Weather and Climate Information Services

WISER-EWSA

Project Deliverable Cover Sheet

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1. Summary

This report is a description of activities carried out during the first Weather and Climate Information Services Early Warning for Southern Africa (WISER-EWSA) testbed, the first of its kind in Southern Africa. It details how the activities laid out in the testbed 1 (T-1) operations plan were executed during the testbed. T-1 took place from 29 January to 9 February 2024 at the different hubs in Zambia, Mozambique, and South Africa, with each having a split site setup, comprising a Testbed Operations Centre (TOC) at the respective meteorological agency, and a community hub, working with community observers to improve access to weather and climate early warning information to the less privileged and vulnerable people in these urban settings – in the case study urban locations (Kanyama in Zambia, Katlehong in South Africa, and Boane in Mozambique).

The Zambian hub was the primary hub, with most of the forecasting happening at the Zambia Meteorological Department (ZMD), while the other two forecasting centres, Instituto Nacional de Meteorologia (INAM) and the South African Weather Service (SAWS) had down-scaled forecasting activities and dissemination responsibilities in Mozambique and South Africa, respectively. The community hubs (which ran daily in Kanyama and Boane, and twice throughout the period in Katlehong) provided an opportunity to gain feedback from community observers and a wider group of end users on the utility and presentation of the information as input to co-producing early warning alerts. At the same time, engaging in the discussions played a key role in raising awareness of the availability and use of weather information as part of the co-production process.

> WISER-EWSA T-1 was a live severe weather forecasting event conducted in Southern Africa over the two-week period. During the testbed, meteorologists, academics, economists, and user-engagement specialists worked to create real-time warnings of severe weather, deliver these to partnering user groups, and co-evaluate the effectiveness of those warnings.

By the end of the testbed, ~300 nowcasts and synoptic forecasts, and warnings had been generated and sent to those community observers. The forecasts were sent at approximately two-hour intervals between 8:00 am and 20:00 pm using WhatsApp messaging. Additionally, unscheduled updates were sent out whenever necessary, as dictated by the changes in the weather. Feedback was officially requested at several points in the day through WhatsApp, and this was then collated and analysed to assess the accuracy and impact of the forecasts. Additionally, the forecasters and researchers did objective verification daily to quantify the accuracy and skill of the forecasts, and discussions around the presentation and utility of the information took place in the community hub sessions. From formal and informal feedback in

the structured evaluation sessions and otherwise; all these aspects of the testbed were noted to have positively evolved over time.

Overall, the exercise was a success, with routine nowcast information generated at the forecasting hubs sent out to the community daily, and the quality and presentation of that information improving over time, informed by feedback from users. Evaluations of the community hub by participants and community observers highlighted that 100% of the participants agreed that their ability to interpret weather information had increased.

Additional activities were carried out during the testbed, capitalising on the variety of experts gathered. This included an engagement day where an update of the testbed process could be given to guests such as the (representative of the) Principal Secretary (PS) of the Ministry of Green Economy and over 20 Zambian representatives from the print media and radio and TV stations. This was reported on Zambian news that same evening. During the engagement day, webinars were also held, attended primarily by representatives from other National Meteorological and Hydrological Services from across Africa and beyond, which provided an opportunity to introduce the project and how the testbed had been run. Intermediary organisations participated in the engagement day and in two parallel discussions around the co-production of inclusive early warnings and the potential to scale this out. ZMD/WISER-EWSA also held lobbying meetings with the PS/Minister of Green Economy and the private sector.

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2. Introduction

2.1. Detailed summary of WISER-EWSA Testbed 1

Dates:
Monday 29 January to Friday 9 February 2024

Venues:
Testbed Operational Centre: Zambia Meteorological Department (ZMD), Lusaka.
South Africa Testbed Office: South African Weather Service (SAWS), Pretoria.
Mozambique Testbed Office, Instituto Nacional de Meteorologia (INAM), Maputo.

Website:
https://www.wiser-ewsa.org/

Contact:
WISER-EWSA Project Office (wiser-ewsa@ncas.ac.uk)

This document describes the activities and outcomes of the first Weather and Climate Information Services Early Warning for Southern Africa (WISER-EWSA) testbed (T-1) which took place from 29 January to 9 February 2024. The document follows the structure of the operations plan, examining the different items, reflecting how the plan panned out. The report also captures the reflections of the participants, highlighting what worked well and not so well, lessons learnt, and plans for improvement.

The testbed was multi-sited in each location, with testbed offices in the meteorological agencies in each country (Zambia Meteorological Department [ZMD] in Zambia, the South African Weather Service [SAWS] in South Africa, and the National Institute of Meteorology [INAM] in Mozambique) and concurrent community hubs in the urban communities of Kanyama (Zambia), Katlehong (South Africa) and Boane (Mozambique). The main centre, the Testbed Operations Centre (TOC), was at the ZMD offices. The three testbed centres were in contact throughout the day and interacted during the 12:00 and 4:30 pm daily briefings, which were also represented by the WISER-EWSA engagement team to feed inputs from the community hubs.

2.2. Background

WISER-EWSA T-1 was a live severe weather forecasting event conducted in Southern Africa over a period of two weeks early in 2024. During the testbed, meteorologists, academics, economists, and user-engagement specialists created real-time warnings of severe weather, delivered these to partnering user groups, and co-evaluated the effectiveness of the warnings. Learning from T-1 will be used to design and deliver a second testbed early in 2025.

The testbed was being conducted as part of the WISER-EWSA (2023–2025) project. The WISER-EWSA team of meteorologists, academics, economists, and user-engagement specialists from South Africa, Zambia, Mozambique, and the UK worked with disaster risk management agencies and non-governmental organisations, focusing on women and people with disabilities, to reduce disaster risk through the co-production of new weather and climate information services and early warnings.

T-1 was building on experience in the first African testbeds, conducted in the GCRF African SWIFT project (2017–2022) and documented by Fletcher *et al.* (2023)[1]. It contributes to the Theory of Change of the WISER-EWSA project and the wider WISER programme. As such, the intended outputs and outcomes of T-1 are as follows.

2.3. Outputs and outcomes

The testbed has contributed to delivering the following:

a. Early warning systems (EWSs), which have been co-produced between forecast providers (in a network of agencies and countries) and users and tested and evaluated in the testbed.
b. Standard operating procedures (SOPs) of the EWS, which have been tested and evaluated.
c. Documentation of other good practice as part of Knowledge Management and Applied Learning (KMAL).
d. Training and practical experience of forecasters and users in the use of nowcasting as a part of EWS.
e. End-to-end evaluation of the value-chain associated with urban EWS.

The testbed contributes directly to **WISER-EWSA outputs**:

- Urban populations who know how to access, understand, and use EWSs.
- Improved capacity to generate EWSs and co-produce alerts in three countries.

The testbed will also be used to provide evidence to support the other WISER-EWSA outputs:

- Business models for co-produced EWS sustainability.
- Regional awareness of nowcast potential for disaster risk reduction.

[1] Fletcher, J.K., C.A. Diop, E. Adefisan, M. Ahiataku, S.O. Ansah, C.E. Birch, H.L. Burns, S.J. Clarke, J. Gacheru, T.D. James, C.K. Ngetich Tuikong, D. Koros, V.S. Indasi, B.L. Lamptey, K.A. Lawal, D.J. Parker, A.J. Roberts, T.H.M. Stein, E. Visman, J. Warner, B.J. Woodhams, L.H. Youds, V.O. Ajayi, E.N. Bosire, C. Cafaro, C.A.T. Camara, B. Chanzu, C. Dione, W. Gitau, D. Groves, J. Groves, P.G. Hill, I. Ishiyaku, C.M. Klein, J.H. Marsham, B.K. Mutai, P.N. Ndiaye, M. Osei, T.I. Popoola, J. Talib, C.M. Taylor, and D. Walker. "Tropical Africa's first testbed for high-impact weather forecasting and nowcasting", Bulletin of the American Meteorological Society (published online ahead of print 2022), doi: https://doi.org/10.1175/BAMS-D-21-0156.1

In turn, this contributes to four **WISER-Africa Outputs**:

Output 1: Strengthened co-production between producers, intermediaries, and users to improve the uptake and use of weather and climate information services across weather to climate timescales.

Output 2: Strengthened networks, partnerships and regional and national coordination mechanisms that support the generation, uptake and use of enhanced weather and climate information services.

Output 3: Strengthened designated producers' capacity to deliver enhanced user-led weather and climate information services.

Output 5: Better evidence and learning, continually strengthening co-produced weather and climate information services and programme decision-making.

3. Locations

> The testbed created and shared forecasts of severe and high-impact weather in the Southern African region. This was conducted as a co-production and evaluation exercise in partnership with a selected group of forecast users, vulnerable people for urban communities. The activity did not replace or duplicate any mandated weather services and early warning systems.

The creation and delivery of forecasts was conducted in three centres. Most of the scientific participants came together at the Testbed Operational Centre (TOC). Schematics in *Figure A* and *Figure B* illustrate the setup of the testbed with the hubs, estimated personnel numbers, and information flow highlighted.

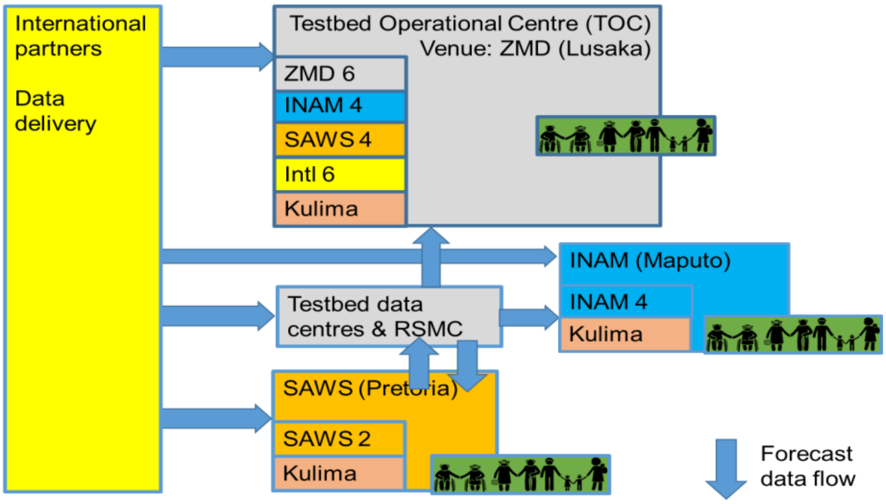

Figure A: Schematic diagram of the testbed sites during the planning phase. The TOC was hosted at ZMD, Lusaka. Numbers against the organisations are what was expected during the planning phase. Actual numbers that attended the testbed are given in ***Table 1***. "Intl" indicates additional international contributors from the UK, WMO and elsewhere. The green boxes indicate engagement with users in each centre.

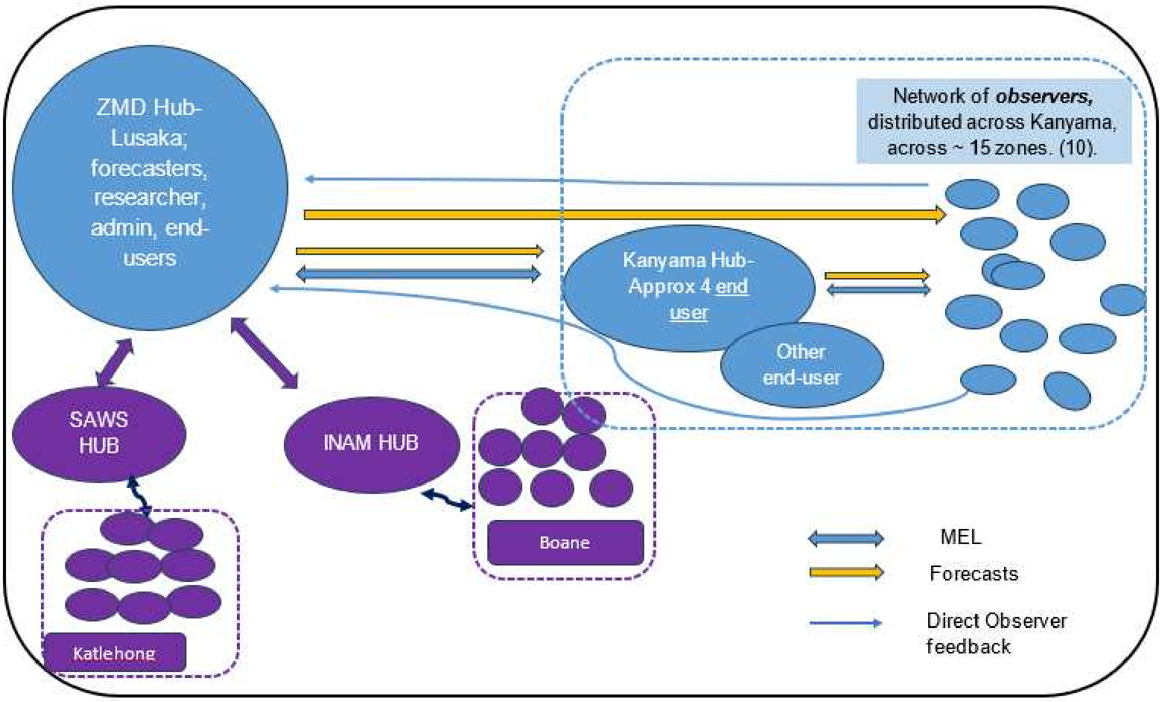

Figure B: T-1 simplified multi-sited schematic and information flow. The TOC was located at the ZMD, where most of the testbed activities happened. From the TOC, forecasts were sent to the community which was composed of the community observers and the other community members (dotted rectangles). The feedback from the community observers was sent to the TOC through WhatsApp questionnaires sent twice per day, and community observers were also encouraged to send messages informing of the onset and cessation of rains in between those times. Similar activities to those happening in Zambia were replicated in Mozambique and South Africa, albeit at a smaller scale.

4. Personnel and operational teams

In Zambia, at least 32 people worked at the TOC every week either forecasting, researching, secretarial or engagement (with the community and other testbed guests) duties. Details of the different roles are shown in the daily testbed schedules (***Appendix C***). The community hubs were led by team members from work package one on user engagement (three in Zambia, two in South Africa, two in Mozambique), together with collaborators from allied projects and the WISER Southern Africa coordinator in the case of Kanyama. In Mozambique and South Africa, four to five people worked at SAWS and the community hubs daily. Therefore, all together, at least 40 people actively participated in the testbed activities in each of the two weeks. A breakdown of the number of participants is given in the table below.

Table 1: Number of people who participated in the testbed activities.

	Zambia	Mozambique	South Africa
Week 1	~37	4	5
Week 2	~32	5	5

To ensure smooth operations, several forecasters were required to populate the five daily shifts that covered a 24-hour period. At least 15 forecasters, drawn from ZMD, SAWS and INAM, manned one synoptic shift, three nowcasting shifts and one evaluation shift at the TOC daily. The day shift (08:00 am to 17:00 pm) comprised all the forecasting and evaluation activities. Two nowcasting shifts took place during the night, one running from 17:00 pm to 12:00 pm, handing over to the next team which ran until 08:00 am the next day. Besides the forecasting and evaluation teams, teams of researchers (meteorologists), logistics, and scientific secretaries worked during the day shift at the TOC. A daily roster specifying the core role of each team member was drawn and edited whenever necessary. A TOC Floor Leader (FL) was assigned for each day to coordinate the activities of the day, chair meetings and make decisions whenever necessary. The community hubs were run daily in the mornings (typically from 9am to 11.30am) and followed a similar daily roster specifying roles for each team member (presenter/coordinator, observer for groupwork tables, photographer, logistics assistant for completing attendance forms, evaluation forms and travel refunds).

The next section briefly explains the roles of the different teams listed above, while reflecting on the lessons learned.

4.1. Short-range severe weather forecast team (meteorologists and impact specialists)

The synoptic forecasters produced the 12-72h forecast outlooks. Specifically, they produced the 12-72h forecast using an ensemble of NWP model forecasts, created maps of severe weather likelihood and some written forecasts and alerts, created risk maps and colour-coded alerts, provided a synoptic summary of drivers relevant to the nowcasting, among other activities. They did these tasks following clearly drafted ***Standard Operating Procedure (SOP; Appendix F)***.

While the NMHS already produced synoptic forecasts, the forecasting during the testbed positively impacted the forecasters and the forecasting process. For examples:

- The forecasters were exposed to new forecasting tools which they did not use previously. Because the testbed compiled a suite of forecasting and observation products, most of the forecasters picked up on some new one that they had never been familiar with. Moreover, because of the increased interaction between people with varied skills and backgrounds, a lot of learning happened.
- Because of the synoptic SOPs, the forecasting was structured, following clearly laid out steps, ensuring consistency.
- The NMHS presented their operational forecasts during the testbed briefing at 12:00 pm local time, meaning that they received feedback from a varied audience.

4.2. Nowcasting team (meteorologists and impact specialists)

The nowcasting team/forecasters continuously monitored the state of the weather. They were responsible for nowcasting of high-impact weather according to user needs, using all available observations and projections. They were also responsible for creating and updating maps and timelines and delivering alerts through various communication channels whenever necessary. To aid them do these tasks, the nowcasting ***Standard Operating Procedure (SOP; Appendix G)*** was followed. The SOP was based on the SWIFT nowcasting SOP (Roberts *et al.* 2022).[2]

The nowcasting team made significant achievements, key among them being:

- Introduction of a new function for most of the forecasters.
- Exposure to a number of new products and platforms.
- Production of impact-based forecasts (IBF), which was key for early warning services.

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[2] Roberts AJ, Parker DJ, Marsham JH. Fletcher JK, Gijben M, Diop, A-L, Porthuphy J, Lamptey B, Ansah S O, Adefisan E, Popoola TI, Koros D, Dione C. 2022. GCRF African SWIFT Nowcasting Standard Operating Procedure (SOP), grant number NE/P021077/1, https://doi.org/10.48785/100/96

The nowcasting SOPs largely served their purposes, acting as guideline for the nowcasting activities during the testbed. Some specific reflections from forecasters for improvement include:

- During the synoptic briefing and handover with the oncoming Nowcasting team at 08:00 am, the single summary map was not provided.
- Creation of outlook risk maps: Need for better and easier drawing tools. Options may include; a) Colleagues at INAM working on a GIS approach which they may be able to share. More information will be obtained during the co-production and co-design meetings, b) what about the Met Office tool? Could we request to use what they currently use? and c) could we invest time to develop a new tool?
- There were a lot of different products used during the testbed. There is a need to select those that work best and devise ways of accessing all on a single platform. Creating an ensemble of products may be a good alternative. Additionally, forecasters should be given further technical training and practice to aid them in selection of products.
- Although it was a good idea to identify storms using alphabetically assigned names, this was not done.
- A copy risk awareness Metrics should always be on the desk, or on the walls for easy access as forecasters took time looking at the matrix.
- Creation of the risk timeline took a lot of time. Do we need this for both 6h outlook and 2h update? If the storm covers a large region of the country, listing all towns may not be practical. At what warning level should we include timelines? Maybe timelines should be limited to towns where a significant level of warnings have been issued.
- Production of nowcasting bulletins - This depends on the testbed communication method/medium – for example we used WhatsApp for Kanyama, CAP?
- In-depth technical product training might be useful. Training was focussed on application, but technical details can assist to know additional details such as inputs into products, advantage/disadvantages of product, limitations, etc.
- Additional training might be required on risk areas and levels. Size of risk areas were questionable. Often 6-hour outlook and 2-hour nowcasts areas were comparable and covered a very large area of the country. These areas could also be compared to a short-range forecast one would expect from a synoptic forecast shift. In addition, risk levels were quite high with level 5 (high likelihood of significant impacts) frequently used. Verification on whether the risk levels and areas were representative is required to confirm. False alarms or over nowcasting/forecasting should be avoided for confidence levels in users and for providing added benefit of nowcasts over short-range forecasts.
- Is the SAWS impact table representative of Zambia/Mozambique?

4.3. Evaluation (meteorologists, impact specialists, social scientists)

This team performed scientific validation of forecasts and nowcasts of the previous day(s). To help with the validation, ZMD availed to the evaluation team their network of automatic weather stations (AWS). The team used both objective and subjective approaches to validate the forecasts. Given that the evaluation SOP was not finalised in time for the testbed, the evaluation procedure was adapted at the testbed. The evaluation activities carried out during the activities revealed the following:

- The need for sub daily in situ observations for verification. ZMD and SAWS provided automatic weather station data to aid with the verification, which greatly helped the exercise. However, data gaps and sparse network means more stations are needed for more robust verification of nowcasts.
- Coding skills are needed for preprocessing and analysing the high resolution nowcast and observation data sets. Most of the forecasters lacked these skills, and therefore need to be trained to carry out the verification tasks. During the testbed, PhD students from the University of Leeds substituted for most of the verification tasks. For the next testbed, the role of PhD students will be encouraged, and extended to include students from African Universities.
- For standard evaluation metrics could be designed to form the base of the evaluation activities, with any supplementary approach adopted at the testbed. This would require prior access to the necessary observational data that the NMHS may have.

Feedback on the validity of the forecast information was obtained by sending two daily questionnaires by WhatsApp to the community observers. This was received by the TOC team who created and updated a database. In addition, more qualitative feedback was gathered daily in the community hubs, comprising information on the nature of information provided, its timeliness, its presentation, and the implications of these properties for its utility.

4.4. Management and decision making

A management structure for day-to-day running of the testbed, including chairing of meetings, record-taking, decision-making, logistical management, and organisation and leadership of the forecasting teams. A TOC Floor Leader and deputy were designated for each day of the testbed. The TOC-FL chaired discussions and meetings, ensured timekeeping and reporting, enabling seamless operation of the testbed.

The TOC-FL was assisted by the Scientific Secretary (SS), who were also designated for each day to; maintain notes from meetings and discussions, ensure timekeeping and reporting, coordinate documents and keep shared file spaces tidy, help with publicity (for example, sharing highlights of the day over social media), and make daily summaries, following the T-1 daily summaries sheet. These daily reports included details of what was happening in quite a detailed way in both the forecasting and community hubs. This included details on the weather, how products compared with the experienced weather on the ground, whether forecasts were considered good or bad, thoughts on the warning dissemination process, changes in how things should be done, for example, on the second day, it was agreed to start using the common alerting protocol (CAP) format. How the teams were feeling about the tasks and how the information was being received and understood was also captured. Details of the roles of the SS can be seen in the *SS task form.* During the testbed, the role of TOC-FL was rotated among eight people, while the SS role was primarily done by the PhD students (at least two on each day).

5. Schedules

5.1. Weekly including periodic reviews

The testbed ran for 12 days (29 January to 9 February 2024), including weekends. However, a small team of three people arrived in Zambia earlier (24 January 2024) to conduct the pre-testbed training. As shown in the table in ***Appendix C***, the testbed featured the regular forecasting/nowcasting activities, regular meetings, i.e., short reviews (30 mins) were be held daily, and longer formal review meetings were held on; Saturday, 3 February; Thursday, 8 February; and on Friday, 9 February. These longer meetings allowed for the team to reflect on the testbed activities at the periods, and hence capture key lessons and agree on changes for improvement.

5.2. Daily

To ensure smooth operations, a schedule of daily activities was drawn (***Appendix Ci*** for the TOC, and ***Appendix Cii*** for the community hubs). In the TOC, a 24-hour routine was maintained, with most activities happening during the day shift, synoptic forecasting, second nowcasting, evaluation shifts, and all the support services happening between 8:00 am to 17:00 pm. During the evening/night shifts, mostly forecasting/nowcasting took place. As shown in the schedule, regular handoff briefings, meetings, forecast transmission, feedback receiving happened. Community hubs were also operational daily in Kanyama and Boane and twice over the period in Katlehong. The community hubs had a common structure of activities and outcomes that needed to be achieved, with flexibility for how they were applied (for example flood risk mapping after a heavy rainfall event). Community hubs were run in the morning, typically from 9-11:30 am, with the time changing on Sunday to accommodate community observers’ attendance at church.

5.3. Intermediary organisations

Intermediary organisations within WISER-EWSA are the national-based agencies and NGOs, typically focusing on disaster risk reduction, gender, and disability, who have a key role in the communication chain of information. During the testbed, intermediary organisations were invited to participate on two days: the first and second Wednesday.

On the first Wednesday, they joined the community hub activities to observe and participate in the co-production of early warning alerts with community observers and communities; and then participated in an intermediary organisation focus group session on the communication of climate information (co-organised with the SALIENT project). Written narratives and map presentations were preferred to box plots. The former are more accessible as a child could read a written narrative to a blind person and still understand it, while the child would not so easily be able to recount the map.

On the second Wednesday, they joined the engagement day and then participated in a focus group discussion on scaling the provision of inclusive weather information and early warning alerts. Intermediary organisations that were represented included the Disaster Management and Mitigation Unit, Adventist Development and Relief Association, University of Zambia, Red Cross, Zambia Federation of Disability Organisations, Zambia Agency for People with Disabilities, and the Ministry of Community Development.

5.4. Engagement day

The engagement day took place on Wednesday, 7th February 2024. The aim was to raise awareness of the testbed among varied audiences. These efforts started a week early, for example, Mr Nico Kroese from SAWS was interviewed by one of South Africa's most watched news channels – eNCA. The interview was about the WISER-EWSA project and what nowcasting means for Southern Africa and the plans for T-1. An online article followed on the same day, 31 January 2024:
https://www.news24.com/fin24/climate_future/news/sa-weather-scientists-to-test-early-warnings-for-severe-thunderstorms-20240131

The engagement day was attended by the (representative of the) Principal Secretary of the Ministry of Green Economy and over 20 Zambian representatives from print media and radio and TV stations (Prime Media, ZNBC, Daily Mail, Komboni radio, Millennial FM, Phoenix FM, One Love Radio, Times of Zambia, ZANIA, Diamond TV, Live Radio and MGEE. The event received media coverage from the ZNBC and Prime TV (Prime Media TV, 7th of January 2024: https://www.facebook.com/primetelevisionzambia/videos/1572975229935065/).

During the engagement day, webinars were also held, attended primarily by representatives from other National Meteorological and Hydrological Services from across Africa and beyond, of which 149 participants attended from, Benin, Botswana, Burkina Faso, Cabo Verde, Cameroon, Comoros, Germany, Ghana, Guinea, Liberia, Libya, Madagascar, Malawi, Mali, Mauritius, Morocco, Mozambique. Niger, Rwanda, South Africa, Spain, Switzerland, Tunisia, Uganda, United Kingdom, United States, and Zambia. Intermediary organisations participated in the engagement day and in two parallel discussions around the co-production of inclusive early warnings and the potential to scale this out.

> The engagement day offered a unique opportunity to connect, collaborate, and contribute to advance nowcasting and forecasting of severe weather at a shorter time scale, including verification methodology to an Africa-wide audience.

6. Forecast and nowcast products for specialists (NMS / DMM)

6.1. Forecast and nowcast product availability

Following the synoptic and nowcasting SOPs, forecasters used the various resources at their disposal. These resources were spread across a number of different locations. Those available online were linked from a central testbed web portal, which was updated and maintained as and when additional products were available. *Figure 1* shows the testbed links portal and illustrates some of the sources that were used. Of particular importance were: (1) the testbed Regional Specialized Meteorological Centre (RSMC) website created by SAWS, (2) the National Centre for Atmospheric Science (NCAS) WISER-EWSA data catalogue, and (3) the Centre for Ecology and Hydrology (CEH) nowcasting portal. Other trusted online sources were also linked from this central webpage.

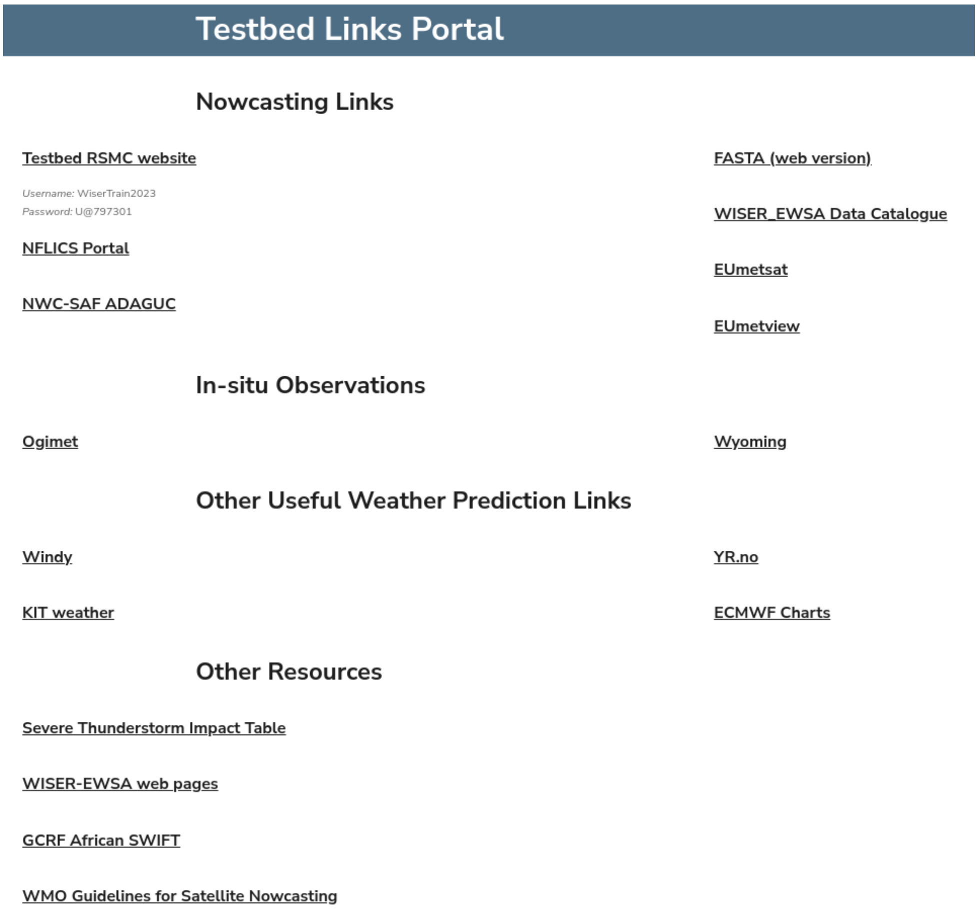


Figure 1: Testbed website links portal page with links to most of the resources for performing the forecasting and nowcasting tasks. The testbed portal link was used by the forecasters to access most of the forecasting resources.

6.2. Model products and synoptic forecasting outputs

Available on the various platforms linked from the central links portal page were several NWP products and forecasts. The SAWS testbed RSMC website included imagery generated from regional 4 km grid spaced Unified Model simulations (initialised twice a day), Arome simulations for coastal Southern Africa, Madagascar and the surrounding Indian Ocean and short- and medium-range guidance forecasts including risk tables. The NCAS data catalogue hosted imagery generated from daily simulations performed using the Weather Research and Forecasting (WRF) model, a wide range of imagery was generated for two model domains at 20 km and 4 km grid spacings. Alongside maps plots, cross sections, and skew-T Log-P plots were also available for sites across all three participant countries. In addition to simulations being run by partner organisations, trusted online sources of model data were also used during the daily forecasting. This included the use of ECMWF, GFS, and ICON model data available over the region on the Windy.com web application, more UM simulations available on the UK Met Office African Web Viewer and deterministic and ensemble simulations from NCEP. Alongside model products, observations and retrievals were used by forecasters to inform their forecasts; due to their importance for nowcasting, these will be discussed in the following section. An example of products used by the forecaster to come up with the weather outlook for the next 24–72h is displayed in *Figure 2*.

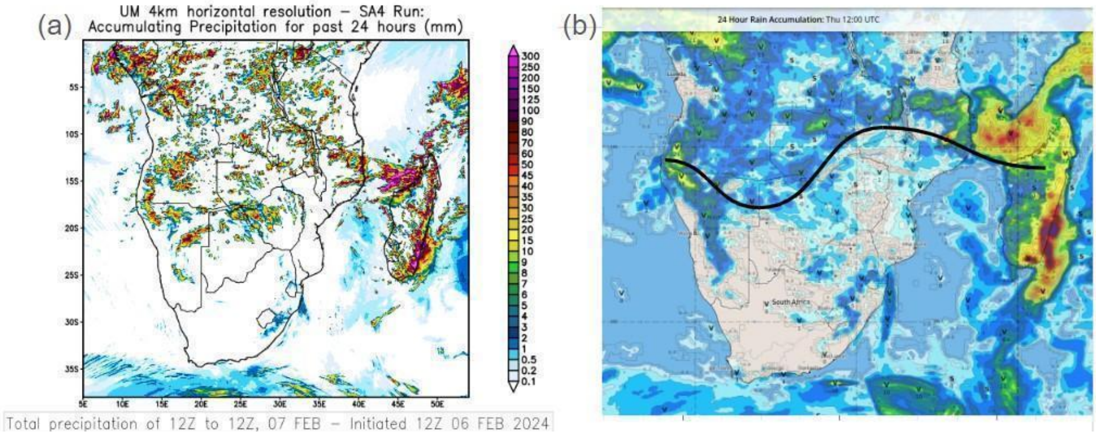


Figure 2: Model output products used by the forecasters to create the weather outlook for the next 24–72 hours on the 7th of February 2024. (a) is the accumulated precipitation over Southern Africa for the past 24 hours, and (b) is 24hr rainfall accumulation for the next day taken from the Met Office model.

From their analysis, the forecasters came up with an outlook of the weather for the coming days. An example of the forecasts for Zambia, issued on the 7th of February is shown in *Figure 3*. The forecasts gave the probability of precipitation for different regions of Zambia. Similar forecasts were also made for Mozambique and South Africa.

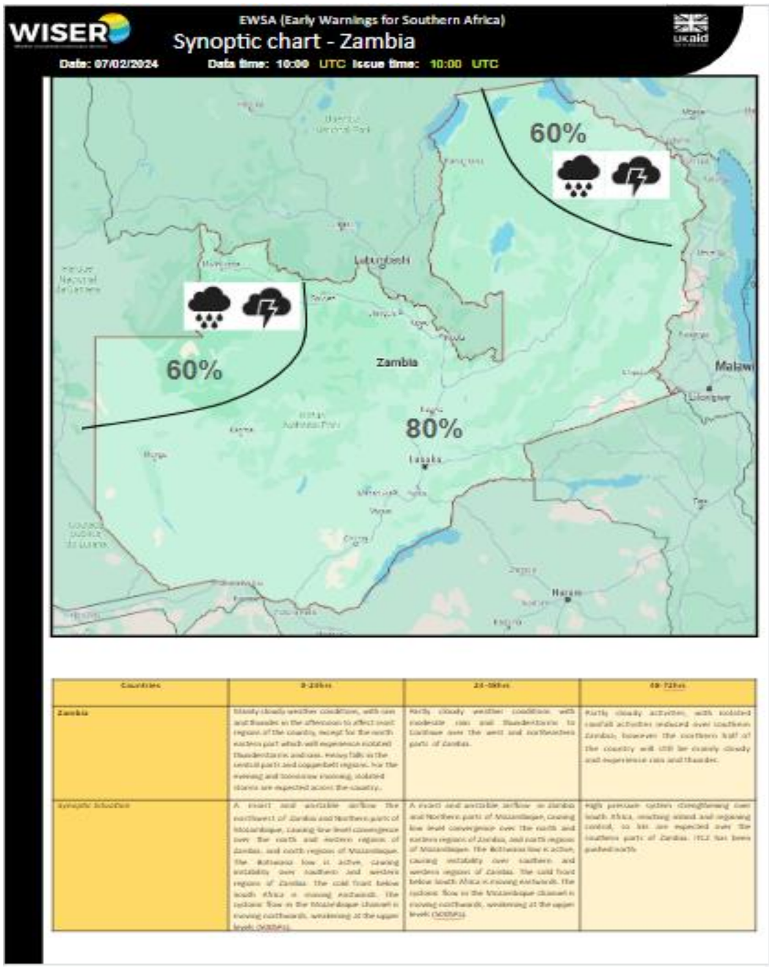


Figure 3: Synoptic forecast map issued for Zambia on the 7th of February 2024

6.3. Nowcasting products and outputs

Based on the outlook forecast generated by the synoptic forecasting groups, the nowcasting forecasters analysed the weather at fine spatial-temporal scales to come up with a warning of significant weather impacting different locations of the country. They used different nowcasting resources and a specific nowcasting SOP. Resources that were available for nowcasting were largely based on geostationary satellite data (Meteosat Second Generation [MSG]). However, the use of a wide range of approaches meant that many different nowcasting products were available to testbed participants.

Many NWCSAF products were available via the NCAS data catalogue, the ADAGUC viewer (https://adaguc.nwcsaf.eumetsat.ewcloud.host/) and the SAWS RSMC website. In addition to standard NWCSAF imagery, two NWCSAF products (convective rainfall rate [CRR] and rapidly developing thunderstorms) form the basis of the Forecasting African STorms Application (FASTA), a publicly available mobile and web app (https://fastaweather.com/web/zm/) developed by NCAS at the University of Leeds that provides near-real-time information about the position and strength of African storms.

Other well-established nowcasting products that were available included single and multichannel (red-green-blue [RGB]) satellite imagery created using MSG data and Hydrology Satellite Application Facility (HSAF) rainfall rates.

In addition to these well-known and used products, the testbed was used as an opportunity to introduce forecasters to newly developed satellite nowcasting approaches.

The first of these is the nowcasting method developed by CEH (initially for West Africa but recently expanded to Southern Africa). The CEH nowcasting portal allowed users to view convective cores, land surface temperature anomalies and the statistically generated probability of convection in the near future, all on an interactive map of the whole region. Another new product available via the CEH nowcasting portal was the Rain over Africa product. This rainfall retrieval was developed at the Department of Space, Earth and Environment, Chalmers University of Technology, Sweden, and makes use of a machine learning approach to indicate regions that are likely to be receiving rain. Also available was the newly developed Thunderstorms product from the German national weather service Deutscher Wetterdienst which attempts to identify convective storm intensity using MSG and lightning data (Vaisala GLD360) and make short-term predictions of storm position. An example of some of the nowcasting resources available to the forecasters are shown in *Figure 4*.

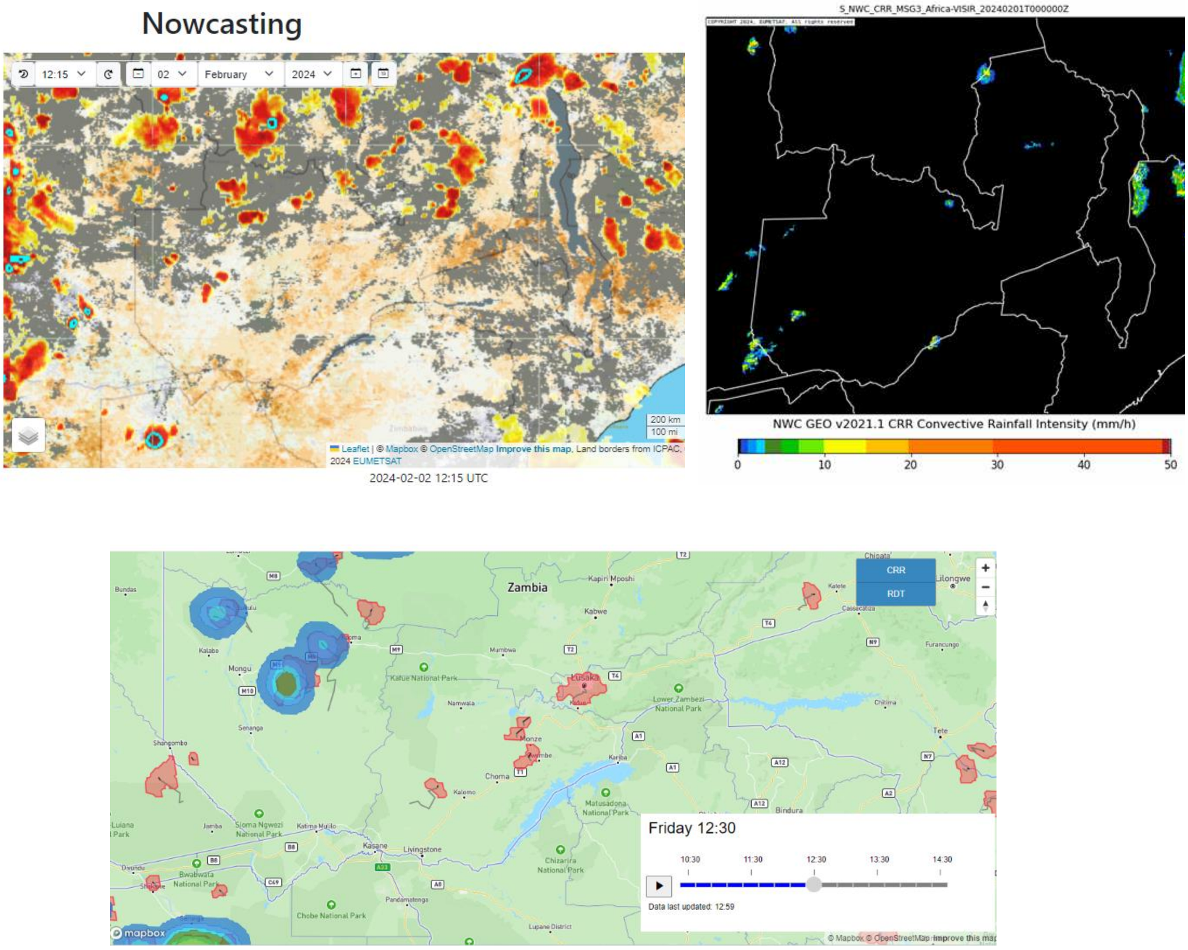


Figure 4: Some of the nowcasting tools used to produce the nowcast warning on the 2nd of February 2024 at 12:15 UTC. Top left figure shows the cloud top temperature, land temperature anomaly, convective cores at the time; the top right image is a loop of CRR on the same day, and the bottom image is the FASTA web version CRR and RDT imagery at 12:30 UTC.

The nowcast forecasters produced a six-hour risk outlook map and two-hour risk maps (*Figure 5*). They then monitored the weather continuously, producing two-hour risk updates. Whenever necessary, the nowcast forecasters produced warning bulletins specific to a location for warning purposes.

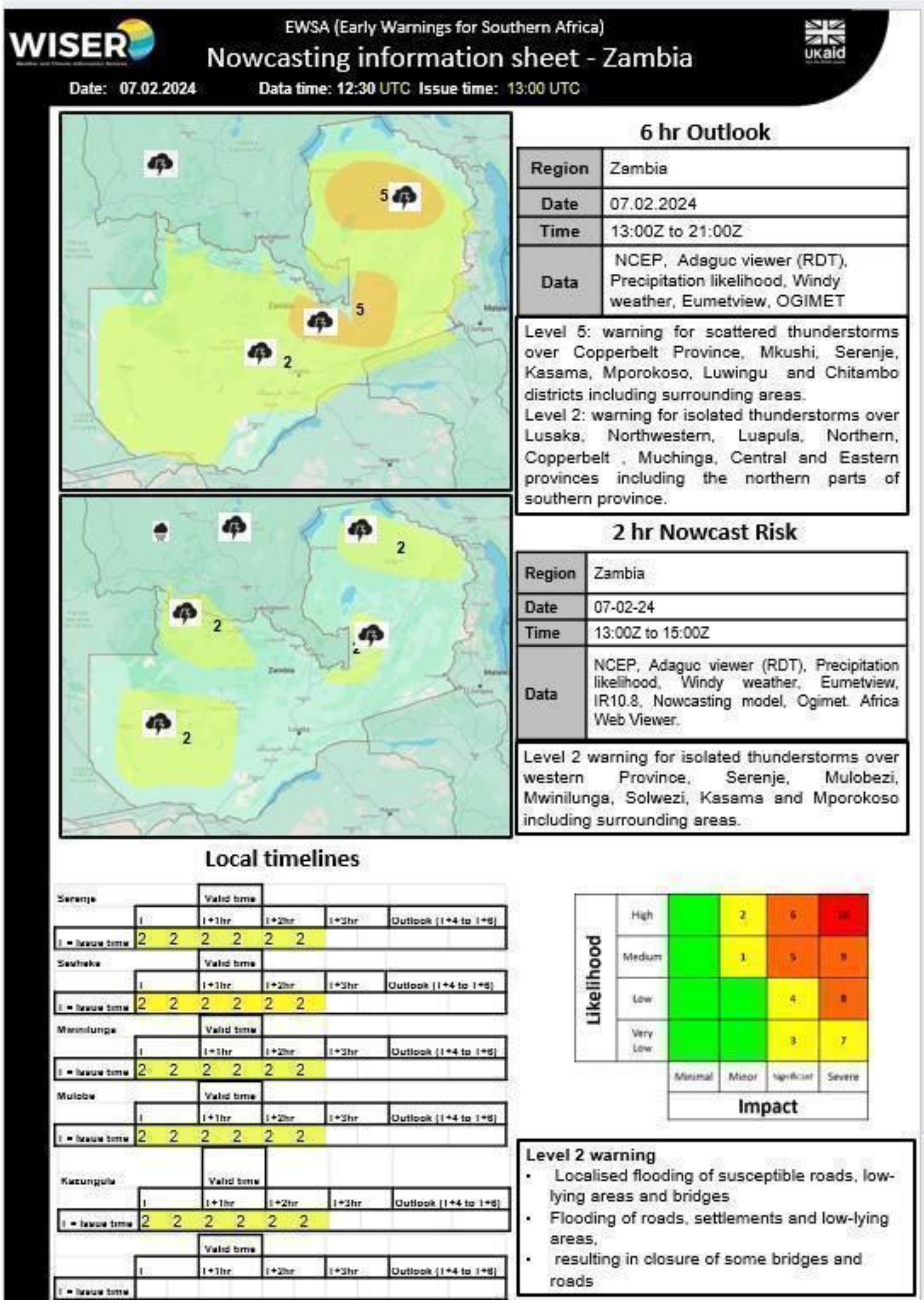


Figure 5: Six-hour outlook risk map and two-hour risk map with associated timelines and advisory for Zambia, issued on 13:00 UTC on the 7th of February 2024.

7. Communications channels and feedback mechanism

An important aim of the project was to exploit a broad range of media for the communication of early warnings, and to evaluate how these are used. These included written guidance documents and summaries, WhatsApp, SMS, web products, and apps: SAWS WeatherSmart app (South Africa) and FASTA app (Zambia and Mozambique). During the testbed, the major avenue used to send the nowcasts to the communities of Kanyama, Boane, and Katlehong was WhatsApp. All participating end users, and end-user and intermediary organisations belong to WhatsApp groups formed to specifically share forecast information and receive feedback.

To ensure that the participants understood their roles and responsibilities with respect to the testbed, Terms of Reference (ToR) was written. The ToR spelt out the times for sending forecast information and when feedback was received. Feedback included regular feedback from the community observers, and non-scheduled feedback, which included information from any end user who received the testbed forecast information. It also stated which and when meetings were held at the community hubs.

During the two weeks, in Zambia, ~300 weather reports (120 two-hour nowcast updates, 24 six-hour outlooks, 12 synoptic forecasts, and 144 nowcast bulletins) were disseminated for Kanyama community. By the end of the testbed on 9 February 2024, at least 186 feedback messages were received from the community and logged in a database. The feedback consisted of the location, timing, weather experience and its characteristics (intensity, start, and end).

The community observers also sent visual evidence in the form of videos and images of the weather, and additionally, they reported any impacts resulting from the weather. Sample images after an event of rainfall on the 6th of February are shown in *Figure 6* below.

Figure 6: Photos taken by community observers at different locations in Kanyama, Lusaka, after a rainfall event on the 2nd of February 2024. As seen in the photos, most locations experienced light flooding, causing minor effects on the activities of people in the area.

8. Evaluation of the forecast products

The evaluation team reviewed the previous day’s forecasts and warnings and presented a report during the day's testbed meetings at 12:00 pm and 16:30 pm. The evaluation was both subjective and objective. The objective verification was done using the EWSA subjective verification form, which is an adapted version of the Met Office subjective verification form.

The form is a scoring system, based on whether the community observers monitored the forecast weather and impact. Although the form was easy to use, it was not very meaningful for low-impact weather. Therefore, subjective verification was only done for significant level warnings (Level 3 and above).

Objective verification was mainly done by evaluating the forecasts/nowcasts against observation from satellite-based products and the network of ground weather stations from ZMD, SAWS and INAM. The skill of the forecast was computed using the Fractions Skill Score, for example, evaluating the forward propagation of CRR against its observation. Examples of figures taken from some verification reports are shown in *Figure 7*.

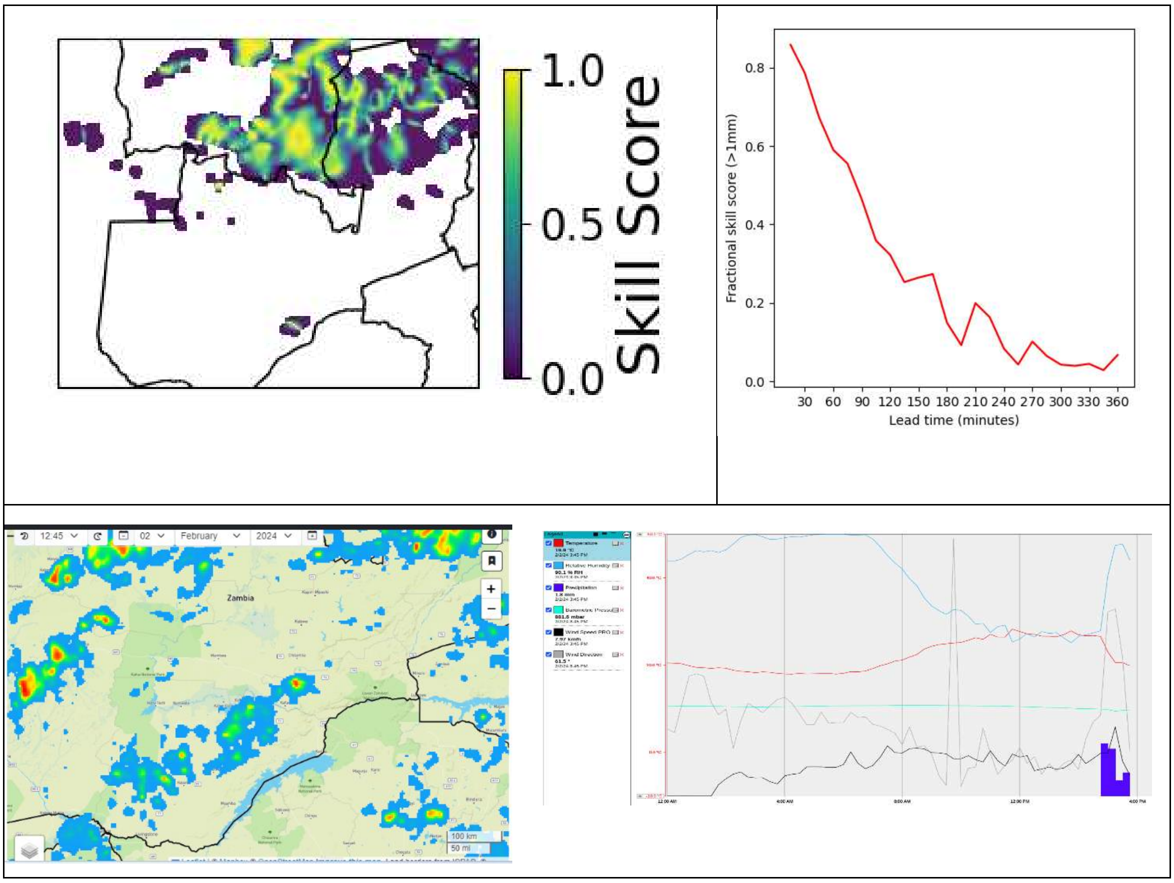


Figure 7: Sample results of verification of nowcasts. Top-left is the fractional skill of the nowcasts issued for Zambia on the 29th of January 2024, top-right is the evolution of the skill score at a location in northern Zambia with lead time. Bottom left is a satellite-based observation, Rain Over Africa, showing heavy precipitation over Lusaka (black box) on the afternoon of the 2nd of February 2024. Finally, bottom-left is a display of rainfall accumulation (dark blue bars) from an AWS at Lusaka International Airport.

Although evaluation was done and proved very useful, some aspects of it could be better, for example:

- The forecasters did not fully participate in the evaluation due to limitations of the required skills. Therefore, forecaster training on verification practices and skills should be done before testbed 2.

- Although the NMHS shared data for the evaluation, there were still huge data gaps, either due to, among other reasons, a sparse network, non-functional instruments, or power outages. It was suggested that the project could procure some rain gauges for the communities the project is targeting to enable better evaluation of the forecasts.
- The subjective verification was not fully done due to several reasons, for example, lack of expertise, tools, limited data for verification, and the generally low cases of extreme weather events. Therefore, better preparation is needed in terms of subjective verification tools and training prior to testbed 2.
- Because the verification SOPs were not fully developed, some of the verification was ad hoc. This needs to be streamlined in the SOPs currently being finalised.

9. User engagement team, activities, and survey feedback

One of the major aims of EWSA is to increase awareness of the community with respect to weather and climate information. This was done through a range of activities in the three communities of Kanyama, Boane, and Katlehong. Daily engagement between project members and the community took place, lasting two to three hours in the morning. Activities included:

- Review of weather forecasts of the previous day.
- Analysing different weather forecast formats.
- Assessing impacts of weather and climate on health.
- Community visits to see first-hand the impacts of weather and climate.
- Capacity building of the community observers – training in weather observation and reporting by meteorologists from the NMHSs.
- Weather and climate information communication and access channels.
- Impacts of weather and climate disasters on the economy.

The Kanyama community hub hosted 70 men, 65 women, and 11 community observers over the duration of the testbed. Community members with sight, mobility, and other physical disabilities (no hearing disabilities) were in attendance.

Activities throughout the testbed period included direct feedback on testbed-issued forecasts and nowcasts, discussions around other presentations of weather information and early warning alerts (using ZMD daily forecasts, daily and weekly national and district forecasts from Mozambique, tropical cyclone early warnings, flood early warnings and weekly forecasts from Malawi), flood risk mapping, and discussions on the economic impacts of extreme weather events.

Current access to and use of weather information

Very few community members reported receiving weather information (and no one had seen the forecasts that were discussed before they were shared). In general, having weather information is deemed useful. Weather information can be used for a variety of purposes: deciding what clothes to wear/whether to carry an umbrella, how to engage in economic activities (e.g. whether or not to sell goods in an open market), when to charge solar panels, when to do washing, as well as gardening tasks. However, to be useful, it first has to be received. Many highlighted that there is a big gap here, with cell phones proposed as the best communication channel (for example modelled on the cholera messaging which was distributed universally through local cell phone networks as SMS).

Improving accessibility and utility of weather information

Using the examples of weather information and early warnings enabled distillation of lessons in how to improve the accessibility and utility of information.

Language of communication was highlighted as essential, with two dimensions. First is the use of the English language (which not everyone understands) and second is the use of complicated weather terms and jargon (for example "isolated storms", "intertropical convergence zone", "Tmin" and "Tmax"). Language of communication leads to social differentiation in terms of who understands and who does not.

Pros and cons were identified in the *presentation of textual information versus graphical information*. Use of symbols and graphics can be more understandable to people who are illiterate or unable to read. However, it is important that symbols are well understood, for example using a key. Textual information – in simple words that can be understood by non-specialists – can be useful for people with visual disabilities as family members, including children, would be able to read them out loud (which they might not be able to do with symbols which require interpretation). Availability of information in multiple languages and communication through multiple channels, increase likelihood that it reaches the greatest number of people.

Community members valued the *impact-based forecasts and advisories*. The impact-based forecast contains useful information to guide daily activities (for example when to engage in economic activities), and the advisory contains useful information to protect lives and personal safety (for example when to stay home).

Misinterpretation of information

It is important to note that there were some important misinterpretations of information. When a combination of observations and forecast information were presented concurrently, the two categories were commonly misunderstood. In addition, when higher resolution forecast information was presented, for example at district level, this was typically favoured. However, one participant noted "districts will have more accurate information compared to provincial forecasts", potentially indicating the false assumption that higher resolution information is necessarily more accurate than lower resolution.

Nowcast-specific feedback

In terms of the *timing and frequency of nowcasts*, community members were generally in favour of receiving information 24 hours a day. This is because people have different daily routines, meaning that they can get information at times that suit them, particularly if they wake up early. Some people were happy with ZMD's current forecast release times (lunchtime for the afternoon and evening, and early evening for the next day), while others thought receiving a daily forecast in the morning would be helpful to plan for the day's activities, particularly if that was then updated with nowcasts.

Issuing information at a high frequency can run the risk of it being overlooked, particularly if there are many "no impact" messages. There were *differing views on the utility of a "no significant weather" update*. Some people felt that any information is useful information and should be sent, not least for continuity of information. Others did not think it was useful to keep repeating null messages and would prefer less frequent messages be sent until there is a significant change to report.

There were also differing opinions on the *length and comprehensiveness of the message*: some felt that compact messages were more digestible, while others indicated that one more detailed forecast (say in the morning to cover the day) could then be accompanied by shorter updates throughout the day.

The *terminology* used in nowcasts is important (with the inconsistency of terminology depending on the forecaster noted as a learning elsewhere in this report). Over the testbed, the nowcasts experimented with different wording. The advisory "business as usual" was interpreted in one session as literally relating to economic business activities. Despite that, "business as usual" was still favoured relative to the alternative "(no) disruption to life" and "(no) disruption to activities".

Setting thresholds for impact-based forecasts

Discussions around impact-based forecasts took place, using South Africa and Malawi as examples. In general, the group preferred that forecasts contain an indication of impacts, although the use of the table was not clear to all. The majority of groups found the traffic light colour system clear to understand ("we can see that red indicates danger") although one said this required further explanation. Reading the scores from the impact and likelihood was less clear.

Throughout the testbed, whenever there was a rainfall event, the opportunity was taken to unpack community perceptions of the level of impact in order to link to quantitative indicators. Using the example of one thunderstorm during the testbed, different members of the group described the impact as 4–7 in South Africa's impact table. To try and understand the relative magnitude of impacts from that event – and to begin to contextualise the levels as per the impact-based table – groups were asked to consider what a Level 10 (most severe) warning would look like, and what a Level 1 (minor) would look like. For Level 10, most groups spoke of widespread flooding, to the extent that gumboots would be submerged; with water in roads and houses and infrastructural damage, to the extent that it would impede movement (going to work, children going to school); with potential injury (for example children falling into wells and people falling into full drainage canals) and loss of life. For Level 1, there may be puddles and wet ground but no other discernible impact, and activities could continue as normal.

Since the testbed was generally a dry period, community members were also asked to identify how, using the South African impact table, they would classify the mid-January intense rainstorms in Kanyama. Responses varied from significant to severe (also reflecting the fact that different participants came from different parts of Kanyama), based on the impacts that they had observed. Overall, the South African impact tables are likely to be applicable in Zambia, with further elaboration required among different audiences about what the different levels of impact look like in different contexts.

Synthesis exercise-creating and presenting fictional forecasts

On the penultimate community hub day, groups were asked to develop a fictional forecast that would be accessible to and understandable by Kanyama residents. This built on the discussions of previous days which surfaced preferred presentation styles through critiquing forecasts of different types from Zambia, Mozambique, and Malawi. One group presented a five-day forecast, one group presented a two-day forecast, one group presented a daily forecast accompanied by nowcasts, and one group presented a severe weather warning. To "test" the mandate to create a forecast that would be understandable by other Kanyama residents, a community observer from another group was tasked with presenting the forecast.

There were some inaccuracies in the forecasts (for example giving different levels of heat warning when the forecast temperatures were similar), and details that are not realistic for forecasts (e.g. a prediction that rain would start at 10:35 am). However, in terms of presentation, the forecasts took on board some of the preferred key features that had been identified. This included the use of impact-based forecasts, advisories, and visual presentations (with accompanying keys and/or explanations). The date and time of issue and, where relevant, the timing of the forecast information was also clear. Groups presented information in English for the benefit of the wider testbed audience, but recognised the need for Nyanja, and one group signed the delivery of the forecast, highlighting the importance of accessibility for people with hearing disabilities. Details of the activities can be found in the daily community reports in ***Appendix D***.

Figure 8: Some of the community observers from Kanyama presenting their work after one of the group-work exercises.

10. Economic analysis

Analysis of the conduct of the testbed will contribute to the economic analysis of the delivery and use of EWS. The economic analysis team has already begun conducting interviews with the weather service staff and collecting evidence of costs.

11. Logistics

To have an event of the magnitude of T-1, a logistics team was selected and tasked with planning and executing critical resource needs of the testbed. One of such needs was internet connectivity. Almost all testbed activities relied on stable and fast internet. Therefore, to ensure that there was seamless connectivity, two internet sources were procured, 5G and Starlink. The 5G sim cards preloaded with enough data to serve the TOC were bought the week before the testbed, and the Starlink equipment borrowed from NCAS was sufficient, hence, all activities needing internet proceeded smoothly. Although it did not cause any operational delay, it should be noted that the Starlink equipment did not arrive on the intended date due to baggage misplacement by the airline. Therefore, to mitigate such risks, a local solution should always be preferred. Indeed, procurement of Starlink equipment for ZMD that was planned is now underway. Moreover, the fact that an advance team arrived in Zambia a few days before the testbed activities provided a time-buffer. Therefore, local solutions and advance arrival teams will be implemented for the next testbed.

The logistics team also planned for data access platforms. These were easily accessible via the testbed web portal. Shared spaces for reports, alerts, etc., and a shared Google Drive were communicated with all that needed access prior to the testbed. The logistics team also liaised with the local organisers at ZMD to ensure the adequacy of office space at the ZMD offices and the community centre. Both venues were ideal. Having the TOC at ZMD's offices allowed interaction and sharing of ideas between the testbed participants and ZMD staff, especially the forecasters, while the location of the community centre in Kanyama allowed the target community members to travel easily to the centre for engagement activities.

ZMD offices: H8MC+H2H, Haile Selassie Ave, Lusaka 30200, Lusaka, Zambia.
Community centre: St. Daniel Comboni Social Development Centre, just off Los Angeles Boulevard Makeni Villa Kanyama, Lusaka.

Because many testbed participants were international, accommodation and airport transfer were booked in advance at the Holiday Inn, Lusaka. Additionally, due to the multiple sites of the testbed, and the fact that nowcasting was done in the night too, transport services were very critical. Therefore, two service vehicles were hired for the duration of the testbed, and these played their critical role to the satisfaction of all the participants. It is recommended that the same should be done for the next testbed.

12. Visitors to the testbed

To cater for the visitors who were invited to come and observe the testbed, a Visitor Protocol was drawn up. Additionally, every visitor was assigned a contact project participant who arranged for their visit and directed them during their visit. For example, visitors from Google Africa Research Centre, Accra, visited the testbed for three days.

13. Community hub evaluation

Daily evaluations of sessions attended by community members were undertaken through a simple and accessible process. The evaluation comprised three questions. In Kanyama, these questions were read out to the group. Individuals were then invited to complete a simple and largely graphical form. In Boane, there was a flipchart for the day where participants could make their mark. Generally, the feedback from the community members in Zambia, South Africa, and Mozambique was near-unanimously positive, with participants expressing that the testbed activities were useful and that they did feel better able to use weather and climate information.

- Gender?
- Age?
- Do you feel you will be better able to use weather and climate information after today's workshop?

Community observers completed a more detailed evaluation form at the end of the testbed. In Zambia, 100% of the community observers reported an improved understanding of weather and climate. All the sessions received average scores exceeding four (out of five) in terms of utility. What people have learnt from being involved in the testbed and being community observers is an understanding of weather and how to understand forecasts, how weather information can be used to plan activities, and how to communicate with community members and give weather feedback to ZMD. All participants said they intend to use the information they have learnt from involvement in the testbed to improve their daily lives, and to share it with their broader community.

Further details on the evaluation, and summaries of the evaluations from Boane and Katlehong, are found in ***Appendix E***.

Example quotations from the community observer evaluations:

"I have learnt a lot especially on the weather because I am able to warn my fellow community people when I receive the testbed [forecast], and it has helped me plan for my daily activities." (female community observer, Kanyama)

"I have learnt to give weather feedback, helping people with disabilities and engaging other departments like the ZMD." (male community observer, Kanyama)

14. Knowledge Management and Applied Learning (KMAL)

Our KMAL planning was used to design a) structured outputs bringing in learning from all participants, for instance ensuring that insight from all partners is used to evaluate and refine our SOPs, and b) collection of unstructured learning and insights, for instance through discussion groups and through quick notes collated in a shared document. KMAL is strongly based on evaluation. As outlined earlier, structured review sessions formed a part of the TOC, and the entire event ended with a participatory reflection session. In the community hubs, the end user community participants (who participated for individual days) completed a daily brief evaluation form, while the community observers (who attended every day of the testbed) completed individual evaluation forms at the end of the event (with more detail than daily participants). They also participated with the WISER-EWSA team in a reflection and learning session on the last day of the community hub (the findings of which were also fed into the TOC participatory reflection session in the afternoon of the same day). Subsequent to the TOC, a series of "testbed wash up" sessions were held virtually, the lessons from which are distilled at the end of this report and form the content for our KMAL.

During the testbed:

- We worked with the REPRESA project to share learning: representatives of REPRESA were active in T-1.
- We worked with the SALIENT project which is interested in the communication of climate information, and we are interested in the communication of weather information. Representatives of SALIENT were active in the community hubs of T-1 and co-led the session with intermediary organisations in the first week.

The REsilience and PReparedness to tropical cyclones across Southern Africa (REPRESA) project is a "groundbreaking research initiative under the Climate Adaptation and Resilience (CLARE)" framework programme, with funding from the UK Foreign Commonwealth and

"Salient is a research project exploring new ways to understand and communicate future climate change for adaptation planning." Research funding is from UK Research and Innovation (UKRI) through a Future Leaders Fellowship.

We will be further exploring:

- Links with the MECHANICS project (CLARE funding from FCDO), which involves the Met Office (REPRESA and SALIENT team member) and the University of Zambia (intermediary organisation in T-1).
- A nowcasting portal developed by the UK Centre for Ecology and Hydrology and ANACIM (the National Agency for Civil Aviation and Meteorology in Senegal) to help forecasters in West Africa predict severe weather in the next six hours has now gone live over Southern Africa. Alongside storm observations, the portal provides unique analysis in near-real time of land surface conditions (soil moisture and surface temperature) which provides an additional source of predictability for convective storms. The portal was tested by forecasters and researchers during the Testbed. (https://eip.ceh.ac.uk/hydrology/sub-saharan-africa/nowcasting/).

Lessons from T-1 will form the basis of additional knowledge products. An interdisciplinary paper is planned which will contextualise the information presented in this report within the current theory and practice on nowcasts and early warnings in an African context.

15. Value for money

The testbed planning process was informed by the principles of value for money. Attention was paid to the main cost-drivers and optimal budgeting for these. However, equity is also a key consideration given that WISER-EWSA has a particular focus on women and people with disability.

Value for money included consideration of workloads associated with preparing, delivering, and evaluating the event. The cost drivers were identified as those items with significant costs where decision-making can optimise the expenditure, for example, hotel accommodation, meals, and transport provision. For these items, we obtained multiple quotes and made transparent, recorded decisions.

The TOC was at ZMD offices, which ensured minimal hosting costs (limited to lunch and refreshments and the provision of reliable connectivity). The community hub venues were selected to be appropriately convenient to participants.

In the Kanyama case, the St Daniel Comboni Social Development Centre was also used in the co-production workshop. However, the step access proved cumbersome to people with mobility disabilities. To rectify this barrier, a ramp was procured. Where required, assistance was also procured to ensure participation of people with disabilities (whether through welcoming an assistant or family member, and recruiting sign language interpreters, in this case only relevant in Boane).

16. Conclusions and recommendations

T-1 offered a unique learning experience to all involved. These lessons will be used to plan for T-2 happening in Maputo in January 2025. The Following are some of the lessons:

- Logistical planning and organisation need to happen well in advance. The planning should consider timelines for procurement, which are often lengthy and different for the various partner organisations. For T-2, the logistical organisation should start as early as May 2024 in association with our second all-project meeting. Additionally, sending advance teams to the testbed location proved to be very valuable and should be encouraged going forward.
- The feedback confirmed the need and value of nowcasts in the region. There was also a consensus that a two-weeks testbed may not comprehensively achieve the full potential of

a nowcasting testbed, especially if it coincided with a dry spell. Therefore, there is a need to extend the testbed to cover most of the rainy season. For T-2, the idea of a "king-size" testbed has been fronted. The testbed activities will start in October 2024 at varying levels as dictated by prevailing weather, and end in April 2025. There will be a two-week period with intense nowcasting activities like T-1. This is in line with the planned upscaling of dissemination of the nowcasts beyond the focus communities of Boane, Kanyama, and Katlehong.

- The testbed highlighted the importance of meaningful inclusion of people with disabilities. This was enabled by the co-production and co-design approach that the project advocates. The co-production raised the confidence and capacity of the community to interpret information, ensuring their subsequent participation in the testbed was beneficial. For T-2, these activities should be continued and planned early as well as consider the needs of a diverse population (for example, ensuring access to sign language interpreters, and accessibility for the physically disabled, among other needs).
- The forecasting activities were largely successful with three different forecasting (synoptic, nowcasting, and evaluation) desks. Approximately 300 forecasts were issued to the communities during the two-week period. The feedback received from the community and observation data were used to evaluate the forecasts. Based on the evaluation, certain aspects of the forecasting for T-2 must be improved. For example:
    - Designing better and easier-to-use drawing tools will aid both synoptic and nowcasting forecasters by ensuring faster production of risk maps.
    - Designing case studies to aid learning and offer alternative forecasting activities during periods of inactive weather will help improve forecasters' skills.
    - Forecasters must participate more in the evaluation and verification activities.
    - Impact tables and risk level tables should be printed and displayed on counters and/or walls at the TOC for reference.
    - Most of these aspects of forecasting need to be planned for and unpacked in the SOPs. Therefore, the review of these SOPs is key and should be done well in advance.
- A key ingredient for the testbed success is the infrastructure, for example, a network of rain gauges to improve the observation network, especially in partnering communities, stable internet options, and more computers for the testbed. Although these aspects were sufficiently planned for in T-1, it was also noted that the solutions used were not optimum. There is a need to have local solutions in place to mitigate any risks. For example, instead of carrying internet equipment from the UK, the NMHS should be equipped with stable and reliable internet connections. Plans to address these are in place with procurement of hardware for the NMHS already happening.
- To reach the desired audience, there is a need for a robust communication plan. During T-1, the target audience was adequately covered with over 300 forecasts received and feedback returned. Indeed, even after the testbed, the community observers in Kanyama, Boane and Katlehong continued sending feedback on the operational forecasts issued by ZMD, INAM and SAWS, respectively. This feedback, which is archived in a database, is useful for the ongoing verification work. To reach even more people during the next testbed, there is need to:

- Advertise the event earlier through, among other mechanisms, press releases.
- Plan the engagement day well in advance.
- Expand the use of WhatsApp for dissemination of forecasts.
- Explore other communication channels for forecast dissemination.
- Keep a database of nowcast recipients.
- Engage in other awareness campaigns like the WMO day, besides issuing weather forecasts; and
- Strengthen the engagement between NMHSs and the media.

Appendix A: WISER-EWSA project summary

Severe thunderstorms cause significant damage in Southern Africa, threatening lives, damaging property, and destroying livelihoods. This is particularly the case in cities and urban areas.

Nowcasting techniques using satellite data enable weather forecasters to observe thunderstorms as they form, how intense they are and provide **early warnings** of where they will move within the coming two hours. Working with urban populations, including disadvantaged groups (such as women and people with disabilities), we can help to ensure that people receive these early warnings in a timely manner (including through direct alerts to cell phones). It is vital that people know what actions to take to reduce the risk of negative impacts once they have received a warning.

The WISER-EWSA team of meteorologists, academics, economists, and user-engagement specialists from South Africa, Zambia, Mozambique, and the UK will work with disaster risk management agencies and non-governmental organisations, focusing on women and people with disabilities to reduce disaster risk through the co-production of new weather forecast information services and early warnings.

Outputs include:

- Strengthening the capacity of national meteorological agencies in severe weather forecasting and nowcasting techniques, using current and new satellite data (Meteosat Third Generation) and working through the World Meteorological Organization's Regional Specialised Meteorological Centre in Southern Africa (South African Weather Service).
- Building strong links between the people who generate nowcast early warnings (national meteorological agencies) and the people who can use them, to reduce their risk (or communicate warnings to others who can use it to reduce risk).
- Generating user-focused early warning alerts for severe thunderstorms that are understood and can be acted upon by urban communities, including women and people with disabilities.
- Investigating business models to finance and sustain the process and analyse the cost-benefit of services.
- Demonstrating the potential to scale up such an approach to other countries in Southern Africa, and to other sectors beyond cities and urban environments.

Our approach is one of co-production of knowledge by all partners working collaboratively. This will be enabled through an ongoing participatory process that culminates in annual testbeds, to be held at the beginning of 2024 and 2025.

Appendix B: Table of acronyms

ADAGUC	Atmospheric Data Access for the Geospatial User Community
AI	Artificial Intelligence
AWS	Automatic Weather Station
CRR	Convective Rainfall Rate
ECMWF	European Centre for Medium-Range Weather Forecasts
EWS	Early Warning System
EWSA	Early Warnings for Southern Africa
FASTA	Forecasting African Storms Application
GFS	Global Forecast System
INAM	Instituto Nacional de Meteorologia, Mozambique
KMAL	Knowledge Management and Applied Learning
LAM	Limited Area Model
MEL	Monitoring, Evaluation and Learning
MSG	Meteosat Second Generation
NCAS	UK National Centre for Atmospheric Science
NCEP	National Centers for Environmental Prediction
NMS	National Meteorological Service
NWCSAF	Nowcasting Satellite Application Facility
NWP	Numerical Weather Prediction
REPRESA	REsilience and PReparedness to tropical cyclones across Southern Africa
RGB	Red-Green-Blue
RSMC	Regional Specialised Meteorological Centre
SAWS	South African Weather Service
SOP	Standard Operating Procedure
SWFP	Severe Weather Forecasting Programme
SWIFT	UK Global Challenge Research Fund African Science for Weather Information and Forecasting Techniques (GCRF African SWIFT)
T-1	Testbed 1
T-2	Testbed 2

TOC	Testbed Operational Centre
TOC-L	Testbed Operations Centre Leader
UM	Unified Model
WISER	Weather and Climate Information Services programme
WMO	World Meteorological Organization
WWRP	World Weather Research Programme
ZMD	Zambia Meteorological Department

Appendix Ci: Daily and weekly schedule of the testbed-main forecasting site

	Schedule of forecasting (Synoptic and Nowcasting) and Evaluation									Other roles			
Time	Evaluation	Synoptic	Nowcasting I	Nowcasting II	Nowcasting III	Briefings	Forecasts issued	Kanyama hub	Community observers	Floor leader	IT	Logistics	Scientific Secretary
6:00 AM													
7:00 AM							N2						
8:00 AM						Nowcasting III brief			Weather Report				
9:00 AM							N2	Wx disussion					
10:00 AM								Additional community activities					
11:00 AM							N2						
12:00 PM						Synoptic briefing (30m), Daily Testbed Discussion (30m)	N6						
1:00 PM							N2						
2:00 PM													
3:00 PM						Synoptic review & NWC briefing	N2						
4:00 PM						Nowcasting I handover briefing	SYNOPTIC						
5:00 PM						*Testbed Review Meetings (30 minutes)*	N2						
6:00 PM									Weather Report				
7:00 PM							N2						
8:00 PM													
9:00 PM							N2		Weather Report				
10:00 PM													
11:00 PM							N6						
12:00 AM						Nowcasting II handover briefing							
1:00 AM							N2						
2:00 AM													
3:00 AM							N2						
4:00 AM													
5:00 AM							N6						
N6	6-hour NWC												
N2	2-hour NWC												

TIME (UTC)	TIME (CAT)	DATE						
		Monday, 29 January	Tuesday, 30 January	Wednesday, 31 January	Thursday, 1 February	Friday, 2 February	Saturday, 3 February	Sunday, 4 February
		Please see Daily timetable tab below for schedule of forecasting and Evaluation						
06:00 - 07:00	08:00 - 09:00	Testbed Induction/ Kickoff Briefing						
07:00 - 08:00	09:00 - 10:00							
08:00 - 08:30	10:00 - 10:30							
08:30 - 09:00	10:30 - 11:00	Tea/ Coffee	Tea/ Coffee	Tea/ Coffee	Tea/ Coffee	Tea/ Coffee	Tea/ Coffee	Tea/ Coffee
09:00 - 10:00	11:00 - 12:00							
10:00 - 11:00	12:00 - 13:00	Daily All-testbed meeting	Daily All-testbed meeting	Daily All-testbed meeting	Daily All-testbed meeting	Daily All-testbed meeting	Daily All-testbed meeting	Daily All-testbed meeting
11:00 - 12:00	13:00 - 14:00	Lunch	Lunch	Lunch	Lunch	Lunch	Lunch	Lunch
12:00 - 13:00	14:00 - 15:00					Exec Meeting 14:00 - 15:45		
13:00 - 13:30	15:00 - 15:30	Tea/ Coffee	Tea/ Coffee	Tea/ Coffee	Tea/ Coffee	Tea/ Coffee	Tea/ Coffee	Tea/ Coffee
13:30 - 14:00	15:30 - 16:00							
14:00 - 14:30	16:00 - 16:30					aily review meetingAgenda		
14:30 - 15:00	16:30 - 17:00	aily review meetingAgenda	aily review meetingAgenda	aily review meetingAgenda	aily review meetingAgenda		aily review meetingAgenda	ily review meetingAgend
15:00 - 15:30	17:00 - 17:30							
15:30 - 16:00	17:30 - 18:00							
16:00 - 17:00	18:00 - 19:00							
17:00 - 18:00	19:00 - 20:00					Testbed Dinner		–
18:00 - 19:00	20:00 - 21:00							

TIME (UTC)	TIME (CAT)	DATE						
		Monday, 5 February	Tuesday, 6 February	Wednesday, 7 February	Thursday, 8 February	########	Saturday, 10 February	Sunday, 11 February
		Please see Daily timetable tab below for schedule of forecasting and Evaluation						
06:00 - 07:00	08:00 - 09:00			Engagement Day	Cross-project interaction day			
07:00 - 08:00	09:00 - 10:00			Registration - as guests arrive				
08:00 - 08:30	10:00 - 10:30			Webinar I				
08:30 - 09:00	10:30 - 11:00	Tea/ Coffee	Tea/ Coffee		Tea/ Coffee	Tea/ Coffee		
09:00 - 09:30	11:00 - 11:30			Media Engagement				
09:30 - 10:00	11:30 - 12:00			Webinar II				
10:00 - 10:30	12:00 - 12:30	Daily All-testbed meeting	Daily All-testbed meeting		Daily All-testbed meeting	Daily All-testbed meeting		
10:00 - 11:00	12:00 - 13:00			Wrap-up				
11:00 - 12:00	13:00 - 14:00	Lunch	Lunch	Lunch	Lunch	Lunch		
12:00 - 13:00	14:00 - 15:00							
13:00 - 13:30	15:00 - 15:30	Tea/ Coffee	Tea/ Coffee	Tea/ Coffee	Tea/ Coffee	Tea/ Coffee		
13:30 - 14:00	15:30 - 16:00							
14:00 - 14:30	16:00 - 16:30					aily review meetingAgenda		
14:30 - 15:00	16:30 - 17:00	aily review meetingAgenda	aily review meetingAgenda	aily review meetingAgenda	aily review meetingAgenda			
15:00 - 15:30	17:00 - 17:30							
16:00 - 17:00	18:00 - 19:00							
17:00 - 18:00	19:00 - 20:00					Farewell Dinner		
18:00 - 19:00	20:00 - 21:00							

Appendix Cii: Schedule of the testbed-community hubs

Community hubs took place daily in the mornings in Kanyama and Boane, and twice over the period in Katlehong. A draft agenda was available to ensure consistency across all sites but was focused on achieving common outcomes with scope to modify according to local context. Key sessions included:

1. Verification of nowcasts (daily)

Reflection on the nature of weather over the preceding 24 hours; comparison to forecasts and nowcasts (bearing in mind that beyond community observers, not everyone will have received this information); and impacts and responses (with particular focus on social differentiation). What level of advisory should have been issued for this? Further questions to be determined in conjunction with the testbed team depending on arising weather.

2. Training sessions (at least twice)

Led by the meteorological service, the aim is to sensitise community members to weather and climate and how to access and interpret forecasts and early warning alerts.

3. Vulnerability/risk mapping

The aim of this participatory exercise is to identify the levels of spatial vulnerability to flooding in Kanyama, with particular focus on infrastructure damage and the costs and social differentiation of impacts.

4. Feedback on different ways of presenting weather information (multiple times)

Using examples of weather forecasts and advisories, flood forecasts and advisories and tropical cyclone warnings from Zambia, Malawi, Mozambique and South Africa with structured discussion questions to unpack how accessible (comprehensible) the information is, and how useful the information is that is provided, and the pros and cons of the different visual presentations.

5. Setting alert levels/advisories for people with disabilities to accompany likelihood/impact tables (at least once)

Synthesising insights gleaned throughout the testbed with the facilitating team; towards the end, some draft impact tables will be presented for feedback.

6. Creating and presenting fictional forecasts

To synthesise the critiques of the different forecast presentations, and to build on the learning among users about weather information and how to present it in an accessible way, groups work together to present a fictional forecast that contains information and a presentation that is accessible and useful to their fellow community members. As a test of how comprehensible it is to someone who has not seen it, a member of a different group will be asked to present the forecast.

Appendix D: Community hub daily reports

Kanyama day 1: 29 January 2024

Twenty-six community members and 11 community observers participated in the community hub in Kanyama on 29 January. This group included a variety of ages (up to 90s!) and people with sight and mobility disabilities. The group discussed the daily forecasts issued by ZMD on their WhatsApp group on 28 January 2024 (one issued at noon to cover the afternoon and evening; one chart on rainfall observations and one on temperature observations and predictions).

Weather information is used for a variety of purposes: deciding what clothes to wear/whether to carry an umbrella, how to engage in economic activities (e.g. whether or not to go and sell goods in an open market), when to charge solar panels, when to do washing, as well as gardening tasks.

Very few members of the group reported receiving weather information (and no one had seen the forecasts that were discussed before they were shared). In general, information is deemed useful (although in the community observer training one participant noted that the forecast is not useful as “it is always the same"). Of course, to be useful, it first has to be received. Many highlighted that there is a big gap here, with cell phones proposed as the best communication channel (for example modelled on the cholera messaging which was distributed universally through local cell phone networks).

Language of communication was also highlighted as essential, with two dimensions. First is the use of the English language (which not everyone understands) and second is the use of complicated terms (one group highlighted that the meaning of “isolated” is not clear). Language of communication leads to social differentiation in terms of who understands and who does not. Overcoming this could be achieved through more use of symbols and graphics (that said, the groups were given the temperature and rainfall tables that ZMD transmits and largely did not focus on them during discussions), as well as local language transmissions and the use of multiple channels to suit varied needs.

Kanyama day 2: 30 January 2024

Nine community members and 10 community observers participated in the community hub in Kanyama on 30 January. This mixed-gender group included a variety of ages and one person with a hearing and speaking disability. The group discussed the testbed-generated synoptic forecast and nowcasts issued from 16:00 on 29 January to 06:57 on 30 January (one synoptic, one Level 5 alert targeting Luapula province, and five nowcasts (although none indicated significant weather).

Synoptic forecast, sent 29 January 2024, 16:23 24h forecast for Kanyama No significant weather. Chance of slight rainfall Tuesday afternoon. Business as usual. Day-to-day activities not disturbed. NYANJA: Mawa sikudzakhala mvula kwenikweni, koma kumadzulo chiyembekezero chiliko chaching’ono kuti mvula ingagwe

All groups noted that the impact-based forecast contains useful information to guide daily activities, and the advisory contains useful information to protect lives and personal safety. It was clear from feedback that “business as usual” in the nowcasts was interpreted very narrowly by some groups as relating only to economic business activities, as opposed to the entirety of their daily activities.

There were differing views on the utility of a “no significant weather” update. Some people felt that any information is useful information and should be sent, not least for continuity of information. Others did not think it was useful to keep repeating null messages and would prefer less frequent messages be sent until there is a significant change to report.

There were also differing opinions on the length and comprehensiveness of the message: some felt that compact messages were more digestible, while others indicated that one more detailed forecast (say in the morning to cover the day) could then be accompanied by shorter updates throughout the day.

The groups then undertook a participatory flood risk mapping activity which gave rise to three very differently presented maps! One highlighted an area that regularly floods and then spatially located them; another focused on key features in the settlement; and the last one indicated the severity of flooding that occurs in different places. These maps will be built upon in future group work, with a particular focus on the economic impacts of flooding.

Kanyama day 3: 31 January 2024

Eleven community members, 10 community observers and representatives from a range of intermediary organisations (including the Adventist Development and Relief Agency, the

Ministry of Community Development and Social Welfare, Zambia Agency of Persons with Disabilities, Disaster Management and Mitigation Unit, and the University of Zambia) participated in the community hub in Kanyama on 31 January. This mixed-gender group included a variety of ages, one person with a sight disability, and two people with a mobility disability.

The group discussed the testbed-generated forecasts and nowcasts issued from 16:31 on 30 January to 07:32 on 31 January (one synoptic, one Level 2 alert targeting Kanyama and five nowcasts). The nowcasts experimented with different wording, given the previous day's feedback that "business as usual" had been literally considered to relate to economic business activities. Despite that, "business as usual" was still favoured as much as "people can go about their normal business". "(No) disruption to life" and "(no) disruption to activities" were less favoured overall, with the former recognised for impacts on personal safety and more serious than the latter.

Given that the previous day had a rainstorm that led to flooding, discussions considered the level of alert that would be deemed appropriate given the level of observed impact – which ranged from 4–7. To try and understand the relative magnitude of impacts from that event – and to begin to contextualise the levels as per the impact-based table – groups were asked to consider what a Level 10 (most severe) warning would look like, and what a Level 1 (minor) would look like. For Level 10, most groups spoke of widespread flooding, to the extent that gumboots would be submerged; with water in roads and houses and infrastructural damage, to the extent that it would impede movement (going to work, children going to school); with potential injury (for example children falling into wells and people falling into full drainage canals) and loss of life. For Level 1, there may be puddles and wet ground but no other discernible impact, and activities could continue as normal.

The second part of the discussion focused on the economic impacts of flooding. Many group members and their families had experienced personal loss as a result of flooding, including damage to property (e.g. roof blowing off, collapsed toilets, submerged houses, damage to electrical goods), loss of small livestock and loss of life (due to outbreak of water-borne disease). Relocation rarely takes place, and no one was aware of anyone who had been supported by government relocation last season. Costs of house rental in Kanyama vary from K350–1500 per month for a one- or two-room house, K1200+ for rental of a three-room house. Costs of building a house vary from K50,000 to K500,000 depending on size and materials. Indicative wage rates are shown in the table.

Job	**Indicative Wage**
Domestic worker/housekeeper/gardener	K500–1800 per month
Labourer/piece work	K25–50 per day
Shopkeeper	K700–1500
Teacher (part time in private community school)	K500–600 per month

In the afternoon, 10 intermediary organisation representatives joined the forecast hub at Zambia Meteorological Department for a focus group discussion (co-organised with the SALIENT project) to critique different presentations of longer-term climate information. Written narratives and map presentations were preferred to box plots. The former are more accessible as a child could read a written narrative to a blind person and still understand it, while the child would not so easily be able to recount the map.

Kanyama day 4: 1 February 2024

Twelve community members and 10 community observers participated in the community hub in Kanyama on 1 February. This mixed-gender group included a variety of ages (but few very elderly people) and two people with mobility disabilities (wheelchair users).

The group discussed the testbed-generated forecasts and nowcasts issued from 09:32 on 31 January to 07:16 on 1 February (one synoptic, one Level 1 alert targeting Kanyama and 9 nowcasts). The nowcasts varied in presentation, with or without the use of the term "warning" even if no negative impacts were predicted, and with or without a timeframe of validity of the information (e.g. "WARNING ISSUED AT 18:00 LOCAL VALID FOR 2 HOURS There is a very low likelihood of rainfall over Kanyama. No impacts expected within 2hrs" compared with "No significant weather over Kanyama. No disruption of activities").

Community members reported that rainfall predicted the previous afternoon had materialised in some parts of Kanyama (e.g. John Spy, Banda Masuka, Kanyama West), but not others. Discussion centred on the preferred time frame of forecasts, and the timing of their distribution. Opinions varied on preferred timeframes: some people favoured six hours, while 24 hours was also popular (particularly if accompanied by two-hour updates if adverse weather were to be predicted). Similarly, opinions varied on the timing of distribution. Some are happy with ZMD's current forecast release (lunchtime for the afternoon and evening, and early evening for the next day), while others thought receiving a daily forecast in the morning would be helpful to plan for the day's activities.

In the second part of the discussion, groups had the opportunity to analyse a tropical storm warning issued by the Department of Climate Change and Meteorological Services (DCCMS) in Malawi (see below). This gave the opportunity to compare with information from ZMD and the testbed. Most felt that the explanation of the movement of tropical storm was clear, as were the impacts (although one noted a contradiction between mentioning no impacts and then heavy rainfall and thunderstorms). Many also appreciated the fact that DCCMS issues the warnings in both English and Chichewa, but felt it contained technical language that was not necessary (e.g. tropical storm, inter-tropical convergence zone, Congo airmass). The graphics were popular, but some felt that the map could be clearer if it contained a key and if the projected range of the track was in red (due to its conventional use in signalling warning).

This was the fourth day of the community hub and, although attendance was good, energy in the room was a little flat at the start (although it picked up as the exercises began). Community observers may be getting accustomed to the two-part small group discussion format. To provide some variety, the next day's community hub featured a training session by ZMD on weather and how to access and use weather information. There will also be a tour of Kanyama at the end of the session.

MINISTRY OF NATURAL RESOURCES AND CLIMATE CHANGE

DEPARTMENT OF CLIMATE CHANGE AND METEOROLOGICAL SERVICES

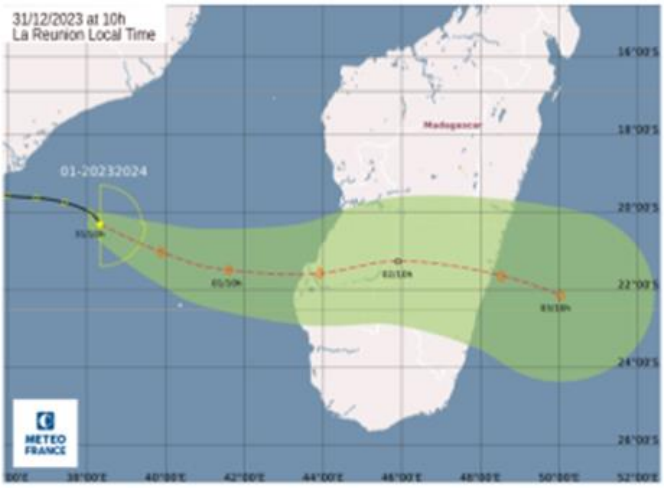
TROPICAL STORM DEVELOPMENT IN THE MOZAMBIQUE CHANNEL

UPDATE: Date and Time of issue: Sunday 31 December, 2023; 10:00am.

Issue No.TC2023-12-02

The Department of Climate Change and Meteorological Services (DCCMS) would like to update the Malawi nation on the development of the **Tropical Storm in the Mozambique channel**. The storm is anticipated to strengthen while moving eastward towards Madagascar Coast.

Current weather models consistently predict an **eastward trajectory towards Madagascar coast, with potential intensification into a moderate Tropical Storm by Monday morning, 1st January 2024.** The storm is forecasted to make landfall over south-west coast of Madagascar on Monday night or early hours of Tuesday 2nd January 2024.



At its current location and strength, the Tropical Storm is not named and **has no direct impact on Malawi weather**. Nevertheless, the combine effect of Inter-Tropical Convergence Zone and Congo Air Mass over Malawi will sustain **heavy rains and thunderstorms** in most areas. The public is strongly advised to **avoid crossing flooded and fast flowing waters**.

Meanwhile, DCCMS will continue monitoring the movement and strength of the Storm. Any potential impacts on Malawi weather will be promptly communicated to the nation.

For further information, contact:
The Director, Department of Climate Change and Meteorological Services P.O. Box 1808, Blantyre. Tel :(265) 882 266 579 Fax: (265) -1- 822 215
Email: metdept@metmalawi.gov.mw Web: www.metmalawi.gov.mw
Facebook: https://www.facebook.com/malawi.weather WhatsApp: +265 995 155 050

Kanyama day 5: 2 February 2024

Fifteen community members and 10 community observers participated in the community hub in Kanyama on 2 February. This mixed-gender group included more younger people than old, and one person with a disability.

The group corroborated the forecasts sent over the previous day and night, indicating that there had been no rain during that period in Kanyama. They also confirmed that they like receiving information 24 hours a day as people have different daily routines and this means that they can get information at times that suit them, particularly if they wake up early.

As part of the co-production process, it is important to raise awareness and build capacity among users to ensure that they can be discerning consumers of weather and climate information. With that in mind, Kenneth Sinachikupo from ZMD gave an introductory presentation that focused on what ZMD does and its products and services and invited the opportunity for questions and comments. Considering discussions this week, one particularly useful slide outlined terms that are used to describe weather (e.g. isolated and widespread for rain), and weather phenomena (e.g. intertropical convergence zone, Congo air mass), in forecasts and products.

Questions and comments related to certainty and uncertainty, provision of information that proved to not be correct, and normal and abnormal conditions. Recommendations from community members to transmit forecasts widely included the use of a DMMU-style universal SMS system, which Kenneth clarified is under development with Smart Zambia and ZICTA through an SSD code, and use of Instagram as a social media channel. There was also some discussion of tropical cyclones and why Zambia is rarely affected by this phenomenon, and climate change, which was widely known as a term and understood in terms of its meaning. Mention was also made of the new rain gauges that were being installed in Kanyama. Rainfall figures as read from the already-installed rain gauges showed that the amount of rainfall that fell in Kanyama on one day in mid-January (80mm) was a significant portion of the usual monthly rainfall (around 250mm in Lusaka).

Red Cross colleagues and the community observers then accompanied the WISER-EWSA team on a walk around parts of Kanyama, where we got to see firsthand how the features of the settlement make it very vulnerable to flooding. Kanyama is situated on impermeable bedrock with rocky outcrops in the roads – and some toilets are built up over the rock as that is easier than trying to dig them into the ground (these are typically emptied compared to the ground-level pit latrines). Some roads have drainage ditches, but they are often blocked by rubbish and sediment, leading to pools of stagnant water which also appear in the roads. Some houses have been abandoned due to flooding, with residents having to find other homes. In many cases getting around requires wading through water and this will likely remain the case until July/August because the flat topography means the water is unlikely to drain away and will instead evaporate. On the way back, we got caught in a rainstorm described as "normal" by the community observer residents – less than one hour of rainfall was measured as minimum 15mm at Comboni sisters (it was still raining lightly at the time we took the reading) and led to widespread pooling of water on the roads.

Full drain with rubbish (before rainstorm)

Flooded road and raised toilet (before rainstorm)

One of our community observers demonstrates why gumboots are essential to be able to move around in Kanyama

Road after less than one hour of rain

Kanyama day 6: 3 February 2024

Thirteen community members and 11 community observers participated in the community hub in Kanyama on 3 February. This mixed-gender group included a variety of ages, one mother with a (5-week-old!) baby and one person with a mobility disability.

The group discussed the testbed-generated Level 1 warnings issued at 14:00 and 17:00. All participants had experienced rain in Kanyama after the first warning, but no one had experienced rain after the second warning. Consensus was that the rainstorm was moderate in intensity.

Groups then had the opportunity to analyse a weekly weather statement (including one-week forecast) issued by the DCCMS in Malawi, and a flood warning issued by the Department of Water and Sanitation in Malawi (see below). This built on earlier exercises in the week which analysed various weather products from Malawi and Zambia.

Several commonalities were observed with the earlier exercise. Overall, this group has not been accessing much weather information and there is therefore a general sentiment that all information is welcome and can be useful. Community members felt they understood the information well, particularly when the timing, duration and location of any weather is clear. Advisories are useful in informing decisions about activities (for example when to stay at home, or when to engage in economic livelihood activities). They highlighted some technical terms that were not clear (e.g. ITCZ and Congo airmass) and we took advantage of the presence of Gillean and Richard to explain these and their role in influencing Zambia's weather. In the presentation of information, some people were happy with words (also noting their accessibility to people with disabilities as they can be read out), while others like the visuals (although sometimes people have false confidence in their capacity to understand information).

Weekly weather statement:

MINISTRY OF NATURAL RESOURCES AND CLIMATE CHANGE

DEPARTMENT OF CLIMATE CHANGE AND METEOROLOGICAL SERVICES

WEEKLY WEATHER STATEMENT

1ST TO 7TH JANUARY 2024

SUMMARY OF WEATHER AHEAD

Widespread heavy rains and occasional thunderstorms to persist over Northern Malawi and extending to Central parts of the country during next week. While scattered rains expected in Southern Malawi. This weather pattern results from the combined influence of the **Inter Tropical Convergence Zone (ITCZ) and Congo Air Mass**. **The risk of flash floods persists as heavy rainfall continues.**

Meanwhile **Tropical Storm ALVARO** is expected to make landfall over south-west coast of Madagascar on Monday night or early hours of Tuesday 2nd January 2024 and poses no direct threat on Malawi weather.

WEATHER DURING PAST WEEK

Widespread rains were experienced during the past week across Malawi. The highest rainfall was 131.1mm at Naluva EPA followed by Chinguluwe EPA with 101.0mm on 31st December both in Salima district. Another set of notable figures were recorded on 28th December from Kasinthula Research in Chikwawa and Madisi EPA in Dowa with 87.5 and 87.2mm respectively. The maps below show reported rainfall per district across the country on 28th,29th and 31st December 2023.

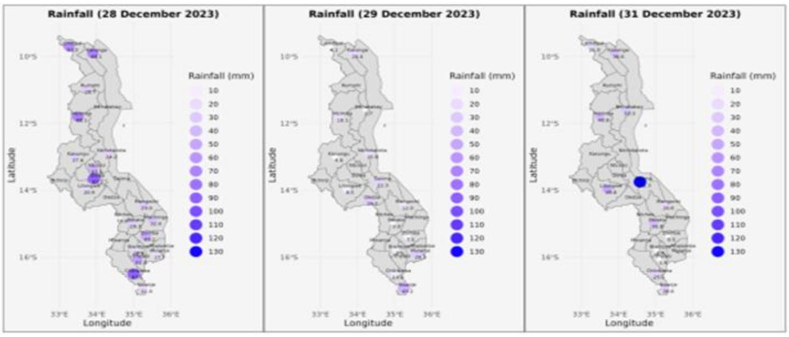


Figure: Rainfall reports per district on 28th, 29th and 31st December 2023.

ADVISORIES FOR THE COMING WEEK

- Thunderstorms are often associated with lightning and possible damaging winds. Therefore, stay in a safe and closed shelter whenever a thunderstorm is within vicinity until it dissipates.
- Do not attempt to cross flooded and fast flowing waters.
- Make sure that waterways and drainages are free from debris.

For further information please contact: *The Director, Department of Climate Change and Meteorological Services, Ministry of Natural Resources and Climate Change, P. O. Box 1808, Blantyre, Malawi. Tel: (265) 882 266 579; Email: metdept@metmalawi.gov.mw , Website: www.metmalawi.gov.mw*

Place of issue: Blantyre **Date of issue: Sunday 31st December, 2023**

Happy New year to all our Followers! Let's continue being weather-wise in 2024!

Flood warning:

Issue No. FN/2023/24/12/002 **Time :** 9:00 a.m.

GOVERNMENT OF MALAWI

MINISTRY OF WATER AND SANITATION

Department of Water Resources

FLOOD NOTICE

31ST DECEMBER, 2023 – 2ND JANUARY, 2024

The Ministry of Water and Sanitation through the Department of Water Resources would like to notify the general public that most major rivers in the country are expected to continue experiencing high water levels between 31st December, 2023 and 2nd January, 2024 which may result in flooding.

The increase in water levels and the possibility of flooding will be due to heavy rains and thurnderstoms that are being experienced in the Lakeshore, Northern, Central and Southern areas. According to the Ministry's flood forecasting model, the following rivers that are expected to have high water levels in the next 72hrs: Dwangwa, Kaombe, Bua, Chirua, Lingadzi and Nkula in Nkhotakota; Hara, Nyungwe, Wovwe, Songwe, Kyungu and North Rukuru in Karonga; Linthipe, Lifidzi, Lingadzi in Salima; Likangala, Thondwe, Mulunguzi and along Lake Chilwa in Zomba, Phalombe in Phalombe, Namadzi in Chiradzulu; Likhubula, Mwanza, Lisungwi, Mkulumadzi, Mkombedzi wa fodya, Nyachipere and Thangadzi in Chikwawa; Thuchira in Mulanje.

The Ministry is, therefore, advising the general public to refrain from settling in and crossing the flooded rivers and streams and to be alert when visiting these areas. The communities along some of the mentioned rivers are also advised to utilise the Community Based Flood Early Warning Systems (CBFEWS) installed to prevent loss of life caused by floods.

The public is further advised to pay attention to the continuously available updates on water levels/floods from the Department of Water Resources to be safe from any flood-related threats.

For further information, please contact the Ministry's Public Relations Officer, James Kumwenda on +265994672697.

Eng. James H. Chitete

DIRECTOR OF WATER RESOURCES

31ST DECEMBER, 2023

Kanyama day 7: Sunday 4 February

Informal team building lunch with community observers.

Kanyama day 8: Monday 5 February

Forecasters from the ZMD and Testbed Operations Centre visited Kanyama to engage in dialogue with community observers.

Kanyama day 9: Tuesday 6 February 2024

Eleven community observers and 10 community members participated in the community hub in Kanyama on 6 February. This mixed-gender group included mainly middle-aged men and women community members and one person with a mobility disability.

The group discussed an example of a district level forecast produced by the National Institute of Meteorology in Mozambique. Information was presented in a table, with a combination of observed data and forecasts for temperature, precipitation and wind. Community members and observers found this presentation difficult to understand. They often could not discern the difference between observations and forecasts, and temperature and rainfall data, and did not pick up the significance of the wind direction icon. There was also lack of clarity of the meaning of some terms, for example Tx and Tn. In general, they indicated that they would prefer words to accompany and explain the table, a key to elaborate the symbols, and specific advisory information. The district level forecasts were appreciated. However, one participant noted "districts will have more accurate information compared to provincial forecast". This highlights a different meaning of "accurate" to the way it is used by a forecaster – and could potentially indicate the false assumption that higher resolution information is necessarily more accurate than lower resolution.

The second part of the discussion focused specifically on impact-based forecasting, and involved sharing South Africa's impact table for thunderstorms, together with an example of a five-day forecast from the DCCMS in Malawi which uses impact-based forecasting. Understanding the forecast in terms of temperature, rainfall and wind was better in this case (and the use of both icons and explanatory words noted in the case of rainfall). In general, the group preferred that forecasts contain an indication of impacts, although the use of the table was not clear to all. Most groups found the traffic light colour system clear to understand ("we can see that red indicates danger") although one said this required further explanation. Reading the scores from the impact and likelihood was less clear.

The groups were also asked to identify how, using the South African impact table, they would classify the mid-January intense rainstorms in Kanyama. Responses varied from significant to severe (also reflecting the fact that different participants come from different parts of Kanyama), based on the impacts that they had observed. Overall, the South African impact tables are likely to be applicable in Zambia, with further elaboration required among different audiences about what the different levels of impact look like in different contexts.

Day 10: Wednesday 7 February 2024

Community observers came to ZMD to participate in the engagement day activities.

Kanyama Day 11: Thursday 8 February 2024

Eleven community observers and 10 community members participated in the community hub in Kanyama on 8 February. This mixed-gender group included mainly young and middle-aged men and women community members and two people with mobility disabilities.

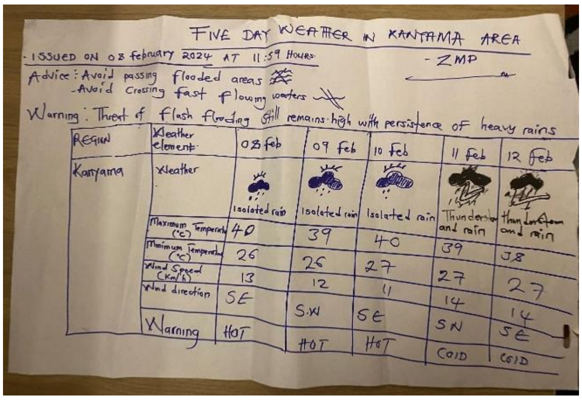
The groups initially discussed healthcare access in Kanyama. There is one hospital and four clinics, with referral on to the University Teaching Hospital in Lusaka in the case of critical cases or more serious illnesses. Wait time to be seen are often long (for example queuing from 8:00 am to 14:00 pm), except for people with disabilities who are seen first.

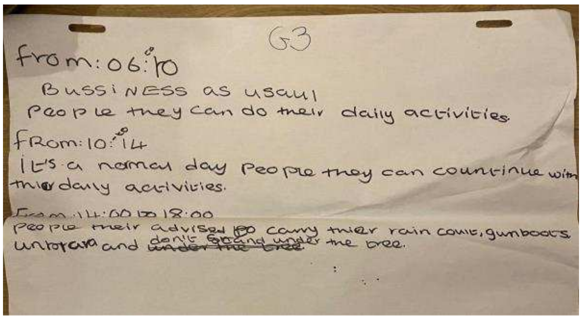
Availability of medication is poor, so prescriptions are given, and patients are expected to purchase their own medications, and pay for diagnostic tests and surgery if required. Dental and optical treatments are not available so have to be paid for privately. Indicative costs are K30–50 for blood tests, K500 for surgery, K500 for an eye test and K1500 for glasses.

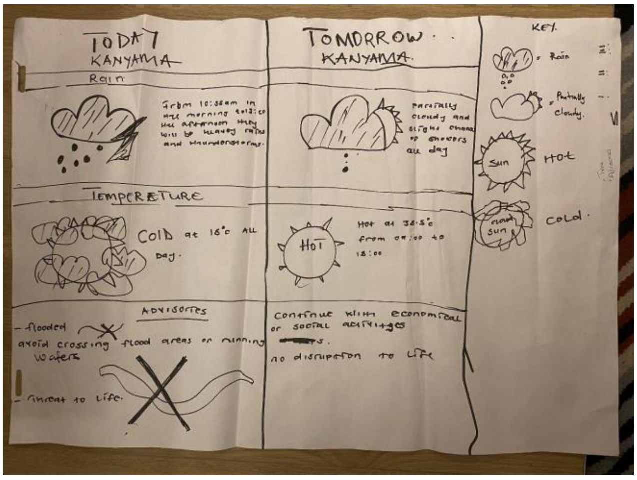
Mental health support is available through public facilities but there remains stigma around access, particularly for men. Barriers to access to healthcare are mainly cost of treatment and cost of getting to the healthcare facilities.

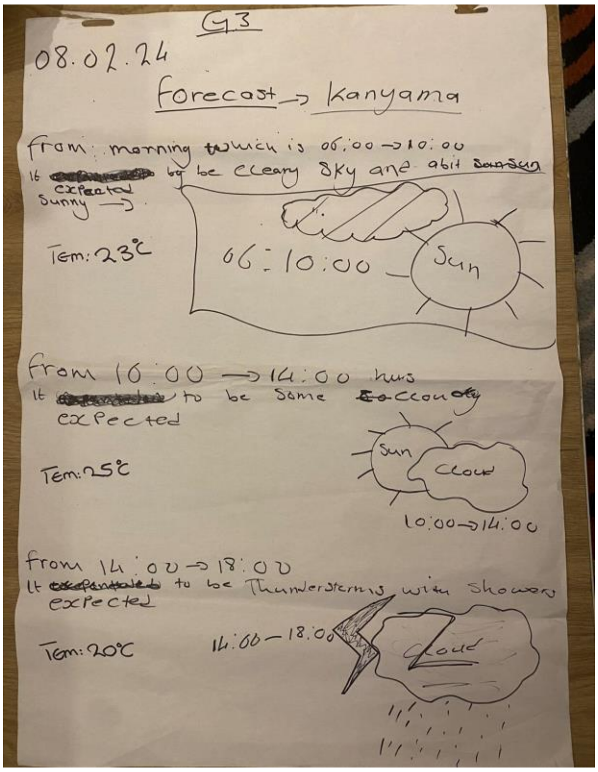
The second part of the day involved groups presenting a fictional forecast that would be accessible to and understandable by Kanyama residents. This built on the discussions of previous days which surfaced preferred presentation styles through critiquing of forecasts of different types from Zambia, Mozambique, and Malawi. One group presented a five-day forecast, one group presented a two-day forecast, one group presented a daily forecast accompanied by nowcasts, and one group presented a severe weather warning. To "test" the mandate to create a forecast that would be understandable by other Kanyama residents, a community observer from another group was tasked with presenting the forecast.

There were some inaccuracies in the forecasts (for example giving different levels of heat warning when the forecast temperatures were similar), and details that are not realistic for forecasts (e.g. a prediction that rain would start at 10:35 am). However, in terms of presentation, the forecasts took on board some of the preferred key features that had been identified. This included the use of impact-based forecasts, advisories, and visual presentations (with accompanying keys and/or explanations). The date and time of issue and, where relevant, the timing of the forecast information were also clear. Groups presented information in English for the benefit of the wider testbed audience, but recognised the need for Nyanja, and one group signed the delivery of the forecast. The forecasts are presented below.









Kanyama Day 12: Friday 9 February 2024

The WISER-EWSA team and community observers undertook a reflection session on the community hub and the community observers' roles. An additional anonymous evaluation was conducted (see appendix E for a summary).

Appendix E: Evaluations of the testbed (community hub) by community observers

Zambia

- Composition of sample: 7 women and 4 men, all aged between 18–30. One reported a physical disability
- As a result of participating in the testbed, 100% of participants reported an improved understanding of weather and climate
- Based on scale ratings of 5 (very useful) to 1 (not useful), the session received the following average scores:
    - Commenting on forecasts from Zambia, Malawi and Mozambique – 4.55 (female – 4.57; male – 4.5)
    - Drawing a map of flood risk in Kanyama – 4.09 (female – 4.43; male – 4.5)
    - Discussions around loss and damage caused by floods – 4.67 (female – 4.57; male – 4.75)
    - Training by ZMD forecaster – 4.73 (female – 4.71; male – 4.75)
    - Dialogue between community observers and ZMD forecasters – 4.66 (female – 4.57; male – 4.75)
    - Attending the Lusaka testbed hub for community engagement day – 4.09 (female – 4.43; male – 4.5)
- What people have learned from being involved in the testbed and being community observers:
    - About the weather, including different weather patterns, how to understand different weather forecasts (including terms and icons) and climate change
    - How weather can help to plan for different activities, and the difficulties the community is facing due to a change in climate
    - How to communicate with community members and how to give weather feedback to ZMD
    - Some quotations:

"I have learnt a lot especially on the weather because I am able to warn my fellow community people when I receive the testbed [forecast], and it has helped me plan for my daily activities." (female)

"Have learnt how to read weather forecasts. Understood some terms I did not, e.g itcz. Have been able to understand in more detail the difficulties our community is facing due to change in climate. Have understood the importance of the weather information and how best I can use it." (male)

"I have learnt to give weather feedback, helping people with disability and engaging other departments like the ZMD." (male)

- How people intend to use the information they have learnt from involvement in the testbed is:
  - To use in their daily lives
  - To share it with and educate the community
  - Some quotations:

"I'll educate my community on the things I've learnt here and also sensitize them on issues to do with climate change." (female)

"I would use it to improve people's daily activities, by going around informing them, teaching them about weather, by doing so it will really improve on the risks that we used to face in Kanyama." (female)

"To tell people about how weather is going to be, especially those that have disabilities."

- 100% of participants are willing to continue providing feedback to ZMD on a less involved basis.
- 100% of participants are interested in remaining involved in WISER-EWSA.
- Additional comments expressed appreciation for the opportunity to participate and the wish for it to continue
- Quotations:

"The programme should not just end from here, it should continue, so that [it] will be able to give warning to people living with disabilities, when we have received the testbed that the[re] will be rain, so it should not end please but it should continue and give us jobs." (female)

"This project was very insightful, and I would like to get involved more. I would like to continue providing education to the community and pursue more research on the same in my community." (male)

Mozambique

- Composition of sample: three women and five men, aged between 18–80. Three reported a physical disability and three reported a visual impairment.
- As a result of participating in the testbed, 100% of participants reported an improved understanding of weather and climate.
- Based on scale ratings of 5 (very useful) to 1 (not useful), the session received the following average scores:
  - Commenting on forecasts – 5 (female – 5; male – 5)
  - Drawing a map of flood risk in Boane – 4.38 (female – 5; male – 4.8)
  - Discussions around loss and damage caused by floods – 4.67 (female – 4.57; male – 4.75)
  - Training by INAM forecaster – 4.5 (female – 4.33; male – 4.6)

- Dialogue between community observers and INAM forecasters – 4.75 (female – 5; male – 4.6)

- What people have learnt from being involved in the testbed and being community observers:
  - Learnt about weather phenomena (e.g. temperatures, storms over the ocean, extreme events) and climate
  - Learnt about weather forecasting and how to interpret technical terms
  - Learnt about how to reduce risk from extreme events
  - Some quotations:

"As a community observer, I gained new knowledge about weather forecasting and more subjects related to meteorology." (female)

"I learned about weather warnings." (female)

- How people intend to use the information they have learnt from involvement in the testbed:
  - To share information with community members (weather forecast and early warnings)
  - To use for themselves
  - Some quotations:

"I will teach many people to spread information in the community about early warnings." (male)

"The information I got from this training will be useful for me and also for the people close to me and will help us a lot to prevent or avoid climate change disasters. And I'll be able to teach other people about the importance of weather forecasting." (female)

"I will use it for myself and for the people around me." (male)

- 100% of participants are willing to continue providing feedback to INAM on a less involved basis.
- 100% of participants are interested in remaining involved in WISER-EWSA.
- Additional comments expressed appreciation for the opportunity to learn, the good facilitation, and the wish that the interaction will continue and be expanded.
- Quotation:

"I would like this training to be repeated for other districts because natural disasters are in most districts of Mozambique. We had the opportunity to be part of the disaster management committees." (male)

South Africa

- Total sample size: 19 of whom three were community members, 14 were intermediary organisation representatives and two were unclear in terms of group affiliation.
- Composition of entire sample: 10 females and 9 males
- Age breakdown by entire sample group:
  - 25–30: 4 (21.05%)
  - 30–39: 6 (31.58%)
  - 40–49: 9 (47.37%)
- Age breakdown by gender:

  Female:

  - 25–30: 3 (30%)
  - 30–39: 4 (40%)
  - 40–49: 3 (30%)

  Male:

  - 25–30: 1 (11.11%)
  - 30–39: 2 (22.22%)
  - 40–49: 6 (6.67%)
- None of the participants were asked to disclose their (dis)ability status in this survey.

Community members

- Age breakdown:
  - 25–30: 1 (33.33%)
  - 30–39: 1(33.33%)
  - 40–49: 1 (33.33%)
- All the individuals in this group were female.
- The accuracy of the weather forecasts as perceived by community members was as follows:
  - All the community members (three) surveyed found the forecasts to be accurate. Of these community members, one commented that they were accurate overall, except for one or two days.
- Participants reported the following challenges and recommended improvements to the weather forecast and Weather Smart app:
  - Technological accessibility: Improvements in the app's technological accessibility were suggested by one community member, who proposed that the app needed to be made compatible with Android devices to reach a broader audience.
  - Quotation:

"Make the app accessible with androids." (Female, community member, 30–39 years old).

- Education and awareness: Two respondents emphasised the need for education and awareness campaigns and increased advertising to inform the community about weather forecasts and early warnings.
- Some quotations:

"More advertising." (Female, community member, 40-49 years old).

"I think they need to educate everyone, be it on social media networks, or local newspapers in our communities so that everyone can have broad knowledge about what is happening around them." (Female, community member, 25-30 years old).

- As a result of participating in the testbed, two community members (66.67%) reported an improved understanding of weather work. Only one participant stated that her level of understanding had diminished.
- Each of the surveyed community members varied in terms of the languages they believed weather information should be best communicated in and around Katlehong, as shown by the quotations, below:

"All indigenous." (Female, community member, 40-49 years old).

"English." (Female, community member, 30-39 years old).

"Isizulu because even though we are from different tribes, isizulu is the easiest and most popular language and everyone knows and understands the language." (Female, community member, 25-30 years old).

- What community members liked the most from being involved in the workshop:
  - Learning about the weather, including different weather patterns.
  - Learning about important lifestyle changes needed to mitigate climate change/hazards – namely separating waste such as food and cans.
  - Being able to see a weather station.
- Community members identified that weather information would bring the following advantages to the community:
  - Disaster and risk reduction: Two community members regarded the advantages of access to weather information as being the enhancement of safety and the ability to plan accordingly. Participants highlight that access to accurate weather forecasts enables them to make informed decisions about activities and preparations.
  - Some quotations:

"Safety and planning accordingly." (Female, community member, 40-49 years old).

"Always knowing how to dress appropriately for the day" (Female, community member, 30-39 years old).

- Behavioural changes for climate change/hazard mitigation: One community member acknowledged the potential for weather information to facilitate behavioural changes that contribute to environmental preservation. She stated that by understanding how certain actions, such as waste mixing, can impact weather forecasts, community members are empowered to adopt more sustainable practices, thus mitigating adverse effects on weather patterns.
- Relevant quotation:

"The thing I liked about the workshop is that I was able to learn … about changing our lifestyle including separating waste such as food and cans because it also contributes to the greenhouse gas which affects our atmosphere." (Female, community member, 25–30 years old).

  - All the community members stated that they understood the map risking exercise.
- Two community members provided suggestions and feedback:

"More awareness." (Female, community member, 40–49 years old).

"My wish is that everyone in my community can have a WeatherSmart app so that they can prepare early for heavy rains and floods" (Female, community member, 25–30 years old).

Intermediary organisation representatives

- 14 individuals who participated in this survey were representatives from intermediary organisations.
- Age breakdown:
  - 25–30: 2 (14.29%)
  - 30–39: 4 (28.57%)
  - 40–49: 8 (57.14%)
- Gender breakdown:
  - Male: 8 (57.14%)
  - Female: 6 (42.86%)
- Age disaggregated by gender:

  Male:
  - 25–30: 1 (12.50%)
  - 30–39: 1 (12.50%)
  - 40–49: 6 (75%)

  Female:
  - 25–30: 1(16.67%)
  - 30–39: 3 (50%)

- 40–49: 2 (33.33%)

- The intermediary organisation representatives cited the following roles in forecasting and early warning:
  - Five (35.71%) intermediary organisation representatives stated that they exclusively communicate early warning alerts directly to user groups (e.g. communities).
  - Three (21.43%) intermediary organisation representatives stated that they exclusively communicate weather information directly to user groups (e.g. communities).
  - One (7.14%) intermediary organisation representative stated that they create and issue warnings relating to weather information.
  - One (7.14%) intermediary organisation representative stated that they communicate weather information to other organisations.
- Several representatives stated that they performed a variety of roles pertaining to forecasting and early warning. These were detailed as follows:
  - Three (21.43%) intermediary organisation representatives stated that they:
    - Produce weather information.
    - Create and issue early warnings relating to weather information.
    - Communicate weather information and issue early warning alerts to other organisations; and
    - Communicate weather information and issue early warning alerts directly to user groups (e.g. communities).
  - One (7.14%) intermediary organisation representative stated that they communicate weather information and issue early warning alerts directly to user groups (e.g. communities).
- As a result of participating in the testbed, four (28.57%) intermediary organisation representatives reported an improved understanding of weather work. Seven participants (50%) stated that their level of understanding had remained the same, with one representative highlighting that their level of understanding had diminished. Unfortunately, two participants provided answers which made it difficult to assess changes in understanding.
- The accuracy of the weather forecasts as perceived by intermediary organisation representatives was as follows:
  - Most intermediary organisation representatives (10) found the forecasts to be accurate. One of these participants commented that they were accurate, except for one day. Of this group who found forecasts to be accurate, five were female and five were male.
  - Two participants (one male and one female) stated that the forecasts were not accurate.
  - One participant (a male) stated that he did not know whether the weather forecast was accurate or not.
  - One participant (male) stated that he did not reside in Katlehong and so could not comment.

- Participants reported the following challenges and recommended improvements to the weather forecast and weather smart app:
    - Technological accessibility: Some respondents highlighted the issue of technological accessibility.
    - Relevant quotations:

"Some people don't have smartphone in our communities, and they don't have access about WeatherSmart app. So early warning should be communicated through smses to accommodate everyone" (Female, intermediary organisation representative, 25-30 years old).

"WeatherSmart app must be available for every smart phone and easy to download" (Male, intermediary organisation representative, 40-49 years old).

-
    - Education and awareness: A participant emphasised the need for education and awareness campaigns to inform the community about weather forecasts and early warnings.
    - Relevant quotation:

"I would like the funders or the role players to help in doing a road map educational campaign in different malls/schools/community, also do Facebook pages to help in educating and spreading the word across the country." (Male, intermediary organisation representative, 40-49 years old).

-
    - Improvement in quality of information: One participant mentioned the importance of integrating satellite data into weather forecasting to enhance accuracy and reliability.
    - Information from other sources: Some participants highlighted the need to receive weather forecast from other sources, such as the television (SABC and e-news), radio, and the internet. It was unclear whether they felt this should be in addition to the app or instead of.
    - Relevant quotations:

"We must get daily news online." (Female, intermediary organisation representative, 40-49 years old).

"As, wise, weather forecast SABC, e-news, radio station." (Male, intermediary organisation representative, 40-49 years old).

"Improve communication between local radio stations and SAWS." (Male, intermediary organisation representative, 25-30 years old).

- The majority of participants (9) expressed a preference for weather information to be communicated in English. Four participants suggested communication in both English and IsiZulu. One individual advocated for weather communication to be inclusive of all 11 official South African languages.
- What community members liked the most from being involved in the workshop is:

    - Interactivity and participation: Four participants appreciated the interactive nature of the workshop, highlighting the opportunity for active engagement and participation.
    - Learning and educational content: A recurring theme is the educational value of the workshop, with many participants expressing appreciation for the informative content presented. Participants reported gaining new insights and knowledge about weather-related topics and terms.
    - Idea sharing: One participant noted the usefulness of discussions about community-specific issues, such as flooding prevention strategies.
- Intermediary organisation representatives identified that weather information would bring the following advantages to the community:
    - Disaster and risk reduction: Most participants regarded the advantages of access to weather information as enhancing safety and the ability to plan and prepare accordingly.
    - Some quotations:

"Prevent weather hazards impact from increasing" (Male, intermediary organisation representative, 25-30 years old).

"The community will be more prepared if they know ahead of time." (Female, intermediary organisation representative, 40-49 years old).

"It makes the community aware and helps them prepare for any situation." (Female, intermediary organisation representative, 30-39 years old).

"The community will know about the coming floods, the heatwave in time." (Male, intermediary organisation representative, 40-49 years old).

    - Behavioural changes for environmental preservation: One community member acknowledged the potential for weather information to facilitate behavioural changes that contribute to environmental preservation (i.e. placing rubbish in bins).
    - Enhanced understanding of weather forecasts: One participant expressed the advantage of gaining a deeper understanding of weather forecasts and their readings.
    - Relevant quotation:

"We learnt about different types of weather forecast, understanding of the weather forecast, how its readings work and understanding of the weather forecast readings." (Female, intermediary organisation representative, 40-49 years old).

- A significant majority (78.57%) of intermediary organisation representatives affirmed their comprehension of the map risk exercise, while two representatives (14.29%) reported a lack of understanding. One participant was unable to recall the exercise.
- The following was provided as suggestions and feedback from some individuals:

- Satisfaction with the information and warnings provided to the community about weather-related issues was expressed. A positive shift in community behaviour noted and emphasised the importance of continued efforts in this regard.
- The need for collaboration among stakeholders (e.g. radio stations, libraries and clinics) to ensure comprehensive outreach to the community.
- The need for road department engagement to help with redesign of damaged infrastructure.

- Two individuals did not indicate whether they are affiliated with an intermediary organisation or are community members. Consequently, they have been categorised as 'unknown'.
- Age breakdown:
  - 25–30: 1 (50%)
  - 30–39: 1 (50%)
- Age breakdown by gender:

  Female
  - 25–30: 1 (50%)

  Male
  - 30–39: 1 (50%)
- Both participants indicated that their understanding of weather work remained unchanged after having participated in the workshop.
- Both participants stated that the weather forecast was accurate.
- Participants reported the following challenges and recommended improvements to the weather forecast and WeatherSmart app:
  - Technological accessibility: Both participants cited issues of technological accessibility, noting that not everyone in the community had access to smartphones or weather smart apps. Suggestions from both participants included utilising SMS alerts to disseminate early warnings, as SMS is accessible to a wider audience. One participant went on to say that these SMS should also be sent to ground forces or agents so that they could teach the community about weather forecasts and early warnings.
  - Relevant quotes:

"Some people don't have smartphones in our communities, and they don't have access to weather smart app. So early warning should be communicated through smses to accommodate everyone" (Female, unknown, 25–30 years old).

"We should also use SMSes to send weather forecasts to the community, ground force or agents to teach our community about weather forecasts and early warnings." (Male, unknown, 30–39 years old).

- One participant expressed a preference for weather information to be communicated in English, while the other suggested communication in both English and IsiZulu.
- What community members liked the most from being involved in the workshop:

- Increased understanding of weather and weather conditions.
- Watching the video.

- Participants identified that weather information would bring the following advantages to the community:
  - Disaster and risk reduction: Both participants regarded the advantages of access to weather information as being an enhancement of safety and the ability to plan and prepare accordingly.
  - Education: One participant highlighted the potential of weather information to educate the community and foster a better understanding of weather forecasts.
  - Relevant quotations:

"Since our area is exposed to floods, early warnings will help community members to prepare before." (Female, unknown, 25-30 years old).

"It will keep people safe from danger. Be prepared on time. To teach everyone to understand weather forecast." (Male, unknown, 30-39 years old).

- Both participants affirmed that they understood the map risking exercise.
- The following were provided as suggestions and feedback from the participants:
  - Increased education and awareness initiatives (e.g. through roadshows or increased presence of ground agents) in the area to educate people about WeatherSmart app and weather conditions.
  - The verbal transmission of weather-related information.

Appendix F: Synoptic SOP

WISER-EWSA Project

Synoptic Forecasting (Day 1 to 3)

Standard Operating Procedure

Testbed 1

1. Purpose

This document outlines the recommended procedures to produce a day 1 to 3 synoptic forecast (0-72 hr) during Testbed 1 of the Weather and Climate Information Services (WISER) Early Warning for Southern Africa (EWSA) project. Multiple products, tools and methods are available for the testbed and this standard operating procedure outlines the recommended practices to produce valuable nowcast warnings during the testbed.

2. Introduction

The WISER-EWSA project, led by the National Centre for Atmospheric Science and University of Leeds, aims to transform access to weather early warning systems for communities in South Africa, Zambia and Mozambique. Over the two-and-a-half-year period (2023–2025), the WISER-EWSA project will focus on providing weather information to socially disadvantaged urban populations to reduce the damage caused by storms. One of the project’s main objectives will be to build capacity for nowcasting where the use of real-time satellite images and other tools are used to predict weather conditions over the next 0–6 hours. One of the outcomes to address the capacity development on nowcasting is the hosting of testbeds to evaluate current weather services and set-up new services tailored to user needs. A dedicated nowcasting working group will form part of the testbed.

3. Scope

The aim of this document is to describe the steps that should be taken in the production of day 1 to 3 synoptic forecasts in preparation for nowcasts on the WISER-EWSA Testbed 1. The document outlines the necessary steps to produce a synoptic forecast as a forerunner to the nowcasts and early warnings to be produced. Various inputs will be utilized in the testbed for generating the synoptic forecast, ranging from Meteosat Second Generation (MSG) Satellite channels, upper air information and numerical weather prediction model output. This operating procedure describes the recommended steps to identify the 0–72-hour outlook as well as sensitizing the nowcasting shift of anticipated areas where severe weather can be expected in the next 72-hour period.

4. Process flow

Below is a flow diagram indicating the activities (left) and outputs (right) from the synoptic operating procedure. The looped section of the flowchart is indicated as having a six-hour repeat frequency to accommodate the 06:00 and 12:00 GMT synoptic updates. However, it is planned that this frequency can be increased if weather conditions are rapidly developing and therefore require more updates/warnings to be made. Detailed descriptions of each of the steps in the flow diagram can be found in section 5.

There are two main outputs that are recommended, these are:

1) a longer-term (72 hour) forecast, and
2) a short-term (24 hour) forecasts which will include locations of anticipated high impact weather (HIW) for the next 24 hours.

Examples of each of these can be found in section 6. It will include a synoptic summary captured on pre-developed templates to record and report in a standardised format. The summary will consist of short written bulletins summarising the information. The summary should also be produced in a format to aid in communication through other dissemination methods, e.g. SMS/WhatsApp messaging, radio/TV alerts etc.

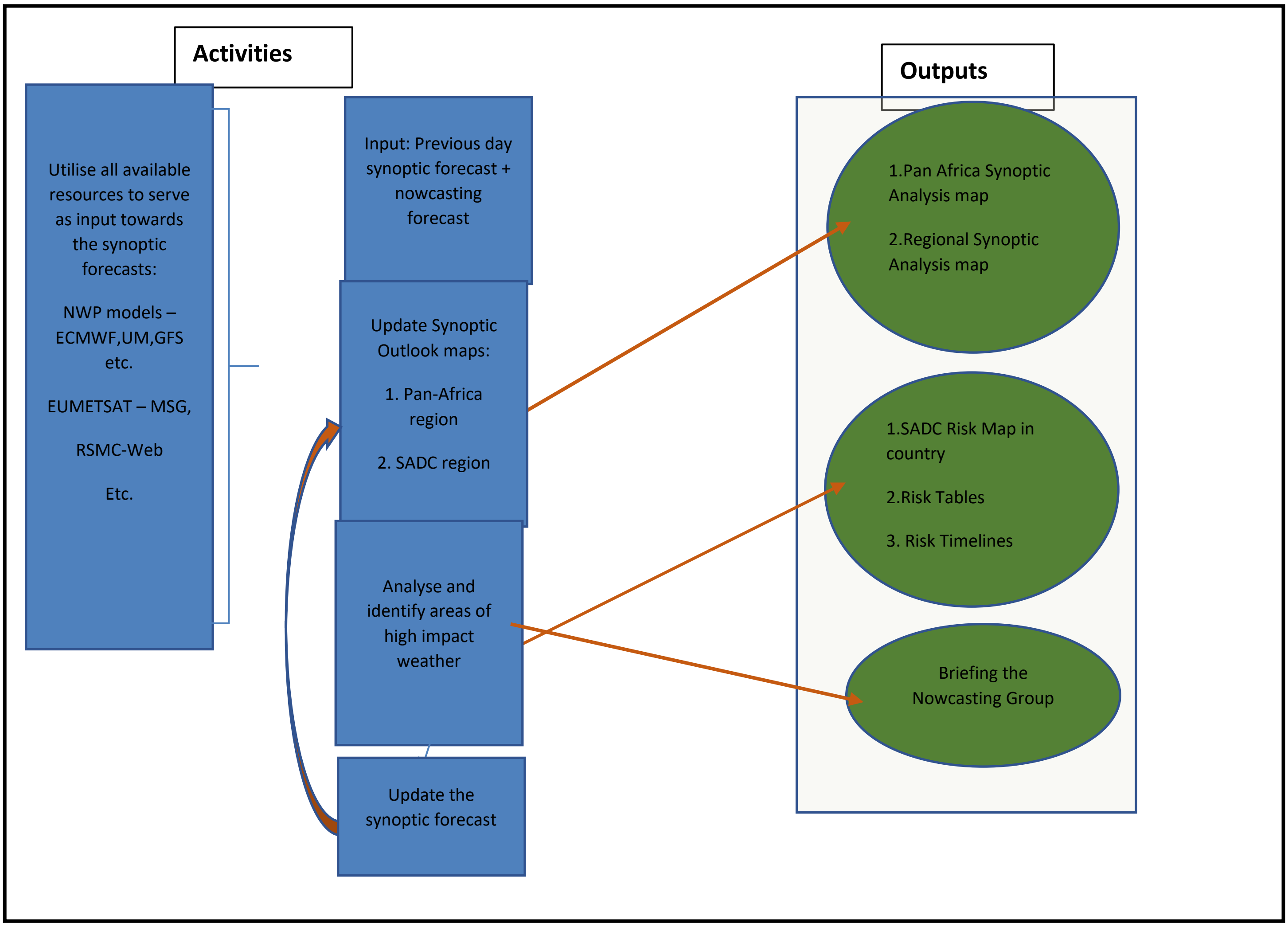


Figure 1: Flow diagram detailing the activities and outputs recommended for the operation of a synoptic forecasting shift. Blue colours indicate activities to be undertaken to produce specific outputs (green colour). Although synoptic forecasts will not be sent out to the public in the testbed, dummy bulletins for dissemination on SMSs, WhatsApp, etc. messages as well as TV and radio broadcasts of warnings could be shared with the operational forecasters.

5. Detailed procedure

Step s	Activity	Time	Tools	Output	Responsible
1	● Shift starts – shift lead (duty forecaster) goes through the latest synoptic observations, the nowcasting forecast for the previous day/evening, the synoptic forecast produced for the next 24 hours by the previous shift, and any reports of impacts experienced the previous day. ● During analysis of synoptic observations, assess developments (decay, persistence/movement, strengthening, and/or new developments) up to current situation. ● Briefing to the synoptic forecasting shift on the synoptic forecast for the day and a discussion on the previous evening nowcasting shift events. Suggested format: o Overview of the latest observations including satellite & radar imagery. o Review of observations vs the forecast for the previous day/evening, and any reports of impacts. ● A run through the preferred model solutions for the next 72 hours, highlighting areas of uncertainty & risks of HIW.	30 minutes Suggested Time: 06:00 GMT (08:00 Zambia/ Mozambique/SA)	● Computers ● Beamers ● Internet connection ● Latest ECMWF, GFS, MateoF, UKMO products on SYNERGIE /PUMA ● RSMC (Unified Model 4x4 kilometre resolution model) products ● NOAA website ● WRF products. ● MSG satellite imagery. ● Previous day's synoptic & nowcast forecast (bulletins).	Briefing on the synoptic situation as perceived by the lead forecaster.	Duty forecaster assisted by previous day's nowcasting shift output.
2	● Analyse global model (ECMWF, GFS, MeteoF, RSMC, NOAA, UKMO) products to get an overall idea of the mean sea level pressure for pressure and wind flow patterns & developments from current situation. ● Analysis of MSG satellite imagery MSG on SYNERGIE/PUMA system and from the web. ● Analyse the main synoptic features: o Surface high pressure centres / low pressure centres / troughs,	1 hour Suggested Timeline: 06:30 GMT (08:30 - Zam, Moz, SA)	● Analyse surface charts to determine current synoptic conditions and changes over the next 72 hours. ● Internet connection ● Access to latest ECMWF, GFS, MeteoF, UKMO products on SYNERGIE	Automated synoptic maps: 1.Pan-Africa map 2. SADC regional map	

	convergence & confluence zones o Relative humidity at low and medium levels (850, 700, 500). o Major development areas (ridges/troughs) at low/middle and upper levels. o Instability indices (KI, Totals, CAPE, …). o Areas of current and anticipated precipitation ● Local effects: Orography (mountains, valleys, water bodies, …). Strong heating of land areas. Diurnal cycle. ● Prepare and create annotated Pan-Africa and SADC regional forecasts of the major synoptic features for the next 72 hours using automated analysis, to give an idea of the position and strength of the four subtropical and mid latitude high-pressure systems; Atlantic Ocean, Indian Ocean , tropical systems, and to determine the direction of wind flow at low levels using streamlined GFS imagery can also be used to look at variables/levels that are not included in the synthetic charts, but the overall aim is that the automated charts will be the predominately utilized tool since these will allow for a much quicker synoptic forecast to be created. ● Forecasts and notes to be captured in a consistent format (use templates)		/PUMA-station ● RSMC (Unified 4x4 kilometre resolution model) ● NOAA website ● WRF products ● Previous day's synoptic & nowcast bulletins. ● Features to look for: o MSLP, moisture, humidity, winds, streamlines, convergence / divergence, dew point temperature ● GFS/UM automated synthetic analysis plots for Pan-Africa and Southern Africa		
3	● Based on the synoptic forecasts, create daily guidance bulletins for 1-3 days (text message filled on the forecast bulletin template).	1-hour minutes Suggested Timing: 07:30 GMT (09:30 - Zam, Moz, SA)	● Computer ● Internet ● Synthetic analysis automated plots Extra NWP plots to be downloaded (GFS, UM etc.)	Daily guidance bulletins for 1–3 days for briefing and handover for the nowcasting shift.	All on shift. Specific person attached to selective tasks.

4	● Using the Pan-Africa & regional Africa maps and guidance bulletins, note areas of potential HIW in Country Guidance bulletins and produce SADC risk maps for Zambia, Mozambique, South Africa If extreme weather is forecasted: Use UKMO and other tools to: a) prepare colour-coded risk table, showing areas at risk with green (no risk), yellow (low risk – be aware), orange (medium risk – prepare and red (high risk – take action) and risk timelines b) impact map, demarcating areas at risk (yellow/orange/red), including risk timelines and accompanied by impact statements.	1.5 hours Suggested timing: 09:00 GMT 11:00 – Zam, Moz, SA)	● Internet connection ● Updated model runs ● Access to Africa VCP viewer for UKMO deterministic models. ● Access to ensemble products on website. ● Automated figure downloads to a PowerPoint presentation for ease and speed of analysis. ● Precipitation forecasts – particularly the chance of precipitation ensemble plots. ● Wind Speed probability plots. ● Meteograms for point location forecasts.	Country Guidance bulletins to be established (Focus is on Zambia for the 1st testbed) SADC risk map in country Risk tables Risk timelines	All on shift
5	● Using the outputs produced earlier in the shift, including the Pan-Africa Synoptic Analysis; Regional Synoptic Analysis map; daily guidance/country bulletins; SADC risk map in country; risk tables & risk timeline, produce briefing to give to the nowcasting team. ● This will include filling out a table that will ask for the same information each day to keep things consistent. ● Split into two groups, i.e. synoptic briefing and HIW briefing. ● Give more specific instructions below in bullet points.	1 Hour Suggested timings: 10:00 GMT 12:00 (Zam, Moz, SA)	● PowerPoint templates ● Charts ● Table to fill out (template)	Preparation of documents and templates for briefing session with nowcasting shift. 1. Three hourly guidance for the expected weather conditions covering the remaining 12-hour period.	All on shift (Split into 2 x groups)
6	Give a briefing to nowcasting team ● Potentially not all the synoptic team will give the briefing to allow for the others in the group	1 hour Suggested timings:	● Internet connection for zoom meetings ● Zoom ● PowerPoint	Briefing to the nowcasting shift and discussion	All on shift

	to finalize the forecast and guideline documents.	11:00 GMT 13:00 Zam, Moz, SA	● Completed table/ document from stage 6.	1. Template (to be designed) to be completed	
7	Share information with operational forecasters at ZMD/INAM.	10 minutes	Meeting room	Template as in Step 6 to be utilised.	Duty forecaster

Detailed information on each of the stages of the forecast process above:

Stage 1)

Time allocated to this stage: 30 minutes

- Shift lead will complete a briefing to the rest of the synoptic group. The briefing will consist of succinctly going through the synoptic forecast created the day before for today along with highlighting what occurred in the nowcasting shift overnight. This will allow the team to get an idea of the forecast expected today.

Stage 2)

Time allocated to this stage: 1 hour

- The synoptic team will work together to produce a SADC regional (Pan-Africa) synoptic forecast for the next 72 hours. The forecast will be produced using:
  - o Automated SADC regional (Pan-Africa) synthetic analysis/forecast charts:

To give an idea of the position and strength of the four subtropical and mid latitude high-pressure systems: Atlantic Ocean, Indian Ocean, tropical systems.

To determine direction of wind flow at low levels using streamlines.

- o Satellite imagery: Satellite images can be accessed from the Met Office VCP viewer and can be used to give a picture of the current weather along with an indication of where the ITCZ is located related to where the moisture/clouds are forming.

Stage 3)

Time allocated to this stage: 1 hour

The synoptic team will work together to produce the SADC (Southern Africa) synoptic forecast for the next 72 hours. The forecast will be created by using the various automated synthetic analysis/forecast charts. In conjunction with these, GFS imagery can also be used to look at variables/levels that are not included in the synthetic charts, but the overall aim is that the automated charts will be the predominately utilized tool since these will allow for a much quicker synoptic forecast to be created.

Stage 4)

Time allocated to this stage: 1.5 hours

- This stage will be in tandem to stage 3 and will require the synoptic team to produce daily guidance bulletins for the next three days regarding the synoptic forecast. The purpose of this will be to give an overview of the large-scale conditions for the next three days so that these can be expanded upon when the high impact weather forecast is completely later in the shift.
    - These forecasts will include things like: Atlantic High, Indian Ocean High, mid-latitude frontal systems, barotropic and baroclinic systems over land areas and areas of any convergence…
    - This guidance will be filled out using a sheet that will be provided to the team and the same sheet will be filled out each day to create consistency within the guidance products/forecasts. **This sheet needs to be created by synoptic working group leads.**

Stage 5)

Time allocated to this stage: 1 hours

- The purpose of this stage is to produce an in-depth analysis of the Met Office deterministic and ensemble products for both the global and convection permitting simulations to produce a high impact weather forecast for your country. These forecasts should be for 1–3-hour timescales and for more small scales rather than forecasting for a whole country or regions within a country. This stage will also require a document/table to be filled out that can be used to not only produce an HIW forecast but can be used in stage 6) for the nowcasting briefing. **Sheet needs to be created by the synoptic working group leads.**

Stage 6)

Time allocated to this stage: 1 hour

- This stage is to produce a briefing for the nowcasting team. This briefing will be kept to a consistent format each day by filling out a table/document that will be provided which will be produced in collaboration with the nowcasting team so that we can guarantee we are providing them with the most relevant information they require. **Table/document needs creating in collaboration between the synoptic working group leads and the nowcasting working group leads.**

Stage 7)

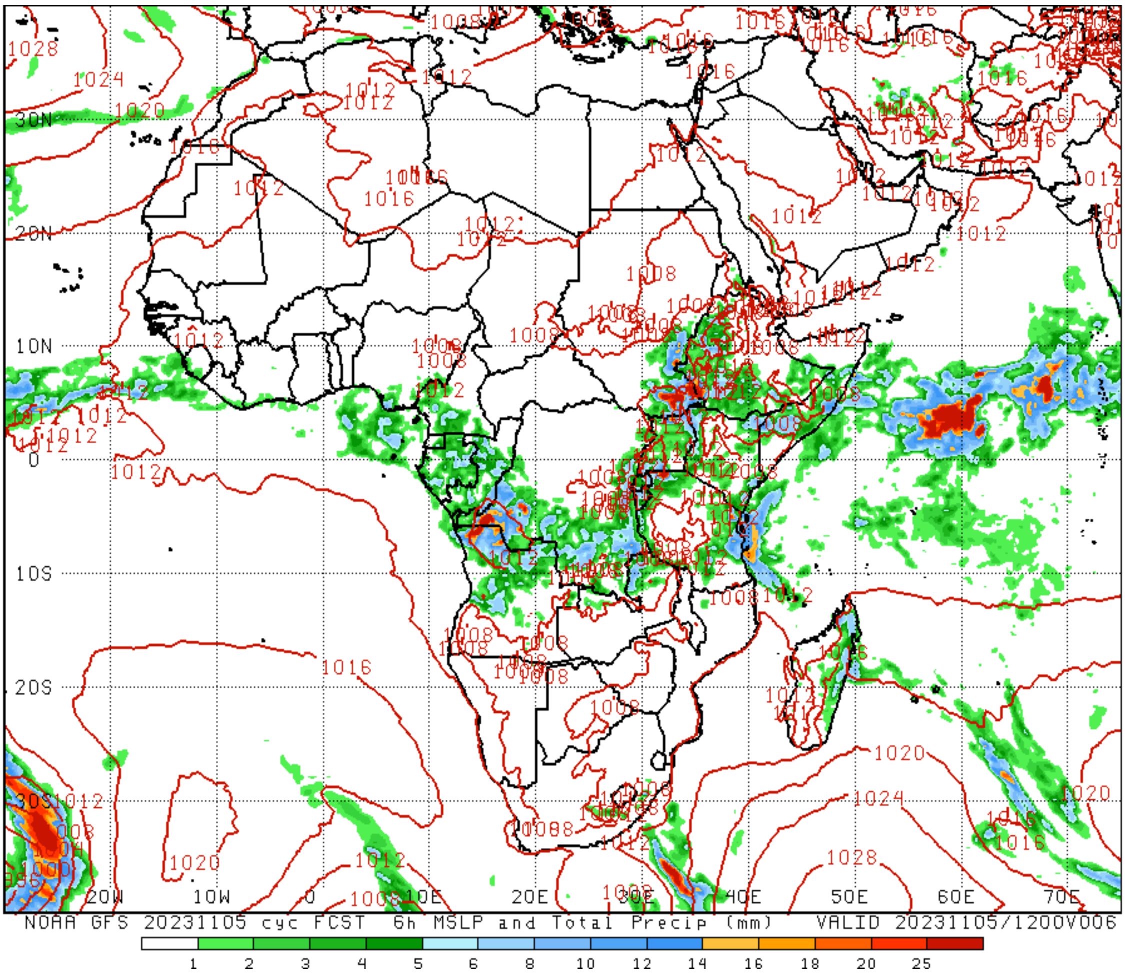
Time allocated to this stage: 1 hour

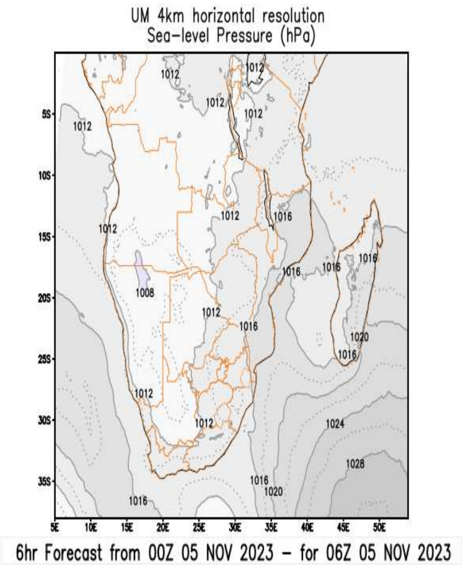
- Nowcasting briefing not all the synoptic team will participate in this. Anticipate that one or two people will give the briefing to the team. This briefing will go through the document created in Stage 6) and will allow time for the nowcasting team to ask questions.
- In the meantime, the rest of the synoptic team can finalise any documents that have been created and upload them to the testbed document repository.

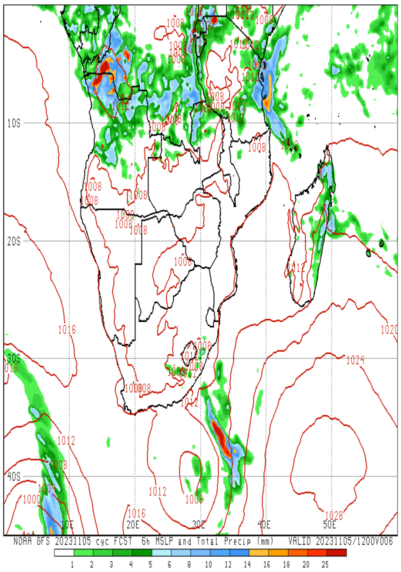
6. Outputs

   a) Synoptic Forecast for Pan-Africa and SADC Region Map

Synoptic maps auto generated to give a 72-hour forecast. They give an overview of the larger area synoptic situation (Pan-Africa) as well as the regional perspective (SADC region) to be generated. Maps are to be accompanied by risk tables. Below can be found an example of the type of image that might be generated as a synoptic outlook.







Countries	0–24hrs	24–48hrs	48–72hrs
Zambia:	Partly cloudy with scattered afternoon TS over central parts	Severe TS expected over the central parts	Partly cloudy with isolated TS
Include different regions of the country, if necessary.			
Mozambique	Partly cloudy becoming cloudy in the south with strong south-easterly winds	Cloudy with light rain over the southern parts	Rain spreading to the central parts of the country
Include different regions of the country, if necessary.			
South Africa	Partly cloudy with isolated TS in the north	Partly cloudy but cloudy in the northeast with rain along the escarpment	Cloudy in the east with light rain along the escarpment
Include different regions of the country, if necessary.			

Figure 2: Example of a dummy synoptic forecast map for Pan-Africa as well as SADC region

b) Synoptic forecast (in country)

Synoptic maps for each country (as well as SADC, if possible)

Regions	12-15hrs	15-18 hrs	18-21 hrs	21-24 hrs
Coastline	▪ partly cloudy	▪ misty morning ▪ cloudy ▪ cool night temperatures	▪ misty morning ▪ cloudy ▪ cool night temperatures	▪ cloudy ▪ cool night temperatures
Slightly north of the coastline	▪ cloudy	▪ mist/fog patches ▪ slight rain /drizzle ▪ cool night temperatures	▪ mist/fog patches ▪ cloudy ▪ cool night temperatures	▪ mist/fog patches ▪ slight rain /drizzle ▪ cool night temperatures
Middle	▪ cloudy	▪ slight rain/drizzle	▪ slight rain/drizzle	▪ partly cloudy
Transition	▪ partly cloudy	▪ misty morning ▪ partly cloudy	▪ partly cloudy	▪ slight rain/drizzle
North	▪ slight/moderate rain	▪ slight/moderate rain	▪ slight/moderate rain	▪ partly cloudy

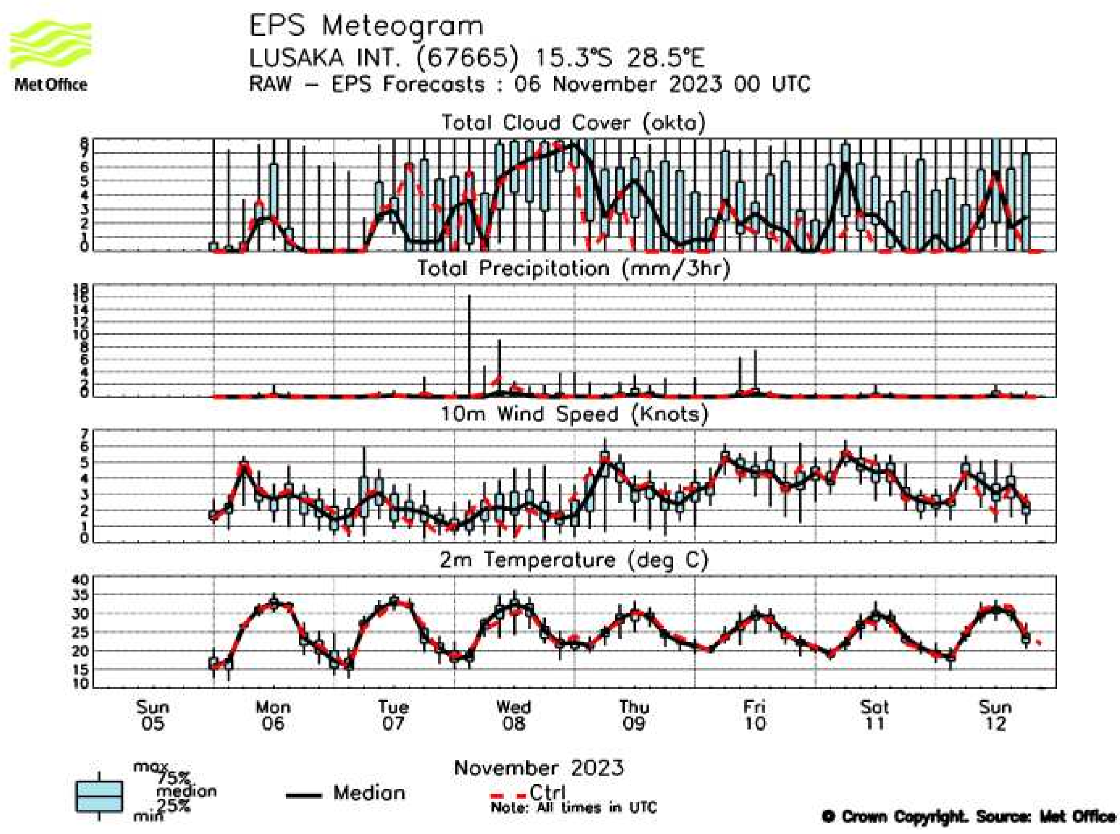


Figure 3: Example above is not a synoptic map, but it gives an indication of HIW areas (Met Office: EPS)

7. Impact Risk Matrix

Below is the risk matrix to produce risk maps and risk timelines. This risk matrix should allow synoptic forecast to give guidance to nowcasters on anticipated HIW.

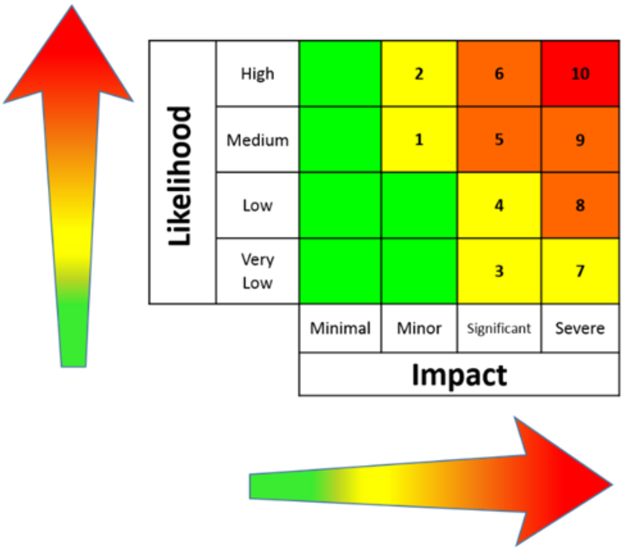


Figure 5. *Nowcasting risk matrix used to indicate what colours should be used in risk maps and risk timelines. Conditions that have very low likelihood of occurrence and low and very low impacts are to be uncoloured. Risk levels are then graduated from green to red based on both the likelihood and impact of an event. Alpha numeric values help to differentiate cells of the same colour.*

To understand the impact categories, definitions of the different impact levels are given below.

Very low – Little to no impact is expected; everyday activities continue uninterrupted.
Low – For most there is little impact associated with this category, weather might present an inconvenience to most and only interrupt weather-sensitive activities.
Medium – Interruption to daily activities is likely such as causing logistical problems and delays, but generally, only minor damage to property is expected.
High – Damage to property is likely and there is significant potential to cause harm to people.
Very high – Significant threat to life and property.

Appendix G: Nowcasting SOP

WISER-EWSA

Nowcasting Standard Operating Procedure

Testbed 1

1. PURPOSE

This document outlines the recommended procedures to produce nowcast warnings during Testbed 1 of the Weather and Climate Information Services (WISER) Early Warning for Southern Africa (EWSA) project. Multiple products, tools and methods are available for the testbed and this standard operating procedure outlines the recommended practices to produce valuable nowcast warnings during the testbed.

2. INTRODUCTION

The WISER-EWSA project, led by the National Centre for Atmospheric Science and University of Leeds, aims to transform access to weather early warning systems for communities in South Africa, Zambia, and Mozambique. Over the two-and-a-half-year period (2023–2025), the WISER-EWSA project will focus on providing weather information to socially disadvantaged urban populations to reduce the damage caused by storms. One of the project's main objectives will be to build capacity for nowcasting where the use of real-time satellite images and other tools are used to predict weather conditions over the next 0–6 hours. One of the outcomes to address the capacity development on nowcasting is the hosting of testbeds to evaluate current weather services and set up new services tailored to user needs. A dedicated nowcasting working group will form part of the testbed.

3. SCOPE

The aim of this document is to describe the steps that should be taken in the production of nowcasts from the nowcasting working group of the WISER-EWSA Testbed 1. The document outlines the necessary steps to produce a useful nowcast during a specific nowcast shift, ranging from a synoptic briefing to dissemination. Various methods will be utilized in the testbed ranging from Meteosat Second Generation (MSG) Satellite channels, RGB combinations thereof, Nowcasting Satellite Application Facility Software output, artificial intelligence methods, NFLICS, etc. This operating procedure describes the recommended steps to identify the 0–6-hour outlook as well as 0–2-hour risks of high impact weather elements, as well as the production of useful outputs that could be disseminated to the public and users by means of standard dissemination platforms.

4. PROCESS FLOW

Below is a flow diagram indicating the activities (left) and outputs (right) from the nowcasting operating procedure. The looped section of the flowchart is indicated as having a two-hour repeat frequency. However, it is planned that this frequency can be increased if weather conditions are rapidly developing and therefore require more updates/warnings to be made. Detailed descriptions of each of the steps in the flow diagram can be found in section 5.

Three main outputs are recommended, these are:

1) a longer-term (6–hour) outlook risk map,
2) a short-term (2–hour) risk map, and
3) two-hourly risk timelines for specific locations.

Examples of each of these can be found in section 6. Each of the outputs makes use of a common risk matrix to inform users of the current and future risk from high impact weather. The risk matrix can be found and explained in section 7. These outputs can then be assembled into a single page nowcasting summary with the expectation that such a summary should be published online or distributed to relevant stakeholders in near-real time (section 8). Alongside this, short written nowcast bulletins summarising the information contained in the one-page summary should also be produced to aid in communication through other dissemination methods, e.g. SMS/WhatsApp messaging, radio/TV alerts etc.

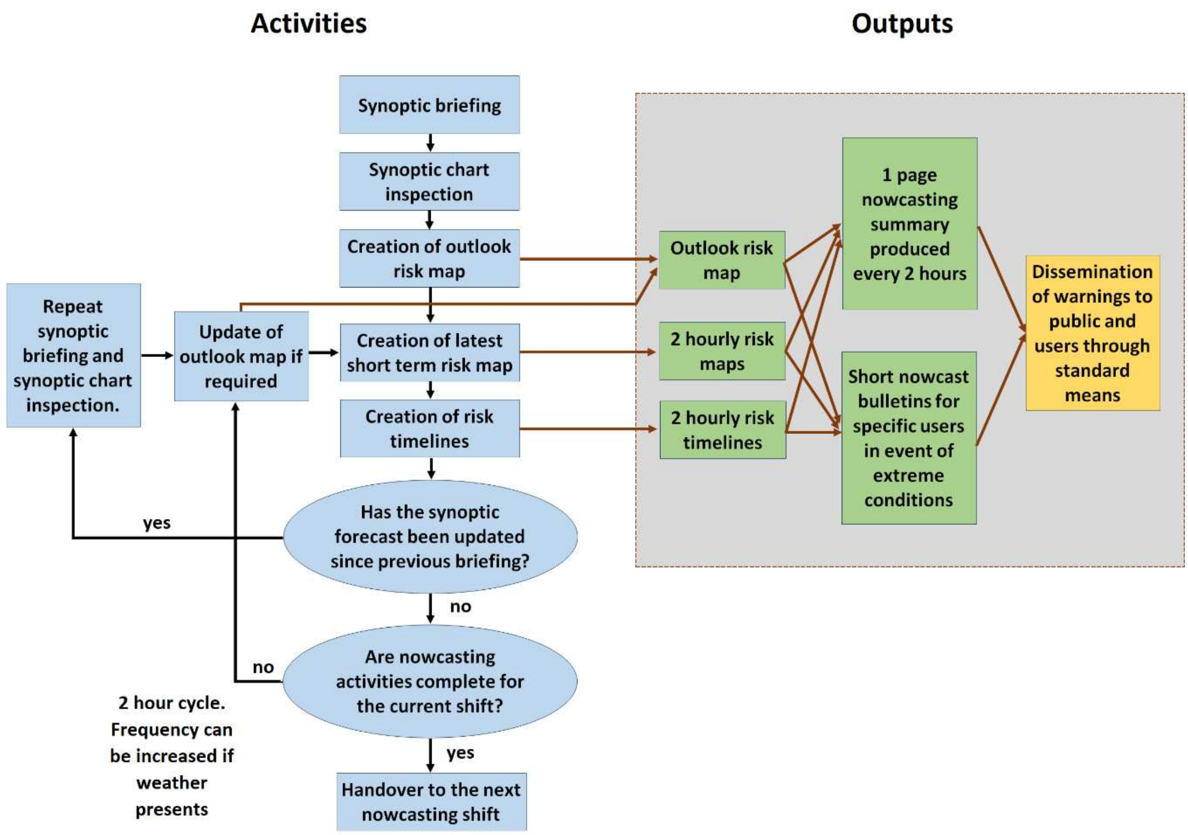


Figure 1: Flow diagram detailing the activities and outputs recommended for the operation of a nowcasting shift. Blue colours indicate activities to be undertaken to produce specific outputs (green colour). The yellow box indicates the final dummy dissemination of outputs to selected users. Although nowcasts will not be sent out to the public in the testbed, dummy SMSs, WhatsApp, et.c messages as well as TV and radio broadcasts of warnings could be considered.

5. DETAILED PROCEDURE

Steps	Activity	Timing	Tools	Responsibility
1	**Synoptic briefing.**	Start of nowcasting shift (H0)	AV presentation equipment.	Forecasters from the synoptic

	Attend a weather briefing provided by the synoptic working group from previous and/or current shift. Get information on the latest synoptic situation and how this is likely to influence extant or future storms. For example, the synoptic forecasters could focus on: ● Existing storms / high impact weather. ● Atmospheric moisture/instability. ● Vertical structure (jets shear). ● Predictions for extreme rainfall and winds. A single summary map (synthetic analysis) should be reviewed, displaying important weather features to cover the whole region (possibly several indicating changes over the period of the nowcasting shift). A presentation of the forecast should be given, and charts be handed over alongside a short-written forecast for the nowcast period (100–200 words).		Sufficient internet connectivity. Outputs from synoptic forecasting desk.	forecast desk to present information. Nowcasters from the nowcast desk to be informed of the current and predicted weather conditions for the next few hours.
2	**Synoptic chart inspection.** Inspect charts and written forecast from the synoptic working group detailing the current/short-term forecast. Identify regions with high impact weather predicted and further regions where high impact weather is likely/possible. Identify high value regions at risk from current and predicted weather.	H0	Plotted synthetic analysis charts. Written forecasts for the nowcast period.	Nowcasters are responsible for investigating the synoptic forecasts.
3	**Creation of outlook risk maps.** Using tools such as instability indices, forward extrapolation techniques, manual extrapolation methods, AI tools, and forecaster knowledge, indicate storm movement and growth predicted for the next six hours. ****Output**** **Create outlook risk map to cover the next six hours using colour coding from**	H0+1 H0+3 H0+5 H0+7 (Two-hourly iterations of	Plotted synthetic analysis charts. Written forecasts for the nowcast period. Key synoptic forecast products/imagery. Latest satellite-derived imagery (infrared channel, visible	Nowcasters are responsible for creating risk outlooks. Risk outlook maps should be updated if necessary for every iteration of the nowcasting cycle.

	risk awareness matrix. This forms the first panel of the nowcasting information sheet. Short text nowcasting outlook also to be produced. Icons to be used to indicate the nature of risk. This outlook risk map and accompanying text should be updated ready for issuance of nowcast summaries every two hours.	the nowcast cycle, however rapid cycling when conditions require should occur.)	channels, water vapor channels, NWCSAF, RGBs, Instability Indices, NFLICS, AI tools, and other available nowcasting tools).	
4	**Creation of short-term risk maps.** Identify weather features with connection to high impact weather that currently exist in the latest observations. Consider the relationship of current weather to synoptic scale forecast. Create a risk map of current weather conditions based on available data and nowcasting specific products. Using forward extrapolation tools available or manual extrapolation or AI tools, indicate the storm movement and growth predicted for the next two hours. Storms should be identified using an alphabetically assigned letter and referred to using their letter. This will ease communication about the location and predicted development and movement of storms. This short-term risk map and accompanying text should be updated ready for issuance of nowcast summaries every two hours. ****Output**** **Create risk map indicating near-real-time conditions and expected development in the next two hours using colour coding from risk awareness matrix. Short written nowcast also provided to indicate expected conditions at surface and detail nature of risks. Icons to be used to indicate nature of risk.**	H0+1 H0+3 H0+5 H0+7 (Two-hourly iterations of the nowcast cycle, however rapid cycling when conditions require should occur.)	Latest satellite-derived imagery (satellite channels, RGBs, NWCSAF, NFLICS, and other available nowcasting tools). Extrapolated imagery / extrapolation tools / AI tools. Tools to create risk map based on nowcasting imagery (e.g. national map of country of interest and tools to annotate map with risk regions). Risk awareness matrix template with associated risk levels and colour coding for ease of reference when producing risk maps.	Nowcasters are responsible for creating short-term risk maps. Risk maps should be updated for every iteration of the nowcasting cycle.

5	**Creation of risk timelines.** Key locations should be identified at the start of the nowcasting shift for which nowcasting timelines will be generated. These locations should be sufficiently important to justify nowcasting, be geographically limited and well defined. Locations for which risk timelines should be generated should also be based on local knowledge and be on the importance of the locations and the meteorological risk posed to it. Factors for site identification could include population density, vulnerability, and importance to nowcast clients. Create colour coded risk timelines for nowcast locations. The timelines should also identify the alphanumeric risk value from the accompanying risk matrix and should be entered into the timeline. This will enable users to differentiate between events with low likelihood but catastrophic consequences and moderate consequences that are very likely to occur. Timelines should be updated every two hours to be ready for issuance of nowcasting summary. The locations for which timelines are generated should change based on forecasters' assessment of short term and outlook risk. ****Output**** **Risk timelines for specific areas of risk. Locations should be identified in line with needs of users as well as value to the public. Numerous locations can be identified, and predictions of associated risk made on proximity and predicted development of storms.**	H0+1 H0+3 H0+5 H0+7 (Two-hourly iterations of the nowcast cycle, however rapid cycling when conditions require should occur.)	Latest satellite-derived imagery (satellite channels, RGBs, NWCSAF, NFLICS, and other available nowcasting tools). Extrapolated imagery / extrapolation tools / AI tools. List of high value/importance locations, locations of interest to nowcast users. Risk matrix template with associated risk levels and colour coding for ease of reference when producing risk maps. Output risk map from steps 3 & 4.	Nowcasters are responsible for the identification of important regions for which risk timelines should be generated. Once identified risk timelines should be produced every nowcast cycle.
6	**Production of nowcasting summaries.** Using the template provided, create two-hourly, one-page nowcasting information summaries. These should include:	H0+1 H0+3 H0+5 H0+7	Latest satellite-derived imagery (satellite channels, RGBs, NWCSAF, NFLICS, and other available nowcasting tools).	Nowcasters or nowcasting support staff who can assemble the constituent parts of the summary

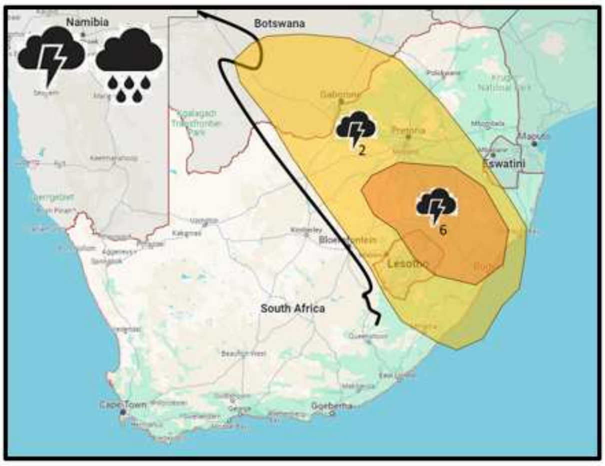
	● Outlook risk map to give a broad overview of expected risks over the next six hours. Brief written description of risks identified for this period (from step 3). Outlook should be updated for every two-hourly nowcasting summary, updates will likely be minor unless observations significantly diverge from synoptic forecast. As such this should be a quick job to perform. ● Short-term risk map with brief written nowcast for the next two hours (from step 4). This will give more detailed risk regions and give information on locations that will likely experience extreme weather in the very short term. This will be updated every two hours and cover the period from the last nowcast summary to the next. Production of detailed and up-to-date risk regions as well as analysis of latest nowcasting information will require fast working practices to complete in a timely fashion. ● Risk timelines for specific locations (from step 5). These should closely tie in with the short-term risk maps and be for locations that have high value (either nationally or for specific nowcast consumers) and are at risk. It might also be appropriate to issue updated information sheets earlier than the two-hourly schedule. This should be undertaken if there is a significant discrepancy between the predicted storm activity and observed storms. Well-predicted nowcast events (even if they pose very high risk) would not necessitate more rapid updates. ****Output**** **Nowcasting one-page summary. Issued every two hours (routinely) but at irregular intervals if high risk events dictate more frequent updates.** **Once produced this can also be distributed via methods appropriate to national meteorological services.**		Extrapolated imagery / extrapolation tools / AI tools. Output from steps 3, 4 & 5.	into a single document ready for dissemination.

7	**Production of nowcasting bulletins.** In case of severe weather that requires proactive dissemination of warnings these should be issued through the appropriate channels. Channels for warnings to be distributed should be in line with existing methods for national weather services to spread weather warnings as long as this does not incur a significant delay. Delay to nowcast warnings prevents them being useful as they cannot be acted upon. Examples of this include the issuance of warnings via national/local media (TV and radio), phone calls to specific users/stakeholders (air traffic control, agricultural co-operatives, disaster relief etc.) and SMS or WhatsApp messaging. ****Output**** **Short informative warnings to be generated and issued to participating users in the testbed through appropriate channels in cases of high risk / high likelihood situations.**	Throughout nowcast shift.	Nowcasting information sheets. Nowcasting products. Methods of warning dissemination to both the public and key users (these might be specific to both national met services and individual nowcast consumers).	Nowcasters are responsible for the writing of short bulletins ready for distribution to users participating in the testbed. Distribution should be through existing channels for weather warning dissemination.

6. OUTPUTS

a) Outlook Risk Map

Outlook risk maps should be generated at the beginning of each nowcasting shift and should be updated as required during the course of the iterative nowcast period (as detailed in step 3 of section 5 and the flow diagram in section 4). Below can be found an example of the type of image that might be generated as an outlook risk map for South Africa. Regions that might be at risk within the next six hours should be highlighted with the appropriate risk level colouring obtained from the Risk Matrix. Appropriate weather symbols should also be used to communicate the nature of the predicted risks. This should be produced with reference to both the current weather situation obtained from nowcasting products and the forecast information provided by the synoptic forecast desk. Alongside the outlook risk map a brief text outlook should be produced. This serves to elaborate on conditions by which regions are most likely to be affected and in what way.



6 hr Outlook

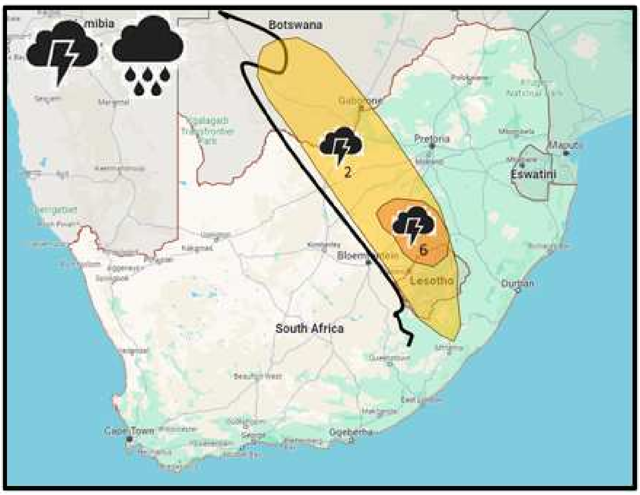
Region	South Africa
Date	2023-11-14
Time	09:00
Data	IR10.8-IR12.0 ; KI, LI, PW instability indices ; Synoptic outlook ; Unified Model rainfall, hail, lightning, instability forecasts ; NFLICS

Level 2 warning for thunderstorms over the central parts of South Africa and a Level 2 warning for thunderstorms over parts of Free State, KZN and southern Gauteng. A dryline is situated over central SA with thunderstorm development expected east of the dryline. Moderate instability is observed over the central parts of the country and high instability over parts of the Free State, KZN and southern Gauteng. Model forecasts also confirm significant weather in these areas. Thunderstorms are expected to develop along the dryline and to propagate eastwards over the next 6 hours with minor to significant impact.

Figure 2: Example of a dummy outlook map for South Africa for the next six hours from issue time. Example reflects how a system and associated risk will propagate in time over a six-hour period.

b) Nowcast risk map

New nowcast risk maps should be generated as part of every iteration of the nowcast period. Conditions (especially those associated with convective storms) are likely to develop significantly in a two-hour window necessitating the production of new risk maps. Nowcast risk maps should indicate risk for the next two hours and be based on the information gathered from nowcasting products as well as the general synoptic situation. The format of the nowcasting risk map remains the same as the outlook risk map including the use of a risk colour scale and appropriate weather symbols. This is to aid in interpretation by nowcast users and to help make the generation of the suite of nowcast outputs easier. Similarly, a short written two-hour nowcast should also be prepared alongside the nowcast risk map. This serves to elaborate on conditions by which regions are most likely to be affected and in what way. It is also likely that such a written nowcast should be able to be issued as a warning (without an accompanying map) without significant modification. This will enable a wider range of routes of dissemination to nowcast users and the public if required (via radio, SMS or any other voice or text only media).



2 hr Nowcast Risk

Region	South Africa
Date	2023-11-14
Time	11:00
Data	Satellite channels ; RGB's ; RDT ; CI ; CRR ; DWD ; KI, LI, PW ; Unified Model

Level 2 warning for thunderstorms over the central parts of South Africa and a Level 2 warning for thunderstorms over parts of Free State. Convection has started to initiate along the dryline over the central parts of South Africa and is expected to develop into isolated thunderstorms with minimal impact over the region in yellow. A rapidly developing storm with high rainfall rates and cold cloud tops is observed northeast of Bloemfontein and is expected to produce significant impact over area in orange in the next hour.

Figure 3: Example of a dummy nowcast risk map for South Africa for the next two hours from issue time. Note the period for predictions is significantly shorter than the outlook risk map and risk regions are more detailed (associated with higher degree of certainty).

c) Timelines

The production of risk timelines is an important step in the nowcasting workflow. These timelines enable information to be provided about the risks presented to specific locations on nowcasting timescales. The meteorological risk should be ascertained with reference to the risk matrix (section 7), and the appropriate alphanumeric code entered each of the timeline panels (as shown below). The first sections indicate 30-minute risk windows (time labelled on table) with the outlook panel being representative of T+4 to T+6-hour time. It is expected that a nowcaster on shift will be able to make decisions about which locations require timelines to be generated and therefore prioritise the locations for which the greatest risk is posed. However, prior to nowcasting operations beginning, it is important to consider locations of interest and produce a list of locations for which nowcast timelines could be generated. Below is a list of criteria that should be considered during the shortlisting process.

1. Locations should be geographically limited (it should not be so broad that use and evaluation of nowcasts is meaningless, e.g. a city and its surrounding suburbs/territory is a good choice while wide, poorly defined regions should be avoided).
2. Locations should be "high value". This could be due to population density, infrastructure, or importance to specific users etc.
3. For each location it is important to consider what would constitute high impact weather. It is possible that this might change depending on the specifics of how a nowcast might be used or the time of year. For example, sensitivity for heavy rainfall for one sector might be significantly different for a different user in the same area. Also, when there has been little rain previously, light but persistent rain is not likely to pose a risk, however in a city that has recently flooded any additional rain might trigger further inundations.
4. While not a requirement for nowcasting, it would be advantageous in the long term if locations had a good observation network (such as rain gauges, weather stations, weather observers that reliably report etc.). This will aid in evaluation work and over time will provide evidence to help improve the production of impact-based nowcasts.

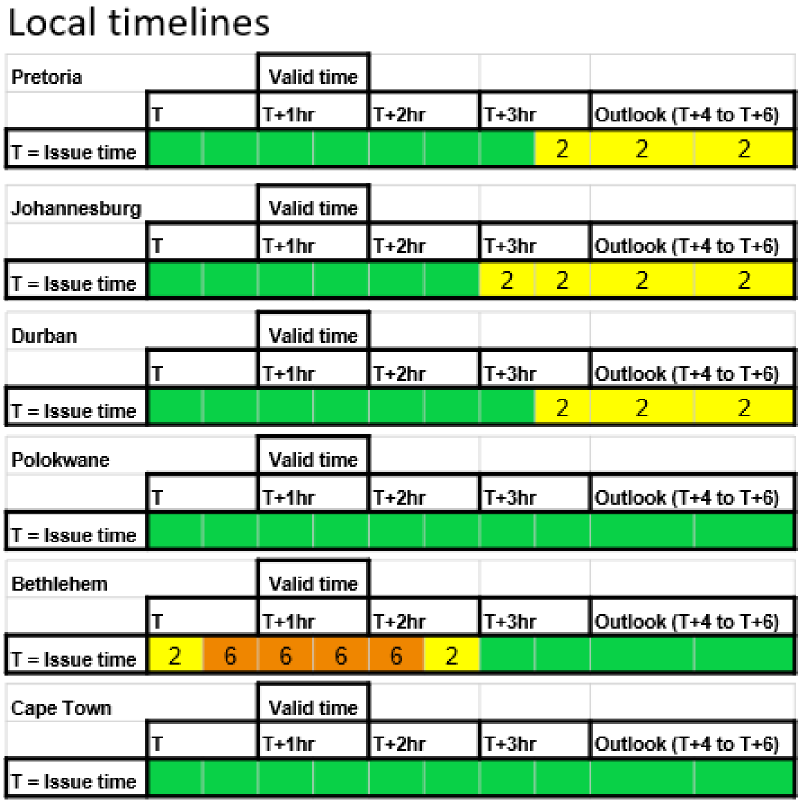


Figure 4. *Example of risk timelines produced for the same time as Figures 2 and 3 for specific locations. Each location has weather risk indicated in 30-minute increments out to four hours and two one-hour outlook increments to a maximum period of six hours. Numeric values in risk timeline cells are in reference to the impact risk matrix shown in Figure 5.*

7. RISK MATRIX

Below is the risk matrix to produce risk maps and risk timelines. This risk matrix should allow nowcasters to decide on the appropriate risk level for a given situation. In the case of risk timelines, it has been decided to include an alphanumeric marker that corresponds to each of the cells in the risk matrix. This will enable users to understand the difference between the different types of warning with the same colour scheme. To understand this, we must consider that the action taken by a user might vary considerably if there is a very high likelihood of a low-impact event compared with a low likelihood of a very high-impact event. For example, we would expect users to behave very differently to predictions of almost certain light rain compared to being on the edge of a tropical cyclone track. One of these predictions requires little to no mitigating action (maybe take an umbrella) while the other requires plans to be made in the event that the unlikely but very high-impact event does occur.

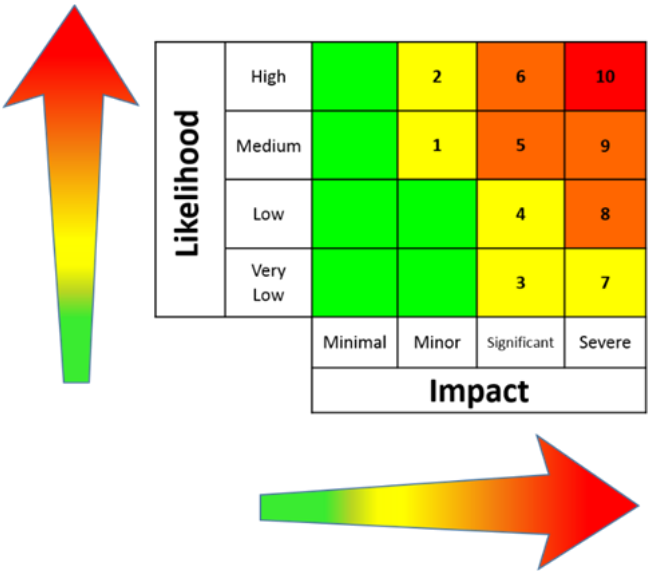


Figure 5. *Nowcasting risk matrix used to indicate what colours should be used in risk maps and risk timelines. Conditions that have very low likelihood of occurrence and low and very low impacts are to be uncoloured. Risk levels are then graduated from green to red based on both the likelihood and impact of an event. Alpha numeric values help to differentiate cells of the same colour.*

To understand the impact categories from Figure 5, an accompanying Impact Table should be developed for each country. An Impact Table provides a detailed discussion on the various impacts that may result from adverse weather conditions. It specifically defines the impacts associated with the minimal, minor, significant, and severe categories in Figure 5. It should be noted that Impact Table should be produced with Disaster Managers in each of the countries, and this is a lengthy process to achieve relevant information. Annexture A shows the impact-based forecasting table for severe thunderstorms that is in use by SAWS. This table was developed with Disaster Management in South Africa over a period of months.

8. NOWCASTING INFORMATION SHEET

Below can be found an example of a nowcasting one-pager. This assembles the individual parts detailed above into a single document. It is expected that this can be issued every two hours as part of the routine nowcasting operations and distributed to users. For specific nowcast customers (e.g. from a specific sector) a tailor-made product could be produced which takes into account their region of interest, level of vulnerability and the nature of meteorological risks faced. However, it is likely much information from a standard operational nowcast could be used in more tailored products, especially the more general parts of the information sheets such as the six-hour outlook.

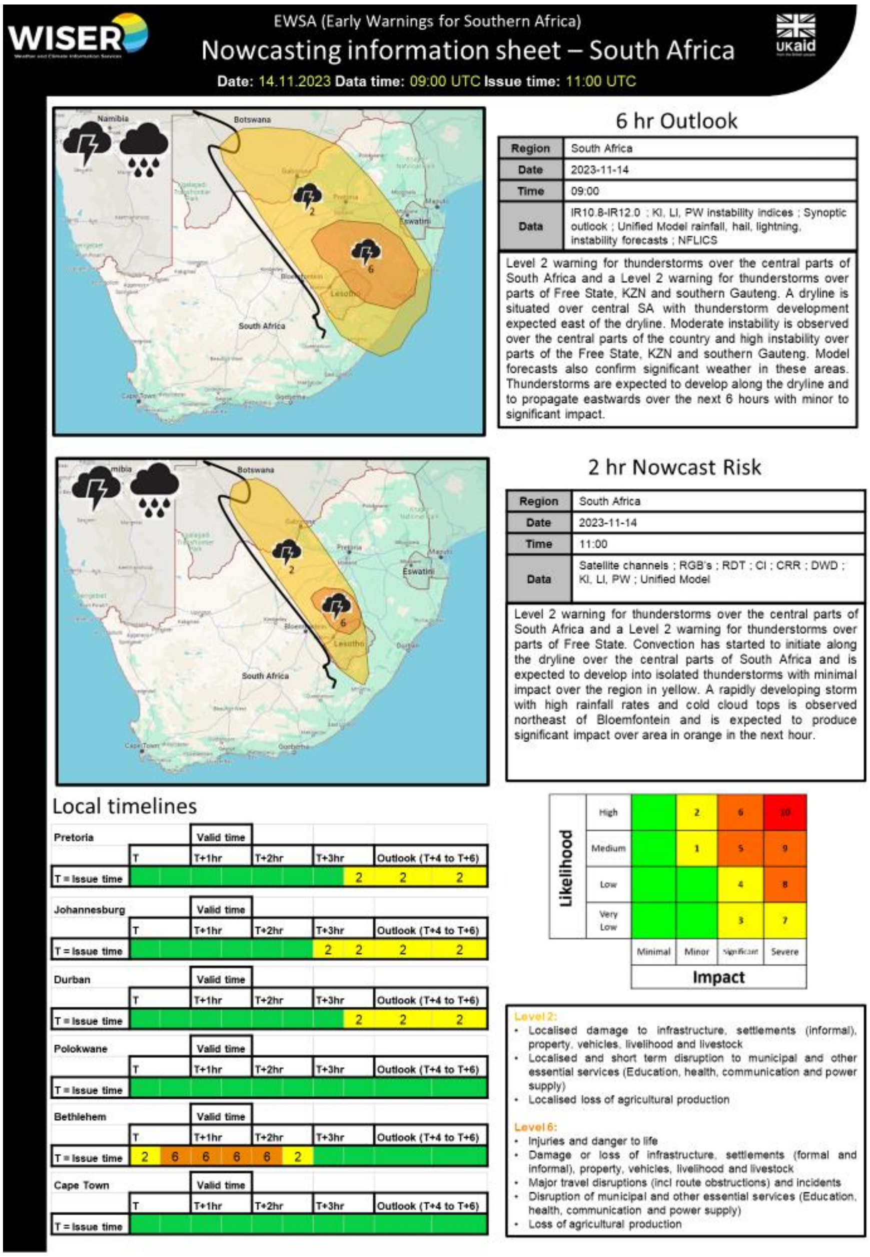


Figure 6. Example of nowcasting information sheet. A combination of outputs generated from nowcasting activities into a single easy to digest sheet. Rapid production of such sheets will enable nowcasting warnings to be disseminated to users in a timely manner in an easy to digest format.

9. TIMETABLE

Figure 7 below shows the envisaged schedule for the synoptic and nowcasting shifts during testbed 1. Three nowcasting shifts will be performed in a day. Shift 1 from 06:00–14:00; Shift 2 from 14:00–22:00; and Shift 3 from 22:00–05:00. There will be a nowcasting briefing and handover at 06:00, 14:00, and 22:00.

Schedule of forecasting (Synoptic and Nowcasting) and Evaluation										
Time	Evaluation	Synoptic	Nowcasting I	Nowcasting II	Nowcasting III	Briefings	Issuing forecasts	Kanyama hub	Community observers?	
6:00 am						Nowcasting III brief				
7:00 am							N2			
8:00 am								Weather Report	Weather Report	
9:00 am						Synoptic briefing	N2	Weathe discussion		Daily all-testbed meeting
10:00 am								Weathe discussion		
11:00 am							N2			
12:00 pm										
1:00 pm							N6			
2:00 pm						Nowcasting I handover briefing				
3:00 pm						Synoptic review & NWC briefing	N2			
4:00 pm							SYNOPTIC			
5:00 pm							N2			
6:00 pm									Weather Report	
7:00 pm							N2			
8:00 pm										
9:00 pm							N6		Weather Report	
10:00 pm						Nowcasting II handover briefing				
11:00 pm							N2			
12:00 am										
1:00 am							N2			
2:00 am										
3:00 am							N2			
4:00 am										
5:00 am							N6			
Should all the Nowcasting shifts produce both the 6-hour outlook and 2-hourly updates?										
N6	6-hour NWC									
N2	2-hour NWC									

Figure 7. Envisaged schedule for the nowcasting shift and activities during Testbed 1.

10. WEBSITE

During Testbed 1, the WISER-EWSA website will be utilized to access different products to be used in the testbed. Most products will be aimed to be loaded to this single site for ease of access. The WISER-EWSA website is a clone of the SAWS RSMC website with some adaptation for WISER-EWSA.

URL: TBC

Username: TBC

Password: TBC

Figure 8 depicts the header of the current WISER-EWSA website cloned from the SAWS RSMC website where all the products for Testbed 1 are envisaged to be uploaded.

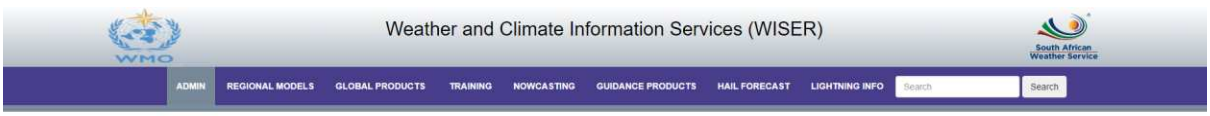


Figure 8. Header of the current WISER-EWSA website for products and services.

11. Appendix A: SAWS Impact Table Example

Impact-Based Forecasting: SEVERE THUNDERSTORMS Impact Table

South African Weather Service

Minimal	Minor	Significant	Severe
Business as usual	Business as usual	Short term strain on emergency personnel	Prolonged strain on emergency personnel
General (applicable also to flooding, wind and hail)	General (applicable also to flooding, wind and hail): • Localised damage to infrastructure, settlements (informal), property, vehicles, livelihood and livestock • Localised and short term disruption to municipal and other essential services (Education, health, communication and power supply) • Localised loss of agricultural production	General (applicable also to flooding, wind and hail): • Injuries and danger to life • Damage or loss of infrastructure, settlements (formal and informal), property, vehicles, livelihood and livestock • Major travel disruptions (incl route obstructions) and incidents • Disruption of municipal and other essential services (Education, health, communication and power supply) • Loss of agricultural production	General (applicable also to flooding, wind and hail): • Injuries and danger to life • Widespread damage or loss of infrastructure, property, vehicles, livelihood and livestock • Widespread major travel disruptions (incl route obstructions) and incidents • Widespread disruption of municipal and other essential services (Education, health, communication and power supply) • Widespread loss of agricultural production
Flooding: • Some Pooling of water on roads- resulting in minimal traffic route disruption • Day to day activities not disturbed	Flooding: • Localised flooding of susceptible roads, low-lying areas and bridges • Minor vehicle accidents	Flooding: • Flooding of roads, settlements and low-lying areas, resulting in closure of some bridges and roads • Displacement of affected communities • Danger to life (fast flowing streams / deep water)	Flooding: • Widespread flooding of low-lying areas, resulting in closure of some bridges and major roads • Widespread displacement of affected communities • Danger to life (fast flowing streams / deep water)
Hail: • No hail or small amount of small hail	Hail: • Large amounts of small hail over an open area • Large hail over an open area • Localised damage to vehicles • Localised structural damage (homes, car ports etc)	Hail: • Large amounts of small hail over a populated area • Large hail over a populated area • Damage to vehicles • Structural damage (homes, car ports etc)	Hail: • Large amounts of small hail over a widespread, populated area • Large hail over a widespread, populated area • Widespread damage to vehicles • Widespread structural damage (homes, car ports etc)
Winds: • Day to day activities not disturbed	Winds: • Localised damage to settlements over an open area • Falling trees blocking minor roads • Localised injuries due to flying debris	Winds: • Damage to settlements or structures over a populated area (urban or rural villages) • Falling trees blocking major roads • Injuries due to flying debris	Winds: • Tornado observed and confirmed over populated area • Widespread damage to settlements or structures over a populated area (urban or rural villages) • Widespread injuries due to flying debris
Lightning: • Day to day activities not disturbed	Lightning: • Localised fire incidents (dwelling/veld fire)	Lightning: • Fire incidents (dwelling/veld fire)	Lightning: • Widespread fire (dwelling/veld fire)

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	• Localised service disruption due to power surges/disruptions • Localised injuries (humans and livestock) and localised damage to property	• Disruption of services due to power surges/disruptions • Danger to life (humans and livestock) and damage to property	• Widespread, prolonged service disruption due to power surges/disruptions • Danger to life (humans and livestock) and damage to property over a widespread area

12. Appendix B: Zambia Nowcasting Information Sheet Template

WISER

EWSA (Early Warnings for Southern Africa)

Nowcasting information sheet - Zambia

UKaid

Date: dd.mm.yyyy **Data time:** time of most recent image UTC **Issue time:** ???? UTC

6 hr Outlook

Region	Zambia
Date	Provide date
Time	Provide time
Data	Provide sources of data used for outlook

Description of outlook

2 hr Nowcast Risk

Region	Zambia
Date	Provide date
Time	Provide time
Data	Provide sources of data used for outlook

Description of nowcast risk

Local timelines

Location 1		Valid time			
	T	T+1hr	T+2hr	T+3hr	Outlook (T+4 to T+6)
T = Issue time					

Location 2		Valid time			
	T	T+1hr	T+2hr	T+3hr	Outlook (T+4 to T+6)
T = Issue time					

Location 3		Valid time			
	T	T+1hr	T+2hr	T+3hr	Outlook (T+4 to T+6)
T = Issue time					

Location 4		Valid time			
	T	T+1hr	T+2hr	T+3hr	Outlook (T+4 to T+6)
T = Issue time					

Location 5		Valid time			
	T	T+1hr	T+2hr	T+3hr	Outlook (T+4 to T+6)
T = Issue time					

Location 6		Valid time			
	T	T+1hr	T+2hr	T+3hr	Outlook (T+4 to T+6)
T = Issue time					

Likelihood					
	High		2	6	10
	Medium		1	5	9
	Low			4	8
	Very Low			3	7
		Minimal	Minor	Significant	Severe
		Impact			

Provide details of relevant impact/s here from Impact Table for easy reference (E.g. Level 8 impact)

- Widespread flooding of low-lying areas, resulting in closure of some bridges and major roads
- Widespread displacement of affected communities
- Danger to life (fast flowing streams / deep water)

13. Appendix C: Mozambique Nowcasting Information Sheet Template

WISER

EWSA (Early Warnings for Southern Africa)

Nowcasting information sheet - Mozambique

UKaid

Date: dd.mm.yyyy **Data time:** time of most recent image UTC **Issue time:** ???? UTC

6 hr Outlook

Region	Mozambique
Date	Provide date
Time	Provide time
Data	Provide sources of data used for outlook

Description of outlook

2 hr Nowcast Risk

Region	Mozambique
Date	Provide date
Time	Provide time
Data	Provide sources of data used for outlook

Description of nowcast risk

Local timelines

Location 1		Valid time			
	T	T+1hr	T+2hr	T+3hr	Outlook (T+4 to T+6)
T = Issue time					

Location 2		Valid time			
	T	T+1hr	T+2hr	T+3hr	Outlook (T+4 to T+6)
T = Issue time					

Location 3		Valid time			
	T	T+1hr	T+2hr	T+3hr	Outlook (T+4 to T+6)
T = Issue time					

Location 4		Valid time			
	T	T+1hr	T+2hr	T+3hr	Outlook (T+4 to T+6)
T = Issue time					

Location 5		Valid time			
	T	T+1hr	T+2hr	T+3hr	Outlook (T+4 to T+6)
T = Issue time					

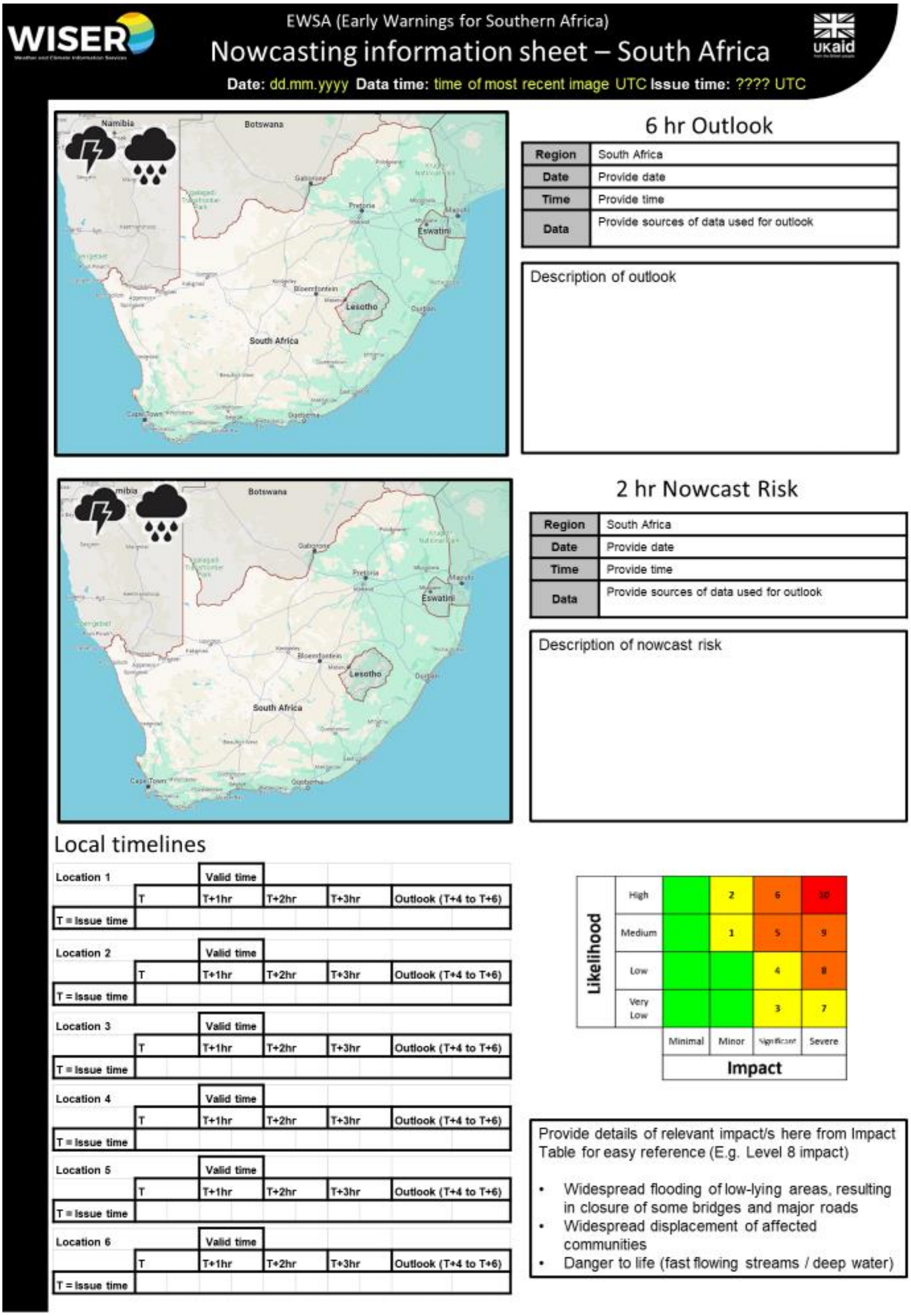
Likelihood	Minimal	Minor	Significant	Severe
High		2	6	10
Medium		1	5	9
Low			4	8
Very Low			3	7

Impact

Provide details of relevant impact/s here from Impact Table for easy reference (E.g. Level 8 impact)

- Widespread flooding of low-lying areas, resulting in closure of some bridges and major roads
- Widespread displacement of affected communities
- Danger to life (fast flowing streams / deep water)

14. Appendix D: South Africa Nowcasting Information Sheet Template



WISER

EWSA (Early Warnings for Southern Africa)

Nowcasting information sheet – South Africa

UKaid

Date: dd.mm.yyyy **Data time:** time of most recent image UTC **Issue time:** ???? UTC

6 hr Outlook

Region	South Africa
Date	Provide date
Time	Provide time
Data	Provide sources of data used for outlook

Description of outlook

2 hr Nowcast Risk

Region	South Africa
Date	Provide date
Time	Provide time
Data	Provide sources of data used for outlook

Description of nowcast risk

Local timelines

Location 1		Valid time			
	T	T+1hr	T+2hr	T+3hr	Outlook (T+4 to T+6)
T = Issue time					

Location 2		Valid time			
	T	T+1hr	T+2hr	T+3hr	Outlook (T+4 to T+6)
T = Issue time					

Location 3		Valid time			
	T	T+1hr	T+2hr	T+3hr	Outlook (T+4 to T+6)
T = Issue time					

Location 4		Valid time			
	T	T+1hr	T+2hr	T+3hr	Outlook (T+4 to T+6)
T = Issue time					

Location 5		Valid time			
	T	T+1hr	T+2hr	T+3hr	Outlook (T+4 to T+6)
T = Issue time					

Location 6		Valid time			
	T	T+1hr	T+2hr	T+3hr	Outlook (T+4 to T+6)
T = Issue time					

Likelihood	Minimal	Minor	Significant	Severe
High		2	6	10
Medium		1	5	9
Low			4	8
Very Low			3	7

Impact

Provide details of relevant impact/s here from Impact Table for easy reference (E.g. Level 8 impact)

- Widespread flooding of low-lying areas, resulting in closure of some bridges and major roads
- Widespread displacement of affected communities
- Danger to life (fast flowing streams / deep water)

Acknowledgements
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