Forgotten accounts of tropical cyclones making landfall in Tanzania

Weather – April 2022, Vol. 77, No. 4

Hellen E. Msemo[1,2], Declan L. Finney[1] and Samwel I. Mbuya[2]

[1]*Institute for Climate and Atmospheric Science, School of Earth and Environment, University of Leeds, Leeds, UK*

[2]*Tanzania Meteorological Authority, Dar es Salaam, Tanzania*

Introduction

Tropical cyclones, also known as hurricanes in the Atlantic and typhoons in the Pacific, typically form over the ocean where there is a sufficiently strong Coriolis force and when the sea surface temperature is at least 26.5°C (Dare and Mcbride, 2011). Several regions of the global oceans meet these criteria at certain times of year, allowing cyclone formation to take place. The timing of the cyclone season varies among the different oceanic regions, with November to April being the tropical cyclone season for the southwest Indian Ocean.

Close to the equator, the Coriolis force is weak, meaning the rotation of winds needed for tropical cyclone formation does not occur. Far from the equator, cooler sea surface temperatures inhibit the formation and maintenance of tropical cyclones. As a result, tropical cyclones tend to form between 5° and 15° from the equator (Anthes, 2016). During the tropical cyclone season in the southwest Indian Ocean, tropical cyclones rarely make landfall north of the Mozambique border (Mavume *et al.*, 2013). The Kenyan coast does not experience tropical cyclones directly and even further south, along the Tanzanian coast, landfalling tropical cyclones are unheard of in recent times. A record from 1872, however, provides the first known instance of a tropical cyclone making landfall along the Tanzanian coast, which crossed over Zanzibar and passed over Bagamoyo city in April 1872, devastating the two towns (Figure 1).

It was recently suggested in an article in *The Conversation* that Cyclone *Kenneth* in 2019 was the first cyclone to make landfall in Tanzania (Fitchett, 2019). Whilst this is true of recent history (notably, since the start of the meteorological satellite era in the 1970s), Tanzania has felt the devastating impacts of tropical cyclones before. In 1872 and 1952 the country was hit by devastating cyclones that made landfall in the far north and south respectively (Figure 1). Meteorological records of these events are limited, but there are eyewitness accounts which provide interesting and important information on tropical cyclones along the coast of Tanzania.

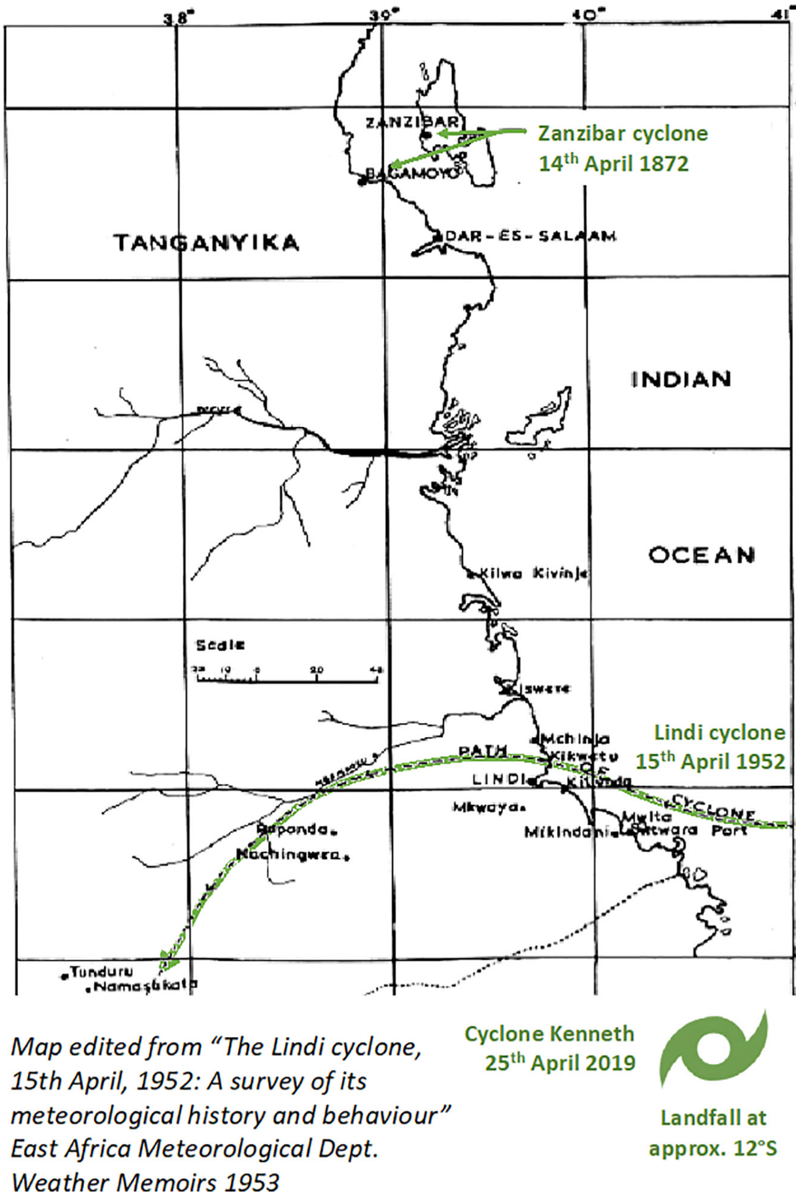

Figure 1. The tracks of the Zanzibar and Lindi tropical cyclones in April 1872 and 1952, respectively. The approximate landfall position of cyclone Kenneth *is also noted as ~12°S to highlight that this occurred much further south than the two historical cyclones presented here.*

Behaviour of tropical cyclones over the southwestern Indian Ocean

Tropical cyclones in the southwestern Indian Ocean are associated with violent weather that cause death and injuries, and damage socioeconomic activities and community livelihoods. In December 2019, tropical cyclones in the Indian Ocean were associated with enhanced rainfall over the East Africa region, even though these cyclones did not make landfall there (Wainwright *et al.*, 2020). The October–December 2019 rainy season saw floods and landslides across the region, with initial estimates suggesting over 2.8 million people were adversely affected (Wainwright *et al.*, 2020). Along with the tropical cyclones, the 2019 rainy season saw a strongly positive Indian Ocean Dipole (IOD), with such events having been shown to play a key role in the high rainfall over East Africa (Black, 2005). In addition, the Madden-Julian Oscillation (MJO) was active over Africa, which can also enhance rainfall. A link between the MJO, Indian Ocean tropical cyclones and rainfall over East Africa has been presented by Finney *et al.*, (2019).

The severity of tropical cyclone impacts varies by location and depends on the intensity and position relative to the coast, as well as community preparedness. A direct hit occurs when the eyewall comes onshore while the centre of the storm may stay offshore (NHC, 2020), as was the case during Cyclone *Idai* in 2019. The eyewall is the most dangerous and destructive part of a tropical cyclone characterised by the strongest winds, heavy rainfall, and deep convective clouds that rise from close to Earth's surface to a height of around 15 000m (49 000ft) (Zehnder, 2019). Tropical cyclone landfall is associated with heavy rain, strong sustained winds and storm surges, which can lead to flooding of coastal areas. Floods exacerbate stress to the community by causing secondary impacts such as breeding sites for parasites and outbreaks of diseases such as malaria, dengue and cholera (WHO, 2020). In addition, through circulation changes, cyclones can indirectly be associated with enhanced or suppressed rainfall in more equatorial locations, as was the case with the very wet long rains in Kenya during 2018 (Kilavi *et al.*, 2018; Finney *et al.*, 2019).

Evidence of the Zanzibar tropical cyclone

The April 1872 tropical cyclone was reported as the 'terrible Zanzibar Cyclone' by the *Times* newspaper of India in its special report, which provides eyewitness evidence of the tropical cyclone eye at ~6.5°S (Trove, 1872). The impact of the April 1872 tropical cyclone triggered the documentation of subsequent disaster data by the colonial government (Figure 2).

Though weather observations from the time of Zanzibar tropical cyclone are not readily accessible, the eyewitness account describes the progression of the storm (Trove, 1872):

1. *'From the early morning until about 8 o'clock the storm of wind and rain steadily increased in violence, and something unusual was apprehended. Roofs, which had withstood the violence of former monsoons, began to give way, and the storm showed signs of increasing intensity.'*
2. *'About one o'clock the storm began to abate, and was soon succeeded by a perfect calm, a calm so complete that even a feather would drop in a straight line to the ground.'*
3. *'Not more than three-quarters of an hour had elapsed since the cessation of the hurricane from the south… I had closed all the doors and windows, while doing so I heard sounds like steam-whistles…The shutter, at which I was engaged with one of my servants, shook four or five times with great force, then a terrific blast forced it open, wrenched off the hinges, and threw us over on the floor. I scrambled up, and holding on by the balustrade (if I may so call it), tried to look towards the north. A man blind from his birth would have seen as much. I could not see the beam that I was holding on by. Torrents of water (I cannot call it rain) were swept in. It was salt water and sand carried from the sea by the hurricane.'*
4. *'The storm lasted till late in the afternoon, and when the weather cleared up, we were able to form some idea of the ruin effected.'*

This account provides clear evidence of tropical cyclone features. Interestingly, the article describes how an older resident had warned others that calming of the southerly winds was just the eye: '*An old friend, who was better acquainted than I was with the laws of storms, advised me to go home and secure the windows and doors having a northerly exposure. At this time the calm was almost as oppressive as the hurricane. Not a ray of sunshine pierced the lead-coloured sky, which deepened to an inky black towards the horizon on the north, with here and there a lurid glare*' (Trove, 1872). This shows that they were aware of the nature of tropical cyclones and the circular wind field, which would cause the winds to swap direction after the passage of the eye. Without advice from his elderly friend, the eyewitness would not have taken precautions during the calm of the eye, thereby highlighting the importance of providing information to residents if another tropical cyclone were to be forecast in future.

Evidence of the Lindi tropical cyclone

The Lindi tropical cyclone made landfall on 15 April 1952, almost exactly 80 years after the Zanzibar tropical cyclone, and was reported in the Survey of Meteorological History and Behaviour of the East African Meteorological Department (Samson, 1953). The 0600 GMT surface pressure analysis from 15 April 1952 (Figure 3a) shows a deep low pressure system of less than 1002mb over the Lindi coastline during the event (Samson, 1953).

Figure 2. Historical artwork of the damage caused in Zanzibar harbour by the cyclone of 15 April 1872 (Science Photo Library, 2020). The accompanying caption from the Science Photo Library (2020) describes the following; 'Zanzibar is an island in the Indian Ocean, off the coast of present-day Tanzania. All the ships in the harbour, with the exception of a steamer that escaped to sea, were sunk or wrecked on the shore with great loss of life. The navy of the Sultan of Zanzibar was also wrecked, affecting his hold over the Arab seaports on the coast.'

RMetS Royal Meteorological Society

The M.V. Tayari vessel of the United Northland Navigation Company passed through the centre of the tropical cyclone and provides strong evidence of the presence of a tropical cyclone over Lindi through its observations. The barogram trace (Figure 3b) captures a sharp drop in pressure from 1011 to 958mb, characteristic of deep cyclonic systems. An interview with the M.V. Tayari Captain provides further evidence of the Lindi tropical cyclone through his observations of weather changes during the ship's voyage.

1. *'After 0500h, the winds rose to hurricane force, with gusts of well-nigh indescribable fury, accompanied by torrential rain which, with the flying spray, limited visibility to about 20m.'*
2. *'At 0615h, the wind dropped to nearly deadly calm, the rains diminished, the sky cleared and daylight increased. The barometer had fallen back from 1011 to 958mb. The waves, however, became more confused and reached great heights from all directions. Birds and insects swarmed around the ship and some fell on deck.'*
3. *'We realized the centre of the cyclone had reached the ship. We used the period of quiet to fasten parts of the ship which had worked loose.'*
4. *'At 0630h, with rising barometer the wind gained force afresh…reaching hurricane force quickly, with violent gusts, heavy rains and flying spray, causing total darkness a second time… The ship had entered the most dangerous phase of the storm.'*

The Oversee Food Corporation health inspector, who was in Lindi for the Easter weekend (12–13 April 1952), wrote a brief note on the development of the heavy storm over the sea. This situation encouraged him return to Nachingwea town early for the fear of the road being impassable (Samson, 1953). A pilot balloon at Lindi Meteorological station on the morning of 13 April showed unusually strong south-southeasterly upper winds. At 1500ft above sea level, the wind speed was 37kn (19ms^{-1}).

Rainfall observations reports on 14 and 15 April 1952 indicate heavy rainfall at various observation stations. During the Lindi tropical cyclone the 24-hour rainfall total was 142mm at Mikindani, 160mm at Mtwara port and 178mm at Kitunda weather stations (Table 1). These individual amounts are close to the monthly average rainfall or more in some areas based on the 1981–2010 climatology. The average rainfall over the southern parts of the Tanzania coastline for the month of April is 163mm at the southernmost point, and increases northwards.

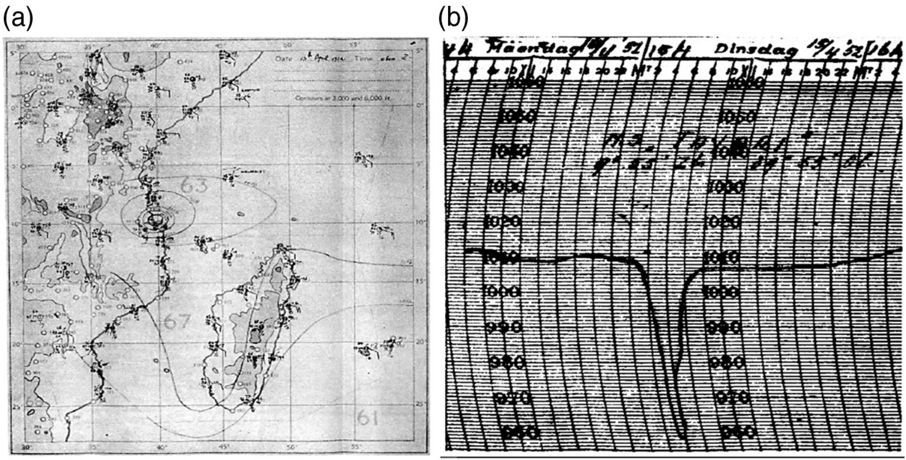

Figure 3. Meteorological analysis from the East African Meteorological Depatment for 0600 GMT 15 April 1952 showing a deep low pressure system reaching the Tanzanian coastline. Ship barogram measuring air pressure aboard the M.V. Tayari on 14–15 April 1952 respectively. (Source: Samson, 1953.)

Societal and human impacts of tropical cyclones in Tanzania

The Lindi tropical cyclone resulted in extensive damage to buildings and property and a considerable loss of life (UNDRR, 2019). The devastated area was confined to a narrow strip of the coast near Lindi, though damage also occurred at Mikindani and Mtwara further south. Fifty percent of buildings in Mtwara, and tugs and cranes at port were badly damaged. Half the buildings in Lindi lost their roofs; electricity, telephone and telegraph services were damaged; and boats were driven from the shore and onto reefs by the cyclone. Houses were flattened, and roads and bridges damaged (UNDRR, 2019). The damage was estimated at 2.5 million GBP, equivalent to 72 million GBP in 2020 (CPI, 2020). There is no evidence of appreciable damage being caused by the cyclone after it had moved inland.

The Zanzibar tropical cyclone caused damage to houses and the harbour (Figure 2). The Sultan lost all his vessels, with the excep-

Table 1

Rainfall readings (inches) from 14 to 16 April 1952 in areas affected by the Lindi tropical cyclone. Table reproduced from Samson (1953). Amounts recorded at 0830h the following morning. Samson (1953) noted in the original caption that it seems certain that the reading of 7.00 inches for Kitunda Sisal Estate should refer to the 14 and 15 April together as the rain at all other places continued for several hours after 0830h on 15 April.

Location	*Position*	*14 April*	*15 April*	*16 April*
Kikwetu Sisal Estate	9°51′S 39°44′E	←	5.91	→
Ruponde	10°16′S 38°45′E	0.85	1.35	-
Nachingwea	10°20′S 39°45′E	0.64	1.17	0.12
Lindi	10°00′S 39°42′E	3.34	1.50	0.05
Kitunda Sisal Estate	10°01′S 39°54′E	7.00	-	0.02
Mtwara	10°07′S 39°39′E	4.20	0.78	-
Mikindani	10°16′S 40°07′E	5.57	2.81	-
Mwita	10°17′S 40°05′E	5.20	3.50	-
Mtwara Port	10°15′S 40°13′E	6.21	1.45	-
Tunduru II	11°06′S 37°22′E	0.22	1.76	0.64
Masasi kata	11°10′S 37°29′E	0.41	1.23	1.81

RMetS Royal Meteorological Society

tion of one small steamer, which happened to be at Mombasa at the time. The Roman Catholic Mission Hospital at Bagamoyo was also destroyed, along with two thirds of the clove and coconut plantations on Zanzibar (UNDRR, 2019). About 150 Arab and Indian boats, many full of cargo, either sank or were wrecked along the shore (Lindström, 2019). It is further reported that in Bagamoyo the tropical cyclone destroyed 50 houses and agricultural scheme of the Catholic Father (Lindström, 2019).

The tropical cyclone season of 2018–2019 in the southwest Indian Ocean reminds us that tropical cyclones can still occur in unexpected locations. The season was characterised by a record number of 11 cyclones, with nine of them classified as intense (WMO, 2019). Cyclone *Idai* was among the most intense cyclones during the season; it formed on 4 March 2019 and lasted until 16 March 2019, after making landfall near Beira in Mozambique. Central areas of Mozambique received extreme amounts of rainfall, in some places 500mm of rainfall within 48 hours. Cyclone *Idai* was associated with 603 deaths and affected over 1.6 Million people (WMO, 2019). Strong winds in excess of 81kn (41.7ms^{-1}) and a storm surge of more than 2.5m hit the region (WMO, 2019).

Cyclone *Kenneth*, which formed on 21 April 2019, was another intense cyclone to hit the southwest Indian Ocean region and made landfall near the border of Tanzania and Mozambique. Cyclone *Kenneth* threatened communities in Comoros, Mozambique, and Tanzania, where more than 30 000 people were evacuated ahead of the cyclone. The impact of *Kenneth* includes a total of 52 deaths in Mozambique and Comoros, with infrastructure damage estimated at 100 million USD (AON, 2019).

Climate change and tropical cyclone activity

Most studies in the scientific literature suggest that tropical cyclone activity is expected to be modified by climate change (Malan *et al.*, 2013; Noy, 2016; Knutson *et al.*, 2019). The intensity and frequency of the most intense cyclones are expected to increase over tropical regions in the twenty-first century (Peduzzi *et al.*, 2012; Schaeffer *et al.*, 2014; Knutson *et al.*, 2019), though it is not clear if there will be an increase or decrease in frequency of weaker tropical cyclones. Due to the vulnerability of coastal regions to storm surges, flooding is expected to increase with future sea-level rise, and further coastal development will elevate the risk to coastal livelihoods. Rising global temperatures could lead to tropical cyclones forming in locations where they are currently unheard of.

A study conducted in the Northern Hemisphere over the Bay of Bengal had identified severe cyclones as being among the possible triggers for IOD occurrences (Francis *et al.*, 2007). As previously mentioned, one of the important climate drivers that prevailed during the 2019 southwest Indian Ocean tropical cyclone season was an extremely positive IOD (Wainwright *et al.*, 2020). The positive IOD is characterised by warmer than average ocean waters in the western Indian Ocean and cooler than average conditions in the eastern Indian Ocean. The 2019 IOD event lead to prolonged heavy rains during the preceding seasons in East Africa, and as such its predictability has become a focus area of study (Doi *et al.*, 2020; Wainwright *et al.*, 2020). Predictability of rare tropical cyclones forming further north in the East Africa region and their potential in triggering strongly positive IOD events requires further research.

Conclusion

The Zanzibar and Lindi tropical cyclones both occurred during the month of April, separated by 80 years, in 1872 and 1952 respectively. These accounts provide clear historical evidence that tropical cyclones do make landfall in Tanzania, even in the more northerly locations towards the equator where there is a lack of evidence of such events in more recent satellite records. The two cyclones discussed here are almost a lifetime apart and even the 1952 cyclone may not be in the living memory of most people. However, the impacts can be devastating, possibly even more so because people have no first-hand experience of tropical cyclones along the Tanzania coastline. The Zanzibar and Lindi tropical cyclones demonstrate that those with experience take the cyclone eye as an opportunity to prepare for the onslaught to come when exiting the eye of the cyclone. But for those unfamiliar with tropical cyclones, the calm of the cyclone eye can encourage complacency.

Nowadays, meteorologists are able to track and model the path of cyclones and can provide impact-based forecasts of cyclones. These are delivered through early warning systems to inform and protect people on the Tanzania coast from these rare and extreme weather events. Although awareness of such events is crucial, it may not always be seen as practical to design infrastructure to protect against such rare events, nor account fully for the effects of climate change on the frequency and severity of these event. Events such as the Lindi and Zanzibar cyclones may not well be captured in the observational records normally used to understand extreme weather. However, we have shown with eyewitness accounts that the recent Cyclone *Kenneth* is not the most northward cyclone to affect the East African coast, as has been suggested. An additional observation is that all three of the northerly-occurring cyclones (Lindi, Zanzibar and *Kenneth*) formed in April, late in the tropical cyclone season for the southwest Indian Ocean.

The reported impacts of these historical cyclones highlights the phenomenon as an important research topic. In particular, exploring teleconnections in the climate system to these rare landfalling tropical cyclone events in Tanzania will be useful for informing and developing preparedness within coastal communities.

Acknowledgements

The authors are thankful to all who provided their constructive comments without which this paper would not have been in the present shape. Special note to John Marsham, Cathryn Birch, Sarah Chapman from the University of Leeds and anonymous reviewers for their comments on the manuscript. Hellen Msemo was supported by the GCRF African SWIFT Project. Global project to improve African weather forecasting. Declan Finney was supported by the Natural Environment Research Council/Department for International Development (NERC/DFID, NE/M02038X/1) via the Future Climate for Africa (FCFA) funded project, Integrating Hydro-Climate Science into Policy Decisions for Climate-Resilient Infrastructure and Livelihoods in East Africa (HyCRISTAL) and Samwel Mbuya was supported by the Tanzania Meteorological Authority.

References

Anthes R. (ed.) 2016. *Tropical cyclones: Their evolution, structure and effects*, Vol. 19. Springer: Switzerland, pp. 48–51.

AON. 2019. *The global catastrophe recap April 2019*. http://thoughtleadership.aonbenfield.com/Documents/20190508-analytics-if-april-global-recap.pdf [Accessed 11 March 2020].

Black E. 2005. The relationship between Indian Ocean sea–surface temperature and East African rainfall. *Phil. Trans. R. Soc. A: Math. Phys. Eng.* **363**(1826): 43–47.

CPI. 2020. *CPI 2020. CPI inflation calculator*. https://www.in2013dollars.com/UK-inflation [Accessed 26 February 2020].

Dare RA, Mcbride JL. 2011. The threshold sea surface temperature condition for tropical cyclogenesis. *J. Climate*, **24**: 4570–4576.

Doi T, Behera SK, Yamagata T. 2020. Predictability of the Super IOD Event in 2019 and Its Link With El Niño Modoki. *Geophys. Res. Lett.* **47**: 1–7.

Finney DL, Marsham JH, Walker DP, Birch CE, Woodhams BJ, Jackson LS, *et al*. 2019. The effect of westerlies on East African rainfall and the associated role of tropical cyclones and the Madden–Julian Oscillation. *Q. J. R. Met. Soc.* **146**: 647–664.

Fitchett J. 2019. *The Conversation. 2020. Why the Indian Ocean is spawning strong and deadly tropical cyclones*. https://theconversation.com/why-the-indian-ocean-is-spawning-strong-and-deadly-tropical-cyclones-116559 [Accessed 25 February 2020].

Francis PA, Gadgil S, Vinayachandran PN. 2007. Triggering of the positive Indian Ocean dipole events by severe cyclones over the Bay of Bengal. *Tellus Ser. A: Dynamic Meteorol. Oceanog*. **59**: 461–475.

Kilavi M, Macleod D, Ambani M, Robbins J, Dankers R, Graham R *et al*. 2018. Extreme rainfall and flooding over Central Kenya Including Nairobi City during the long-rains season 2018: Causes, predictability, and potential for early warning and actions. *Atmosphere* **9**: 472.

Knutson T, Camargo SJ, Chan JCL, Emanuel K, Ho C-H, Kossin J *et al*. 2019. Tropical cyclones and climate change assessment: Part II. Projected response to anthropogenic warming. *Bull. Am. Met. Soc.* **101**: E303–E322.

Lindström J. 2019. *Muted memories: Heritage-making, Bagamoyo, and the East African caravan trade*. New York/Oxford: Berghahn Books.

Malan N, Reason CJC, Loveday BR. 2013. Variability in tropical cyclone heat potential over the Southwest Indian Ocean. *J Geophys. Res., Oceans* **118**(12): 6734–6746.

Mavume A, Rydberg L, Rouault M, Lutjeharms J. 2013. Climatology and landfall of tropical cyclones in the South-West Indian Ocean. *J. Geophys. Res. Atmos.* **118**(1): 6734–6746.

NHC. 2020. *National Hurricane Center 2020. Glossary of NHC Terms*. https://www.nhc.noaa.gov/aboutgloss.shtml#EYEWALL [Accessed 26 February 2020].

Noy I. 2016. Tropical storms: The socio-economics of cyclones. *Nature Clim. Change* **6**: 343–345.

Peduzzi P, Chatenoux B, Dao H, De Bono A, Herold C, Kossin J *et al*. 2012. Global trends in tropical cyclone risk. *Nature Clim. Change* **2**: 289–294.

Samson HW. 1953. *The Lindi Cyclone 15 April 1952: A survey of its meteorological history and behaviour. East African Meteorological Department in Weather Memoirs*, Vol. 3, No. 1. Digitial copy available from the British Online Archive. Printed and published by the Meteorological Dept., under the authority of the Administrator, East Africa High Commission: Nairobi, Kenya. https://microform.digital/boa/collections/72/volumes/495/miscellaneous-1907-1964 [Kenya Under Colonial Rule, in Government Reports, 1907-1964. Miscellaneous, 1907-1964. Weather Memoirs.] [Accessed 16 December 2020].

Schaeffer M, Baarsch F, Charles L, de Bruin K, Freitas S, Hare B *et al*. 2014. *Loss and damage in Africa*. African Climate Policy Centre (ACPC) and UN Economic Commission for Africa (May 2014), pp. 1–59. https://www.uneca.org/sites/default/files/PublicationFiles/acpc-loss-and-damage-report_final_en.pdf [Accessed 25 February 2020].

Science Photo Library. 2020. *Image of cyclone damage purchased from the Science Photo Library for reproduction here*. The image is credited to George Bernard. https://www.sciencephoto.com/media/163657/view [Accessed 3 October 2020].

Trove. 1872. 'Terrible cyclone at Zanzibar.' *The Mercury (Hobart, Tas.: 1860 - 1954)*, 10 July, p. 3. pp. 1–9. http://nla.gov.au/nla.news-article8926435 [Accessed: 24 September 2020].

UNDRR. 2019. *Country profile*. https://www.desinventar.net/DesInventar/results.jsp?bookmark=1&countrycode=tza&maxhits=100&lang=EN&logic=AND&sortby=0&frompage=/results.jsp&viewStandard=Y [Accessed 19 December 2019].

Wainwright CM, Finney DL, Kilavi M, Black E, Marsham JH. 2020. Extreme rainfall in East Africa, October 2019–January 2020 and context under future climate change. *Weather* **76**: 26–31.

WHO. 2020. *Flooding and communicable diseases*. p. 2020. Available at: https://www.who.int/hac/techguidance/ems/flood_cds/en/ [Accessed 26 February 2020].

WMO. 2019. *Reducing vulnerability to extreme hydro-meteorological hazards in Mozambique after cyclone IDAI*. https://library.wmo.int/doc_num.php?explnum_id=6259. [Accessed 11 March 2020].

Zehnder JA. 2019. *Tropical cyclone*. Encyclopædia Britannica Inc. https://www.britannica.com/science/tropical-cyclone. [Accessed 16 October 2020].

Correspondence to: Hellen E. Msemo

eehem@leeds.ac.uk

doi: 10.1002/wea.3921