More than half of them is in Rakhine and Sagaing (841 and 825 thousand people, respectively). Only 0.2 percent of those who are multidimensionally poor live in non-structurally vulnerable dwellings.

Figure 8 pictures the composition of dwelling types of people in multidimensional poverty who also live in structurally vulnerable dwellings. T**here are more multidimensionally poor people living in huts in Magway, Rakhine, and Sagaing**, while the dominant dwelling types for these states/regions are wooden houses if the entire population (i.e., including the non-poor ones) is accounted. **Wooden houses remain the dominant dwelling type in Chin** – accounting for almost 60 percent of the multidimensionally poor population.

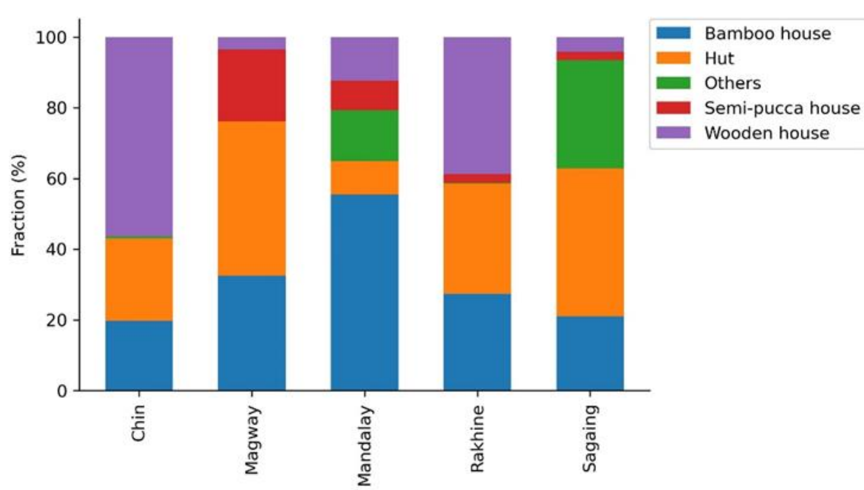


Figure 8 Housing Typology Proportions by State/Region for population classified as multidimensionally poor

2.4.2 Exposure of socially vulnerable households to Cyclone Mocha

Household multidimensional poverty and structural vulnerability layers were further combined with the cyclone hazard layer, in particular the 3-second gust wind speed. Three wind speed thresholds were used: 20 m/s (relatively minor damages to buildings), 35 m/s (some major damages), and 50 m/s (many major damages even to non-vulnerable dwellings). This provides information on exposure of socially vulnerable populations who also live in structurally vulnerable dwellings. They are the ones who are more likely to be impacted by the cyclone, and if impacted the welfare impacts can be substantial.

Looking at the lower wind speed threshold, there are a total of more than 15 million people exposed to 20 m/s gust windspeed (Figure 9). Out of these, 11.32 million people are living in vulnerable dwellings (but not in poverty), 2.6 million people are in multidimensional poverty and live in vulnerable dwellings, and 1.69 million people are those that are non-poor and live in less structurally vulnerable dwellings. On the extreme side, **1.68 million people are exposed to at least 50 m/s gust wind speed, with 1.22 million of them living in structurally vulnerable dwellings (but not in poverty) and more than 300,000 are in both vulnerable dwellings and multidimensional poverty**.

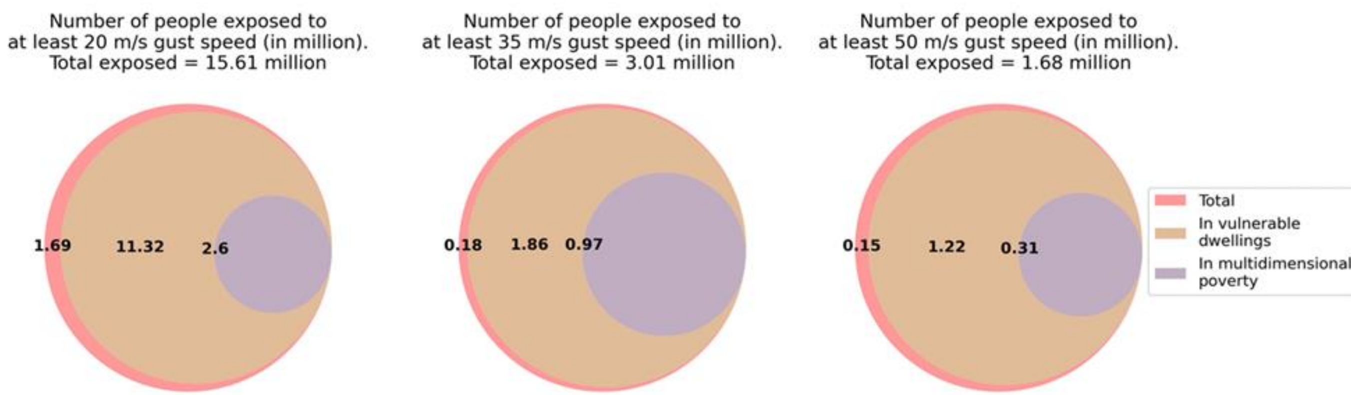


Figure 9 Number of people exposed to different gust wind speeds

The figure can be further broken down for each State/Region (Table 9). In alignment with the physical asset damage estimation, Rakhine is the only State that has exposure to extreme wind speed. **More than 1.5 million people in Rakhine are exposed to at least 50 m/s gust wind speed, 1.2 million of them are living in vulnerable dwellings, and 300 thousand are both multidimensionally poor and live in vulnerable dwellings**.

Table 9: Number of people exposed to different wind speed thresholds across the five affected states/regions (in thousands).

	Rakhine	Sagaing	Chin	Magway	Mandalay
At least 20 m/s - Total	2991.6	4293.7	421.9	3079.8	4827.9
In vulnerable dwellings, not in poverty	2012	3126	122	2328	3730
In vulnerable dwellings + multidimensional poverty	789	680	293	535	302
At least 35 m/s – Total	2403.7	180.8	300.6	128.5	-
In vulnerable dwellings, not in poverty	1545	152	43	123	-
In vulnerable dwellings + multidimensional poverty	684	28	256	-	-
At least 50 m/s – Total	1675.2	-	-	-	-
In vulnerable dwellings, not in poverty	1221	-	-	-	-
In vulnerable dwellings + multidimensional poverty	305	-	-	-	-

Mandalay Region is exposed to only the lowest wind speed threshold (20 m/s), though the total number of people are higher than those of Chin State and Magway Region. **More than 70 percent of multidimensionally poor people exposed to a significant 35 m/s gust wind speed live in Rakhine, around 26 percent of them are in Chin, and the rest is in Sagaing.** As most people who are multidimensionally poor live in structurally vulnerable buildings, they are more likely to be affected by the cyclone. Recovery effort focusing on them can minimize the overall welfare and poverty impacts borne by the country.

Note that the focus of this analysis is on exposure, rather than on impact. Not all exposed people were eventually impacted, and thus harmed, by the event. Section 1.2 provides a more detailed picture of the figures for the affected population.

3 Interpretation of results

The estimated damages from Tropical Cyclone (Cyclone) Mocha, amounting to approximately $2.24 billion, indicate that the event represents a significant disaster with a return period of 20-30 years. This level of damage, combined with the cyclone's path and the impacts of wind and flooding, underscores the severity of the event.

Cyclone Mocha was the most severe cyclone to make landfall on the Rakhine coast since the 1968 cyclone that impacted the same areas. The damages from Cyclone Mocha are about a quarter of those from Cyclone Nargis, after adjusting for inflation and GDP growth from 2008 to 2023. To put this in perspective, **Cyclone Mocha's estimated damages are equivalent to 3.4% of Myanmar's 2021 GDP, while the damages from Cyclone Nargis in 2008 were equivalent to 11.2% of Myanmar's 2007 GDP**.

After making landfall near Sittwe, Cyclone Mocha moved rapidly inland across Chin State and Magway Region before dissipating over Sagaing Region. The rapid movement of the storm meant that, although the rainfall was severe, it was less than if the storm had stalled. Consequently, the wind component was the primary factor causing damage. This pattern of damage resulted in **less damage to roads, water infrastructure, and agriculture than might have been expected if the storm had stalled and caused more prolonged rainfall**.

Given that Rakhine State has one of the highest poverty rates in the country (69%), it is expected that the most vulnerable households, living in structurally weak houses, suffered the most damage and will face significant challenges in recovery without assistance.

The wind component of Cyclone Mocha caused more damage than the flood component. While infrastructure damage was high, the primary damaging factor was the wind, which particularly affected the Information and Communications Technology (ICT) and power networks. In contrast, other types of events often cause major damage to roads, railways, and other infrastructure. In Myanmar, residential damage also includes household-based infrastructure such as water, power, irrigation, and ICT components, which in other countries is often included under "infrastructure" damages.

There were some storm surge and coastal flooding issues, which caused salt intrusion problems in water ponds, leading to damages to Water, Sanitation and Hygiene (WASH) infrastructure. However, the potential losses associated with water supply are potentially far greater than the damages incurred.

Cyclone Mocha has impacted Myanmar's agricultural sector, destroying crops and livestock, and severely affecting the country's food security.[24] The UN has recently included Myanmar in a list of 18 "hunger hotspots" where critical food insecurity is projected to intensify.[25] **The cyclone has led to a sharp increase in food prices, which has put a strain on household budgets (the average price of rice increased by 24% in Rathedaung and 51% in Pauktaw)**.[26] This is also true in the inland provinces of Sagaing and Chin, affected by Cyclone Mocha to a lesser extent than Rakhine State but home to different armed groups in conflict with the ruling military. Increased food

[24] OCHA (2023). Myanmar: Cyclone Mocha - Flash Update #7. May 18, 2023. Available from: https://reliefweb.int/report/myanmar/myanmar-cyclone-mocha-flash-update-7-1400-18-may-2023 [accessed 22/05/2023]

[25] https://news.un.org/en/story/2023/06/1137277

[26] World Food Program, May 2023. Initial Rapid Situation Monitoring Report in Cyclone Mocha-affected Townships in Central Rakhine State.

insecurity due to Cyclone Mocha has potential to increase social unrest and crime, but also increase tensions between different ethnic groups over access to basic resources.

Sectoral damages estimated using GRADE, particularly in Rakhine state, are generally in agreement with field observations. Based on field visits to 64 villages in Rakhine State conducted by the World Food Programme (WFP) between May 20th and 21st [27], the following sectoral impacts were reported:

- *Food security.* Most of the rice stocks at the villages visited were largely ruined by heavy rain and floods. Around 8 percent of villages had serious difficulties accessing markets and 7 percent have no access at all.
- *Livelihoods*. Almost all business and livelihood activities (agriculture, livestock, fishing, and casual labor) have stopped. Agriculture areas have been damaged by saltwater and strong winds; fishing boats, nets/crab traps were lost and damaged; almost all the fish/prawn ponds were washed out by floodwaters; hundreds of cattle were killed. No jobs for casual laborers in village areas.
- *Infrastructure*. In total, 48 percent of schools need to be rebuilt and more than 50 percent need a major renovation. Electricity has been totally cut off in the five townships and only a few villages use solar power for lighting. Only one mobile network is working intermittently. Most of the villages use the water from ponds flooded in by saltwater and some villages use dug or tube wells. However, the quality of water is poor.

4 Conclusions

This GRADE report provides a summary of direct economic impacts (in terms of damages to buildings, infrastructure, and agriculture) caused by Tropical Cyclone (Cyclone) Mocha in Myanmar. This GRADE analysis is based on satellite imageries, wind modelling, census and township statistics, and reports from national/local agencies including those published by NDMC. The main conclusions from the assessment are below:

- The cyclone caused significant damages to five States/Regions in the west and northwestern part of the country: Rakhine, Sagaing, Magway, Mandalay, and Chin; though the impacts extend further inland States/Regions. **Approximately 20 million people live in these five states, with 89 percent of them living in dwellings with relatively vulnerable materials**.

- The most severe damage is observed in Rakhine where approximately 1.2 million people were affected. The worst impacts were observed in eight townships: Sittwe, Rathedaung, Ponnangyun, Pauktaw, Mrauk-U, Kyauktaw, Munaung and Buthidaung. **More than**

[27] World Food Programme, 2023, Initial Rapid Situation Monitoring Report in Cyclone Mocha-affected Townships in Central Rakhine State. May 2023.

200,000 buildings were damaged and destroyed, making the cyclone one of the most impactful ones that happened in at least the past 15 years.

- **The median estimate of total direct damages from this cyclone is US$ 2.244 billion (equivalent to 3.4 percent of Myanmar's 2021 GDP),** with almost half of it is attributed to damages to residential dwellings. Infrastructure across the affected regions suffered extensive damage, including health facilities, schools, and transportation systems. More than 80 percent of the damages occurred in Rakhine and Sagaing.

- The human toll of the cyclone was substantial, although there are **varying reports on the exact number of casualties. The National Disaster Management Committee reported 148 deaths and 132 injuries**, while other sources suggested higher figures.

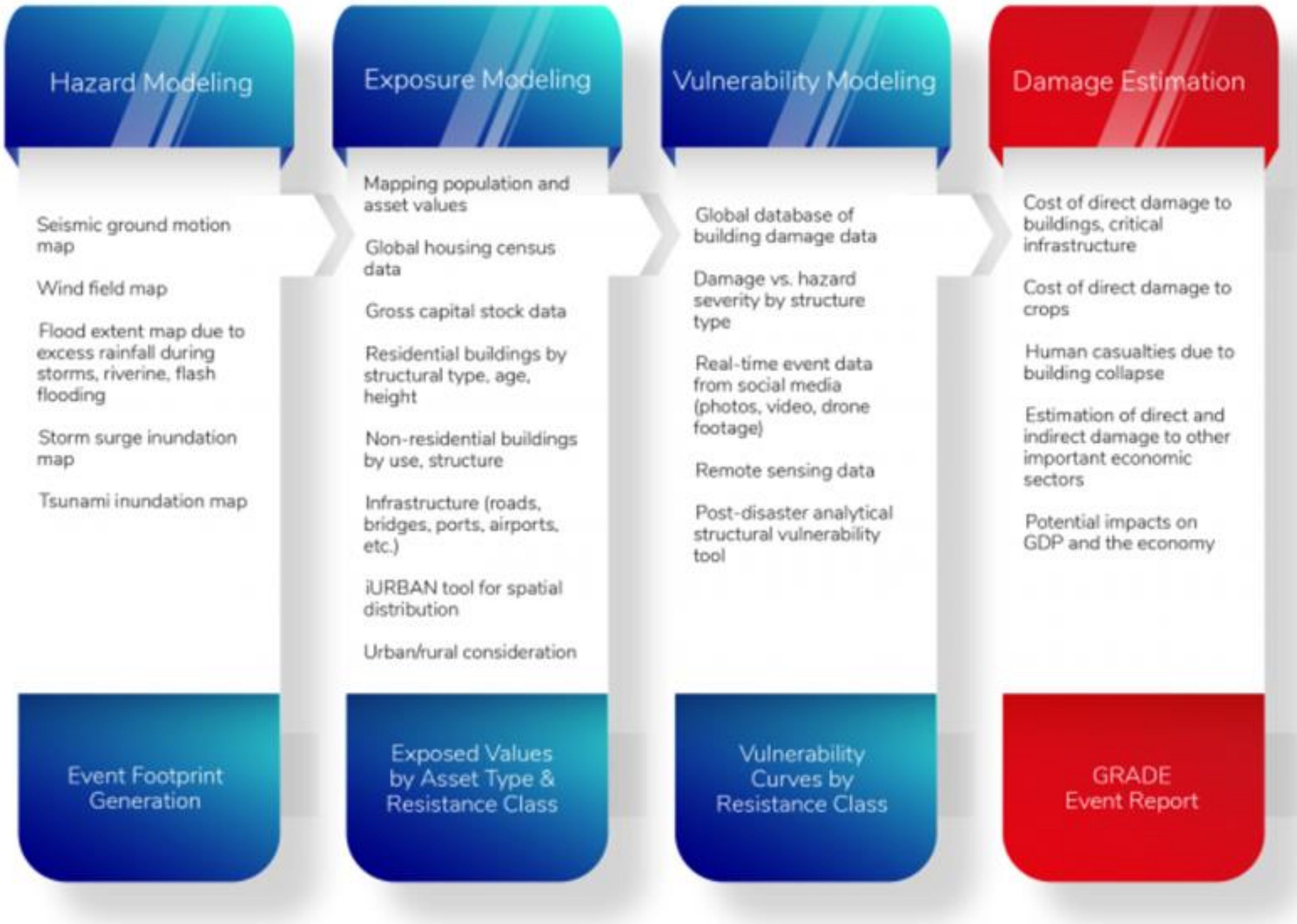
- **The primary source of damage from Cyclone Mocha was wind rather than flooding**. This led to widespread destruction of buildings and infrastructure, particularly in areas with structurally vulnerable dwellings.

In conclusion, the damages caused by Cyclone Mocha were significant and widespread, with the most severe impacts occurring in some of the most vulnerable communities. The wind component of the cyclone was the primary cause of damage, affecting both residential and non-residential buildings and their contents, as well as infrastructure.. The recovery process will require significant resources and targeted assistance to the most vulnerable households.

Annex 1 – Methodology

1. Preliminary damage statistics of this event were derived from COPERNICUS, ALOS, AIC, National Disaster Management Committee (NDMC) and media sources. For the assessment of Cyclone Mocha, 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. It represents the best estimation of the two cyclones' track and wind-field; however, there was significant uncertainty in this across multiple sources, also contributing to the uncertainty in final wind-field. In addition, rainfall estimates from global products including IMERG Late Run were used.
2. 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.
3. Estimated damages in the housing sector are derived using knowledge of the replacement value of the housing stock in the affected region. The mean replacement value across Myanmar was considered on the basis of different building typologies in Township Intercensal Surveys, Census and exposure models adjusted through to 2023, including household contents. Variations from this mean value were there per different type of construction.
4. Exposure was determined by scaling up and adjusting the previous GRADE exposure models using capital stock models, new data, the METEOR OED exposure model and data for Myanmar based on the methodology of Gunasekera et al. (2015).
5. Myanmar-specific vulnerability analysis was conducted based on detailed assessment information from Nargis, the 2015 and 2019 floods and other datasets. This supported the derivation of damage ratios for different construction typologies. The non-residential building sector impacts were also examined as per previous sectoral damage assessments for Myanmar, with vulnerability functions applied.
6. Infrastructure modelling was undertaken for power, transport, ICT and water, in a hybrid approach with the ratios from previous regional events, as well as a review of tropical cyclone/hurricane PDNAs and sectoral damage assessment data around the world to create wind and flood vulnerability functions for infrastructure. This was combined with damage report data.
7. For the agriculture sector, the direct damage estimates were evaluated by reported data on damaged crop and other information, including damage proportions and functions versus previous GRADE and external assessments for Myanmar.
8. Conflict data was sourced and applied at a township level.
9. Aerial, satellite and social media products, which provide snapshots of damage for specific areas, were used as checks for various locations in Myanmar.

An overview of the GRADE approach and datasets typically used in an assessment and a schematic flowchart of disaster modeling using the GRADE approach are shown in Figure 10 and Figure 11, respectively.


Hazard Modeling
Seismic ground motion map
Wind field map
Flood extent map due to excess rainfall during storms, riverine, flash flooding
Storm surge inundation map
Tsunami inundation map
Event Footprint Generation
Exposure Modeling
Mapping population and asset values
Global housing census data
Gross capital stock data
Residential buildings by structural type, age, height
Non-residential buildings by use, structure
Infrastructure (roads, bridges, ports, airports, etc.)
iURBAN tool for spatial distribution
Urban/rural consideration
Exposed Values by Asset Type & Resistance Class
Vulnerability Modeling
Global database of building damage data
Damage vs. hazard severity by structure type
Real-time event data from social media (photos, video, drone footage)
Remote sensing data
Post-disaster analytical structural vulnerability tool
Vulnerability Curves by Resistance Class
Damage Estimation
Cost of direct damage to buildings, 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 GDP and the economy
GRADE Event Report

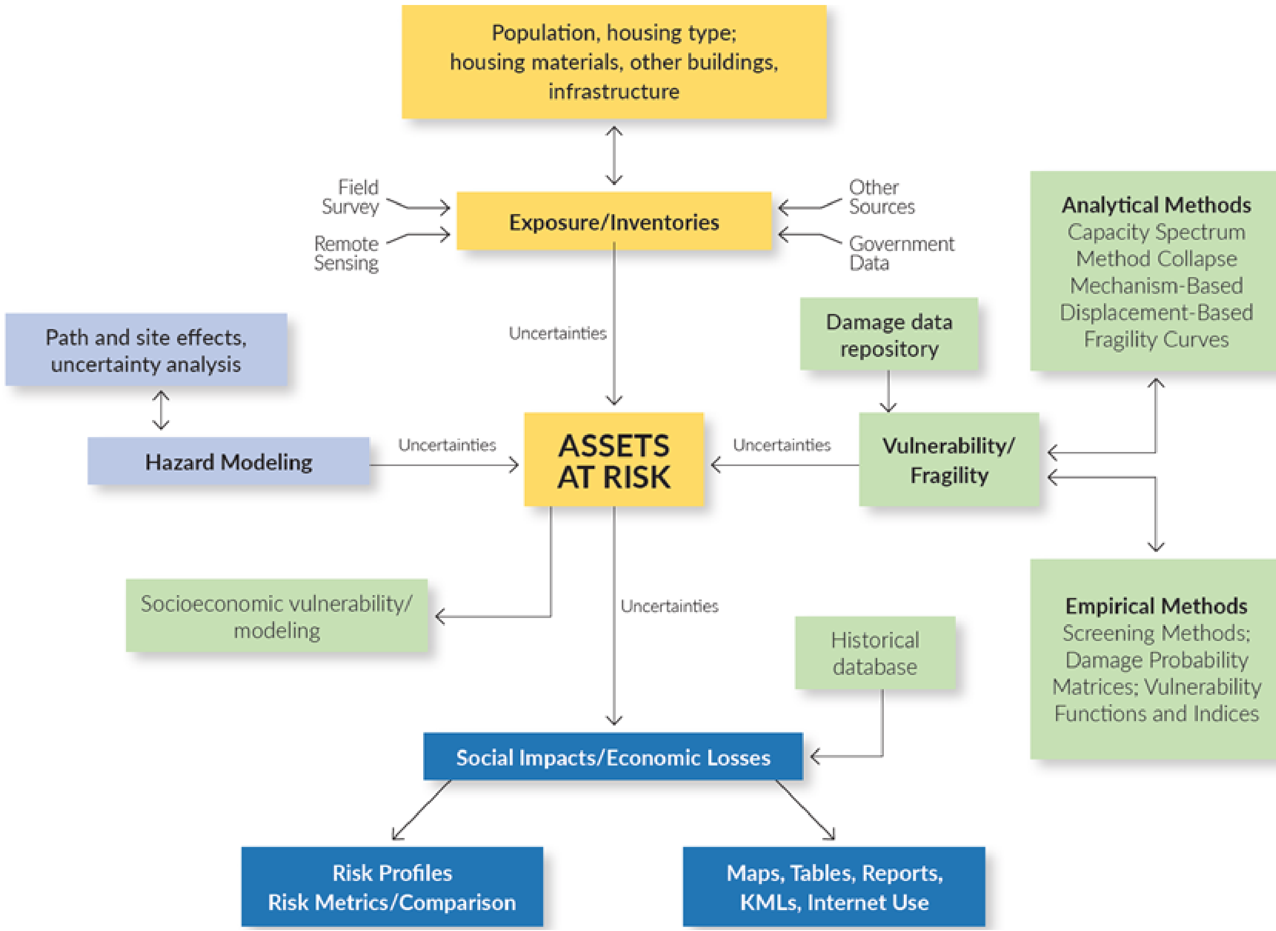


Figure 10: Overview of the GRADE approach and datasets typically used in an assessment.

Figure 11**:** Schematic flowchart of disaster modeling using the GRADE approach

Annex 2 – GRADE Data Summary

The main data sources used in the GRADE Analysis are summarized below.

Exposure Data

1. Admin data
   - MIMU admin boundaries for the purposes of analysis (Township, Village etc.)
   - geoBoundaries
2. Population data
   - The General Administration Department (GAD), and Ministry of Home Affairs townships survey (2017 and 2019)
   - Department of Population (DoP), Ministry of Labor, Immigration and Population 2014 census + 2019 Intercensal Survey
   - WorldPop
   - GHS-POP
   - HRSL checks
3. Building Exposure
   - Myanmar Statistical Yearbooks
   - 2014 Census + 2019 Intercensal Survey
   - General Administration Department 2017 data
   - CATDAT
   - METEOR OED database for Myanmar
   - Microsoft AI Driven Building Footprints
   - GHS BUILT-C, BUILT-V, BUILT-H, BUILT-S products
   - MIMU Township data (Township Profiles)
   - 2009-10 Integrated Myanmar Household Living Conditions Survey
   - World Bank (2019). Myanmar's Urbanization: Creating Opportunities for All
   - Myanmar Post-Disaster Needs Assessment of Floods and Landslides, July–September 2015, December 2015
   - GRADE 2019 Floods Assessment.
4. Infrastructure
   - Myanmar National Accounts
   - State accounts and other datasets from IMF and World Bank
   - OSM roads, waterways and other datasets
   - MIMU airport data, railway and road data
   - CATDAT
   - Various OpenData portals (OpenDevelopment, OSM etc.)
   - MIMU Baseline datasets
5. Agriculture
   - State and District Agriculture sections of Government Websites
   - Myanmar Statistical Yearbook quoting Agricultural censuses
   - MOALI
   - Myanmar: Analysis of Farm Production Economics - World Bank

- Agricultural Census 2010
- FAO
- ESA 10m WorldCover Product

Hazard Data

1. Flow Gauge Data
    - Myanmar's Department of Meteorology and Hydrology (DMH)
        - https://www.moezala.gov.mm/
2. Wind Modelling
    - Reask 3-second gust wind model footprint, updated with ground observations of wind.

Internal wind modelling.

3. Satellite Imagery (Flood and Storm Surge)
    - COPERNICUS
    - ALOS-2 data
    - MODIS
    - EO-RS (JAXA)
    - UNOSAT
    - SENTINEL raw data
    - WFP-ADAM
    - GDACS
    - MAXAR
    - GIC-AIT
4. FABDEM (Hydrologically cleaned Digital Elevation Model)
5. Previously affected townships (2008-2021) from floods.
6. IMERG Rainfall Data from NASA

Damage Data and Observations

1. Myanmar Institutions Reported Damage Data
    - State and District Government offices
        - e.g. http://www.rakhinestate.gov.mm/ or https://chinstate.gov.mm/
    - Ministry of Humanitarian Affairs and Disaster Management (MOHADM)
        - https://mohadm.nugmyanmar.org/situation-reports/
    - Ministry of Social Welfare Relief and Resettlement (MOSWRR) National Disaster Management Committee (NDMC)
        - https://www.moswrr.gov.mm/
        - https://www.ddm.gov.mm/
    - Ministry of Information (MOI)
        - https://www.moi.gov.mm/
    - Ministry of Transport and Communication (MOTC)
        - https://www.motc.gov.mm/

- Other Department websites, Facebook, Twitter and Telegram feeds
    - https://www.facebook.com/icncc/
    - https://twitter.com/kyawhsanhlaing1
    - https://t.me/HDCORelief
    - https://t.me/CycloneMochaERRCA
2. News and media outlets
    - https://infosheet.org/
    - https://www.gnlm.com.mm/
    - https://elevenmyanmar.com/
    - https://news-eleven.com/
    - https://www.mizzima.com/news
    - https://english.dvb.no/
    - https://burmese.dvb.no/
    - https://www.bbc.com/burmese
    - https://www.irrawaddy.com/
    - https://www.dmediag.com/news
    - https://www.dmgburmese.com/
    - https://www.bnionline.net/
    - https://www.rfa.org/burmese/
    - https://arakanbaynews.com/
3. Agricultural damage reports
    - e.g. https://www.mdn.gov.mm/newspaper/public/ebooks/download/8723
4. Myanmar disaster loss and damage database (MDLD-RRD)
5. UN OCHA and UNICEF Flash Updates and Situation Reports
6. AHA Centre
    - https://ahacentre.org/situation-updates/
7. Myanmar Information Management Unit (MIMU)
    - https://themimu.info/emergencies/storm_mocha_may23
8. Previous vulnerability functions work from previous Myanmar events for wind, storm surge and flood.
9. Conflict data: IISS Myanmar Monitor
    - https://myanmar.iiss.org/
10. Conflict data: ACLED
    - https://acleddata.com/tag/myanmar/
11. Conflict data: Internal Displacement (UNHCR)
    - https://data.unhcr.org/en/situations/myanmar
12. Conflict data: Myanmar Peace Monitor
    - https://mmpeacemonitor.org/

Annex 3 – Impacts of tropical cyclones/storms affecting Myanmar (1968 to 2022)

1. **Tropical cyclones or storms occurring in or near the Rakhine coast.**
   a. **May 9, 1968** – A **severe cyclone** struck northwestern Myanmar near Sittwe, becoming the country's worst natural disaster at the time and eventually the worst cyclone of the 20th century. The storm killed at least 1,037 people (including 553 in Pauktaw and 415 in Myenbon), left 297,768 people homeless and destroyed more than 57,000 houses.
   b. **May 19, 1992** – A **cyclonic storm** struck Rakhine State, killing at least 27 people. The storm destroyed 433 homes and caused the loss of many livestock.
   c. **May 2, 1994** – A **powerful cyclone** made landfall in southeastern Bangladesh killing 17 people in Myanmar. The storm affected particularly Maungdaw and Buthidaung townships of Rakhine State, damaged or destroyed 8,872 houses, leaving more than 8,000 people homeless, as well as dozens of schools and hospitals, left more than 8,000 people homeless, with damage estimated at 60 million kyat (US$10 million).
   d. **May 19, 2004** – An **extremely severe cyclonic storm** made landfall in Rakhine State with winds of up to 165 km/h. Officially, there were 236 deaths in Myanmar, although there were unconfirmed reports of a death toll as high as 1,000 (most of the deaths were fishermen from Rakhine State caught at sea). Damage totaled over 621 million kyat (US$99.2 million). Up to 500 mm of precipitation fell along the Bay of Bengal coast in Myanmar. There were reports of waves 15 m in height along the coast and a high storm surge and coastal flooding inundated four towns in Rakhine State (Pauktaw, Myebon, Sittway and Kyaukpyu), causing loss of life, and damage to buildings, infrastructure (particularly the water systems). It was the worst storm in Rakhine State since the May 1968 cyclone. It seriously affected five of the 17 townships in the state and damaged another three. The storm destroyed over 2,650 homes and severely damaged another 1,385, leaving around 25,000 people homeless, mostly in Pauktaw.
   e. **April 29, 2006** – **Very Severe Cyclonic Storm Mala** hit Rakhine State, with wind speed of 240 km/h and a storm surge of nearly 4.6 m in Gwa township (Thandwe district) where human settlements are comparatively less dense. Damage was relatively minimal, while timely and effective evacuations minimized loss of life along the coast. The greatest damage resulted from a thunderstorm near Yangon on April 28 that spawned a possible tornado in an industrial zone, damaging 586 homes. Just outside the city in the Hinthada district, a flash flood killed at least 18 people. Overall, the storm claimed 37 lives in the country and left 1.24 billion kyat (US$6.7 million) in damage. Rakhine State suffered a direct hit, with Gwa Township reporting the worst damage (88 homes destroyed and 1,246 damaged). Ra Haing Ku Toe village suffered significant losses as well, with 132 homes destroyed and 531 damaged.

f. **October 22, 2010** – **Extremely Severe Cyclonic Storm Giri** made landfall in Rakhine State, killing 157 people (138 in Myebon Township, 11 in Pauktaw Township, 5 in Minbya Township and 3 in Kyaukpyu Township), with damage in Kyaukpyu Township estimated at 2.34 billion kyat (US$359 million). About 53,000 people evacuated ahead of the storm. A storm surge up to 3.7 m, along with waves up to 8 m and winds in excess of 260 km/h hit parts of the Rakhine coast. In Kyaukpyu, much of the city was left under 1.2 m or more under water and roughly 70% of the city was destroyed. Myebon Township was the hardest-hit area with several villages completely destroyed and many others severely damaged. According to the United Nations, roughly 15,000 homes were destroyed by the storm leaving more than 70,000 people homeless throughout Rakhine State. The cyclone occurred at the only harvest period of the year for Rakhine State. According to the United Nations Food and Agriculture Organization, 16,187 hectares of rice paddies were destroyed, and another 40,468 hectares were damaged.

g. **July 30, 2015** – **Cyclone Komen** was a tropical storm spawned by a monsoonal depression that made landfall along the coast of southeastern Bangladesh between Hatiya and Sandwip. The slow-moving storm brought heavy rainfall to northwestern Myanmar exacerbating the effects of monsoonal flooding that had started two weeks earlier. The combined effects of cyclone Komen and preceding monsoon rains and flooding resulted in about 103 deaths and affected up to 1 million people. Most of the casualties were reported from the Irrawaddy Delta region. Torrential rains that began on 16 July destroyed farmland, roads, rail tracks, bridges and houses, leading the government to declare a state of emergency on July 30 in the four worst-hit regions in the northwest - Magway Region, Sagaing Region, Chin State and Rakhine State. Some 17,000 homes had been destroyed as of data released on August 17 from the more than two weeks deluge. In what was the worst flooding for decades all but one of the country's 14 states and regions were impacted. Myanmar's Ministry of Agriculture reported that more than 1.29 million acres of farmland have been inundated and 687,200 acres damaged. Among the worst affected were, Kale and Kanbalu Townships (in Sagaing Region) and Pwintbyu, Sidoktaya and Ngape Townships (in Magway Region).

2. Tropical cyclones occurring in the Irrawaddy deltaic coast.

a. **May 2, 2008** – Extremely Severe Cyclonic Storm Nargis made landfall in the low-lying Irrawaddy Delta near Yangon, with wind speed of 240 km/h sending a catastrophic storm surge, that reached as high as 7.2 m, 40 km up the densely populated Irrawaddy delta, killing an estimated 146,000 people including around 56,000 missing and injuring another 19,359 people and becoming Myanmar's worst natural disaster on record. Labutta Township alone was reported to have 80,000 dead, with about 10,000 more deaths in Bogale Township. Some 2.4 million people were severely affected by the cyclone, out of an estimated 7.35 million living in the affected townships, with the number of people displaced possibly as high as 800,000, with some 260,000 living in camps or settlements throughout the Delta in the initial days. Myanmar was largely unprepared for the cyclone, lacking shelters and an early warning system. The cyclone damaged or destroyed more than 700,000 homes, leaving more than 1 million people homeless (in the town of Labutta, 75 percent of buildings had collapsed, and 20 percent had their roofs ripped off, while as much as 95 percent of buildings in the Irrawaddy Delta area were destroyed). About two to three weeks after the disaster it was communicated that the losses were estimated by the Myanmar Government at **US$10 billion**, but in July 2008 the tripartite Joint Assessment by the Government of the Union of Myanmar, ASEAN (supported by the Asian Development Bank and the World Bank), and the United Nations estimate the effects at **US$ 1.754 billion in damages and around US$ 2.324 billion in losses**.