Center for Disaster Management and Risk Reduction Technology

CEDIM Forensic Disaster Analysis Group (FDA)

Tropical Cyclone 18S IDAI

Information as of 30 April 2019 – Report No. 1

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SUMMARY

Official Disaster Name	Date	Landfall UTC	Local	Duration
Tropical Cyclone 18S IDAI	**14-03**	**23:30 UTC**	**+2**	
Tropical Depression, Tropical Storm, Tropical Cyclone Cat 1 - Cat 4, Tropical Depression	**03-03 – 16-03**			**14 days**

Preferred Hazard Information:

Location	Movement	Definition (Meteo France)	Min Sea Level Pressure	Wind Gusts	Time	Wind Sustained
18.0S 38.0 E 390 km NE of Beira		**Tropical Depression**		**75 kt 139 kph**	**04-03 00 UTC**	**30 kt 55 kph**
17.3S 37.3 E 385 km NE of Beira	**N 4 kt**	**Zone of Disturbed Weather**		**35 kt 65 kph**	**04-03 18 UTC**	**24 kt 45 kph**
16.9S 40.2 E 655 km NE of Beira	**E 12 kt**	**Tropical Depression**		**46 kt 85 kph**	**09-03 06 UTC**	**30 kt 55 kph**
17.2S 42.2 E 830 km ENE of Beira	**ESE 4 kt**	**Moderate Tropical Storm**		**59 kt 110 kph**	**10-03 00 UTC**	**40 kt 75 kph**
17.2S 43.2 E 935 km ENE of Beira	**ENE 3 kt**	**Tropical Cyclone**		**89 kt 165 kph**	**10-03 18 UTC**	**65 kt 120 kph**
17.4S 42.9 E 895 km ENE of Beira	**WSW 2 kt**	**Intense Tropical Cyclone**		**124 kt 230 kph**	**11-03 06 UTC**	**89 kt 165 kph**
18.0S 42.2 E 800 km ENE of Beira	**SW 4 kt**	**Tropical Cyclone**		**105 kt 195 kph**	**12-03 00 UTC**	**76 kt 140 kph**
19.5S 38.6 E 395 km ENE of Beira	**W 5 kt**	**Intense Tropical Cyclone**		**140 kt 260 kph**	**13-03 18 UTC**	**100 kt 185 kph**
19.7S 37.9 E 320 km E of Beira	**WSW 6 kt**	**Intense Tropical Cyclone**		**151 kt 280 kph**	**14-03 00 UTC**	**105 kt 195 kph**
19.6S 34.7 E 35 km NNW of Beira	**W 9 kt**	**Intense Tropical Cyclone**		**124 kt 230 kph**	**15-03 00 UTC**	**89 kt 165 kph**
19.3S 34.1 E 100 km NW of Beira	**WNW 6 kt**	**Severe Tropical Storm**		**70 kt 130 kph**	**15-03 06 UTC**	**51 kt 95 kph**
19.2S 33.5 E 160 km NW of Beira	**NW 6 kt**	**Moderate Tropical Storm**		**46 kt 85kph**	**15-03 12 UTC**	**35 kt 65 kph**
19.1S 32.8 E 230 km NW of Beira	**WNW 12 kt**	**Zone of Disturbed Weather**		**35 kt 65 kph**	**15-03 18 UTC**	**24 kt 45 kph**
18.1S 31.0 E 450 km NW of Beira	**WNW 4 kt**	**Zone of Disturbed Weather**		**30 kt 55 kph**	**16-03 12 UTC**	**19 kt 35 kph**

Location Information:

Country	ISO	Provinces/Regions	Most Impact	Economic Exposure	HDI (2014)	Urbanity	Pop. affected
Mozambique	**MZ**	**Sofala, Zambezia, Manica, Inhambane**	**Beira, Buzi**				**1,850,000**
Malawi	**MW**	**Southern**					**868,900**
Zimbabwe	**ZW**	**Chimanimani, Chipinge**					**270,000**

1 Overview

Over a period of 2 weeks, the long living tropical system IDAI hit large parts of South East Africa. At the beginning it was only the precursors of a tropical cyclone that caused major flooding in Malawi. Some days later, over the warm waters of the Mozambique Channel, the system went through all stages of development and finally became a full-grown tropical cyclone with sustained winds of 195 kph and gusts of 280 kph. Shortly after peak intensity, IDAI fell ashore in Mozambique a few kilometers north of the city of Beira in the night from 14 to 15 March 2019.

A slow propagation speed, a destructive storm surge, heavy winds and enormous precipitation led to extensive damage and flooding. And even the remnants of the weakening tropical system caused further floods and landslides far inland in the east of Zimbabwe.

A total of around 3 million people were affected by IDAI and its impacts. IDAI claimed several hundred lives and left hundreds of thousands of people homeless and displaced across the region. For Mozambique, IDAI could even become the most devastating and deadliest tropical cyclone in history.

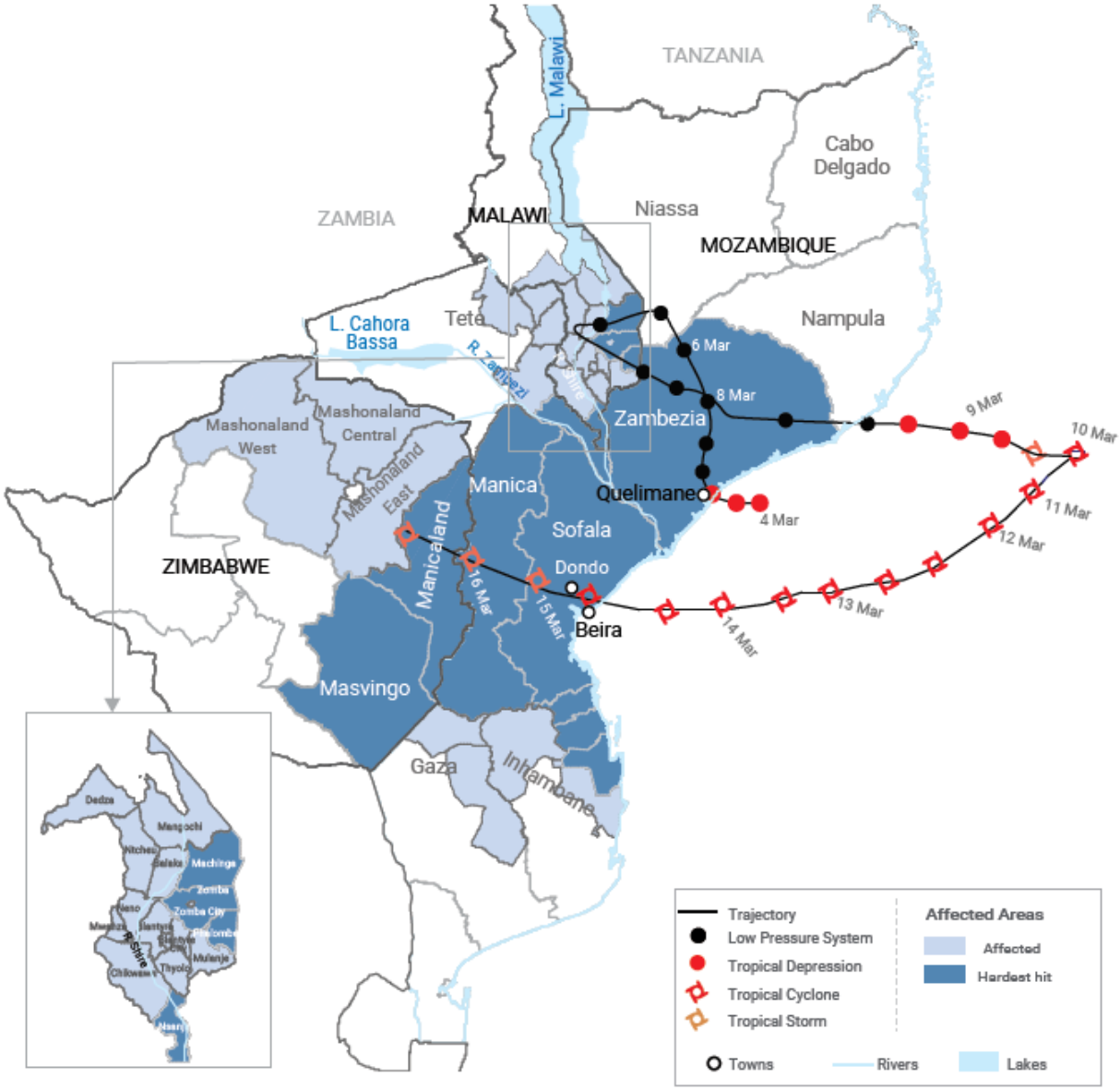


Figure 1: *Track of IDAI, hardest hit areas (dark blue) and affected areas (light blue) in the states of southeastern Africa (Mozambique, Malawi and Zimbabwe; Image source: reliefweb.int).*

2 Meteorological Information

2.1 Preliminary Remarks

With respect to tropical cyclones, Meteo France is responsible for the southwest Indian Ocean area. In this region a specific classification for tropical weather systems is in use. The classification system, its thresholds and terms differ from the widely-used Saffir-Simpson Hurricane Scale, which is applied for the Atlantic and Eastern Pacific storm basins (Table 1).

***Table 1**: The classification of tropical weather system in the southwest Indian Ocean and the corresponding terms of the Saffir-Simpson Hurricane Scale.*

kt	kph	Classification Meteo France	Saffir Simpson Scale
< 28	< 52	Zone of Disturbed Weather	Tropical Depression
28-29	52-54	Tropical Disturbance	Tropical Depression
30-33	56-61	Tropical Depression	Tropical Storm
34-47	63-87	Moderate Tropical Storm	Tropical Storm
48-63	89-117	Severe Tropical Storm	Tropical Storm - Cat 1
64-85	119-157	Tropical Cyclone	Cat 1 - Cat 3
86-113	159-209	Intense Tropical Cyclone	Cat 3 - Cat 4
> 113	> 209	Very Intense Tropical Cyclone	Cat 4 - Cat 5

2.2 Evolution of Tropical Cyclone IDAI

IDAI was the seventh intense tropical cyclone of the Indian Ocean basin's 2018-2019 season. The beginnings of IDAI can traced back until 3 March 2019 where it was born just off Mozambique's coast over the warm waters of the Mozambique Channel. The Mozambique Channel is part of the Indian Ocean and stretches as a 400 km wide arm between the coast of Mozambique and the island of Madagascar. First, IDAI developed as a tropical disturbance and increased into a tropical depression until 4 March 2019. The following days IDAI made a loop crossing the far south eastern tip of Malawi and finally turned into an easterly to south-easterly direction (Fig. 1). While looping inland, heavy rain occurred already across parts of Mozambique and southern Malawi resulting in devastating flooding.

After a slight decrease, IDAI entered the Mozambique Channel on 9 March 2019. Very warm surface water temperatures and the absence of strong winds in the upper troposphere created favorable conditions for a rapid development. On 10 March 2019, 18 UTC, IDAI reached its easternmost point of its track, just 100 km west of the coast of Madagascar. The following day after a sharp U-turn, IDAI was a Category 3 tropical cyclone between 03 and 06 UTC with respect to the Saffir-Simpson hurricane scale. Maximum wave heights were 8 meters. Until 12 March 2019, 03 UTC, IDAI weakened into a Category 2 storm but developed a well-defined eye. While maintaining Category 2 – 3 strength, cloud top temperatures were at -57 °C. IDAI's eye was 37 km in diameter although covered by high clouds (Fig. 2).

On 14 March 2019, 00 UTC, IDAI reached maximum intensity with 10-minute sustained winds of 105 kt (195 kph) and gusts of 151 kt (280 kph). Landfall was on 14 March 2019, 23:30 UTC, few kilometers north of the city of Beira in Mozambique, sustained winds were 95 kt (177 kph) making IDAI an upper Category 2 tropical cyclone at that time (cf. Fig 3).

While travelling slowly overland into a westerly direction, it took 2-3 more days for IDAI to dissolve. During that time the remnants of the cyclone caused heavy rains, riverine and flash flooding all affecting eastern Zimbabwe.

The series of satellite images covering the period from 11 to 16 March 2019 (Fig. 2) shows how IDAI gained strength when reaching the warm waters of the Mozambique Channel. With an undisturbed circulation over open waters IDAI formed a well pronounced eye. After a U-turn

IDAI headed for Mozambique, where the tropical cyclone finally made landfall late on 14 March 2019 near the city of Beira. While slowly moving inland IDAI quickly lost intensity, however, was responsible for enormous rain amounts for two more days even in eastern Zimbabwe, 500 km west of the coastline.

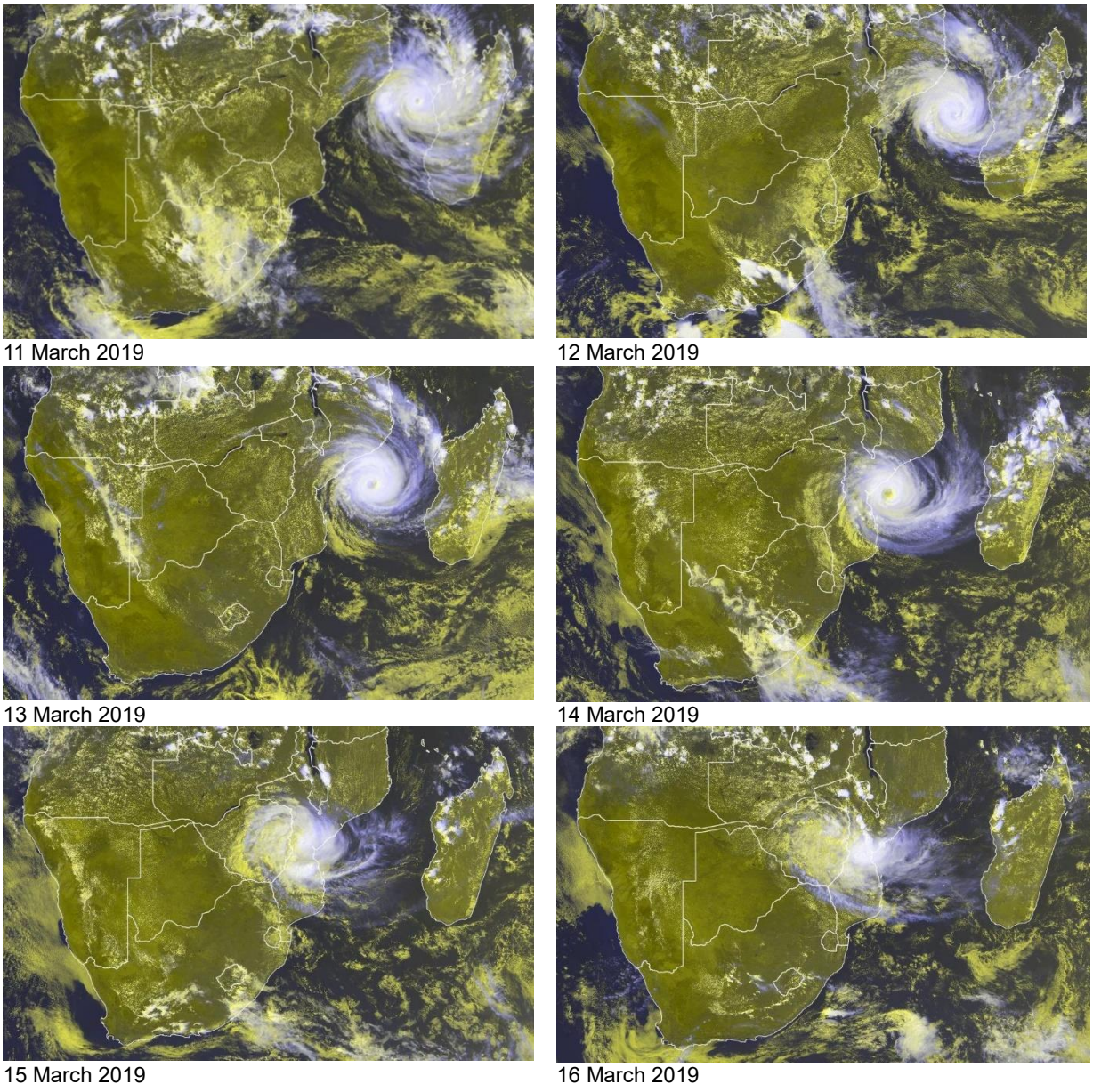


***Figure 2**: Satellite images (11-16 March 2019, 12 UTC; Image source: Eumetsat).*

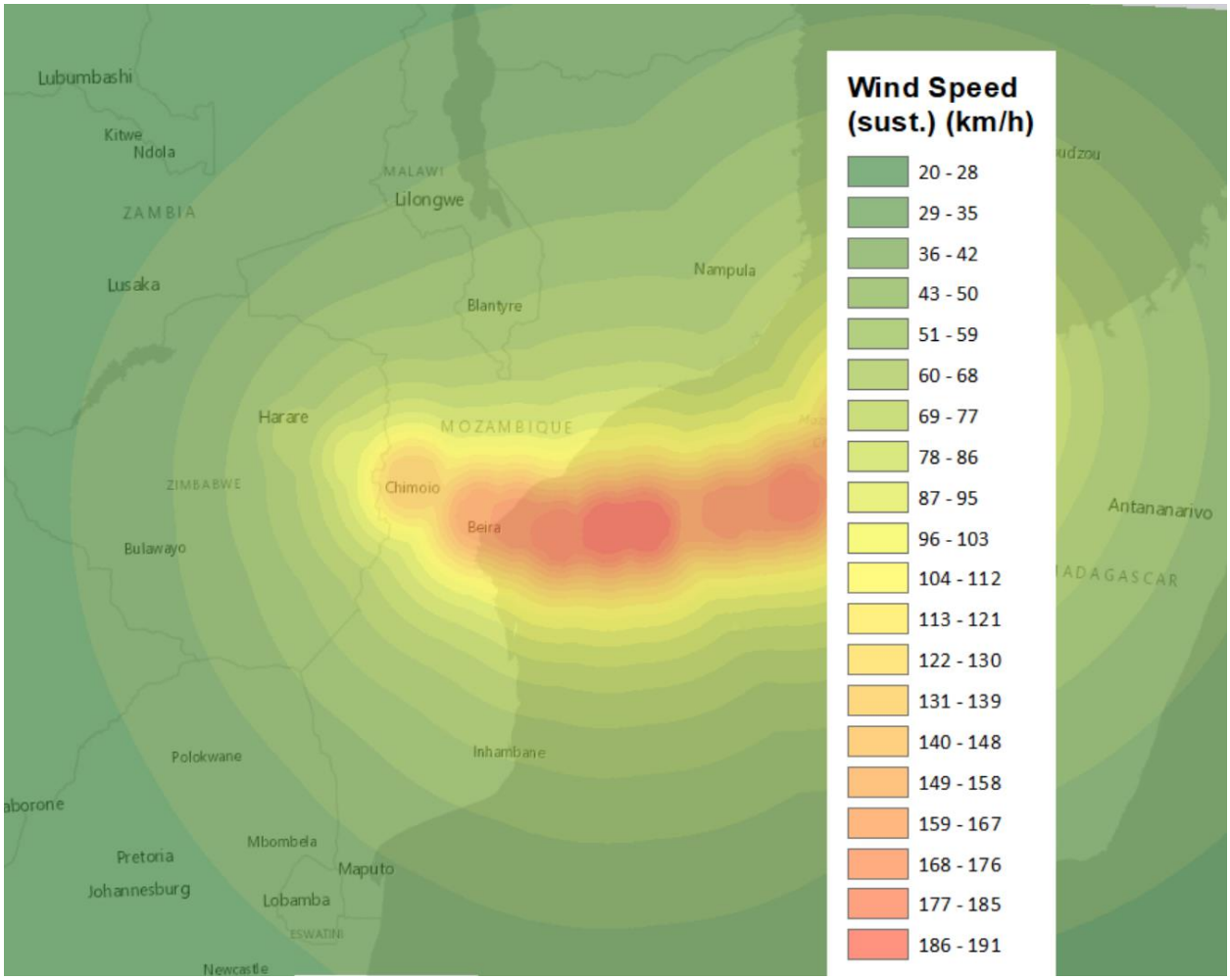


***Figure 3**: Wind Speed (sustained 3-min) in km/h from Cyclone Idai as calculated from Best Track data from NCAR. The wind field was calculated using a Holland windfield model, and the sustained wind speed was checked against damage and wind speed "recordings" through.*

2.3 Precipitation

IDAI dropped enormous amounts of rain along its path. Due to its large spatial extent and low propagation speed during landfall, the tropical cyclone was responsible for rain accumulations in excess of 500 mm in many regions of central Mozambique (Fig. 4); in the Sofala province even more than 600 mm have been calculated (Fig. 5). As there are no direct measurements, these estimates are based on satellite data from the Integrated Multi-Satellite Retrievals (IMERG), which is a product of the Gobal Precipitation Measurement mission (GPM). Locally, rain amounts may have been even higher. Intense rainfall did also occur in the eastern parts of Zimbabwe, where the dissipating cyclone brought rain amounts well above 200 mm.

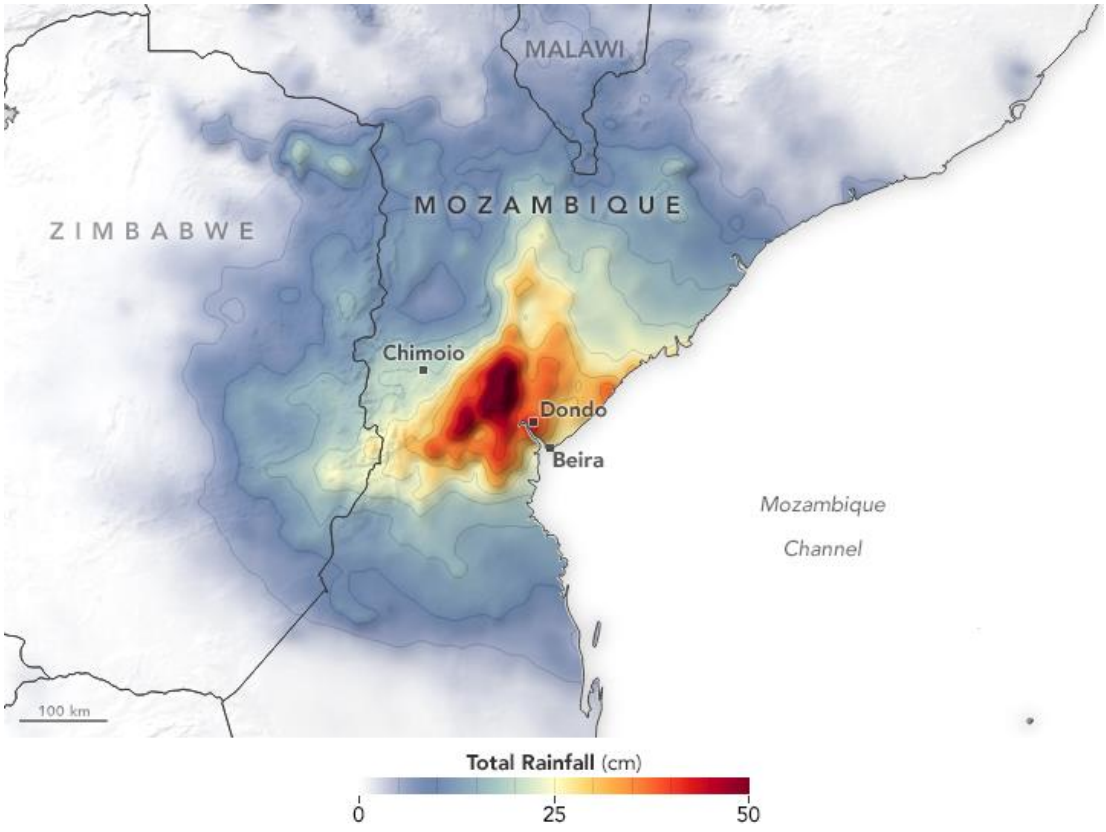


***Figure 4**: Accumulated 7-day precipitation (13-20 March 2019; Image source: NASA).*

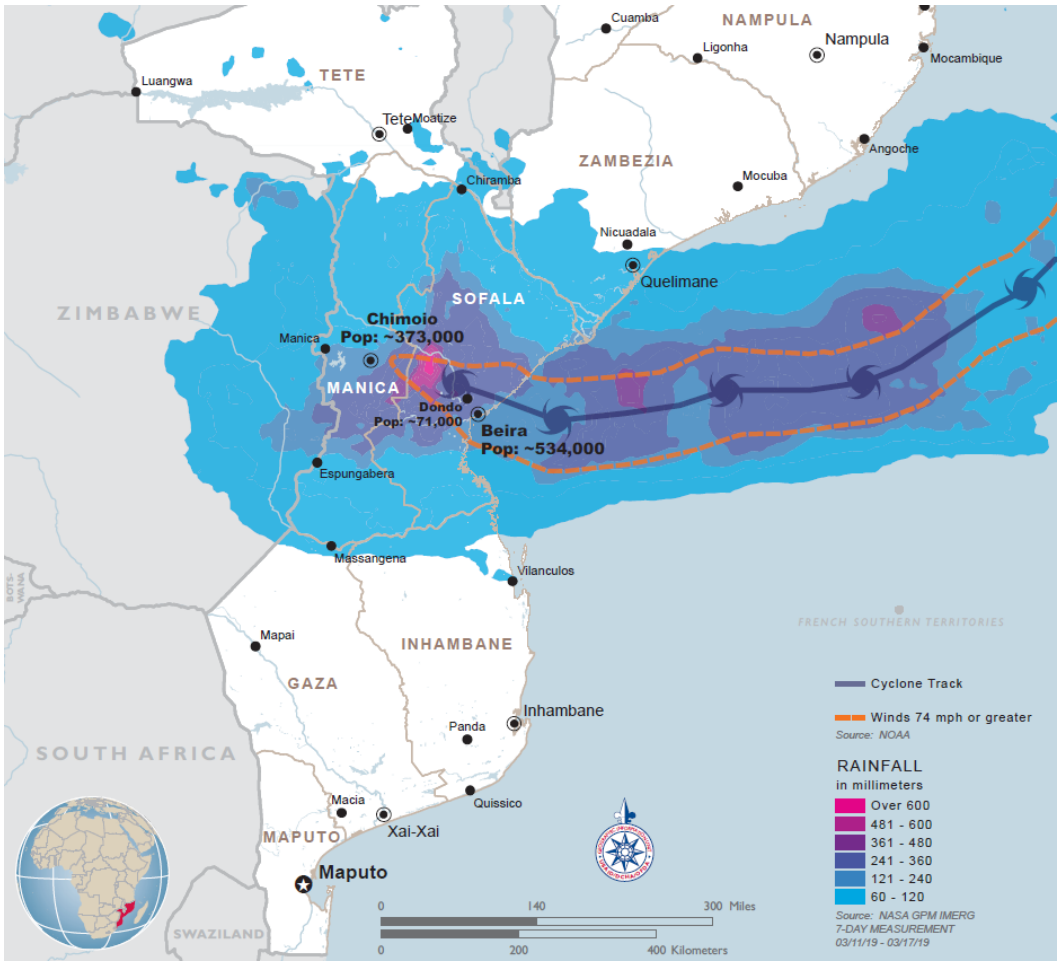


***Figure 5**: Accumulated 7-day rain along IDAI's path over the Mozambique Channel and south eastern Africa. Within the area encircled by the red dashed line winds speeds exceeded 119 kph (Image Source: US AID).*

3 Impacts

Tropical cyclones in general can cause serious damage in many ways:

1.) Intense rainfall that causes flooding of rivers and their floodplains. In mountainous terrain, landslides often occur.
2.) The effect of persistent high average wind speeds and gusts on buildings and other facilities (such as trees, electricity pylons, agricultural crops, etc.), especially on islands and along coastal shores.
3.) By the storm surge, generated by a hurricane already before its arrival in coastal areas, bays and larger estuaries and deltas. In particularly shallow coastal areas can be submerged.

Although the intensity of tropical cyclones is based almost entirely on wind speeds, even tropical storms or weaker systems corresponding to Category 1 or 2 can sometimes cause more damage than the worst tropical cyclones. Destructive wind speeds usually affect only smaller areas around the center of the cyclone with a peak near the eye-wall, and also decrease rapidly inland. The flooding caused by storm surges and large-scale heavy rainfall has a much greater potential for damage.

The simultaneous occurrence of a storm surge and a spring tide can particularly damage coastal areas. The weather conditions during the weeks before landfall, especially the antecedent rainfall related to soil moisture conditions, also play an important role in addition to the terrain configuration. The coastal shape and estuaries can further increase a rising storm surge. On mountain slopes, landslides can occur.

And last but not least, the propagation speed of the tropical systems is of crucial importance as quasi-stationarity causes enormous rainfall for days.

3.1 Impacts of tropical cyclone IDAI

The World Bank D-RAS KSB along with other parts of World Bank GSURR released an estimate at the end of March, in the order of 1.77 billion EUR (over 2 billion USD; Reuters). For the three countries, very different values were seen with regard to government estimates, aid estimates and information coming out from various agencies. An important thing to note is the difference in the numbers between the 26 March 2019 and 14 April 2019 from the three agencies (see Table 2 and 3).

Table 2: *Key figures for affected countries as of 26 March 2019 (Data Source: reliefweb.int).*

	Malawi	Mozambique	Zimbabwe
People affected	868,900	797,340	270,000
People displaced	86,980	248,000 (est.)	4,500
In Shelters		**127,626**	
Deaths	59	468	172
Injuries	672	1,522	186
Buildings destroyed		**50,619**	
Buildings damaged		**24,556**	
Inundated		**15,784**	
Ag. Hectares Affected		**252,000 – 474,154**	
Classrooms		**3,202**	
Students affected		**90,756**	
Medical Centers		**52**	

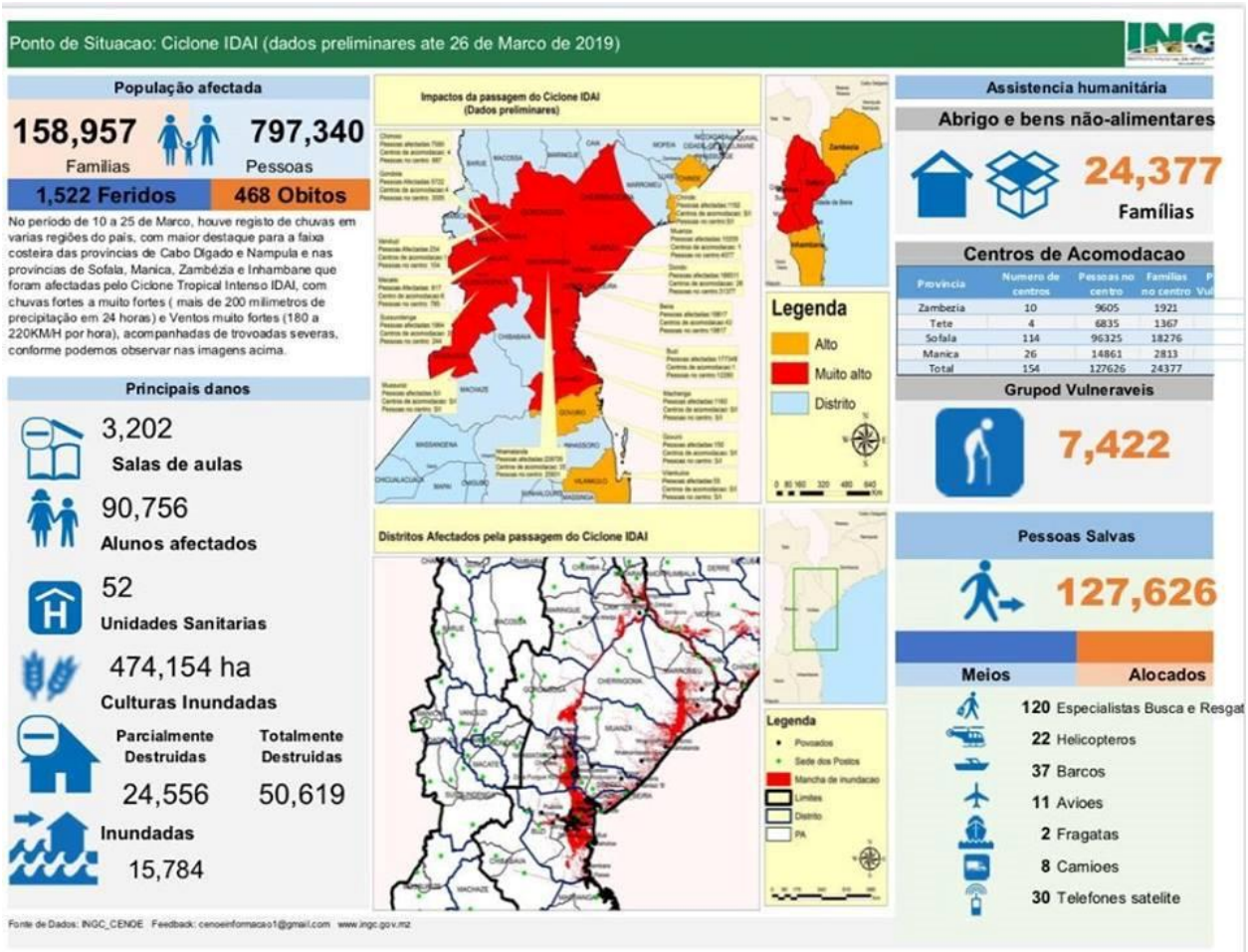
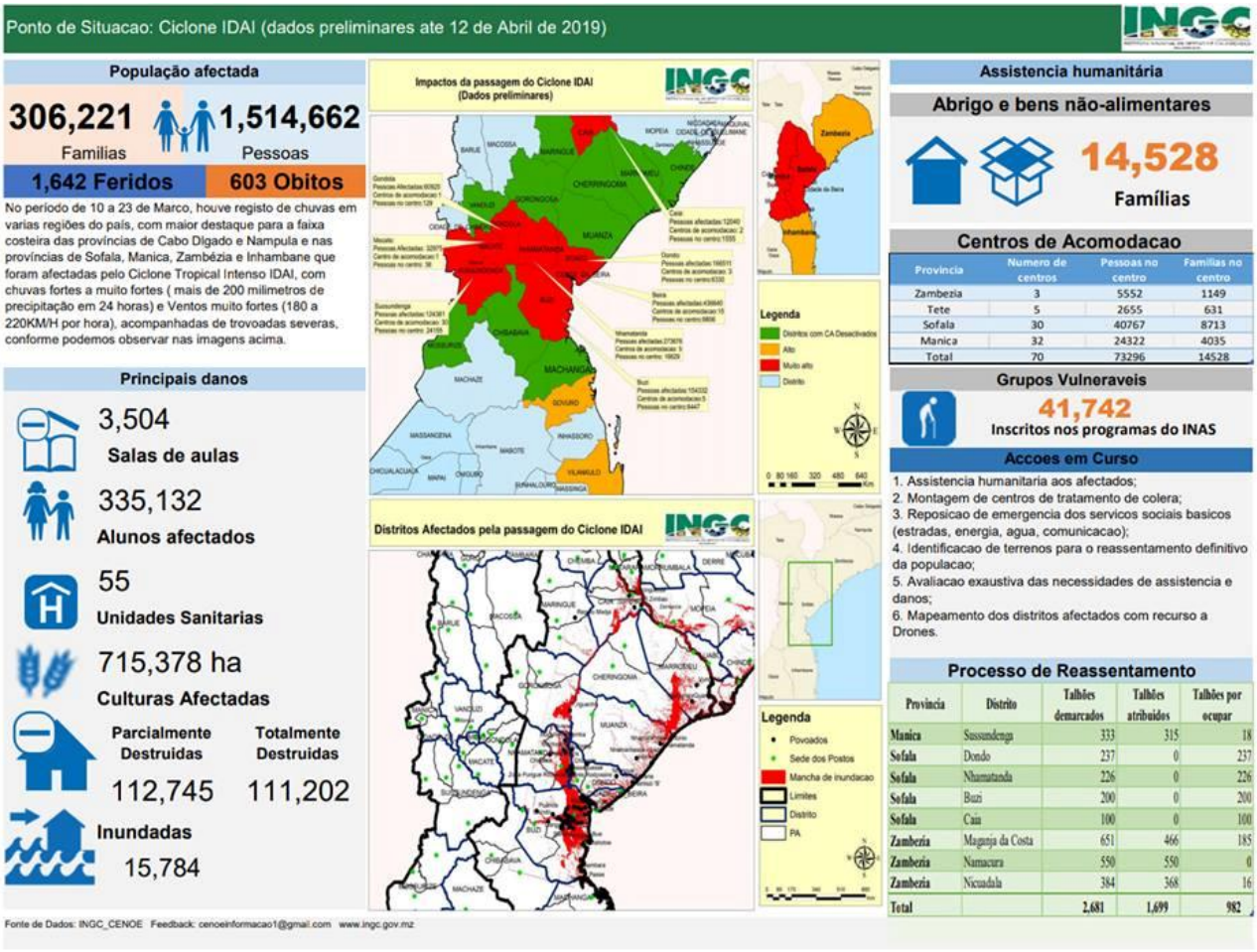


Table 3: *Key figures for affected countries as of 14 April 2019 (Data Source: Individual Disaster Response).*

	Malawi	Mozambique	Zimbabwe
People affected	868,900	1,514,662	270,000
People displaced	86,980	546,000 (est.)	70,000
In Shelters		**73,296**	
Deaths	**59**	**603**	**517 (181 + 330 + 6)**
Injuries	**672**	**1,642**	**192**
Buildings destroyed		**111,202**	
Buildings damaged		**112,745**	
Inundated		**15,784**	
Ag. Hectares Affected		**252,000 - 715,378**	
Classrooms		**3,504**	
Students Affected		**335,132**	
Medical Centers		**55**	



Provincia	Numero de centros	Pessoas no centro	Familias no centro
Zambezia	3	5552	1149
Tete	5	2655	631
Sofala	30	40767	8713
Manica	32	24322	4035
Total	70	73296	14528

Provincia	Distrito	Talhões demarcados	Talhões atribuidos	Talhões por ocupar
Manica	Sussundenga	333	315	18
Sofala	Dondo	237	0	237
Sofala	Nhamatanda	226	0	226
Sofala	Buzi	200	0	200
Sofala	Caia	100	0	100
Zambezia	Maganja da Costa	651	466	185
Zambezia	Namacura	550	550	0
Zambezia	Nicuadala	384	368	16
Total		2,681	1,699	982

3.2 Storm surge

IDAI made landfall on 14 March 2019 at around 23:30 UTC which coincided with high tide. Both the storm surge and the high tide led to a worst-case scenario with IDAI pushing a wall of water inland. The storm surge was estimated as high as 6 meters in some places and caused large flooding in low lying areas along the Pungwe river.

3.3 Large-scale flooding due to heavy rain

Water proved to be the most destructive element. The storm surge and subsequent excessive amounts of rain led to an inland lake. Entire communities and villages disappeared under water. Based on Sentinel-1 data from 19 March 2019 water covered an area of 2,165 km² (cf. Fig. 6). In some places the water surface was as wide as 45 km.

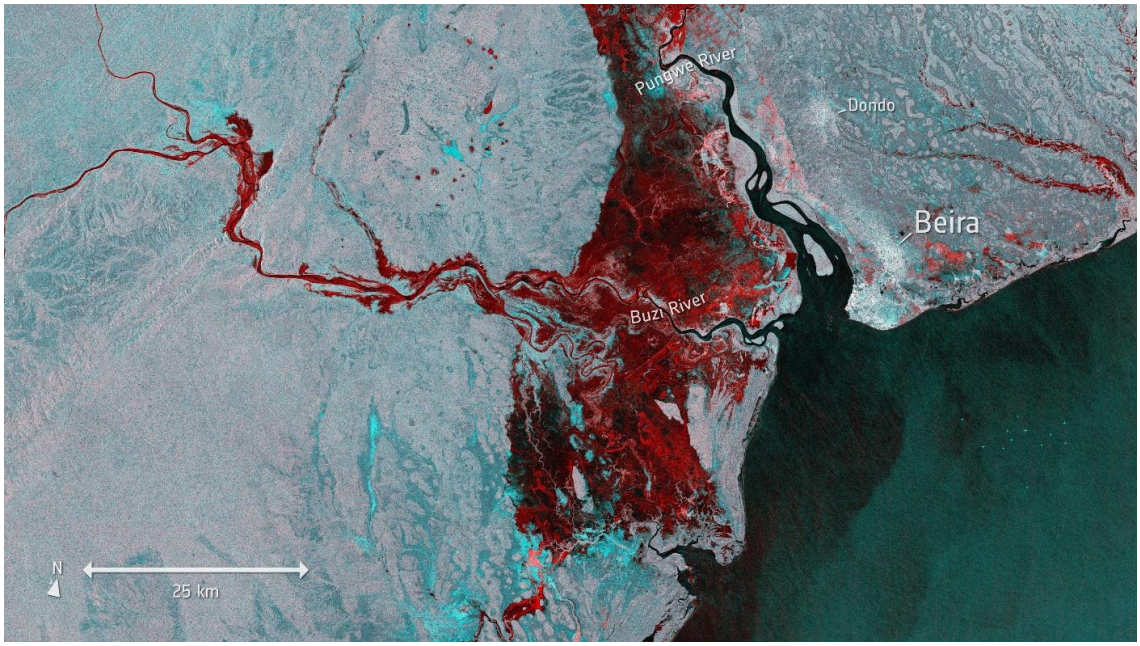


***Figure 6**: Image of satellite Copernicus Sentinel-1 showing the flooded areas, depicted in red, in the aftermath of tropical cyclone IDAI in Mozambique (Image credit: ESA; CC BY-SA IGO 3.0).*

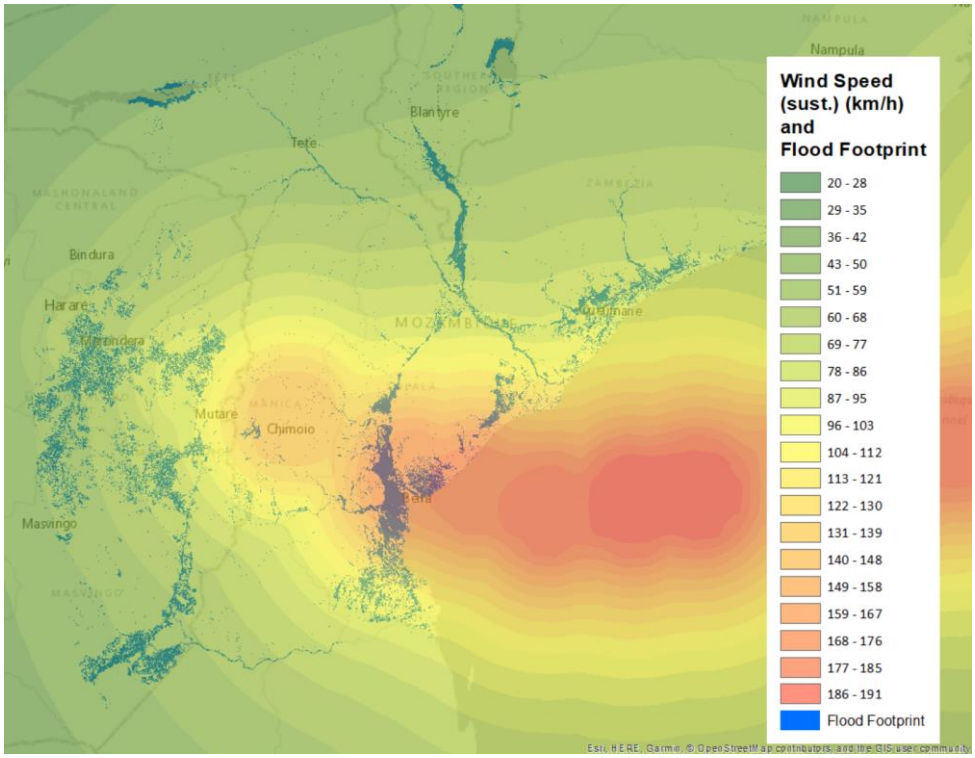


***Figure 7**: Flood footprint (from 4 March to 31 March in blue) and wind speed (from 13 – 20 March).*

3.4 Damages and Consequences

In terms of the total capital damage, Mozambique, Zimbabwe and Malawi have all seen significant damage. The distribution as expected is due to the high wind speed areas in Mozambique, and for the other two countries the dristribution is driven from the main flood inundation (Fig. 8). The agricultural losses are expected to cause huge issues in the three countries. Using local crop data from Geonode as well as the ESA 20 m land cover product for Africa, modelling was undertaken to examine the exposed crops (Fig. 9).

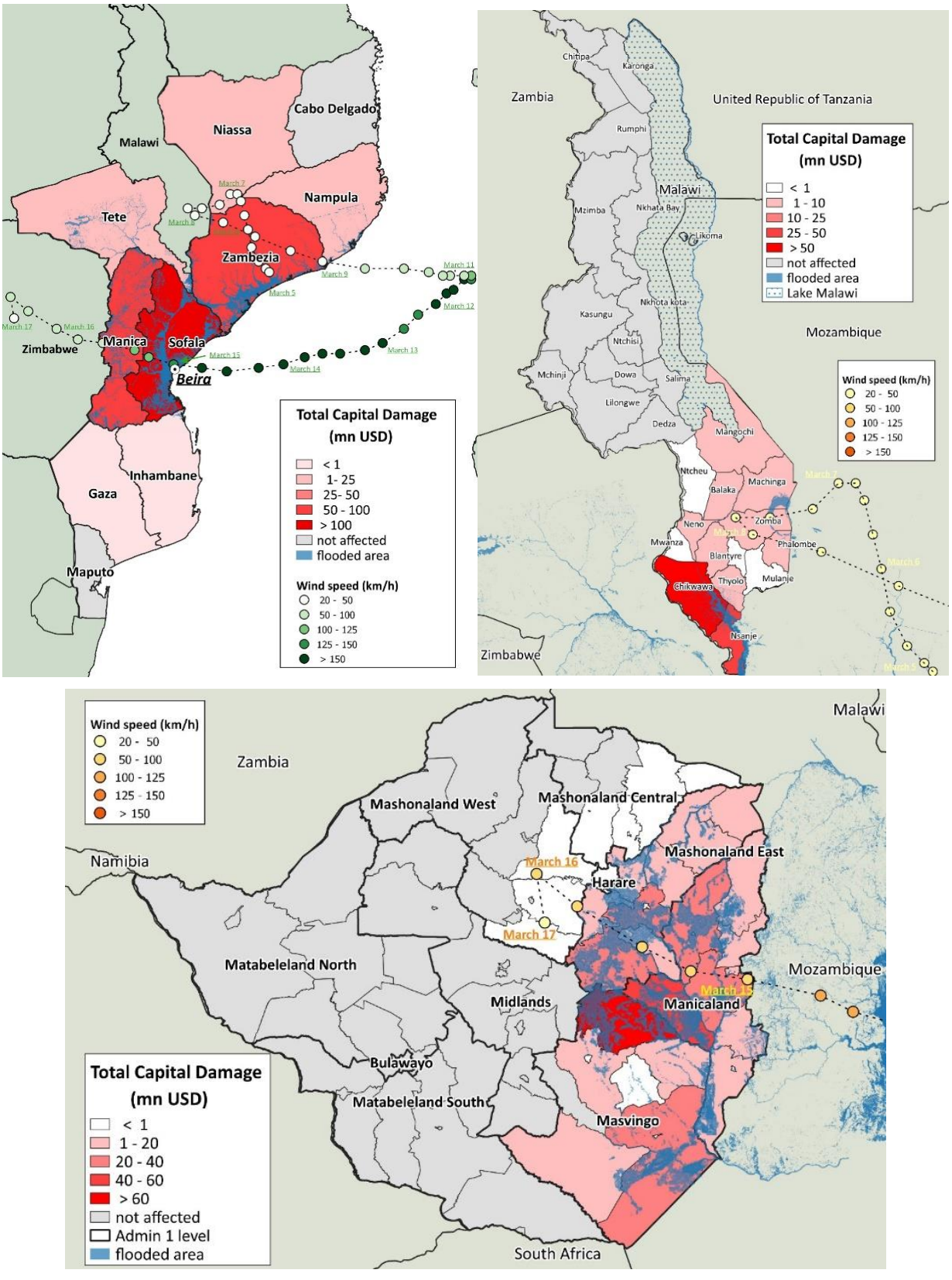


Figure 8: *Preliminary estimates of losses and footprints in the three countries from World Bank.*

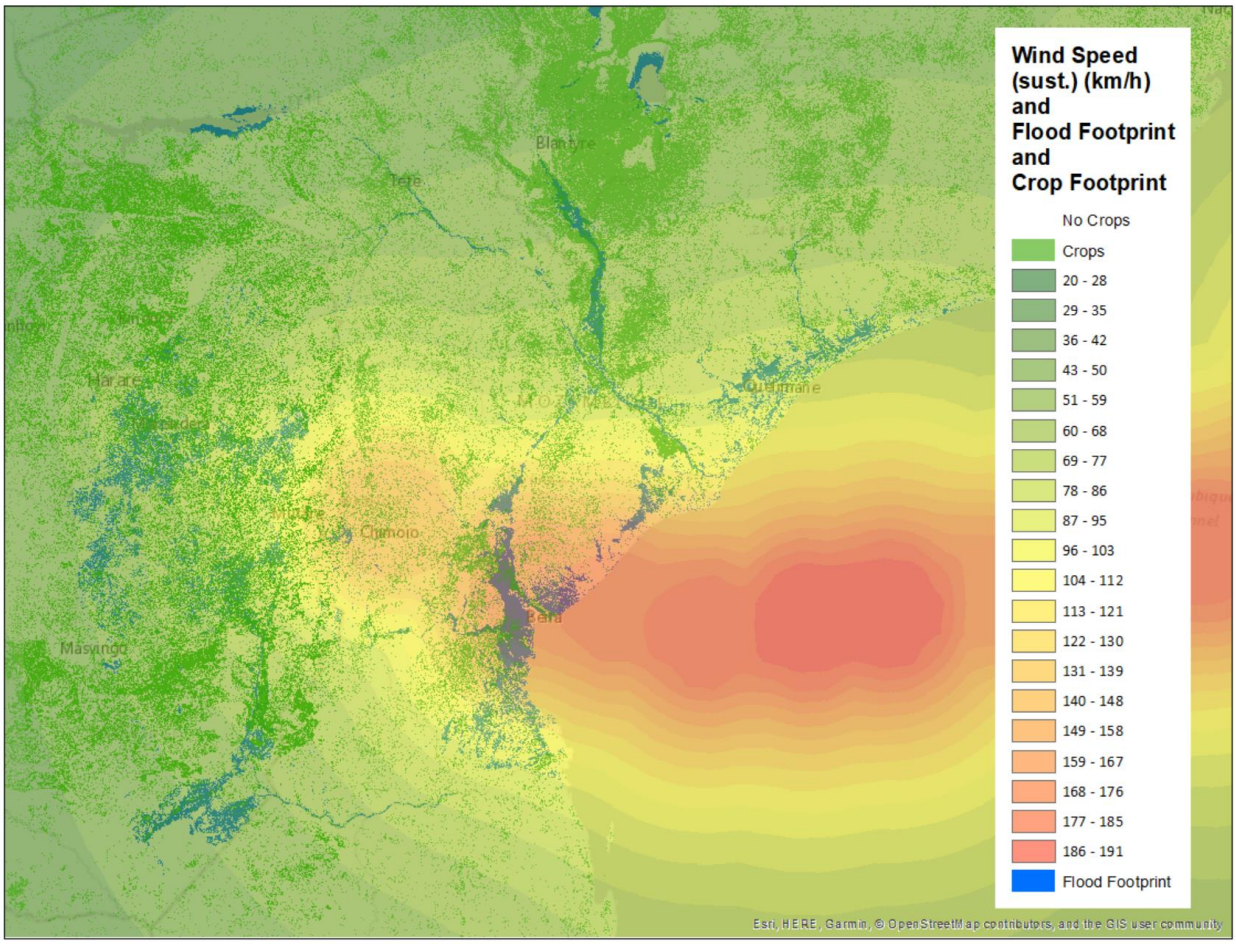


Figure 9: *Crop footprint overlay (in green) with flood and wind speed (cf. Fig. 7).*

A total of nearly 3 Million people have been affected by tropical cyclone IDAI. Even the precursors of IDAI caused widespread flooding in southern Malawi and were responsible for at least 50 deaths. After landfall IDAI ravaged through the central parts of Mozambique, namely the provinces of Sofala, Zambezia, Manica and Inhambane. In the coastal town of Beira, which is the Mozambique's 4th largest city with a total population of 538,000 and equipped with an important harbor and an international airport, some of the area was destroyed and damaged.

The remnants of IDAI affected at least half of the total population of eastern Zimbabwe's Chimanimani and Chipinge districts. At least 16,000 households need shelter assistance in Chimanimani, Mutare, Chipinge and Buhera, according to the government.

Overall, there were:

- Many roads destroyed, main access bridges washed away.
- The water and energy supply and telecommunication and other services interrupted.
- Significant damage to educational and health facilities.
- Hundreds of thousands of hectares of crops have been flooded, causing severe problems for the food supply for the months ahead, especially because the losses coincide with the annual harvest period (somewhere between 178,000 and 252,000 hectares in Mozambique;
- Increasing risk of water born diseases (first cholera cases are already recorded).

3.5 Tropical Cyclone Climatology

In the southwest Indian Ocean, the tropical cyclone season is between October and May. The activity peaks in mid-January and again from mid-February until early March. According to a climatological study (Leroux et al., 2018), 16 tropical systems directly hit Mozambique in the 17-year period between 1999 and 2016. Five of these 16 tropical systems were tropical cyclones of at least Category 1 when making landfall. Every three to four years a tropical cyclone is expected to come ashore somewhere along Mozambique's coast.

On average, the entire southern Indian Ocean basin experiences 10 tropical storms and 4 tropical cyclones per year. In Mozambique, the deadliest tropical cyclone so far was ELINE. Being a Category 4 cyclone, the landfall was on 22 February 2000 in southern Mozambique with sustained winds of 113 kt (209 kph). ELINE was responsible for large flooding and caused more than 700 deaths. The flooding in the aftermath of tropical cyclone DINEA claimed 259 lives in Zimbabwe in January 2017 according to government estimates.

Sources:

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