D.10 Regional Action Plans

Provision of a scoping study to assess the current landscape of early warning and Impact-based Forecast initiatives across Africa

May 2026

Table of Contents

List of Abbreviations

ACMAD	African Centre of Meteorological Applications for Development
AGRHYMET	Regional Centre for Agriculture, Hydrology and Meteorology
AI	Artificial Intelligence
AIFS	Artificial Intelligence Forecasting System (ECMWF)
AMHEWAS	African Multi-Hazard Early Warning and Action System
ANAM	Agence Nationale de la Météorologie (Burkina Faso)
AR6	Sixth Assessment Report (of IPCC)
AUC	African Union Commission
CAP	Common Alerting Protocol
CAPC-AC	Centre for Climate Prediction and Applications for Central Africa
CHIRPS e	Climate Hazards Group InfraRed Precipitation with Station data
CREWS	Climate Risk and Early Warning Systems
Delft FEWS	Delft Flood Early Warning System
DMN	Direction de la Météorologie Nationale
DRM	Disaster Risk Management
ECMWF	European Centre for Medium-Range Weather Forecasts
ESA	European Space Agency
EWS	Early Warning System
EWSA	Early Warning System for Southern Africa
FEWS Net	Famine Early Warning Systems Network
FFGS	Flash Flood Guidance System
GFS	Global Forecast System
GHACOF	Greater Horn of Africa Climate Outlook Forum
GHSL	Global Human Settlement Layer
HPC	High-Performance Computing
ICPAC	IGAD Climate Prediction and Applications Centre
IFS	Integrated Forecasting System
IGEBU	Institut Géographique du Burundi
IMERG	Integrated Multi-satellitE Retrievals for GPM
IOC	Indian Ocean Commission
IPCC	Intergovernmental Panel on Climate Change
JRC	Joint Research Centre
KMD	Kenya Meteorological Department
LAM	Limited Area Model
LMS	Liberia Meteorological Service
ML	Machine Learning
NWP	Numerical Weather Prediction
PRESAC	Prévisions Saisonnières en Afrique Centrale
PRESASS	Prévisions Saisonnières en Afrique Sub-Saharienne
SADC	Southern African Development Community
SADC-CSC	SADC Climate Services Centre
SARCOF	Southern Africa Regional Climate Outlook Forum
SARFFGS	Southern Africa Flash Flood Guidance System
SAWS	South African Weather Service
SDS-WAS	Sand and Dust Storm Warning Advisory and Assessment System
SEWA	Strengthening Early Warning in Africa

SPAM	Spatial Production Allocation Model
SWFP	Severe Weather Forecasting Programme
WIMES	Water Information Management Ecosystem and Services
WIS	WMO Information System
WISER	Weather and Climate Information Services
WMO	World Meteorological Organization
WRF	Weather Research and Forecasting model
ZMD	Zimbabwe Meteorological Department

1. Introduction

In this document, we present Regional Action Plans for *West Africa*, *East Africa, Central Africa and Southern Africa*, bringing together the findings of all work packages undertaken as part of the *"SEWA scoping study to assess the current landscape of early warning and Impact-based Forecast initiatives across Africa"*. The Action Plans are intended to support ECMWF in defining the scope of the upcoming call for proposals on *Regional Pilots*, which aim to co-develop Impact-based Forecast (IbF) demonstration tools and services at a regional level in sub-Saharan Africa. Further, it suggests complementary actions for follow-up/scale-up.

Please note that the hazards included in SEWA and this study are the following: droughts & dry spells, dust storms, flash floods, heatwaves, riverine floods, thunderstorms, tropical cyclones, wildfires & smoke. Unless stated explicitly, we refer to these hazards when we talk about hazards as a group.

The report opens with the hazard focus for each region, followed by a reverse assessment that identifies, for each hazard, the regions in which it may be of interest. It then turns to challenges and gaps that are continent-wide rather than region-specific, and in some cases global in scope. The final part returns to the individual regions, setting out region-specific gaps, challenges and a regional action plan for each.

Note on inventory counts

All project counts cited in this document are taken directly from the D.2 reference catalogue. Continental projects are not included in regional counts: they would otherwise be double counted across all four regions. Counts of projects by hazard may exceed regional totals because most projects address multiple hazards.

1.1 Deliverables

In the report, references are made to earlier Deliverables. The table below shows the number of the deliverables and the name of the deliverables. This report refers then to e.g. D.3.

Deliverable number	Title
1	Stakeholder engagement plan
2	Reference Catalogue of Reviewed Initiatives and Documents
3	Synthesis Summary of Literature Review and Mapping
4	User Requirements Database (URDB)
5	Data catalogue
6	Interactive Map or Dashboard
7	Stakeholder influence vs priority matrix
8	Narrative storylines
9	Hazard Prioritisation summary
10	Regional Action plans
11	Visual Summaries
12	Reflection Chapter
13	Final Report
14	Risk Register
15	Inception Report

2. Hazard focus

2.1 Bias / uncertainty

The hazard focus should be seen as informed but also temporary. We highlight five main uncertainties:

1. The stakeholders involved. Most input comes from NMHSs, RCCs, RBO and RSMCs. While they have strong forecasting expertise, other groups, like disaster agencies, ministries (health, agriculture), or humanitarian actors might rank hazards differently.
2. Hazard footprint. Hazards vary in how widely they occur and how they are forecasted. Some cover large areas (like cyclones, heatwaves or droughts), while others are very local (like flash floods, wildfires or thunderstorms) and may cause serious damage in one place but not appear significant at the national level used here.
3. The hazard list. The exercise uses SEWA's predefined hazards (see Introduction). This keeps things manageable but limits results, since hazards outside the list cannot be included.
4. Literature. The review is extensive and designed to be as comprehensive as possible, while recognising that some perspectives may not be fully represented.
5. Timing. Recent events influence perceptions, ongoing floods, droughts, or heatwaves can raise a hazard's priority, while less recent risks may be overlooked. For example, landslides were highlighted repeatedly in East Africa.

Overall, the results reflect the situation at the time of the study and could shift if repeated under different conditions, although they are unlikely to change fundamentally.

2.2 Summary: proposed focus hazards per region

This section summarises the proposed focus hazards for the four regions. This is based on three lines of evidence: the data-driven hazard scoring in D.9, the literature review findings in D.3, and stakeholder rankings and discussions during the four regional workshops. It is explained further in the respective chapters where the action plans for the regions are addressed.

West Africa. Droughts & dry spells and riverine floods are the two leading focus hazards, ranked in the top three across all evidence sources, with the Sahel as the drought core area. Heatwaves and flash floods complete the list: although they scored lower in D.9, both were rated highly important by workshop participants (e.g. the deadly April 2024 Sahel heatwave) and D.3 projects strong future intensification. Although dust storms are not amongst the four hazards that were prioritised, they are flagged as a complementary pilot component, given the disconnect between low stakeholder awareness and well-documented health impacts in the Sahel meningitis belt.

East Africa. The focus hazards are droughts & dry spells, flash floods and riverine floods, all in the top three across D.9, D.3 and the workshops. Drought dominates the regional EWS landscape, shaped by the 2011, 2017 and 2021–2022 events, with 51 of 88 projects targeting it. Flash floods (particularly in urban areas) tied with droughts at the top of the individual workshop ranking, although they are underrepresented in the project portfolio (only 4 of 88 projects reference them explicitly). Riverine floods are widely covered (57 of 88 projects). Although not amongst the focus hazards proposed, it is worth mentioning that heatwaves stand out as an emerging concern with limited dedicated EWS capacity. Landslides (outside the SEWA hazard set) were strongly raised as a cascading hazard and are proposed as a complementary pilot component.

Central Africa. Riverine floods, flash floods, thunderstorms and droughts & dry spells are the focus hazards. Riverine floods score very highly in both D.9 and the workshop, where their transboundary character and political visibility drive very high interest; this is the most flood-dominated hazard profile of any SEWA region (11 of 32 projects address flooding alone). Flash floods follow, with very high prevalence and impact in densely populated cities such as Kinshasa, Bujumbura and Douala. Thunderstorms were placed in the top three by workshop participants, who pointed to their high prevalence (especially around the lake area) and high cascading impacts (floods, landslides). They rank relatively low in D.9, but this discrepancy recurs in West and Southern Africa as well and most likely reflects underrepresentation of thunderstorms in global risk datasets, where their effects are captured under cascading hazards such as flash floods rather than attributed to the thunderstorms themselves. The stakeholder ranking is therefore considered the more reliable signal for this hazard. Drought is included as it ranks second in D.9 and is recognised in D.3 as relevant across multiple Central African contexts, although weakly reflected as a dedicated EWS focus outside multi-hazard programmes.

Southern Africa. Tropical cyclones, flash floods, droughts & dry spells and thunderstorms are the focus hazards. Tropical cyclones are essentially a Southern Africa & Indian Ocean hazard, with very high impacts on Mozambique, Madagascar and Mauritius and cascading effects reaching Zimbabwe, Malawi and Zambia; D.3 highlights further intensification. Flash floods came first in the individual workshop ranking, with very high prevalence and impact, although stakeholders deliberately rated interest as only medium given the role of local action and citizen behaviour. Drought ranks first in D.9 under both unweighted and population-weighted scoring (the only SEWA region where it tops the quantitative ranking) and is identified in the cascading-hazard analysis as a core driver of compounding events (drought; heatwave; wildfire). It did not appear in the stakeholders' top three (cyclones, flash floods, thunderstorms), and workshop interest was rated high rather than very high. Thunderstorms are included based on high stakeholder-reported prevalence and impact, despite low D.9 scores, a pattern also seen in West and Central Africa, likely reflecting underrepresentation in global risk datasets. Although not included in the hazards proposed above, heatwaves stand out as an emerging concern with limited dedicated EWS capacity, and riverine floods, while highly prevalent, were felt as being already adequately addressed through established basin systems (Zambezi, Cuvelai, Songwe).

2.3 Reverse hazard-region mapping

This section inverts the SEWA hazard prioritisation: instead of identifying the most relevant hazards per region, it identifies the most relevant regions per hazard. For each of the eight SEWA priority hazards, the three regions with the strongest case are discussed, drawing on the D.9 quantitative ranking, stakeholder priorities expressed during the four regional workshops, the regional hazard profiles in D.3, and project counts from the D.2 reference catalogue.

Summary tables

Table 1 summarises the three regions where the case for addressing each hazard is strongest.

Table 1: Top three regions per hazard.

Hazard	Most relevant	Second	Third
1. Droughts and dry spells	West Africa	East Africa	Southern Africa
2. Dust storms	West Africa	East Africa	Southern Africa
3. Flash floods	East Africa	Central Africa	West Africa
4. Riverine floods	Central Africa	West Africa	East Africa

Hazard	Most relevant	Second	Third
5. Tropical cyclones	Southern Africa	East Africa	
6. Thunderstorms	Central Africa	West Africa	Southern Africa
7. Wildfires and smoke	Southern Africa	Central Africa	West Africa
8. Heatwaves	West Africa	Southern Africa	East Africa

Droughts and dry spells are most relevant in West, East and Southern Africa. In West Africa the hazard ranks first in both the D.9 quantitative analysis and the stakeholder consultations, with the Sahel as its core area; 38 of the 63 projects in the region (about 60%) list drought as a focus hazard, and IPCC AR6 projects multi-year droughts intensifying in the western Sahel. In East Africa, recurring multi-year droughts in the Horn of Africa and persistent food security crises pushed the hazard to the top of the stakeholder ranking; 51 of the 88 projects in the region mention drought, the highest absolute count of any region, and the hazard sits at the centre of the drought–heatwave–wildfire interaction cluster identified in D.9. In Southern Africa, drought again ranks first in the D.9 analysis and is mentioned in 44 of 68 projects, reflecting its central role in regional food security, particularly maize production.

Dust storms have a strong case only in West Africa, where high D.9 prevalence in the Sahel coincides with the African meningitis belt. ACMAD operates a Meningitis Early Warning System (covering parts of East Africa as well) that combines dust, temperature and humidity forecasts with a lead time of about two weeks during the dry season; D.2 contains two projects in West Africa that explicitly list dust storms. Outside West Africa the evidence is much thinner. In East Africa, stakeholders ranked the hazard moderately in the workshop, and D.3 notes that dust and air-quality hazards are increasingly recognised in national multi-hazard frameworks across the region; D.2, however, contains no East African projects that explicitly list dust storms. In Southern Africa only Namibia flagged the hazard, and workshop participants described it mainly as a local nuisance. Central Africa shows no signal in either the project inventory or the workshop ranking. However, it should be noted that dust only prevails in some of the countries in the respective regions.

Flash floods are a top stakeholder priority across East, Central and West Africa, driven in all three regions by similar dynamics: dense urban and peri-urban exposure, intense convective rainfall, and limited drainage capacity, dynamics that climate projections (D.3) indicate will intensify across all SEWA regions. In East Africa, stakeholders ranked flash floods very high in the workshop and selected the hazard as the regional storyline. In Central Africa, stakeholders likewise ranked it very high, reflecting strong urban EWS demand in flood-prone cities such as Kinshasa, Bujumbura and Douala. In West Africa, flash floods topped the workshop ranking, with major reported impacts on infrastructure and livelihoods. In D.2, flash floods are explicitly listed in relatively few projects (9 in West, 4 in East, 4 in Central, 3 in Southern Africa); this likely reflects that flash flooding is typically addressed under broader flood or urban-resilience programmes rather than as a stand-alone hazard.

Riverine flooding ranks high across Central, East and West Africa in the D.9 analysis. In Central Africa, the hazard ranks first in D.9 and was selected as the regional storyline; 16 of 27 Central Africa projects in D.2 mention it. West Africa shows a strong concentration of flood-related investment, with 51 of 63 projects (about 80%) listing riverine flooding, reflecting major exposure in the Niger and Volta basins. In East Africa, lake basins and seasonal river systems drive widespread exposure and the region records the highest absolute project count (57 of 88); however, workshop stakeholders placed riverine flooding third, behind flash floods and drought, indicating that the hazard remains operationally important even where attention is competing with faster-onset events.

Tropical cyclones are essentially a Southern Africa & Indian Ocean hazard within the SEWA scope. Southern African stakeholders rated cyclones their top priority, with Mozambique, Madagascar and Mauritius directly affected and cascading impacts reaching inland into Zimbabwe, Malawi and Zambia, including cascading hazards such as flash and riverine floods and thunderstorms. The D.2 catalogue records 12 projects in Southern Africa mentioning cyclones, the highest count of any region. East Africa's Indian Ocean coast sees occasional but limited exposure, with stakeholders assigning it medium relevance. In West and Central Africa, the hazard is not operationally relevant.

Thunderstorms are broadly relevant across all four SEWA regions, but stakeholders consistently mentioned them in a third position out of eight in Central and Southern Africa. The D.2 catalogue records 13 projects in West Africa mentioning thunderstorms, and convective systems are intensifying under climate change. Southern Africa similarly places thunderstorms third, with high regional prevalence and impact on lives.

Wildfires & smoke have the strongest stakeholder profile in Southern Africa, where workshop participants reported frequent fires across Zimbabwe, Namibia, Botswana and South Africa, with transboundary fires and impacts on property, livelihoods and downstream economic activity. D.2 records two projects in Southern Africa with wildfires & smoke explicitly listed, and none in the other three regions; this likely reflects that wildfire warning typically falls under environmental or forestry mandates rather than national hydrometeorological services. In Central Africa, wildfires rank second in the D.9 analysis despite featuring less prominently in stakeholder discussions, reflecting strong fire activity in savanna and forest-edge zones. In West Africa, wildfires rank third in the D.9 ranking and form part of the drought–heatwave–wildfire interaction cluster identified in D.9, even though stakeholders did not raise the hazard prominently in the workshop. During the online validation workshop on the 15th of April 2026, it was noted that the high D.9 prevalence of wildfires & smoke may be somewhat misleading: wildfires are local events often happening in remote areas, yet, when aggregated to national and regional scales, they may appear to have a national or regional impact, which is not the case according to the stakeholders.

Heatwaves are emerging as a forward-looking priority, particularly in West Africa. The April 2024 Sahel heatwave caused widespread mortality, and the IPCC AR6 projects rapid growth in extreme heat exposure across West Africa. Heat-related early warning systems, however, remain significantly less developed than those for drought and floods: D.2 records only four West Africa projects that mention heatwaves. In East Africa, D.9 identifies heatwaves as part of the drought–heatwave–wildfire interaction cluster, and the region has the largest number of projects mentioning the hazard (25 of 88); stakeholders rated heatwaves as moderately to highly relevant, noting impacts on agriculture and the energy sector. In Southern Africa, stakeholders flagged high regional prevalence and clear linkages to drought, although the project base remains thin. Across the three regions, heatwave EWS development consistently lags the rising exposure indicated by climate projections.

3. Continental findings

3.1 Training and capacity building

This section describes the structure of training and capacity building provision in Africa, the main gaps in training continuity and depth, and the training needs for IbF. Staffing shortages and staff retention are closely related but are discussed as a human capacity gap in Section 3.2.

Structure of training provision. D.12 concluded that across Africa training is predominantly project-funded, meaning continuity depends on the renewal of external support cycles. By contrast, ICPAC's Training Academy in East Africa is a good example of a permanent regional training academy not present in other regions. In addition, there are the WMO Regional Training Centres (in Niger, Nigeria, Kenya, Cameroon, South Africa and Cairo) each with a different offer for meteorological training (see D.2 for more details).

Training depth and continuity. Participants in the workshops reported that training delivered within projects is often too short and not embedded in long-term capacity development programs. When participants receive only a few days or weeks of training and have insufficient time for skills development, it is difficult to apply the skills in their daily work afterwards.

"I do not like training of 2-3 days, you only receive information, but you are not really trained. You need to deepen and further develop your knowledge." – Participant at West Africa workshop

A second continuity issue is that each project tends to introduce new software, tools or methods rather than building on earlier training. This fragments the skill base and prevents cumulative capacity development across projects.

IbF-specific training needs. Beyond foundational forecasting and IT skills, stakeholders identified a set of IbF-specific training needs that are currently poorly covered by existing provision. These include how to integrate vulnerability and exposure data into forecasting workflows, GIS-based risk assessment, risk analysis, risk communication, and the development of IbF methodologies. Cutting across all of these is a need for stronger data management capacity: it is beneficial to provide training on how to collect data, add metadata, maintain datasets over time, and share data effectively across institutions.

Back-end IT and operational procedures. During stakeholder interviews and regional workshops, two further topics emerged as critical to the success of the pilots: training on the back-end IT components of the systems and on operational procedures for working with IbF systems. Both are typically underserved by standard forecasting training but are essential for operation and maintenance once the pilot ends. D.12 specifically flags training on server administration, virtual machines, FTP servers and network configuration as topics that are often neglected in forecasting training.

3.2 Critical gaps

This section presents the critical gaps identified in Africa regarding early warning and IbF. Gaps are distinguished from challenges: gaps describe what is missing, while Section 3.3 discusses the structural and institutional challenges that make these gaps hard to close.

The gaps are grouped into five categories, presented in order of relevance for SEWA. The first three fall within SEWA's direct scope, while the last two are adjacent topics that are relevant for pilot sustainability but largely outside SEWA's mandate:

1. Gaps in monitoring and forecasting
2. Gaps in IT infrastructure

3. Gaps in human capacity
4. Gaps in policy and governance (adjacent)
5. Gaps in warning dissemination and communication (adjacent)

Many of these gaps stem from the project-based funding model behind EWS development in the region. While this funding helps build new capacity, it often leads to fragmented training, neglected infrastructure after projects end, and outputs that are not integrated into formal systems. The gaps listed below are therefore not separate problems, but recurring effects of how EWS efforts are funded and carried out.

Gaps in monitoring and forecasting

Gaps around monitoring and forecasting were raised consistently by workshop participants and are reflected in D.3 and the User Requirements Database (D.4). Most prominent are gaps in monitoring networks, forecasting capabilities and physical forecasting skill constraints per hazard.

Monitoring networks. This need for improved monitoring networks and their maintenance is expressed by all workshop participants and is also reflected in D.3, and the User Requirements Database (D.4). Budget and capacity for station maintenance are a persistent issue, which is outside SEWA's scope, but the issue should not be forgotten when designing the pilot.

"The main challenge is the observation network, we lack coverage and need more stations." – Workshop participant, SODEXAM (Côte d'Ivoire)

"Namibia has hydro-met stations across the country. The system is called Chales and HYCOS. Challenges are funding, human capacity and vandalism." – Workshop participant, Ministry of Agriculture, Water & Land Reform (Namibia)

"Our station network is very limited. Stations were installed in a project, but after the project, the maintenance was a problem." - Workshop participant , Liberia Met Service (Liberia)

"The spatial coverage of weather stations is a challenge, due to malfunctioning and a general lack of stations." – Workshop participant, METTELSAT (DRC)

These views are echoed in D.4, where about 20 stakeholders call for improvement of the monitoring network. D.4 also shows broad interest in automating processes, from data processing and forecasting workflows to quality control and alert dissemination.

Forecasting capabilities. Most African NMHSs rely on externally produced global forecasts (ECMWF IFS, GFS, UK Met Office, Meteo France) rather than using global forecast models as boundary conditions to run regional models locally. Also, those running their own NWP models frequently mention NWP (or forecasting) strengthening as high priority. It is worth noting that the ClimSA programme has supported all four African RCCs with 31 decision-support tools and institutionalised Standard Operating Procedures, tested at SARCOF-27 (D.12). D.12 also mentions that that RCC platforms in general share only visualisations rather than forecasting data, which limits NMHSs to post-process and tailor the products.

Physical forecasting skill constraints per hazard. Forecasting skill constraints vary per hazard and the most prominent are summarized below.

- **Convective systems, related to thunderstorms and flash floods.** Convective systems produce short-lived, highly localised extremes that are fundamentally difficult to predict accurately in space and time, even with the best models (D.3, citing Burton et al. 2022). As these convective systems are related to both thunderstorms and flash floods, these hazards are strongly related to the forecasting skill of convective systems.

- **Seasonal-to-trigger translation for drought.** Seasonal outlooks are inherently probabilistic, and there is a lack of understanding on how best to convert seasonal forecast information into binary yes/no anticipatory-action triggers. (D.3, citing FEWS NET).
- **Wildfires & smoke.** Skill is limited because these depend on non-meteorological drivers such as vegetation dryness and ignition conditions (D.3).
- **Heatwaves.** D.3 notes that forecast skill is generally higher than for rainfall, but operational warning remains constrained by limited use of heat-health thresholds, suggesting the gap for heat lies on the operational side rather than in forecasting skill itself.
- **Dust forecasting.** Constrained by uncertainty in emissions and atmospheric transport processes (D.3, citing WMO SDS-WAS).
- **Tropical cyclones**. Track and intensity prediction remain physical skill gaps (D.3).
- **Rainfall after landfall**. Cyclone-related rainfall extremes interacting with mountainous inland areas are difficult to predict accurately in space and time (D.3).

Gaps in IT infrastructure

National dissemination and CAP alerting platforms. Most NMHSs in the region operate platforms for disseminating forecasts and issuing warnings. It is good to note that ClimWeb is by far the most widely deployed: live instances are (according to https://climtech.africa/climweb/) operational at the NMHSs of 32 countries and 8 still in development. ClimWeb provides a standardised website template, a CAP-alert composer, satellite product visualisation, an interactive map viewer, and integrates with WIS2Box for international data exchange. Nevertheless, while ClimWeb has been widely adopted, gaps in IT infrastructure remain and were raised by many stakeholders in both the workshop and the interviews captured in D.4 and align with findings in the Pathways to Sustainability chapter (D.12). Five components stand out.

"We do not have organised IT infrastructure. This year we wanted to build a website, and it was a hydromet engineer, having to do that besides his regular work." – Workshop participant

Computing capacity. Across all four SEWA regions, inadequate computing capacity is a direct constraint on forecasting services: national HPC is rarely sufficient for high-resolution NWP or AI/ML workflows, and cloud platforms offer a partial solution but are limited by bandwidth, recurring costs and data-sovereignty rules (D.4; D.12).

Power, connectivity and operational resilience. Across all four African regions, NMHSs, river basin organisations and regional centres record stable electricity, reliable internet and operational backup as high-priority URDB needs. D.12 documents a concrete set of recurring IT issues that apply across the continent: insufficient internet bandwidth, frequent power outages leading to server unavailability, overheating and server crashes, Windows licence problems, limited cybersecurity implementation, and difficulties setting up basic IT components such as FTP servers and reverse proxies. The following quotes from the workshop illustrate this point:

"During the cyclone, Zimbabwe was not able to provide early warning as supposed. There was no electricity, no generator, no dissemination. Impact was huge." – Workshop participant, Department of Meteorological Services (Zimbabwe) (Forensic Evidence session on Cyclone Freddy)

"Interrupted internet and electricity mean our model runs are interrupted. WRF-GFS and WRF-IFS take two days; WRF-CFS takes a week. We lack infrastructure to run our models on a supercomputer." – Workshop participant, CAPC-AC

Data storage, backup, and archiving. NMHSs on the continent require secure storage and digital archives with redundancy and retention policies to preserve historical meteorological and environmental datasets. Weak archiving directly affects IbF, since impact thresholds, model calibration and AI/ML applications all depend on reliable access to long historical records.

Data format and tool interoperability. Participants noted that data arrives in a range of different formats, which makes integration difficult. In Côte d'Ivoire, this was cited as a reason for moving away from PUMA2025 to an alternative system. It was recognised that handling a variety of data formats is a skill that is necessary for some forecasters to develop, whether or not it should be their primary role. Pilot projects should consider that chances of uptake are higher when adapted to data formats stakeholders are used to, and that easing the burden of data processing frees forecasters to concentrate on producing high quality forecasts and warnings.

Cloud hosting as a partial solution. Cloud-based solutions, including the European Weather Cloud (EWC), are considered in D.12 for SEWA pilots because they can relieve pressure on local HPC, power, and bandwidth, and provide data-proximate computing. However, workshop participants flagged limited experience and recurring costs as a concern. D.12 also makes clear that cloud hosting does not by itself close the gap: national data-storage legislation sometimes blocks the use of international cloud facilities, recurrent subscription costs (around EUR 700 to 1500 per month for commercial providers), latency to data centres in North America or Europe, and the continued need for local technical expertise remain bottlenecks. For comparison, the labour cost for an IT expert within an NMHS is around 1000 Euro / month (please note that this will vary from country to country, so should be considered as an indicative figure). A hybrid hosting approach, combined with partnerships with local IT consultants, is likely the most realistic pathway for sustainable EWS and IbF pilots on the continent. At the end of this document, the development of an African Weather Cloud is suggested too.

Gaps in human capacity

Training-related human capacity gaps, including training depth, continuity, and IbF-specific skills, are discussed in Section 3.1. This subsection focuses on two remaining gaps that are largely outside SEWA's direct control but must be factored into the pilot design: absolute staffing shortages and staff retention.

Absolute staffing shortages. Across all four African regions, NMHSs, river basin commissions and regional centres record absolute staffing shortages as a high-priority URDB need. 17 stakeholders mentioned this in the URDB or during the workshops. D.12 documents a region-wide RCC pattern of significant staffing shortages that limit the ability to absorb new technologies and sustain operational activities. This pattern applies directly to all four SEWA regional climate centres (CAPC-AC, ICPAC, AGRHYMET, SADC-CSC) and ACMAD regardless of being in demonstration or operational mode.

"There is a lack of staff members, given the number of systems that we have. We were in a benchmarking visit in Kenya, they have 400 people for the same responsibility […] In Burkina Faso there are 50 people from which half of them are admin." – Workshop participant, ANAM (Burkina Faso)

"Within SADC one expert is responsible for everything. Personnel challenges with IT expertise are a major constraint." – Workshop participant, SADC-CSC

"Our main challenge is a lack of staff. There is just one person who handles all forecasting in the office."- Workshop participant, HYDRO (Ghana)

Staff retention. Staff trained within projects frequently leave for further education or other jobs. IT staff who receive training on back-end server components and IT infrastructure often leave organisations after projects are finished, because general IT skills are in demand in various organisations across disciplines. Education and capacity building pose a further challenge: with no local meteorology programmes available in some countries, staff must be trained abroad, strengthening long-term capability at the cost of short-term availability.

Gaps in policy and governance (adjacent)

Although policy and governance are not directly within SEWA's scope, they have implications for pilot design and sustainability. Three governance gaps stand out.

Government commitment and budget allocation. Participants expressed a lack of government commitment and budget allocation for weather and climate services, which limits the sustainability of projects once external funding ends. The following quote illustrates that monitoring gaps are often a governance and budget issue rather than a technical one:

"We have manual and automatic hydrological monitoring stations, 176 stations all over Ghana and only 3% are automatic. We pay people to read the manual stations, but because payments are not regular, the data is also irregular. Sometimes people are making up the numbers; because the payment is only 50 cedis per month." - Workshop participant, HYDRO, (Ghana)

Participants suggested that the AUC could use SEWA as an opportunity to lobby national governments for stronger commitments and budgets, since this is often difficult for national institutions themselves. D.12 notes that NMHSs rarely engage directly with ministers, whereas the AUC has established mechanisms for ministerial dialogue through existing policy frameworks.

Data and standards. Participants across all workshops noted that data-sharing arrangements and interoperability standards remain a gap, with countries and basin organisations working with incompatible formats and without clear rules on what can be shared, with whom, and under what conditions.

Mandates and formal embedding. Governance was raised in similar terms: mandates between NMHSs, RCCs, DRM agencies and sector ministries are not consistently defined, and SOPs for joint operation are often absent. ACMAD needs a continental governance framework defining roles and SOPs across NMHSs, DRM agencies, sector ministries and humanitarian actors (D.7). These could be considered recommendations for AUC activities under SEWA and links also to the goals and the ongoing implementation of AMHEWAS. On the other hand, D.12 also highlights the that within the AMHEWAS framework national warning mandates need to be respected and sharing visualizations (not data) limits the post-processing possibilities on a national level.

"A recommendation is to harmonise the data, countries use the same format and make data open for the benefit of all" – Workshop participant, SADC-CSC.

Pilot-to-operations gap. There is a persistent pattern of pilots not transitioning into sustained operations. This is partly a funding issue (no operational budget after the pilot closes), partly an institutional issue (ownership of the system unclear), and partly a technical issue (systems built for demonstration rather than long-term operation). Finally, the integration of pilots into national or institutional policies is key to make them become part of day-to-day operations.

Gaps in warning dissemination and communication (adjacent)

Dissemination is outside SEWA's scope, but many participants noted that the dissemination and communication of warnings are often missing from system designs, which limits the effectiveness of the developed systems.

Around 18 stakeholders from the continent asked for improved dissemination, as a priority requirement in the URDB. A lack of trust in warnings (something than could be improved within SEWA) was also listed as a gap, illustrated by the following quote:

> *"The warning was given by the ministry of environment and local leaders, but people did not respond. The people did not respond because previous warnings were false alarms. Also, the people did not want to leave their houses." – Workshop participant, Meteo Benin (Benin)*

For the EWS system itself, it was noted that for national organisations it can be challenging to use output generated by other entities.

> *"Flash Flood Forecasting by Nile Basin Initiative NELSAP uses MIKE-HYDRO forced with GFS. They are only giving hydrographs as output, which makes the outcomes hard to validate. It would be better to run the forecasts ourselves." – Workshop participant, Ministry of Energy & Water Resources (Somalia)*

3.3 Challenges

This section presents the structural and institutional challenges that should be considered when attempting to close the gaps identified in Section 3.2.

Challenges in inter-institutional collaboration

Effective EWS and IbF depend on collaboration across multiple layers: continental bodies (AUC, ACMAD), regional centres, NMHSs, hydrological services, river basin organisations (RBOs), disaster management agencies, and downstream actors such as humanitarian organisations and sector ministries. Coordination gaps appear at each of these layers.

Collaboration between countries. Two structural features complicate collaboration between countries. Africa spans anglophone, lusophone and francophone countries, as well as many other languages, which affects the accessibility of training materials, dashboards and technical documentation, and requires regional platforms and RCCs to operate effectively in several languages. This is a gap that could be addressed through the usage of appropriate machine/automated translation. Second, collaboration between countries is sometimes limited for political reasons and/or limited by lack of willingness to share data internationally. Finally, many cross-border activities are project-based and stop when funding ends. A workshop participant asked:

> *"Why do we not make relationships beyond projects? Share data with other countries to support research."*

Cross-border cooperation is a priority in all the regions, because of shared basins and transboundary climate dynamics.

Cross-sectoral collaboration. D.7's stakeholder matrix adds that DRM authorities face multi-agency coordination challenges, need clear SOPs (Standard Operating Procedures) and CONOPS (Concept of Operations), and are constrained by limited integration of hazard data into operational decisions. Humanitarian actors face fragmented data-sharing platforms and coordination gaps in joint response planning. For IbF specifically, cross-sectoral collaboration with impact sectors such as agriculture, transport, health, and energy is essential for defining impact thresholds and risk information, but this collaboration is currently ad hoc rather than institutionalised. This is also visible between meteorology and hydrology:

> *"A problem in Burkina Faso is that meteo and hydro are separated. The SAPCI system is at hydro, the FFGS is run at meteo." – Workshop participant, ANAM (Burkina Faso)*

“Hydrology is done by Rwanda Hydrology Unit (accessing the viewer and realtime stations), so there is no information about flood forecasting at Meteo Rwanda.” – Workshop participant, Meteo Rwanda (Rwanda)

Comparable institutional challenges exist for other hazards, though less explicitly documented: for drought, coordination is anchored in regional seasonal outlook forums — PRESASS (West Africa), PRESAC (Central Africa), GHACOF (East Africa) and SARCOF (Southern Africa) but cross-sectoral links to agriculture, water and energy remain ad hoc; for heatwaves, there is no formal mandate or heat-health threshold framework linking NMHSs to health authorities; for dust storms, coordination sits within the specialised WMO SDS-WAS framework rather than regional EWS structures. D.7 notes that cross-sectoral collaboration with impact sectors is currently ad hoc rather than institutionalised.

Collaboration between national and regional level institutions. RCCs and continental bodies have high technical influence regionally but limited formal authority nationally. This may create a mandate overlap with NMHSs, especially on warning issuance (D.7). Regional products are often too coarse for national use, and AMHEWAS/RCC platforms share only visualisations rather than processable forecast data, limiting NMHSs' ability to tailor outputs (D.12; workshops) or feed information upward from the national level to inform regional and continental stakeholders.

Project-based initiatives. Project-based support, while essential for funding new capacity, creates structural challenges for sustainability. Four mechanisms drive this pattern: new often systems are introduced per project rather than building on earlier ones; training is project-funded and discontinues after a project ends; stations fall into disrepair once Operation & Maintenance funding ends and project outputs are rarely embedded in formal frameworks. D.12 recommends introducing Continuous Improvement (CI) as a way of working in the SEWA pilots to mitigate this.

3.4 Exposure and vulnerability data

For an overview of available exposure and vulnerability datasets, we refer to D.5. Open global and continental datasets such as WorldPop, JRC GHSL and ESA WorldCover are available, alongside some national and local datasets (D.5). For IbF, these datasets are technically suitable as exposure inputs but capture exposure (where people and assets are) better than vulnerability (how susceptible they are). They can also become outdated in rapidly changing contexts such as expanding urban and informal settlements (D.3). In general, however, the regions make limited use of these data in operational workflows. Where exposure and vulnerability datasets are used in the region, they appear most often in project-based risk mapping and resilience studies rather than as maintained layers embedded in routinely updated operational EWS workflows (D.3). This also means that these data layers, when they exist, are often not made available beyond the specific project or study for which they were produced. IbF would benefit from localized and sectoral datasets. Global layers describe where people and assets are, but not how the assets in each sector incur damage under a given hazard. For a successful IbF sectoral information that includes exposure and vulnerability on people and their assets (DRM and humanitarian aid), transportation and logistics (infrastructure, traffic density, supply routes), Agriculture and food security (crop types, crop maturity, crop yield), water supply, public health, Energy (utilities, yield) is needed. Workshop participants and D.4 indicate limited access to impact data, severity thresholds, and IbF skills as the primary barriers, rather than the absence of hazard forecasts.

3.5 ML/AI for early warning and impact-based forecasting

This section reflects on the role of AI and machine learning in early warning and Impact-based Forecasting in Africa. It describes the current state of AI/ML uptake in the region, the structural bottlenecks that constrain its operational use, and the realistic entry points for SEWA.

Current state of AI/ML in Africa

AI and machine learning in Africa are still in the experimental phase. D.3 identifies six AI/ML tools in West Africa, almost all confined to research or pilot settings, and none embedded in routine NMHS operations. AfriClimate AI from South Africa hosts a research community focusing on AI and climate change adaptation on the continent. D.3. identifies East Africa as 'emerging' and mentions that ICPAC's East Africa Hazard Watch incorporates machine-learning indicators.

Demand for AI-based applications surfaces in the URDB. 7 entries explicitly reference AI/ML demand (ICPAC twice, Lake Victoria Basin Commission, ANAM Burkina Faso, Volta Basin Authority, Mauritius MMS and GWP South Africa.) There is no reference from Central Africa, which is consistent with the finding that the region is still at a foundational building phase.

The broader landscape of AI weather forecasting has shifted rapidly in recent years. Global AI-based systems such as ECMWF's AIFS, DeepMind's GraphCast, and Huawei's Pangu-Weather now produce medium-range forecasts at skill levels comparable to or exceeding traditional NWP, with several released under open licences (AIFS code and weights, GraphCast weights). The specific relevance for Africa is in inference cost rather than forecast skill. Once trained centrally, these models can be run in minutes on a single GPU, whereas running a traditional global NWP system like IFS requires HPC infrastructure that few NMHSs in the region operate. This opens practical options that traditional NWP does not, including local generation of ensembles for probabilistic IbF triggers, fine-tuning or regional adaptation of pre-trained models using open-source frameworks such as Anemoi where data and skills allow.

These benefits should not be overstated. Outputs remain global and coarse and still require the same local bias correction, downscaling and calibration against in-situ data as any global NWP product. For convective rainfall extremes, the dominant forecasting challenge in the region, neither traditional global NWP nor current AI systems resolve mesoscale convective systems at the scales needed for IbF. The realistic role for AI/ML in SEWA is therefore as a tool applied within existing forecasting and IbF workflows, not as a replacement for the global NWP outputs that NMHSs already access.

Structural bottlenecks

Demand for AI-based applications meets a set of structural bottlenecks that shape what is realistic within the pilot window:

- Sparse observation networks limit the availability of ground-truth data for model training, bias correction and verification.
- Weak historical archives constrain ML approaches that depend on long, consistent time series.
- Limited HPC and cloud access restricts the ability to train or fine-tune models locally.
- A thin AI/ML skills base across NMHSs and RCCs limits the capacity to develop, deploy and maintain AI/ML applications in operational settings.

These bottlenecks do not prevent AI/ML applications altogether, but they do mean that SEWA pilots should favour applications that work with sparse data, leverage external computing where appropriate, and build skills progressively rather than relying on advanced AI/ML capacity being in place from the start.

Realistic AI/ML entry points for SEWA

Within the SEWA implementation window of roughly two years, four realistic AI-related entry points are identified: three application-level entry points and one cross-cutting capacity component.

- **Forecast post-processing.** ML-based bias correction and probabilistic calibration of ECMWF IFS, AIFS and regional NWP outputs against station data. This will support issues of verification and false-alarm fatigue as for instance flagged by Meteo Benin after the 2024 floods. AI/ML methods can in principle add value even where in-situ observations are sparse, although verification against ground data remains essential.
- **Convective nowcasting.** Building on SWIFT and WMO'S AI for Nowcasting Pilots Project to operationalise Machine-learning based nowcasting (using Meteosat MSG and MTG, and NASA IMERG rainfall products) as a value-adding layer inside platforms stakeholders already use, such as VoltAlarm and PUMA2025, rather than as a new system alongside them.
- **Impact-layer ML.** Using ML to merge exposure and vulnerability rasters with hazard forecasts to derive location-specific impact thresholds. This is a concrete route to operationalising the exposure and vulnerability integration gap.
- **Capacity building on AI/ML for EWS.** A cross-cutting component covering hands-on skills in bias correction, calibration, verification, and the use of pre-trained global AI forecasting systems (e.g. AIFS, GraphCast) for regional and national applications. Without this, the three application-level entry points risk remaining external inputs rather than being owned and operated by NMHSs and RCCs.

Finally, AI can also be used as a tool to overcome language barriers in various applications.

Recommendations for SEWA pilots

The following recommendations summarise how SEWA pilots in can be designed to address the gaps identified above while working within the region's institutional and capacity constraints.

- Pilots should explicitly integrate exposure and vulnerability datasets with hazard forecasts as maintained operational layers and define verified impact thresholds preferably for specific sectors.

- Where AI/ML is included, it should be a targeted enhancement of existing forecasting and IbF workflows (e.g. post-processing, nowcasting, exposure–vulnerability merging) rather than a standalone pillar; a realistic ambition within the two-year pilot window is to demonstrate operational value, not to build national AI/ML infrastructure from scratch

- Partnerships with local African IT consultants, can provide continuous technical support and knowledge exchange, offering a practical mitigation for high staff throughput that applies whether systems are locally or cloud hosted.

- Capacity development should build IT and forecasting skills as well as knowledge on IbF and should be embedded in formal institutional training programs rather than delivered as short, standalone workshops, favouring longer-form, hands-on training with practice on real cases.

- Capacity development should deliver self-paced modules that can be used after project closure to refresh knowledge or train new staff.

- Pilots should assume attrition and design systems, training, and documentation so that operation does not depend on a single trained individual, using training-of-trainers approaches and documented SOPs to safeguard continuity.

- Pilot design should include a collaboration plan covering data sharing, upward and downward flows between RCCs and NMHSs, within-country hydro-meteo cooperation, and cross-sectoral engagement with (preferably at least two) impact sectors.

- Technical pilot solutions should be embedded in policy, legal and institutional frameworks to ensure their use beyond the project duration. For example, enhancing monitoring networks and developing systems and data-sharing platforms should be combined with formal inclusion of these systems in institutional and national frameworks.

- Pilot projects need to include a thorough sustainability plan with an explicit exit strategy, identifying who maintains, funds, and owns the system after SEWA ends, and specifying the financial, technical, and human capacity (including any structural collaboration) required to sustain it.

- Pilots should follow user-centric design and progressive co-ownership, with end users and operational staff involved from inception through co-design, co-development, demonstration and handover, so that workflows, responsibilities and long-term ownership are established before the pilot ends.

- SEWA pilots should be designed as stepping stones in a longer institutional roadmap rather than as end points in themselves.

- Projects should aim to consolidate and align with existing initiatives, prioritising those already operational or institutionally embedded, rather than introducing additional stand-alone pilots.

- Pilots should prioritise the use of software and systems familiar to the stakeholders and build upon these where possible.

- Integrate the principles of Continuous Improvement (CI, see D.12) in the implementation of the activities

4. Regional findings

This section describes the regional findings for each SEWA region and the objectives for the regional pilots. It opens with the focus hazards for a region, followed by a synthesis of findings specific for that region. The chapter concludes with recommendations for the scope of the Regional Pilot, formulated as a goal and objectives. All four pilots share a foundation of co-development with operating institutions.

4.1 West Africa

4.1.1 Proposed hazard focus for West Africa

The proposed focus hazards for West Africa are droughts & dry spells and riverine floods as the two most important, followed by heatwaves and flash floods.

Proposed focus hazards

Droughts & dry spells and riverine floods ranked in the top 3 across all three evidence sources (D.9, D.3, workshops). Participants in the workshops mentioned that droughts & dry spells are mainly an issue in the Sahel region, and the IPCC suggests that severity will further increase in the future:

"In the Sahel, temperatures are rising faster than the global average, increasing evaporative demand and aridity, and multi-year droughts have become more frequent. Under higher warming levels, drought duration is projected to increase substantially in parts of the western Sahel (IPCC AR6)." – D.3

Heatwaves and flash floods were included next, although not all analyses agreed. Both hazards were considered important by the workshop participants, but to a lesser extent in the D.9 hazard prioritisation. On the other hand, D.3 concluded that both hazards would become more severe in the future climate, which is why they were added to the list of focus hazards.

For heatwaves, participants explained during the workshop that in April 2024 many people passed away during a heatwave in this region. The impacts on agriculture are high, and the informal sector is also impacted due to interruption of their activities. D.3 concluded:

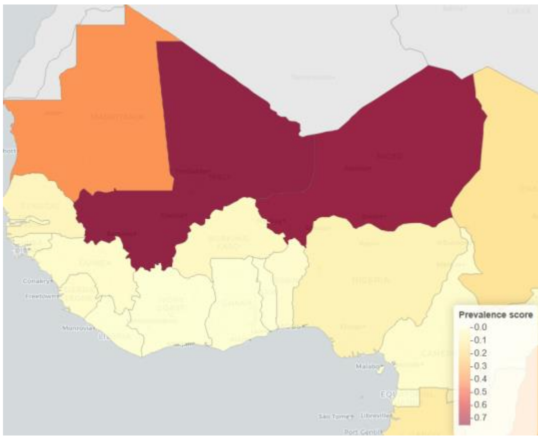
"Heat is emerging as a third major hazard. Projections indicate rapid growth in the frequency of extreme heat exposure and heatwave occurrence across West Africa (Thiery et al., 2021). Despite this trajectory, heat-related early warning systems remain significantly less developed than those for drought and floods, creating a mismatch between evolving risk and early warning priorities." – D.3

Concerning flash floods, participants mentioned that they occur across the region, mainly impacting urban areas where losses are greatest. Flash floods lead to damage to roads, loss of cattle and crops, and harm to citizens. D.3 noted:

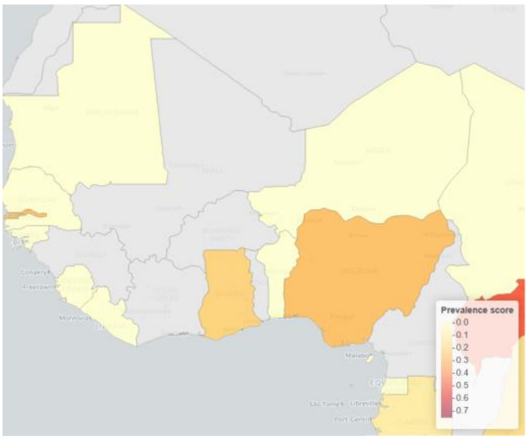
"In coastal areas, evidence points to increases in intense rainfall associated with convection, with implications for both flash flooding and downstream riverine flooding (Taylor et al., 2017)." – D.3

Other hazards

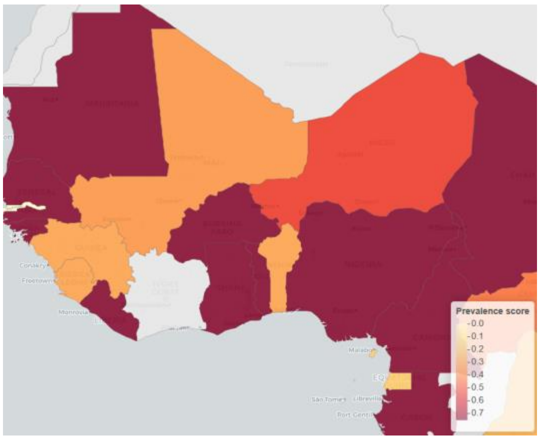
The remaining four hazards: dust storms, thunderstorms, tropical cyclones, wildfires & smoke, were not included for this region. The following figures show the prevalence scores for these hazards from D.9. The darker red a country is, the higher the prevalence of a hazard.



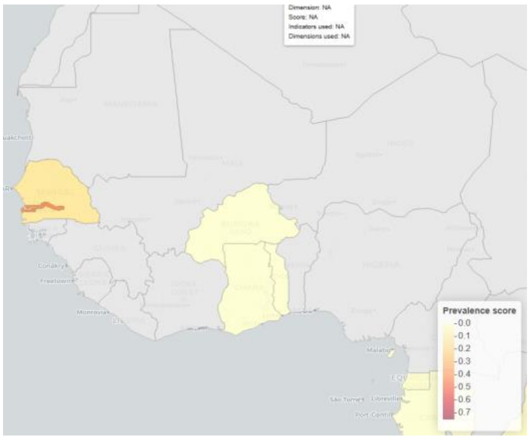
Prevalence of dust storms



Prevalence of thunderstorms



Prevalence of wildfires & smoke



Prevalence of tropical cyclones

Figure 1 Prevalence scores for the non-prioritised hazards: dust storms, thunderstorms, wildfires & smoke, tropical cyclones[1].

[1] Grey means that there are no prevalence data in the underlying datasets. It does not imply a total absence of the hazard. In D.9 more information can be found on the hazard assessment, the databases used and the uncertainties related to it.

The prevalence scores for thunderstorms and tropical cyclones align with the workshop results. Only in Senegal and The Gambia impacts from cyclones were found that rather relate to remnants of developing cyclones in the Atlantic hitting the area than tropical cyclones making landfall. Wildfires & smoke and dust storms, however, score high in D.9. Wildfires & smoke prevalence is comparable to flash floods and riverine floods, while dust storm prevalence is concentrated in the Sahel countries. This contrasts with the lower priority assigned to both hazards by workshop participants.

Furthermore, during the validation workshop participants noted that wildfires occur locally rather than at the national or regional scale shown in the WP3 analysis. This is consistent with the workshop scoring of wildfire impacts and cascade impacts as low. That may be a reason why they are perceived to be less relevant than other hazards.

There was minimal awareness of the impacts of dust storms on health among the stakeholders who participated in workshops, surveys and interviews. The literature, however, states that dust storms have long-term health impacts, and research in this domain appears to have been conducted largely from a health perspective (e.g., Schweitzer et al., 2018; Kanatani et al., 2010; Goudie, 2014). Dust is also a known driver of meningitis outbreaks in the Sahel's "meningitis belt", and ACMAD operates a Meningitis Early Warning System (MEWS), co-produced with WHO AFRO, which combines sub-seasonal forecasts of temperature, relative humidity and dust to issue weekly vigilance maps across the meningitis belt with a two-week lead time during the dry season. This disconnection between stakeholder awareness, and the literature could be considered as a gap and the reason why dust storms can be proposed as a complementary hazard in the Regional Pilot scope.

4.1.2 Specific findings on gaps, needs and challenges

This chapter presents the specific findings for West Africa, additional to the continental findings presented in Chapter 3, and subdivided in findings in these topics:

- Training and capacity building
- Challenges in forecasting
- Data and information on exposure and vulnerability
- Key data interfaces and visualization tools
- Funding
- Regional collaboration
- In-country silos

On training & capacity building

In West Africa training is delivered through the three WMO Regional Training Centres (EAMAC, AGRHYMET, NiMet Lagos) and WASCAL, and project-funded workshops under SWFP, CREWS and AICCRA. Training remains most strongly focused on flood and drought (likely driven by the high prevalence and the future impact according to IPCC reports), while IbF is the most underdeveloped EWS capability relative to the region's project volume. ANAM (Burkina Faso) also addressed the lack of communication expertise, hindering effective dissemination of warnings.

"There is a lack of communication expertise, we have two people for taking pictures and external communication, but they are not involved in communication of our forecasts." – Workshop participant, ANAM (Burkina Faso)

The challenge of effective dissemination was often heard during the workshops, but it was also understood that it is not directly part of SEWA.

Related to forecasting capabilities, the Ghana Meteorological Agency indicated the need to strengthen NWP capabilities through improved data assimilation and post-processing, Meteo Benin the requirement for high-resolution tropical NWP models (around 5 km) supported by HPC infrastructure, and the Liberia Meteorological Service the need to establish an operational NWP workflow producing gridded forecasts. Integrating in-situ data with satellite data and forecasts was also raised.

Specific hazard-related needs include calibration of urban flood models such as WiMES for Abidjan (Côte d'Ivoire), localised flood models (The Gambia), flash flood, riverine flood and coastal flood models (Liberia), drought impact forecasting with ecosystem dataset integration (Benin), and basin-wide heatwave early warning (Volta Basin Authority).

On funding

On funds it was found that Meteo Benin partly self-finances through a levy on private-sector users of meteorological services and GMet (Ghana) relies on internally generated funds.

On regional collaboration

AGRHYMET and ACMAD provide regional monitoring and seasonal outlooks (PRESASS). AGRHYMET is still in demonstration status as RCC and in an ongoing designation process by the WMO. RCCs have high technical influence at regional scale but limited uptake at national level. Workshop discussions highlighted the importance of clear mandates following WMO regulations and guidelines to avoid overlapping mandates with NMHSs, particularly on warning issuance. Participants also flagged that regional seasonal forecasts are often not at sufficient resolution for direct national use, and that dashboards provide visual overviews but do not give NMHSs processable, machine-readable data that can be ingested as input into national forecasting and downscaling workflows.

"It is up to NMHSs to process the information of RCCs. Dashboards are nice for overview, but do not allow to process the data. We need to be able to access the regional data as input to the national activities." Workshop participant

Transboundary collaboration in West Africa is further complicated by two features: the region spans anglophone and francophone countries, which limits the accessibility of dashboards, training materials and technical documentation unless platforms operate in both languages. Secondly (though not specific for West Africa only) most cross-border activities are project-based and stop when funding ends.

On in-country silos

A related example concerns VoltAlarm in Ghana: GMet publishes rainfall bulletins, but the mandate to convert rainfall into river flow forecasts, the step that produces actionable flood warnings, sits with another institution. The disconnect is institutional. The URDB reflects these needs: ANAM (High priority), The Gambia DWR, Cote d'Ivoire and LMS all record formal requirements for national EWS coordination frameworks, institutional role definitions, and alignment of response plans with warning triggers.

On forecasting

Besides the continental gaps and challenges in forecasting presented in Chapter 3, we present the findings about current forecasting status in West Africa.

Most West African NMHSs (Meteo Benin, Gambia DWR, LMS) rely on externally produced global forecasts (ECMWF IFS, GFS, UK Met Office, Meteo France) rather than using global forecast models as boundary conditions to run regional models locally. ANAM is the main exception, running WRF twice daily. NWP strengthening is flagged as high priority by GMet (data assimilation and post-processing), Meteo Benin (high-resolution tropical NWP with HPC) and LMS (operational NWP workflow), as recorded in the URDB.

On data and information of exposure and vulnerability

This section describes the state of exposure and vulnerability data for West Africa and how it is currently used in early warning and Impact-based Forecasting (IbF). Barriers to IbF uptake that relate to coordination, data sharing, impact information, and required skills are discussed under the critical gaps and challenges.

Participants expressed the need to translate forecasts into impacts, operationalise IbF, define warning trigger thresholds, and combine forecasts with exposure and vulnerability data. Benin and Ghana additionally expressed the need to integrate hazard and disaster monitoring. What limits stakeholders from meeting these needs themselves is a combination of factors: limited access to structured impact data and severity thresholds, weak integration of hazard information into operational decision-making, a shortage of IbF-specific skills such as vulnerability and exposure mapping, risk analysis and risk communication, and the absence of a permanent regional training anchor comparable to ICPAC's Training Academy in East Africa.

Only the ongoing RAPIDE project in Burkina Faso has an explicit focus on IbF in the region. Other major initiatives, such as Fanfar and SWFP West Africa, are primarily EWS rather than IbF. D.3 identifies IbF as the most underdeveloped EWS capability in West Africa relative to the region's overall project volume, with only two IbF-specific projects in the inventory.

Taken together, this suggests a clear opportunity for SEWA in West Africa: the hazard monitoring and forecasting foundation exists, and open exposure and vulnerability datasets are available, but the operational integration of the two into routine IbF workflows has not yet been achieved.

Key data interfaces and visualization tools

This section briefly describes the main data interfaces and visualization tools currently in use across West Africa. It also notes the main limitations relevant to the Regional Pilot's design.

Regional warning and decision-support platforms. Two operational regional platforms were identified: the AGRHYMET seasonal forecasting service, which supports regional and national actors with seasonal outlooks (PRESASS), and the VoltAlarm system, which provides flood early warning for the Volta Basin. Several countries also operate national platforms for disseminating forecasts and issuing warnings, based on for example myDEWETRA, Climweb, and Delft-FEWS.

Forecaster workstations. At the NMHS level, the most widely used workstation is PUMA2025, reported by Meteo Benin, the Gambia Department of Water Resources, and ANAM (Burkina Faso), among others. Sodexam (Cote d'Ivoire) and ANAM (Burkina Faso) have both replaced Synergie-web with newer forecasting platforms: Usine Meteo (Meteo Factory) and Meteo WebGIS respectively. The ANAM migration was funded under a HydroMet Green Climate Fund project.

Two main limitations relevant to IbF pilot design are identified. First, the tools in use vary between countries and produce data in different formats, limiting interoperability and complicating regional collaboration. Sodexam cited this as a reason for moving away from PUMA2025. Second, PUMA2025 itself was reported to be unstable by several participants, with Meteo Benin noting that the system frequently fails and that reproducing workflows after training in Niger has been proven to be difficult. These limitations reinforce the case for building the Regional Pilot on an existing operational platform in the region, rather than introducing a new system.

The following box shows the recommendation for SEWA pilot in West Africa, based on the gaps and needs in the region as well as continent.

Recommendations for SEWA pilots based on identified gaps and needs in West Africa:

The following recommendations summarise how SEWA pilots in West Africa can be designed to address the gaps identified above while working within the region's institutional and capacity constraints.

- Pilot projects should pay special attention to the translation from forecasts to impacts, as this is not done structurally in this region. For example, drought forecasting should be related to its impacts on agriculture, water resources or energy.
- Pilot design should reflect the asymmetric capacity across West African NMHSs: some (GMet, WRC, Meteo Benin, ANAM Burkina Faso) have dedicated IT departments, while others (HYDRO, LMS, Gambia DWR) do not. A uniform design is more likely to fail in lower-capacity settings.
- Pilots in West Africa should explicitly support transboundary collaboration, with formal data-sharing arrangements, attention to anglophone–francophone language barriers, and institutional embedding so that cooperation outlasts the project cycle.

4.1.3 Proposed goal

This section presents a proposal for the goal of the West Africa Regional Pilot

Proposed goal statement for West Africa

Further enhance an existing transboundary early warning system in West Africa, moving it from hazard-based forecasting to Impact-based Forecasting (IbF) for at least one of the focus hazards identified in Section 4.1.1, in co-development with the institutions that will operate and maintain it. The pilot should integrate exposure and vulnerability datasets with hazard forecasts, define and verify impact thresholds for at least two sectors, and deliver a roadmap that embeds the system in institutional, national and regional policy frameworks or legislation to ensure its continued use beyond the project.

The need SEWA fills

D.3 identifies IbF as the most underdeveloped EWS capability in West Africa, with only two IbF-specific projects in the inventory (RAPIDE and SWFP West Africa). Exposure and vulnerability datasets are available but not embedded in operational workflows. SEWA's specific contribution could therefore be to operationalise the impact layer: integrating exposure and vulnerability data, defining and verifying impact thresholds, embedding verification in routine workflows, and strengthening risk communication, all built on top of existing hazard monitoring rather than alongside it.

A candidate anchor platform should be selected during the pilot inception phase, building on an existing, familiar system rather than introducing a new one to directly address the sustainability challenges identified earlier. One option would be myDEWETRA, given that it is currently a multi-hazard platform operational in several countries in the region and is actively used in WMO assignments (such as VoltAlarm in the Volta basin). Operational feedback from the AUC and from users who have run it in practice has, however, flagged usability and reliability issues, so the inception phase should include an explicit fitness-for-purpose assessment against the IbF requirements set out in this chapter, alongside consideration of alternatives such as a ClimWeb-based dissemination layer coupled to an appropriate decision-support backend.

4.1.4 Objectives

This section presents proposed objectives of the West Africa Regional Pilot. The proposed objectives and outcomes are grouped into three themes: technical, institutional, and sustainability objectives. Together, they operationalise the goal set out in the previous section.

Technical objectives

- **Strengthen IbF capacity in the region** by operationalising the translation from hazard forecasts to impact-based warnings, including the integration of open exposure and vulnerability datasets (like WorldPop, JRC GHSL, ESA WorldCover or regional/national datasets if available), the definition and verification of impact thresholds, and the embedding of verification procedures in routine forecasting workflows.
- **Structurally develop IT and forecasting capacity** at the institutions involved in the pilot, covering both foundational needs (observation networks, regional NWP, and post-processing, HPC or cloud hosting) and IbF-specific skills (risk analysis, GIS-based impact assessment, risk communication).

Institutional objectives

- **Aim at enhancing transboundary and multi-lingual (EN/FR) collaboration** between RCCs, NMHSs, hydrological services, and River Basin Organisations through the pilot, including mechanisms for data sharing, joint operation, and bilingual accessibility of platforms and training materials.
- **Aim at enhancing cross-sectoral collaboration** between meteorology, hydrology, DRM, and potential impact sectors (for example, agriculture, transport, health, or energy), to support the definition of impact thresholds and verification of impact warnings.

Sustainability objectives

- **Aim to ensure formal institutional and policy embedding** of the pilot system through a roadmap that identifies the relevant institutional, national and regional frameworks or legislation, and through collaboration agreements between the institutions that could operate the system.
- **Aim to ensure sustainable operation and maintenance** through co-development with end users, an explicit exit strategy covering financing, ownership and maintenance, and continuity mechanisms such as self-paced training materials, train-the-trainer approaches, and partnerships with local IT consultants.

4.2 East Africa

4.2.1 Proposed hazard focus for East Africa

The proposed focus hazards for East Africa are droughts & dry spells, flash floods and riverine floods.

Proposed focus hazards

Droughts & dry spells ranked very high across all three evidence sources (D.9, D.3, workshops). Workshop participants shared that droughts often occur several years in a row at large scale, causing crop losses, food insecurity, migration and conflict. The region's long drought history is also reflected in the project inventory: 51 of 88 SEWA-relevant initiatives have a focus on droughts and dry spells (many in initiatives with a multi-hazard focus), with Kenya and Tanzania clearly standing out:

"The region's early warning landscape has been shaped by major drought events, including the 2011 Horn of Africa famine, the 2017 drought, and the 2021–2022 drought. This history is reflected in drought-focused systems: the East Africa Drought Watch provides near-real-time monitoring using Earth observation, and the Eastern Nile Technical Regional Office (ENTRO) supports drought early warning functions for the Nile Basin (Nile DEWS)." – D.3

Flash floods ranked in the top 3 across all three evidence sources (D.9, D.3, workshops) and first in the workshop individual ranking. Participants noted that flash floods occur across the region, especially in urban areas, and that at local scale the impacts are very high, with landslides as an important cascading hazard. D.3 points to further intensification:

"Heavy precipitation frequency and intensity are projected to increase across much of the region (IPCC AR6, high confidence)." – D.3

Despite this high relevance, only 4 of 88 regional projects in the inventory explicitly reference flash floods (3 of which also address riverine floods), compared with 57 references to riverine floods. This likely reflects different terminology used in project titles (e.g. "urban floods") rather than a true absence but still suggests flash floods are underrepresented in the regional project portfolio.

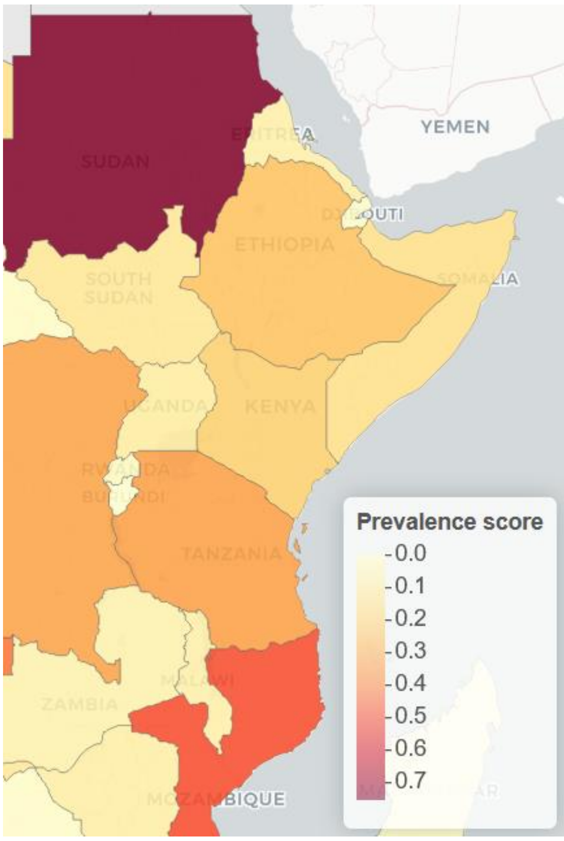
Riverine floods ranked in the top 3 across all three evidence sources (D.9, D.3, workshops) and ranked high to very high in D.9 across almost the entire region. Workshop participants scored prevalence, impacts, cascade impacts and interest very high, placing riverine floods third in the individual ranking after flash floods and droughts & dry spells. The inventory also confirms this: 57 of 88 regional projects reference riverine floods, with Tanzania and Kenya above average, and Eritrea and Djibouti notably underrepresented, likely reflecting political stability and underreporting. A participant shared:

"Prevalence of riverine floods is high, because it is very seasonal, more in the wet season. Flooding can be national but also regional, such as floods in Ethiopia and Kenya. Impacts are very high, people lose their houses. Our interest is very high, we saw some success stories for early warning systems, but these can be upscaled or improved."

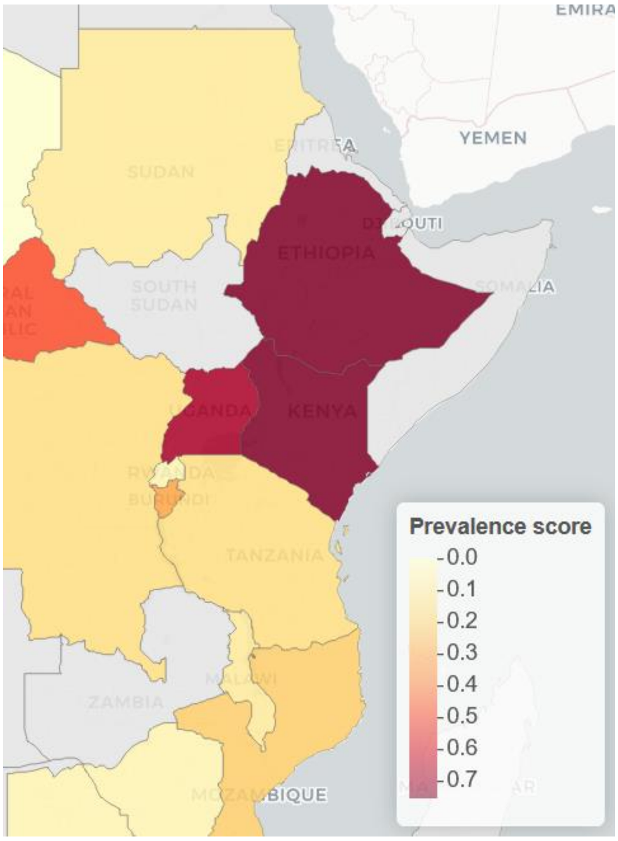
Other hazards

The remaining five hazards, dust storms, thunderstorms, tropical cyclones, wildfires & smoke and heatwaves were not included for this region. Workshop participants also raised landslides as a hazard of high concern, although landslides are outside the SEWA hazard set; they are discussed below and mentioned as a complementary pilot component.

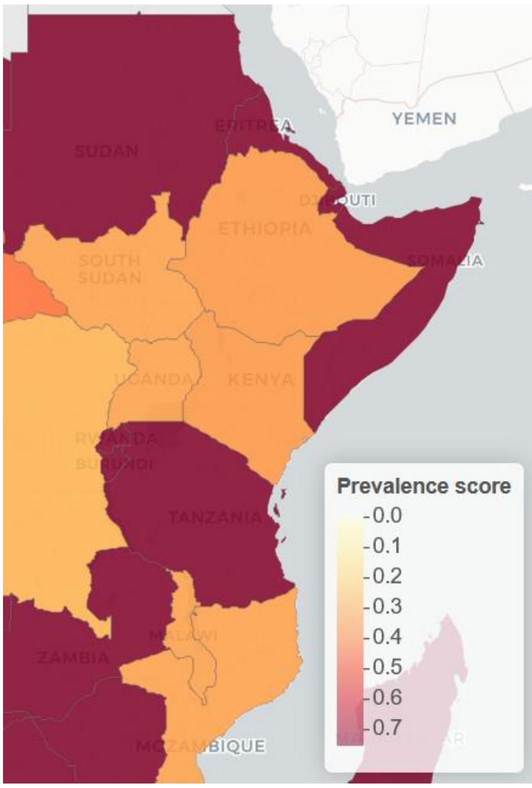
The following figures show the prevalence scores for these hazards from D.9. The darker red a country is, the higher the prevalence of a hazard.



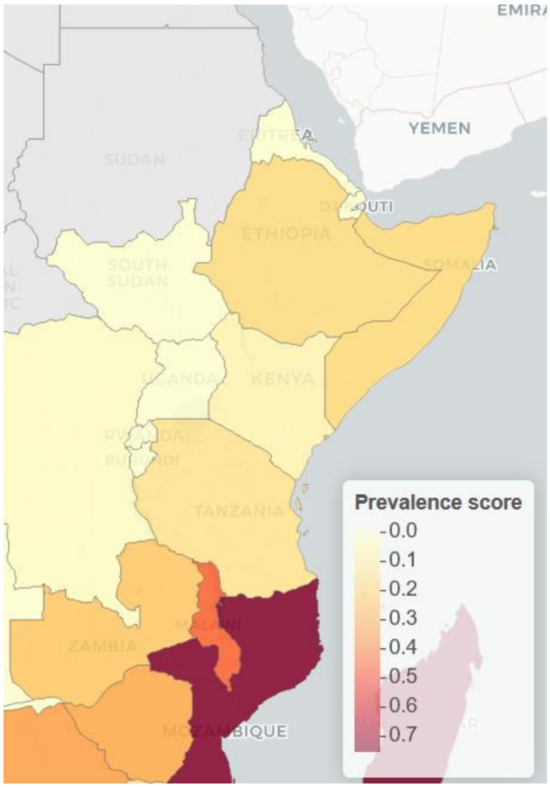
Prevalence of dust storms



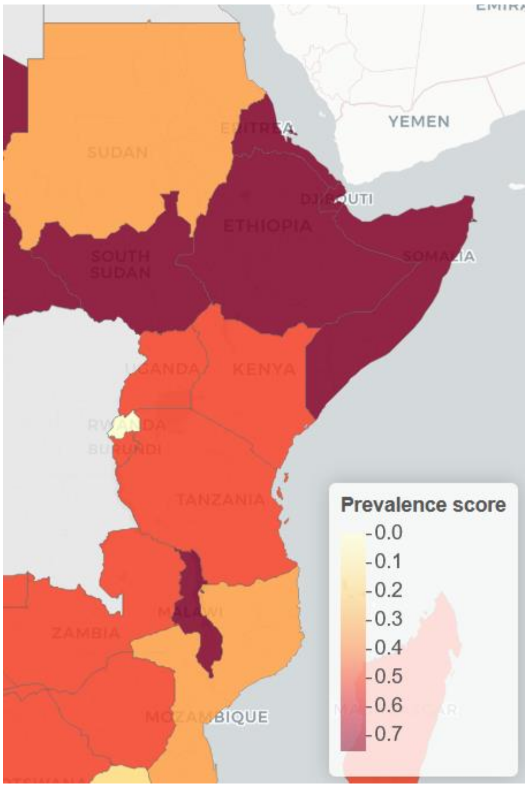
Prevalence of thunderstorms



Prevalence of wildfires & smoke



Prevalence of tropical cyclones



Prevalence of heat waves

Figure 2 Prevalence scores for the non-prioritised hazards: dust storms, thunderstorms, wildfires & smoke, tropical cyclones and heatwave[2].

[2] Grey means that there are no prevalence data in the underlying datasets. It does not imply a total absence of the hazard. In D.9 more information can be found on the hazard assessment, the databases used and the uncertainties related to it.

The prevalence scores for tropical cyclones align with the workshop results, showing low relevance for most of the region (only the coastal areas are affected by Southwest Indian Ocean systems). The D.9 prevalence for thunderstorms, wildfires & smoke and dust storms, however, contrasts with the workshop outcomes. Thunderstorms score lower in D.9 than the very high prevalence reported by participants, particularly for the Lake Victoria basin where storms occur almost daily and pose acute risks to fishing communities, this is likely because thunderstorms are underrepresented in global risk datasets and often captured indirectly through their cascading hazards (flash floods, landslides). Wildfires & smoke prevalence scores high in D.9 across parts of the region, while dust storm prevalence is concentrated in Sudan. Heatwaves score high in D.9, consistent with workshop findings that Somalia, South Sudan, Sudan and Djibouti face severe heat stress.

"In Djibouti, during summer months, people even move to other countries such as Ethiopia, Somalia, Kenya." – Workshop participant

However, participants at the workshops rated their interest in heatwaves as high rather than very high, placing heatwaves fourth in the individual ranking after flash floods, droughts & dry spells and riverine floods.

Workshop participants advocated for including landslides in SEWA even though this hazard is outside the SEWA list of hazards. Landslides are closely cascaded from flash floods and intense rainfall in the highland regions of the Rift Valley and the Lake Victoria basin and are reflected in the URDB by landslide early warning needs recorded by the Lake Victoria Basin Commission and by the State Department of Irrigation in Kenya.

4.2.2 Specific findings on gaps, needs and challenges

This chapter presents the specific findings for East Africa, additional to the continental findings presented in Chapter 3, and subdivided in findings on four topics:

- Training and capacity building
- Challenges in forecasting
- Data and information on exposure and vulnerability
- Key data interfaces and visualization tools

On training & capacity building

In East Africa, training continuity is comparatively strong: ICPAC's Training Academy for Early Warning Experts provides a strong regional anchor that is absent in several other sub-Saharan African regions. Training is further delivered through project and program workshops (e.g. WISER, CREWS, FINKERAT), WMO-linked training activities, and partner-delivered short courses on forecasting, nowcasting, communication, and CAP-related implementation. The D.2 inventory identifies 19 training entries for East Africa, the largest training footprint among SEWA regions. Translation into sustained national operations nonetheless remains uneven, especially for advanced approaches such as IbF, anticipatory action triggers, and routine integration of exposure and vulnerability layers.

Participants in the workshop reported that training delivered within projects is often too short and not embedded in long-term capacity development programs. A further continuity issue is that each project tends to introduce new software, tools or methods rather than building on earlier trainings, fragmenting the skills base and preventing cumulative capacity development across projects. It was also noted that RARS (Regional ATOVS Retransmission Service), the polar-orbiting satellite data suite, was deployed (at ICPAC), but staff were not properly trained on it, which illustrates the capacity building challenges at the regional level.

"One of the main challenges is to automate operation, this requires capacity." - Participant at East Africa workshop

The challenge of effective dissemination of warnings or advisories was often heard during the workshops, but it was also understood that it is not directly part of SEWA.

Related to forecasting capabilities, KMD's priority needs include forecast skill improvement through additional data sources, ICPAC's include regional forecast skill improvement and AI/HPC infrastructure (GPU-enabled HPC) for AI-based forecasting, Rwanda Meteorology Agency's include hazard forecasting capability and NWP modelling expertise, and Somalia's Ministry of Energy & Water Resources records operational NWP integration into hydrology forecasting as a priority. Workshop participants at ICPAC specifically suggested customising ECMWF AIFS for the region and linking it to a data assimilation model. Integrating in-situ data with satellite data and forecasts was also raised across the region (Meteo Rwanda, Uganda Meteorological Service, ICPAC).

Participants to the workshop further expressed a wish to run and operate models themselves in several examples. One example was that the Flash Flood Forecasting by the Nile Basin Initiative, NELSAP, only provides hydrographs as output, which makes it hard to validate. It would be prefered to run the models in-house.

Specific hazard-related needs include expansion and calibration of flash flood forecasting (Somalia's MoEWR is testing EF5 and notes that resolution needs to be improved), expansion of riverine flood forecasting from the Nzoia basin to the Tana basin in Kenya through WIMES, development of nowcasting capability (Somalia MoEWR), drought monitoring with operational indices (Lake Victoria Basin Commission, IGEBU), and landslide early warning foundations (Lake Victoria Basin Commission, State Department of Irrigation Kenya).

In terms of funding sustainability, project-based funding remains the dominant model across East Africa. D.12 notes that for short-term, national-level projects of this kind, there is no clear trace of systems that remained functional after funding ended. Project budgets typically cover procurement, but rarely the 5 to 10 years of maintenance needed to keep systems operational.

On regional collaboration. ICPAC provides strong regional coordination as the designated RCC for the IGAD region, convenes GHACOF, and operates the East Africa Hazard Watch and East Africa Drought Watch. D.7 scores ICPAC the highest among African RCCs for overall maturity (4.0).

On in-country silos. National institutions also work in silos, most visibly between meteorology and hydrology. In Rwanda, hydrology is handled by the Rwanda Hydrology Unit, so flood forecasting information sits outside Meteo Rwanda. In Kenya, KMD and the Water Resources Authority both operate monitoring assets, but as noted in the workshop, many water level gauges and some automatic weather stations have stopped working, and maintenance responsibility is not fully formalised between the two institutions. The URDB reflects these needs: IMTR records formalised KMD-WRA flood EWS coordination, institutional role definitions, joint warning SOPs, and joint training exercises as needs; KMD records institutional coordination as a critical need; and the Rwanda Meteorology Agency records a national multi-hazard EWS strategy as a high-priority need.

Challenges in forecasting

A specific challenge in forecasting for East Africa, additional to the continental challenges, is its complex topography and lake effects. East Africa's complex topography, including the Ethiopian Highlands, the Rift Valley and the Lake Victoria basin, creates sharp spatial gradients and mesoscale circulations, meaning large-scale climate drivers translate into rainfall in highly heterogeneous ways (D.3, citing Palmer et al., 2023). Global forecast models often struggle to capture the location, timing and intensity of rainfall over complex terrain and lake-land environments.

Data and information on exposure and vulnerability

The availability of national datasets in the region is concentrated in Kenya with HOTOSM, Microsoft Open Building and a Kenya settlement extents layer). These layers are derived from satellite products, and do not include local data or information. D.3 mentions that exposure and vulnerability datasets (global products as mentioned in section 3.4) are available but not routinely integrated into operational systems in East Africa. Hazard monitoring and forecasting are generally stronger than systematic impact translation. Regionally, ICPAC's East Africa Drought Watch supports drought situational awareness (Earth observation, indicators and mapping), yet this does not automatically translate into national exposure and vulnerability layers linked to day-to-day alerting.

Key data interfaces and visualization tools

ICPAC operates two operational regional platforms relevant to SEWA: the East Africa Hazard Watch, a multi-hazard monitoring and situational-awareness platform, and the East Africa Drought Watch, which provides near-real-time drought monitoring using Earth observation (D.3). For transboundary riverine flooding the Eastern Nile Technical Regional Office (ENTRO) operates flood forecasting and early warning functions for the Nile Basin, and the Joint Songwe River Basin Commission between Malawi and Tanzania operates a cross-border hydrometeorological system (D.3). At the national level, Kenya Meteorological Department (KMD) and the Kenya Water Resources Authority operate the Water Information Management Ecosystem System (WIMES) for riverine flood forecasting in the Nzoia basin, with ongoing plans to expand to the Tana basin; and KMD operates the FASTA application for storm movement monitoring. Somalia's Ministry of Energy & Water Resources runs MIKE-HYDRO for riverine flood forecasting and is testing EF5 (University of Oklahoma) for flash flood forecasting.

The following box shows the additional recommendation for SEWA pilot in East Africa, based on the gaps and needs in the region as well as continent.

Recommendations for SEWA pilots based on identified gaps and needs in East Africa:

The following recommendations summaries how SEWA pilots in East Africa can be designed to address the gaps identified above while working within the region's institutional and capacity constraints.

- Pilot projects in East Africa should focus on forecasting skills that allow institutions to apply global or regional information to their own context by developing and running Limited Area Models, tailored nowcasting models, downscaling satellite data and/or postprocessing regional information generated by ICPAC.
- Pilot projects should pay special attention to the translation from forecasts to impacts. While East Africa has a relatively strong regional foundation through ICPAC's East Africa Hazard Watch and East Africa Drought Watch, integration into routine national workflows remains uneven. For example, drought forecasting should be related to its impacts on agriculture, water resources or energy.
- Pilot design should reflect the asymmetric capacity across East African institutions: some (ICPAC, KMD, Meteo Rwanda, Uganda Meteorological Service) have stronger NWP and IT capabilities, while others (Somalia MoEWR, IGEBU, Joint Songwe River Basin Commission) face more pronounced staffing and infrastructure constraints. A uniform design is more likely to fail in lower-capacity settings.

4.2.3 Proposed goal

This section presents the proposed goal of the East Africa Regional Pilot

Proposed goal statement for East Africa

Enhance an existing operational hazard forecasting and monitoring capability in East Africa by tailoring and calibrating a Limited-Area Model (building on existing WRF configurations at ICPAC, Meteo Rwanda, Uganda Meteorological Service and KMD), and by moving the resulting forecasts from hazard-based to Impact-based Forecasting (IbF) for at least one of the focus hazards identified in Section 4.2.1, in co-development with the institutions that will operate and maintain the system. The pilot should integrate exposure and vulnerability datasets with hazard forecasts, define and verify impact thresholds for at least 2 sectors, and deliver a roadmap that embeds the system within ICPAC's regional framework and national policy frameworks to ensure its continued use beyond the project.

The need SEWA fills

D.3 notes that East Africa shows a relatively high level of readiness to move from EWS to IbF, underpinned by ICPAC's coordination role and by the East Africa Drought Watch and East Africa Hazard Watch platforms. Exposure and vulnerability datasets are widely available (WorldPop, JRC GHSL, ESA WorldCover, SPAM, WorldCereal in addition to regional or national datasets) but are inconsistently integrated into routine operational warning workflows. Participants further expressed a need to apply global/regional information for their own subregion and to run more forecasting models themselves inhouse.

SEWA's specific contribution in East Africa is therefore twofold: first, to tailor and calibrate an LAM for East African topography and lake/highland environments using in-situ data and existing global forcings (including ECMWF IFS and AIFS); and second, to operationalise the impact layer on top of the improved hazard forecasts, defining and verifying impact thresholds, embedding verification in routine workflows, and strengthening the link to anticipatory action.

Two candidate anchor platforms are proposed: ICPAC's East Africa Hazard Watch as the regional multi-hazard anchor, given that it is already operational as a multi-hazard monitoring platform and that ICPAC scored highest among African RCCs for overall maturity in D.7 (4.0); and WIMES (operational at KMD and the Water Resources Authority in Kenya's Nzoia basin, with plans to expand to the Tana basin) as the operational anchor for the flash/riverine flood IbF layer. Building on these existing, familiar systems rather than introducing new ones directly addresses the sustainability challenges identified earlier, and D.12's caution about pilots that fail to transition into sustained operations.

4.2.4 Objectives

This section presents the proposed specific objectives of the East Africa Regional Pilot. The objectives are grouped into three themes: technical, institutional, and sustainability objectives. Together, they operationalise the goal set out in the previous section.

Technical objectives

- Tailor and calibrate a Limited-Area Model and/or tailor nowcasts for East African topography and lake/highland environments, building on existing WRF configurations (ICPAC, Meteo Rwanda, Uganda Meteorological Service, KMD), integrating in-situ station data for calibration and verification.
- Strengthen IbF capacity in the region by operationalising the translation from improved hazard forecasts to impact-based warnings, including the integration of global, regional or national exposure and vulnerability datasets, the definition and verification of impact thresholds for at least two sectors, and the embedding of verification procedures in routine forecasting workflows.

Institutional objectives

- Aim to enhance collaboration between regional (ICPAC, RSMC Nairobi, RSMC Dar es Salaam), River Basin Organisations (ENTRO, Lake Victoria Basin Commission, Joint Songwe River Basin Commission), and national institutions (NMHSs, water authorities), with explicit mechanisms for sharing of forecasts in machine-readable formats.

- Aim to enhance cross-sectoral collaboration between meteorology, hydrology, DRM (including Kenya's NDMA), and impact sectors (for example, agriculture, transport, health, or energy), to support the definition and verification of impact thresholds and the alignment of warnings with anticipatory action.

Sustainability objectives

- Aim to ensure formal institutional and policy embedding of the pilot system through a roadmap that identifies the relevant institutional, national and regional frameworks, explicitly including ICPAC's regional framework, WMO designations, and national multi-hazard EWS strategies, and through collaboration agreements between the institutions that will operate the system.

- Aim to ensure sustainable operation and maintenance through co-development with end users, an explicit exit strategy covering financing, ownership and maintenance, and continuity mechanisms such as self-paced training materials hosted via ICPAC's Training Academy, train-the-trainer approaches, and partnerships with local IT consultants.

4.3 Central Africa

4.3.1 Proposed hazard focus for Central Africa

The focus hazards for Central Africa are riverine floods, flash floods and droughts & dry spells.

Riverine Floods | Flash Floods | Thunder storms | Drought Dry spell

Proposed focus hazards

Riverine floods were prioritised very high, both during the workshop and in the D.9 analysis. A notable finding is that participants rated prevalence, impacts, and cascade impacts as medium, yet expressed very high interest in the hazard. They explained this as follows:

"The interest however is very high, because floods draw a lot of attention politically and in the media. Also, their transboundary nature makes it suitable for a regional project." – Workshop participant

On this basis, we consider riverine floods a focus hazard for the region. This is consistent with the D.2 inventory, where riverine floods are the most targeted hazard among identified initiatives:

"Flood-related hazards are most prominent in the inventory for Central Africa. This is the most flood-dominated hazard profile of any SEWA region: 11 of 32 projects address flooding alone." – D.3

Thunderstorms were among the three hazards selected by participants during the group discussion, alongside flash floods and riverine floods. Participants explained:

"Thunderstorms happen across the region, especially in the lake area, so the prevalence is high. When they occur, their effects are local and the direct effects are medium, mainly lightning and rain. The cascade impacts are high as they can cause floods and landslides. Therefore, our interest is high." – Workshop participant

Flash floods were ranked second highest in the individual ranking during the workshop, and during the group discussions were indicated as of very high interest. Participants mentioned:

"Flash floods happen across the region, so the prevalence is very high. Their impacts are also very high as they often happen in densely populated areas. They may lead to landslides, so the cascade impacts are also very high. It is clear that the interest is very high." – Workshop participant

This importance of flash floods is partly reflected in D.9, where prevalence scores are medium to high for most countries in the region. Looking at the number of initiatives, most countries have only 1 or 2 identified projects targeting flash floods, and Congo-Brazzaville and Equatorial Guinea have none.

Droughts and dry spells ranked third at regional level (4.1) in the individual workshop poll but were not retained among the three focus hazards chosen during the group discussion (which selected flash floods, riverine floods and thunderstorms). Participants explained:

"Droughts and dry spells are affecting the area, so the prevalence is medium. Impacts are considered medium with low cascade impacts. The interest is therefore medium." – Workshop participant

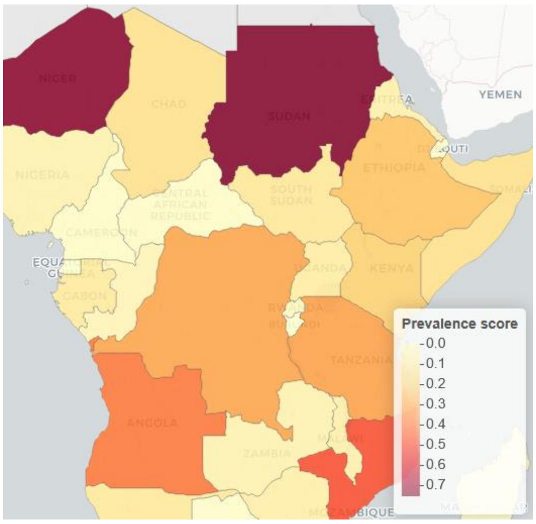
This contrasts with D.9, where drought scores second in the (unweighted) regional ranking. D.3 makes the gap explicit: "Drought risk is relevant in multiple Central African contexts, but it is weakly reflected as a dedicated EWS focus in the WP1 inventory outside multi-hazard programmes."

According to D.3, of the 32 projects identified for Central Africa, 3 projects focus solely on drought while 14 address droughts alongside other hazards within multi-hazard frameworks. Drought is therefore relevant but weakly reflected as a dedicated EWS focus. Including drought among the focus hazards is a deliberate choice, motivated by D.9's regional ranking and by D.3's observation that drought risk is relevant in multiple Central African contexts.

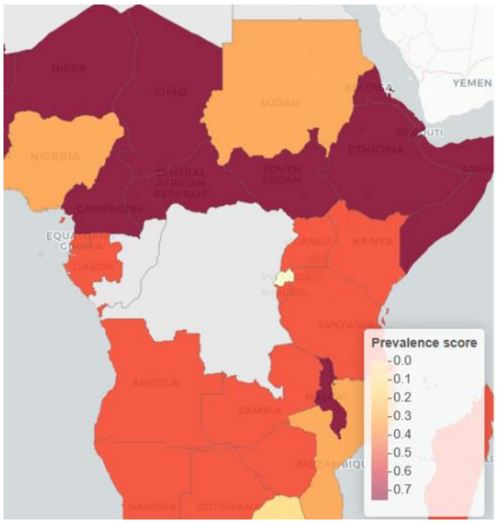
Other hazards

The remaining four hazards (dust storms, tropical cyclones, wildfires & smoke and heatwaves) were not included for this region. Workshop participants did select thunderstorms as one of their three group-discussion priorities (alongside riverine floods and flash floods); thunderstorms are addressed in the region through SWFP Central Africa (D.3) and are mentioned as a candidate complementary pilot component. Workshop participants and the URDB also raise landslides as a cascading hazard from flash floods and heavy rainfall; although landslides are outside the SEWA hazard set, they are flagged as a complementary component as well.

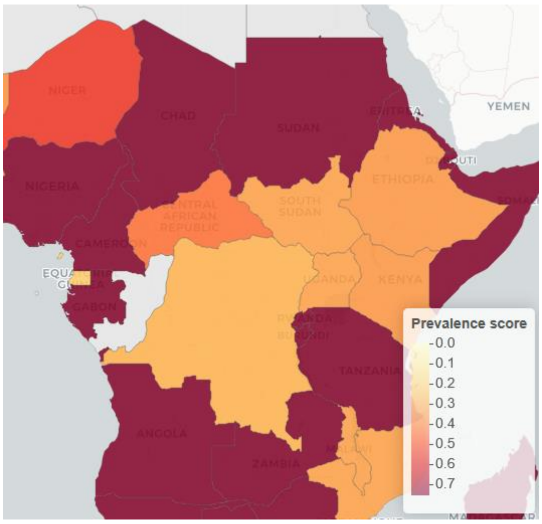
The following figures show the prevalence scores for these hazards from D.9. The darker red a country is, the higher the prevalence of a hazard.



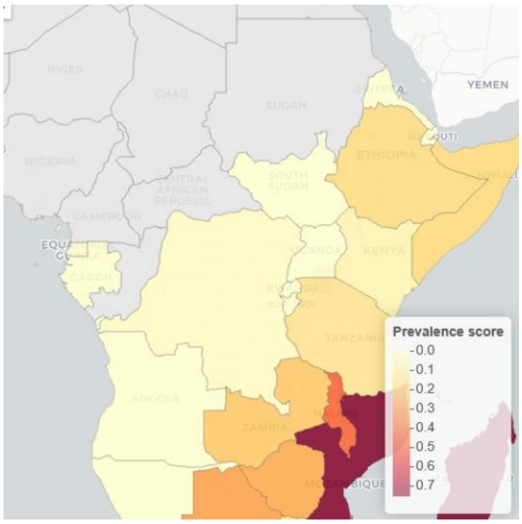
Prevalence of dust storms



Prevalence of heat waves



Prevalence of wildfires & smoke



Prevalence of tropical cyclones

Figure 3 Prevalence scores for the non-prioritised hazards: dust storms, thunderstorms, wildfires & smoke, tropical cyclones and heatwave[3].

The prevalence scores for tropical cyclones align with the workshop results, showing low relevance for the region. The D.9 prevalence for thunderstorms contrasts with the workshop outcomes, where thunderstorms were rated as very relevant by participants, particularly in the lake and Central African Republic sub-regions.

Wildfires & smoke prevalence scores high in D.9 across parts of the region, while dust storm prevalence is medium. One would expect that dust storm prevalence in Chad would have a similar score to its neighbouring countries Niger and Sudan, but this may be due to underreporting from the country.

Landslides were raised by workshop participants as a cascading hazard from flash floods and heavy rainfall and are reflected in the URDB by the Direction de la Météorologie (Congo-Brazzaville), which records landslide EWS as a need.

[3] Grey means that there are no prevalence data in the underlying datasets. It does not imply a total absence of the hazard. In D.9 more information can be found on the hazard assessment, the databases used and the uncertainties related to it.

4.3.2 Specific findings on gaps, needs and challenges

This chapter presents the specific findings for Central Africa, additional to the continental findings presented in Chapter 3, and subdivided in findings on four topics:

- Training and capacity building
- Challenges in forecasting
- Data and information on exposure and vulnerability
- Key data interfaces and visualization tools

On training & capacity building

This section describes the structure of training and capacity building provision in Central Africa and the specific gaps and training needs. For this region, we present the foundational forecasting and IT training needs as well as the IbF specific training needs. General findings for the continent, as well as findings on staffing shortages and staff retention are discussed in Chapter 3.

Structure of training provision. D.3 concluded that Central Africa has the narrowest training footprint of any SEWA region: the WP1 inventory identifies only 8 training entries for the region, the lowest of any region. Training is delivered primarily through SWFP Central Africa (severe weather forecasting), CREWS-funded training (forecaster skills and flash flood forecasting) and PRESAC (co-production of seasonal outlooks). Within the region, training documentation is most concentrated in DRC and Cameroon, which host the majority of CREWS/SWFP activities; Central African Republic, Gabon, Equatorial Guinea, São Tomé and Príncipe, and the island states have minimal or no documented training coverage in the WP1 inventory. The region lacks a permanent regional training academy comparable to ICPAC's Training Academy in East Africa. RSMC Yaoundé is under development and is expected to become a key capacity-building hub for Central African NMHSs (D.7). D.3 further notes that training coverage is narrow in scope relative to other regions, with limited evidence in the WP1 inventory of recurring training on IbF, anticipatory action, advanced GIS/remote sensing for DRM, or operational post-processing methods.

Foundational forecasting and IT training needs are most prominent in Central Africa compared to other regions. This includes needs for training on station maintenance, forecasting, data management, and modelling (METTELSAT, DRC; IGEBU, Burundi). Limited expertise in model adaptation was mentioned in Cameroon (DMN-Cameroon). METTELSAT (DRC) emphasized the need for training in meteorological data management. Chad reported a need for additional human resources and technical support to operationalize early warning systems (ANAM).

"Our staff members need capacity development on station maintenance, forecasting, data management and modelling. International data sources have different formats, different file-types or the data have different units." – Workshop participant, METTELSAT (DRC)

IbF-specific training needs. Beyond foundational forecasting and IT skills, stakeholders identified a set of IbF-specific training needs that are currently poorly covered. DMN Cameroon records cross-institutional EWS coordination (formalising coordination frameworks and clarifying roles among national stakeholders in the EWS chain) as a high-priority URDB need. This is also directly relevant for IbF trigger definition. METTELSAT records skills for co-production with sectoral users as a URDB need as well as training on the concept of IbF and disaster coordination. The Direction de la Météorologie (Congo-Brazzaville) records warning dissemination training (on CAP-based dissemination) as a high-priority need. More generally, DMN Cameroon also expressed a need for additional support on its role as a Regional Specialized Meteorological Centre.

Back-end IT and operational procedures. Like other regions, training on the back-end IT components of systems and on operational procedures for working with IbF systems are typically underserved by standard forecasting training. In Central Africa this is particularly acute: METTELSAT noted staff capacity constraints on station maintenance, forecasting, data management and modelling, and CAPC-AC noted that model run interruptions due to electricity and internet outages are a daily operational issue (workshop). D.12 specifically flags training on server administration, virtual machines, FTP servers and network configuration as topics that are often neglected in forecasting training.

Challenges in forecasting

Weak forecasting capacities. Central Africa faces forecasting challenges related to weak operational NWP capacity and slow model workflows and limited computing resources, connectivity and power more than other regions. CAPC-AC runs WRF forced with GFS and IFS for 15-day forecasts and CFS for 30-day forecasts, and DMN Cameroon runs WRF forced by GFS or IFS. However, CAPC-AC noted that WRF-GFS and WRF-IFS runs take two days and WRF-CFS takes a week, making operational use difficult. In the Rwanda forensic case presented during the workshop, WRF runs were started manually rather than automatically, and daily forecasts relied on global model outputs.

Weak IT infrastructure. The workshop identifies interrupted internet and electricity, limited computational power and poor data-processing infrastructure as core constraints. The URDB confirms this pattern: CAPC-AC lists budget, dedicated maintenance personnel, internet and electricity as infrastructure bottlenecks and calls for a stable server room, maintenance staff and an equipped training room; METTELSAT flags reliable electricity and stable internet as a high-priority need to maintain uninterrupted forecasting and warning operations; and the Direction de la Météorologie in Congo-Brazzaville expressed the need for dedicated operational infrastructure (currently they rely on shared systems and temporary web portals) and for improved compute, storage and network capacity.

Data interoperability and archiving. International data sources arrive in different formats, file types and units, as reported by METTELSAT and CAPC-AC during the workshop. This makes it harder to combine global model output, satellite rainfall products such as GPM IMERG and CHIRPS, station data and hydrological models. While we recognize the capability of handling different data formats as a skill a forecaster generally should possess, we also acknowledge the fact that chances of uptake are larger if pilots especially account for this challenge at the Central African institutions by working with more common and user-friendly datasets and tools. URDB entries from Cameroon also show data-management weaknesses, including manual ingestion and storage on USB or disk without a backup system.

Limited data assimilation, post-processing and nowcasting. DMN-Cameroon reported no or little data assimilation, limited expertise in model adaptation and no nowcasting or short-term forecasting beyond regular weather monitoring. This is significant because D.3 identifies short-lead flash flood prediction as particularly sensitive to rainfall timing and placement; where deterministic NWP skill is limited, nowcasting and post-processing are necessary operational complements.

D.3 notes that in the Congo Basin in particular, limited in-situ observations constrain the evaluation and calibration of rainfall products and hydrological states, contributing to weak confidence in longer-lead rainfall signals and continued reliance on satellite and reanalysis proxies (Nicholson et al. 2021, Fatras et al. 2021). These constraints limit the feasibility of impact-based warning without stronger foundational monitoring and data integration (D.3, citing Hydromet Alliance 2024).

Data and information on exposure and vulnerability

This section describes the state of exposure and vulnerability data for Central Africa and how it is currently used in early warning and Impact-based Forecasting (IbF). General findings for the continent are presented in Chapter 3.

D.3 describes Central Africa as "still in a foundational building phase compared to other SEWA regions", characterised by fewer initiatives, lower operational embedding, and narrower hazard coverage. This is also true for Impact-based forecasting and the use of exposure and vulnerability data. The exception is CAPC-AC, which produces impact-based outputs using HECRAS, SWATPLUS and DTN, and disseminates a malaria hazard bulletin combining meteorological forecasts with land use, population density and vegetation. At national level, Cameroon's DMN reported a multi-risk bulletin under development and specialised sector bulletins co-produced with the Ministry of Livestock, the Ministry of Agriculture and port authorities (workshop). IbF remains uneven across the region, with limited evidence of operational embedding outside multi-hazard programme workshops (D.3).

Cameroon's Direction de la Météorologie Nationale explicitly records integrated impact forecasting systems (integrating hazard, exposure and vulnerability data) as a high-priority URDB need; CAPC-AC records sectoral impact forecasting (sector-specific impact models) as a high-priority need; the University of Douala records sectoral risk assessment models (integrated vulnerability models) as a need; and METTELSAT (DRC) records early warning lead time and user-friendly warning communication as priority needs. What limits stakeholders from meeting these needs themselves is a combination of factors: limited access to structured impact data and severity thresholds, weak integration of hazard information into operational decision-making, a shortage of IbF-specific skills. CAPC-AC reported that the census data was last updated in 2005 and needs an update.

Key data interfaces and visualization tools

This section briefly describes the main data interfaces and visualization tools currently in use across Central Africa. It also notes the main limitations relevant to the Regional Pilot's design.

Regional warning and decision-support platforms. At the regional level, CAPC-AC serves as the designated RCC-ECCAS (in demonstration phase since 2024 per D.3) and convenes PRESAC, the seasonal climate outlook forum for Central Africa. CAPC-AC uses the Multi-Hazard Early Warning System (MHEWS) developed under CREWS Central Africa, together with the AMHEWAS platform (an AU/UNDRR continental early warning and early action initiative). The AMHEWAS system uses MyDewetra as a platform. For transboundary riverine flooding, the Lake Chad Basin Integrated Water Resources Management and Early Warning System (spanning Cameroon, Chad, Niger, Nigeria and the Central African Republic) is the only clearly identified operational transboundary EWS in the region (D.3). The Congo Basin is the focus of emerging early warning development. No dedicated RSMC for severe weather forecasting currently operates within the sub-region; RSMC Yaoundé is under development and is expected to support capacity development for Central African NMHSs (D.7). Given this landscape, the Lake Chad Basin EWS and the CREWS Central Africa Multi-Hazard Early Warning System (MHEWS) (a platform used operationally by CAPC-AC, see above) are concrete platforms to build upon. The base model of MHEWS (software platform, hazard coverage, geographic scope) is Fanfar which is integrated in My Dewetra.

National warning and decision-support platforms. At the NMHS level, stakeholders across the region use a diverse set of platforms. METTELSAT (DRC) uses PUMA2025. DMN Cameroon has developed two platforms, one for data centralization and sharing through WMO's WIS, and one for the Climate Data Management System. It also uses CAP for warning dissemination. IGEBU (Burundi) uses a myDEWETRA platform for fluvial flood forecasting and a Delft-FEWS based system with Meteosat-based pluvial flood forecasting system for Bujumbura is under development visualized in a specific viewer for this system, and CLIMSOFT for data management.

Recommendations for SEWA pilots based on identified gaps and needs in Central Africa:

The following recommendations summaries how SEWA pilots in Central Africa can be designed to address the gaps identified above while working within the region's institutional and capacity constraints.

- Pilot projects in Central Africa should focus on strengthening foundational early warning and IbF capability for one or more of the focus hazards: riverine floods, flash floods and droughts & dry spells. The pilot should be designed for data-scarce settings, making practical use of available global and regional forecast products, satellite data, limited in-situ observations, historical event information and local knowledge.
- Pilot design should explicitly address the region's weak forecasting and IT foundations. This includes support for data management, data-format harmonisation, post-processing, calibration, verification, nowcasting where relevant, server/storage arrangements, and operational procedures that remain workable under unreliable internet and electricity conditions.
- Capacity development should focus on foundational forecasting, data management, modelling, station maintenance, IbF concepts, and back-end IT operation. Training should be hands-on and sustained, supported by self-paced materials, train-the-trainer approaches and francophone documentation, rather than delivered only through short workshops.
- Pilot design should support CAPC-AC's regional role and/or the development of RSMC Yaoundé, while also clarifying how regional products connect to national warning mandates.
- Pilots should explicitly strengthen institutional coordination between meteorological services, hydrological services, civil protection or DRM agencies, River Basin Organisations, CAPC-AC, RSMC Yaoundé and relevant sectoral institutions. This should include practical agreements on data sharing, roles and responsibilities, feedback after events, and procedures for official warning issuance.

4.3.3 Proposed goal

This section presents the proposed goal of the Central Africa Regional Pilot.

Proposed goal statement for Central Africa

Strengthen foundational early warning capability in Central Africa by demonstrating an early warning system and operational forecast workflows for one or more of the focus hazards identified (riverine floods, flash floods, droughts & dry spells), suitable for a data-scarce area and resilient to internet and power interruptions. Show how local knowledge can be used to calibrate forecasting models when field data is limited, by combining open data sources with this local knowledge and datasets. Combine global exposure and vulnerability datasets and local knowledge or data to translate forecasts to impacts. Increase understanding of mandates, roles and responsibilities related to early warning between national meteorological services, national hydrological services and civil protection agencies and when relevant regional institutions.

The need SEWA fills

D.3 describes Central Africa as "still in a foundational building phase compared to other SEWA regions", characterised by fewer initiatives, lower operational embedding, and narrower hazard coverage. It is flood-dominant, urban-focused, and constrained by foundational observation and operational service capacity. SEWA's specific contribution in Central Africa is therefore to strengthen these foundations. Expanding observation networks is outside the scope of SEWA. Pilots should focus on developing systems suitable for data-scarce environments, while integrating the real-time and historic data that is available to showcase the relevance of this data to decision makers.

While D.12 explicitly recommends building on existing systems, the participants from Central Africa mentioned during the workshop that this puts countries which have gotten limited attention from projects in the past at a disadvantage. For this region, we therefore recommend considering both new areas as well as existing platforms for pilots. Examples of existing platforms in the region are the Lake Chad Basin EWS, CAPC-AC's CREWS MHEWS, IGEBU's pluvial and fluvial flood early warning systems, Cameroon's DMN WIS/CDMS platforms.

4.3.4 Objectives

This section presents the potential specific objectives of the Central Africa Regional Pilot. The proposed objectives are grouped into three themes; technical, institutional, and sustainability objectives. Together, they operationalize the goal set out in Section 4.3.3.

Technical objectives

- Demonstrate how an operational early warning and Impact-based Forecasting (IbF) workflow for one or more Central Africa focus hazards (riverine floods, flash floods, and/or droughts and dry spells) could be set-up and designed for areas with sparse observations and intermittent power or internet connectivity.
- Demonstrate use of available global, regional, and national forecast information more effectively for operational warning. This includes consolidating access to products such as ECMWF IFS/AIFS, GFS, WRF where available, GPM IMERG, CHIRPS, and other relevant satellite or reanalysis products; harmonising input data formats; and establishing practical post-processing, calibration, and verification workflows.
- Show how local knowledge, limited field observations, historical event information, and available hydrometeorological data can be combined with open data sources to calibrate or bias-correct forecasts and build confidence in warnings, without making the pilot dependent on a dense monitoring network that is not yet available.
- Showcase the translation from hazard forecasts to impact information by integrating open exposure and vulnerability datasets with locally available data and knowledge.
- Pilot a resilient technical set-up that can continue to support forecasting and warning when internet connectivity, computing power, or electricity are unreliable. This should include minimum operating procedures, backup arrangements, and a hosting approach that is realistic for the participating institutions.

Institutional objectives

- Aim to increase understanding of mandates, roles, and responsibilities related to early warning between relevant stakeholders, which could be national meteorological services, national hydrological services, civil protection or DRM agencies, River Basin Organisations, CAPC-AC, and RSMC Yaounde as it becomes operational.
- Aim to strengthen regional and national coordination without bypassing national warning mandates. The pilot should define how regional and national institutions can work together on official warning issuance connect in practice.
- Aim to establish practical data-sharing and feedback mechanisms between the regional centre and participating NMHSs, including agreement on which data and products are shared as visualisations, which are shared in machine-readable form and how, and how verification feedback is returned.

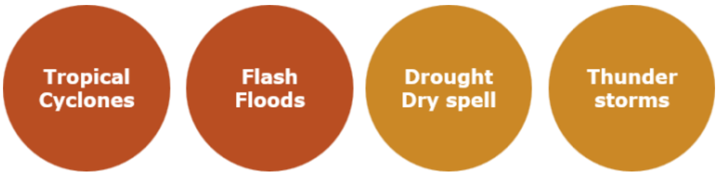
Sustainability objectives

- Show how to embed the pilot in relevant regional, national, and institutional frameworks through a roadmap that identifies the responsible institutions, decisions required, and next steps for operational uptake beyond SEWA. This should be aligned with the clarification of Central African mandates and with CAPC-AC's transition from demonstration status toward a fully operational RCC role.
- Aim to ensure warning and decision-support outputs are understandable and compatible with existing communication practice, without including dissemination in the pilot.

4.4 Southern Africa & Indian Ocean Islands

4.4.1 Proposed hazard focus for Southern Africa & Indian Ocean Islands

The proposed focus hazards for Southern Africa & Indian Ocean Islands are tropical cyclones, flash floods and thunderstorms.



Proposed focus hazards

Tropical cyclones were prioritised as very high during the workshop, and the D.9 analysis confirms high scores along the eastern side of the region. A notable finding is that cyclones ranked only 5th in the individual voting, reflecting that only a subset of countries along the east coast and Indian Ocean islands are directly affected. However, once participants discussed prevalence, impact, cascade impacts, and relevance together, consensus emerged that all dimensions were high, bringing overall interest to very high. They described it as follows:

"Prevalence is high, along the eastern part of the region. From the eastern part of Madagascar, Mozambique, Mauritius towards the continent (impacting Zimbabwe, Malawi and Zambia). The scale of the hazard is regional. The impact is very high, there is a huge loss of life, also economic impact. Cascading impact is also high (thunderstorm, riverine flooding, flash flooding). The interest is very high." – Workshop participant

It was also noted that Zambia becomes increasingly affected, which was not the case before. On this basis, we consider tropical cyclones a focus hazard for the region. This is consistent with the D.2 inventory, where 12 initiatives address cyclones, concentrated in Mozambique (6), Malawi (5), and Madagascar (4), or operating at the regional scale, though none are cyclone-focused; all are multi-hazard programmes. D.3 reinforces the forward-looking relevance:

"Tropical cyclones affecting the Southwest Indian Ocean are projected to become more intense, increasing the potential for extreme rainfall and coastal impacts." – D.3

Flash floods came out first in the individual voting at the country level during the workshop. A finding is that, while participants rated prevalence, impact, and cascade impacts as very high, they deliberately kept the interest score at only medium. They explained this as follows:

"Prevalence is very high, with a local scale. Impact is very high, cascading impact as well (infrastructure damage, life loss, contamination, debris). Interest is considered medium. Could not rank it too high, because it is a 2-way action: citizens can do something to decrease the impact. It continuously happens, though not a lot is done to tackle it." – Workshop participant

Participants also flagged country-level contrasts, e.g. Malawi, where flash floods are the main hazard and "even small rainfall results in flash flooding". On this basis, we consider flash floods a focus hazard for the region, while recognising that adding value will require more than forecasting alone. This is consistent with D.2, which identifies only three dedicated flash flood initiatives in the region (FFGS South Africa, FFGS Zambia, and the regional SARFFGS). D.3 summarises the operational landscape as follows:

"Riverine and flash flooding are addressed through SARFFGS and community-based flood EWS initiatives in several countries." – D.3

Droughts & dry spells rank first for Southern Africa in the D.9 analysis under both unweighted and population-weighted scoring (the only SEWA region where it tops the quantitative ranking) and the cascading-hazard assessment identifies drought as a core driver of compounding events (drought–heatwave–wildfire). During the workshop, however, drought did not make the participants' top three. They rated interest as high rather than very high, and explained this as follows:

"Prevalence is medium, on a national/regional scale with a high impact (food production and farmers who suffer). Cascading is high, it does affect communities on international level (if there is not enough maize, there is an international impact). Interest is rated as high; there are some insurance policies, there are seasonal forecasts." – Workshop participant

Thunderstorms prevalence and impact was rated by participants as high to very high, D.9 scores thunderstorms low across the region, a pattern also seen in West and Central Africa, likely because thunderstorms are underrepresented in global risk datasets and often captured indirectly through cascading hazards such as flash floods and wildfires. Participants described the hazard as follows:

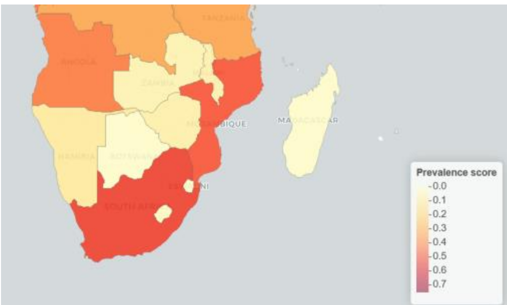
"Prevalence is high on a regional scale. Impact (human lives) is very high. Cascading impact is considered medium. Interest is high." – Workshop participant

On this basis, we consider thunderstorms a focus hazard for the region. This is consistent with D.2, which identifies 9 thunderstorm-related initiatives, concentrated in South Africa (6), Zambia (4), and Mozambique (4), though none focus on thunderstorms specifically; all are multi-hazard programmes (e.g. SWFDP Southern Africa, CREWS Malawi/Mozambique/Zambia, WISER EWSA, SAWS Impact-based Forecasts and Warnings).

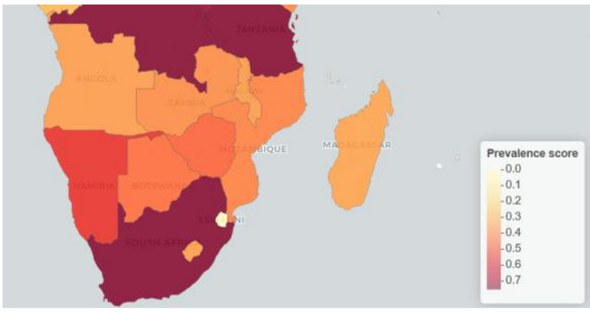
Other hazards

The remaining five hazards, dust storms, riverine floods, wildfires & smoke and heatwaves, were not included for this region. Heatwaves and riverine floods, however, stand out among the other hazards: heatwaves are an emerging hazard with high projected intensification (IPCC AR6, per D.3) and limited dedicated early warning capacity; riverine floods are heavily transboundary in the region and are already addressed through established basin systems (Zambezi, Cuvelai, Songwe).

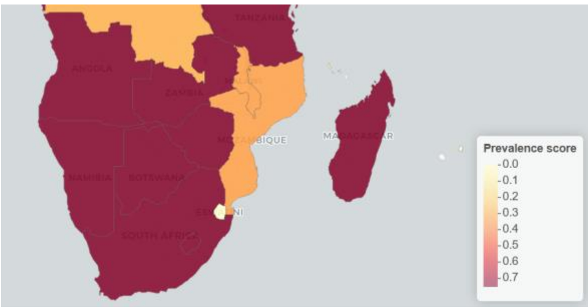
The following figures show the prevalence scores for these hazards from D.9. The darker red a country is, the higher the prevalence of a hazard.



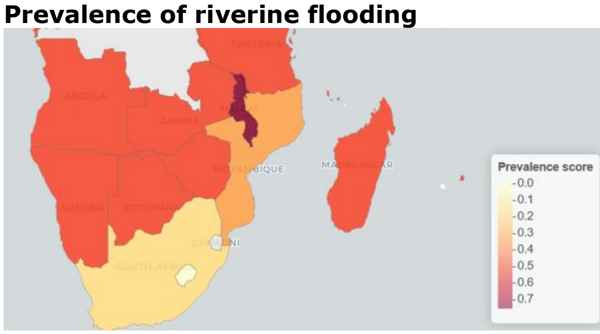
Prevalence of dust storms



Prevalence of riverine flooding



Prevalence of wildfires & smoke



Prevalence of heat waves

Figure 4 Prevalence scores for the non-prioritised hazards: dust storms, riverine flooding, wildfires & smoke, droughts & dry spells and heatwave.

Drought and dry spell prevalence scores are high to very high in the south (Namibia, parts of South Africa, Mozambique and Zimbabwe), consistent with D.3's observation that continued warming is expected to amplify drought stress, especially in the southwest of the region. Heatwave prevalence scores high across the region and is projected to increase (IPCC AR6, per D.3).

Wildfires & smoke prevalence scores high in D.9 across parts of the region, particularly in Zimbabwe, Namibia, Botswana and South Africa, consistent with workshop observations that fires occur across borders and affect property, livelihoods and the economy. Dust storm prevalence is low to medium across the region; workshop participants noted dust storms as relevant only for Namibia, and more as a nuisance than a life-threatening hazard.

Heatwaves are an emerging concern in the region. D.3 notes that heat extremes are projected to increase and are likely to become a more dominant hazard over time, despite limited dedicated early warning capacity; heatwaves appear in 4 of 68 projects in the WP1 inventory. South Africa's SAWS records heat risk early warning as a high-priority URDB need, and Lesotho Meteorological Services records drought early warning indicators as a high-priority need. Riverine flooding has a high prevalence in the region. However, 48 out of 68 projects already address this hazard (though often multi-hazard projects as well) so coverage in the region appears adequate.

4.4.2 Specific findings on gaps, needs and challenges

This chapter presents the specific findings for Southern Africa and the Indian Ocean Islands, additional to the continental findings presented in Chapter 3, and subdivided in findings on four topics:

- Training and capacity building
- Challenges in forecasting

- Data and information on exposure and vulnerability
- Key data interfaces and visualization tools

On training & capacity building

D.3 describes Southern Africa's training structure as "distinctive", with a defining feature being university-based degree programmes alongside specialised meteorological training (including SAWS-linked training) and programme-delivered workshops such as WISER EWSA. The WP1 inventory identifies 13 training entries for the region (D.3). However, training coverage is geographically concentrated in South Africa and does not extend evenly across the SADC membership, creating the same internal asymmetry that characterises the region's operational capacity. The region lacks a permanent SADC-wide regional training academy comparable to ICPAC's Training Academy in East Africa.

Challenges in forecasting

Southern Africa has the most operationally embedded IbF capability of any SEWA region: D.3 notes that the South African Weather Service (SAWS) delivers operational impact-based forecasts and warnings as a routine national service, not as a project or pilot. Other providers of impact-based or CAP-based alerts in the region include the Malawi Meteorological Services, Zimbabwe's Meteorological Services Department, and the Zambia Meteorological Department. The WISER EWSA project (2023–2025) strengthened structured alert dissemination, community observer networks, with nowcasting and short-range forecasting systems operationally embedded at ZMD (Zambia), INAM (Mozambique) and SAWS (South Africa) according to D.12. However, as D.3 observes, "where impact-based warnings are issued (e.g., SAWS), integration of exposure data into warning thresholds and messaging remains an area for development", particularly for cyclones and floods, where understanding exposed populations and critical infrastructure is essential for effective preparedness and response.

D.3 describes Southern Africa as "an overall operationally mature region, but with uneven national embedding", with 49% of the projects classified as operational, the highest share among SEWA regions. The gap between South Africa's operational capacity and that of the wider SADC membership is a crucial aspect of the region. For the Indian Ocean islands, tropical cyclone exposure and the IOC's dedicated hydromet programme create a distinct sub-regional profile that needs separate consideration within pilot design.

Taken together, this suggests a specific opportunity for SEWA in Southern Africa: rather than creating new stand-alone IbF systems, SEWA could extend existing operational IbF mechanisms (SAWS methods, SARFFGS workflows, WISER EWSA products) and reduce the capacity gap national services. Another opportunity for the region is to build further on the experience gained in South Africa or on expertise and knowledge is already available in the region and by promoting intra-regional activities other countries can benefit from this experience.

Transboundary systems include the three flood forecasting and early warning initiatives in the Zambezi Basin (with ZAMCOM as the River Basin Organisation), CUVEWIS in the Cuvelai Basin between Namibia and Angola, and the Joint Songwe River Basin Commission between Malawi and Tanzania (D.3).

Forecasting capabilities. Stakeholder needs range from better access to global and regional forecasts, to tools for downscaling, access to Limited-Area Models and convection-permitting models, and infrastructure to run these models operationally. Workshop participants from SAWS specifically flagged that the ECMWF model excels in forecasting tropical systems, but that improvement is needed for thunderstorms and convective situations, and that models do not capture convective situations well (illustrated by the Botswana early-2025 Gaborone flash flood event) due to its global setup and therewith coarser resolution.

Data and information on exposure and vulnerability

South Africa operates a National Geo-Spatial Information Portal (CDNGI portal) with basemaps and nation-wide maps. Across Southern Africa, integration of exposure and vulnerability data and the operationalisation of IbF emerges as a widespread URDB need (though SAWS is an exception, with operational IbF as a routine national service (D.3)). The need is mentioned by BMS (Botswana), LMS (Lesotho), DCCMS (Malawi), DGM (Madagascar), SMA (Seychelles), MMS (Mauritius), INAM (Mozambique), ZMD (Zambia), EMS (Eswatini), ANACM (Comoros) and the Cuvelai Watercourse Commission (Namibia). Limited access to exposure and vulnerability data and severity thresholds are the limitations mentioned.

Key data interfaces and visualization tools

Regional warning and decision-support platforms. SADC-CSC serves as the WMO RCC (in demonstration phase since 2024), convenes SARCOF (the Southern African Regional Climate Outlook Forum), and uses a CFD tool for seasonal forecasting with inputs from CHIRPS and member-state station data (D.3). RSMC Pretoria (hosted by SAWS) provides severe weather forecasts and hosts the Southern Africa Regional Flash Flood Guidance System (SARFFGS), which operates across multiple SADC countries with dedicated national implementations, including FFGS South Africa and FFGS Zambia (D.3, D.2). SAWS is also a WMO-designated Global Producing Centre for Long-Range Forecasts (GPC-LRF), the only one in Sub-Saharan Africa. South Africa also hosts ADEWS (Agricultural Drought Early Warning System), the SANSA Advanced Fire Information System, and SAWS's operational IbF workflow (D.3). The Indian Ocean islands coordinate through the Indian Ocean Commission and its dedicated hydromet programme (D.3).

Recommendations for SEWA pilots based on identified gaps and needs in Southern Africa:

The following recommendations summarise how SEWA pilots in Southern Africa can be designed to address the gaps identified above while working within the region's institutional and capacity constraints.

- Pilot projects should focus on extending existing operational IbF methods (SAWS's operational IbF workflow, SARFFGS implementations, WISER EWSA nowcasting) to wider SADC membership and the IOC islands, rather than creating new stand-alone systems. D.3 explicitly advises “extend impact-based forecasting by adapting SAWS methods and thresholds for wider Member State uptake rather than building separate IbF pilots that are not embedded in national workflows”.
- Pilot design should explicitly address the asymmetric capacity across the region: South Africa's operational capacity is not replicated across the wider SADC membership, and the IOC islands face a distinct tropical cyclone hazard profile.

4.4.3 Proposed goal

Proposed goal statement for Southern Africa

Demonstrate the added value of hydrometeorological in-situ data for hazard modelling, and its downstream benefits for Impact-based Forecasting (IbF) for at least one of the focus hazards. This will be achieved by automating procedures for data assimilation, forecast verification and observation validation on an existing regional platform, in co-development with the institutions that will operate and maintain it.

In parallel, the pilot should integrate exposure and vulnerability datasets with hazard forecasts, define and verify impact thresholds for at least two sectors, and deliver a roadmap that strengthens intra-regional data *governance and data sharing. The procedures should be designed to be usable by countries with both foundational and more advanced monitoring networks, to ensure continued use and uptake beyond the project.*

The need SEWA fills

In-situ observation networks across Southern Africa vary considerably in density, automation, and integration into operational forecasting workflows, and data sharing between countries and between institutions is often constrained by the absence of formal governance arrangements. At the same time, IbF in the region remains underdeveloped relative to hazard monitoring and forecasting, with exposure and vulnerability datasets largely available but not embedded in routine operational workflows.

SEWA's specific contribution is to strengthen the operational use of in-situ hydrometeorological data as a foundation for improved hazard modelling and downstream IbF. The pilot will demonstrate this by automating procedures for data assimilation, forecast verification, and observation validation on an existing regional platform, while linking hazard forecasts to exposure and vulnerability information for at least two sectors. In parallel, SEWA will support the definition and verification of impact thresholds and develop practical arrangements for intra-regional data governance and data sharing.

4.4.4 Objectives

This section presents the specific proposed objectives of the Southern Africa Regional Pilot. The objectives are grouped into three themes; technical, institutional, and sustainability objectives. Together, they operationalize the goal set out in Section 4.3.3.

Technical objectives

- **Demonstrate the added value of in-situ hydrometerological data for hazard modelling** by automating procedures for data assimilation, forecast validation, and observation validation on an existing regional platform, for at least one of the focus hazards.
- **Demonstrate how improved use of in-situ data can strengthen downstream IbF** by linking hazard forecast quality to exposure and vulnerability datasets and translating these into impact-based warnings for at least two sectors.
- **Strengthen IbF capacity in the region** by showcase the translation from hazard forecasts to impact-based warnings, including the integration of exposure and vulnerability datasets, the definition and verification of impact thresholds for at least two sectors, and the embedding of verification procedures in routine forecasting workflows.
- **Aim at structurally developing forecasting capacity** at the institutions involved in the pilot, covering both foundational needs and more advanced skills, with explicit attention to designing solutions that work across the spectrum from foundational to advanced monitoring networks.

Institutional objectives

- **Aim to strengthen intra-regional data governance and data sharing** between RCCs, NMHSs, hydrological services and River Basin Organisations involved in the pilot, through formal data-sharing arrangements, agreed standards and formats, and shared operational procedures for assimilation, verification and validation.
- **Aim to enhance intra-regional learning** by designing the pilot's operating procedures, documentation and training so that countries with foundational monitoring networks can adopt

them alongside countries with more advanced ones, and by establishing peer-learning mechanisms between institutions at different levels of capacity.

Sustainability objectives

- **Aim to ensure formal embedding of data governance and sharing arrangements** through a roadmap that identifies the relevant institutional, national and regional frameworks or agreements, and through formal data-sharing arrangements between the institutions that will operate the system.
- **Aim to ensure sustainable operation and maintenance** through co-development with end users, an explicit exit strategy covering financing, ownership and maintenance, and continuity mechanisms such as self-paced training materials, train-the-trainer approaches, and ideally partnerships with local IT consultants.

5. During the pilot projects

The action plan aims to distinguish three aspects of demonstrator development and deployment: the technical developments themselves, the documentation and reproducibility of the methods used, and the hosting and infrastructure on which the demonstrator runs. The three are closely linked, and reproducibility practices such as containerization are partly what make a system portable across hosting options.

Technical developments

The technical developments consist of multiple components. These components feed into one another, but they address distinct parts of the workflow and can be owned by different parties:

- Data-processing workflows. The pipeline that ingests global forecast products (ECMWF IFS, AIFS, GFS), satellite products, and available in-situ observations, and applies bias correction, downscaling, quality control, and format harmonization to make them usable.
- Forecasting and model layer. The generation of the hazard forecast itself, for example, NWP/LAM tailoring and calibration, nowcasting, AI-based post-processing of global forecasts, or ensemble generation for probabilistic triggers.
- Impact layer. The integration of exposure and vulnerability datasets with the hazard forecast, and the logic that translates a forecast into impact information using defined, verified impact thresholds.
- Interface and dissemination layer. The user-facing outputs, including CAP-alerts, and dashboards. Dissemination itself is outside SEWA's scope.

The value of explicitly naming layers is that ownership becomes clear at handover: the forecasting layer may sit with an NMHS forecasting team, the data pipeline with its IT, and the impact layer with a DRM or sectoral partner. Each can then be owned and maintained by the institution best placed to do so, rather than treated as a closed integrated system that no single institution fully owns.

Documentation and reproducibility of methods

Documentation is important for the reproducibility and critical for the sustainability of systems. A recurring topic across the regions is the challenge of staff retention, but even staff members who stay need to have detailed documentation to remember how the system is constructed. Several good practices that support documentation and ensure reproducibility of methods are:

- **FAIR data practices**. Documenting the data layers so that they are Findable, Accessible, Interoperable and Reusable, through metadata, persistent identifiers, documented licenses, and machine-readable formats. This addresses the interoperability and format gaps identified in Section 3.2, as well as the tendency for project data layers to remain unavailable beyond the project that produced them.
- **Version control**. Maintaining code and configurations under version control, so that changes are traceable and the system can be restored to a known working state.
- **Containerization**. Packaging the software environment in containers (for example, using Docker or Podman) so that the exact environment can be reproduced. In addition, containerization allows for easy migration between machines or hosting platforms.
- **Decision logs**. Recording the rationale behind the choices made, including model configuration, calibration parameters and impact-threshold values. A decision log allows a new staff member to understand and adapt a system rather than just run it, and it is the documentation most likely to survive staff turnover.
- **Standard Operating Procedures** describe the roles and responsibilities for everyone working with the system
- **Self-paced training materials**, to be used for refresher courses or onboarding of new staff members

Cloud infrastructure usage and integration

Each pilot must decide where its demonstrator runs: locally, in the cloud, or in a hybrid setup. Section 3.2 presents cloud hosting as a partial solution to the region's computing, power, and bandwidth constraints, along with its limitations.

Cloud computing is most useful where computing capacity, rather than connectivity, is the main constraint. Heavy tasks such as AI model training, Limited-Area Model runs, and ensemble generation can be run centrally on cloud infrastructure. Lighter operational tasks, like warning generation, can remain local.

A hybrid setup is therefore preferable: heavy processing runs in the cloud when connectivity is available, outputs are cached locally, and warning generation continues offline using the latest retrieved forecasts. Jobs can be queued and resumed when connectivity returns. In this hybrid setup, the cloud would be the backup layer rather than the full operational system.

As noted in Section 3.2, the main constraints are recurring subscription costs (in the range of EUR 700 to 1,500 per month for commercial providers), national data storage legislation that may restrict the use of international cloud facilities, latency to data centres outside the continent, and the continued need for local technical expertise. Any pilot that uses a cloud solution should document the access, cost, and data-sovereignty arrangements.

Cloud components developed and tested during the pilots, together with the documented limitations encountered, can serve as valuable lessons for an African Weather Cloud set out in Chapter 6.

The constraints mentioned should be taken into account when discussing pathways and sustainability. However, the pilots also provide the opportunity to test tools and workflows in a non-commercial cloud environment, the EWC. Lessons learned could then be used to find the right set-up for a potential future cloud solution.

6. Beyond the pilot projects

The SEWA pilot should be designed as a stepping stone in a longer development trajectory for early warning and Impact-based Forecasting in the region. Many challenges (or goals) related to early warning cannot be solved by a one-time action, they require a continued process of improving. These include: capacity development on forecasting, IT and EW/IbF, collaboration within and between institutions at various levels (regional-national, national-national, cross-sectoral) and data governance, embedding of early warning in formal frameworks. While all four pilots proposed are aiming to contribute to these goals, it will be hard to define when they are reached. As such, these should be considered topics for continuous improvement, at the agenda of all follow up projects on early warning and IbF. The Continuous Improvement (CI) approach presented in D.12 is not only applicable within projects, but also beyond and across projects. While this process is never linear, in what follows, we present goals in three levels of advancement; foundational, progressive and advanced for technical, institutional and sustainability matters. Note that EW/IbF in a region, country or institution can be at advanced level for one hazard, and foundational level for another hazard and vary across the regional or national institution. Furthermore, being at a specific level is not a state, but requires continuous work to maintain that state while circumstances and available technologies evolve. This table should be used as guidance for follow-up after SEWA.

African Weather Cloud

Besides progressively moving to advanced state, participants mentioned a specific opportunity for future developments after SEWA. This opportunity is working towards a joint African Weather Cloud, hosted by one of the RCCs, supported by experiences and technical capability from European partners and the AUC. This would ensure ownership by African partners, providing cloud-based hosting options in Africa. In addition, it may lower barrier of data (sharing) policies as data stays in Africa. We expect that this is an objective that is beyond the duration of the pilots, though pilots may be building blocks towards such a cloud. During SEWA the EWC could be used as a showcase to run some tools in such an environment and gather first hands-on experiences.

Towards stronger collaboration between Europe and Africa

The use of European data and products for enhancing early warning in Africa depends on the awareness of these products and capacity to work with them. At foundational stage, these products may assist institutions to provide early warning services if no local information is in place. In progressive stage the products may form the forcing global forecasts (ECMWF IFS/AIFS) for local forecasting models or continental data (e.g. EUMETSAT, JRC) may form the basis for localized product generation after postprocessing with local data. At advanced level, the forecasts could be tailored to local contexts by assimilating additional data and calibration in collaboration between African and European institutions. AI could play a role in this, for example by considering the use of AI based models or AI based postprocessing of data/model outcomes. While these examples are all presented from a technical angle, we aim to show in this report that these technical solutions will only land in fertile soil under the right conditions in terms of institutional setting and sustainability considerations. This is a case to include those angles in all activities, during SEWA and beyond, to make progress towards stronger collaboration between Europe and Africa sustainably.

The table below provides guidance for follow-up after SEWA by outlining indicative maturity levels for continuous improvement across the technical, institutional and sustainability dimensions of EW/IbF.

Level	Technical	Institutional	Sustainability
Foundational	• Operational early warning based on open data/models. • Local observations are used for validation/verification and saved structurally in archives. • Processes and channels are in place to disseminate forecasting information and warnings structurally to relevant stakeholders (incl citizens).	• Roles and mandates are clear across RCCs/RSMCs, NMHSs and DRM agencies. • SOPs describe the day-to-day operations of officers working on Early Warning/IbF. • Operation and maintenance roles, hosting, data management and backup arrangements are identified.	• A basic roadmap identifies where the EW/IbF system can be embedded in relevant institutional, national or regional frameworks. • Basic training materials are available to support onboarding of new staff members.

Level	Technical	Institutional	Sustainability
Progressive	• Operational early warning is based on local and tailored data and models at higher resolution than global or regional products. • Local observations are used for real-time validation/verification, with structural QC/QA procedures in place. • Forecasts, warnings and impact information are integrated into routine operational workflows for dissemination to relevant stakeholders (incl citizens).	• Roles and mandates are clear across RCCs/RSMCs, NMHSs, DRM agencies, RBOs and sectoral institutions. • SOPs describe maintenance, evaluation and feedback procedures. • SOPs also describe day-to-day collaboration between institutions, including regular evaluations.	• EW/IbF is embedded in formal institutional, national and regional frameworks or legislation, with clear responsibilities and funding routes. • Continuity mechanisms are in place, such as self-paced training, train-the-trainer approaches and partnerships with local IT support.
Advanced	• Operational IbF is based on, calibration, verification and validation of forecasts and observations and data assimilation techniques. • The use of internal or external cloud to ensure resilience and backup of operational systems. • Exposure and vulnerability datasets are integrated operationally with hazard forecasts, with impact thresholds defined and verified for multiple sectors. • Forecasts, warnings and impact information are shared with relevant stakeholders in suitable format, meaning machine-readable format for stakeholders that need to process the data and tailor-made formats for other stakeholders (incl citizens).	• Regional-national, national-national and cross-sectoral collaboration is formalized and practiced. • Data-sharing agreements and shared operational procedures are in place. • Peer-learning mechanisms and regular joint evaluations support continuous improvement across countries and institutions.	• Continuous Improvement is institutionalized, with ownership of the roadmap; institutions bring their own development objectives forward in projects or project definition phases. • Operational ownership, maintenance capacity and staff onboarding are sustained without project support.