WASP

WORLD ADAPTATION SCIENCE PROGRAMME

Science for Adaptation
Policy Brief

#4

Early Warning Systems for Adaptation

About the WASP and Policy Briefs

- The Science for Adaptation Policy Brief Series is an initiative of the UN-led World Adaptation Science Programme (WASP). The briefs target researchers, policymakers and practitioners to help them successfully bridge the science-policy-action interface.
- WASP is led by the Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Environment Programme (UNEP), the World Meteorological Organization (WMO), the Intergovernmental Panel on Climate Change (IPCC), the Green Climate Fund (GCF), the Global Environment Facility (GEF) and the United Nations University (UNU). WASP Secretariat is hosted at UNEP, Nairobi, Kenya. The current Chair of the WASP is Mr Youssef Nassef, Director of Adaptation at the UNFCCC Secretariat in Bonn, Germany.
- WASP's mission is to ensure researchers, policymakers and practitioners have the scientific knowledge and capacity necessary to underpin effective climate adaptation policy and action.

Introduction

Climate variability and change, and particularly extreme weather events, affect people, their livelihoods, and the natural resources on which they depend. With increasing frequency, intensity, and duration of extreme atmospheric natural hazard events already occurring and projected to worsen in the coming decades, traditional Early Warning Systems[1] need

1. For the definition of Early Warning Systems, please see UN General Assembly A/RES/71/276.

Key messages

- **Strengthening Early Warning Systems for Adaptation (EWSA) helps countries prepare for extreme weather events, now and in the future, and improves pathways towards sustainable development.** EWSA complement traditional early warning systems with information about evolving trends in the frequency, intensity and duration of weather and climate hazards, associated impacts, sectors and communities likely to be affected, and preparedness strategies.
- **Past and present climate data and information, along with medium-range forecasts, help identify evolving trends in extreme hazardous events.** The frequency, intensity and scope of hazardous weather events related to climate change are increasing around the globe. Accurate short-range forecasts are critical for triggering warnings and anticipatory action, and need to be complemented by information about the past, present and medium-range future. This helps to inform seamless adaptation and preparedness strategies.
- **Transdisciplinary collaboration, meaningful participation and community engagement are critical for efficient and effective EWSA.** To support robust decision-making, EWSA needs to be co-developed and co-led from the outset by climate data and information providers, practitioners, policymakers and the people and communities at risk, and ensure recognition and integration of local knowledge and practices.
- **Significant improvements to disaster responses can be achieved by reinforcing both scientists' and stakeholders' capacity to access, communicate and integrate climate information into risk management policies and practices to improve resilience.** Response capability for adaptation urgently needs to expand to generate sustainable solutions and trigger behavioural change. Improved capacity of disaster risk reduction practitioners, policymakers and vulnerable communities requires the best available science; understanding of sectoral needs; and tailoring of information for target audiences.
- **Efforts need to be stepped up to reduce the financial and resource disparities in EWSA capacity among countries and regions.** Scarcity of investments in the infrastructure supporting EWSA, weak capacity-building of meteorological and disaster risk reduction agencies, poor interdisciplinary research capacity, and inefficient information services, are barriers that hinder the development of effective EWSA in many developing countries. These need to be overcome by mobilizing earmarked financial support and focused resources.

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to evolve to encompass climate change adaptation to better help communities prepare for the worst, now and in the future. The inclusion of climate change adaptation in early warning systems is essential for the development of disaster risk reduction (DRR) approaches that enhance resilience, i.e. the ability of sectors, communities and societies to resist, absorb, accommodate and recover from the effects of climate change-related natural hazards.

Early Warning Systems for Adaptation (EWSA) are part of the international framework for climate services[2] that link science-based climate predictions, data and information with the management and mitigation of climate-related risks in support of adaptation to climate change in developed and developing countries, as well as in economies in transition. Climate information services can inform decisions that protect individuals and communities – as well as the ecosystems and natural environments on which humans depend – from the damaging effects of both extreme and slow-onset climate events.

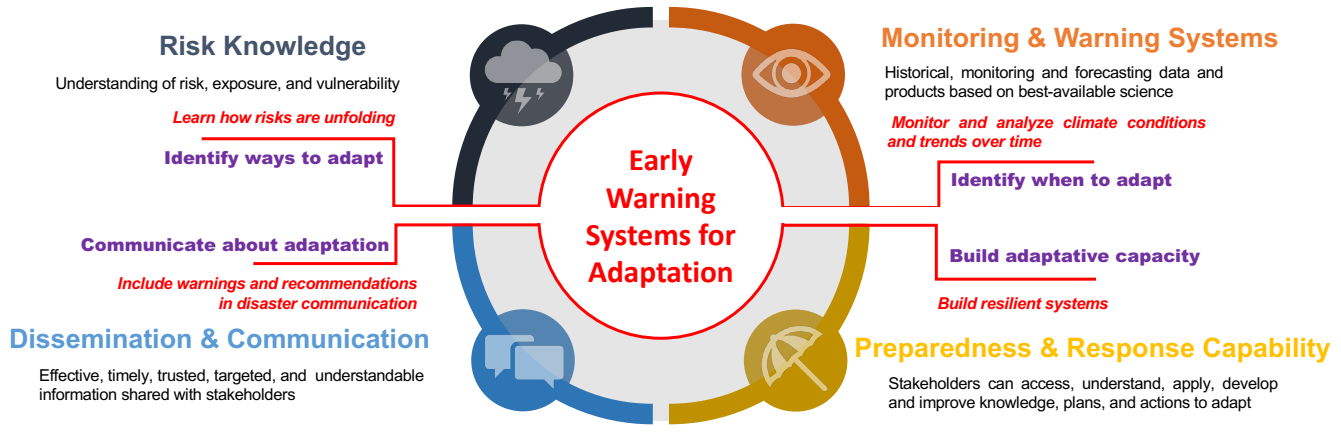
Many Parties to the United Nations Framework Convention on Climate Change (UNFCCC) have identified climate services – and EWSA – as a top priority in their Nationally Determined Contributions (NDCs). This includes 88% of Least Developed Countries (LDCs) and Small Island Developing States (SIDS). EWSA are also important for achieving targets defined within the scope of the Sustainable Development Goals (SDGs) and the Sendai Framework for Disaster Risk Reduction. These agreements commit governments to substantially reduce global disaster mortality, increase access to and availability of EWSA by 2030, and measure progress towards these targets (WMO 2020a).

Dealing with the growing challenges of disasters associated with natural hazards is one of the most critical aspects of climate change adaptation. Around 1.4 million people (70% total deaths) in LDCs lost their lives due to weather, climate and water-related hazards between 1970 and 2020.[3] However, many developing countries lack the capacity – infrastructure, technical capacity, communication systems, data-sharing and political will – to react to climate disasters in their regions. Data provided by 138 members of the World Meteorological Organization (WMO) (including 74% of LDCs and 41% of SIDS) show that just 40% of them have multi-hazard early warning systems.[4] Therefore, it is imperative to expand efforts to build capacity and effective early warning systems in all countries to reach set adaptation goals.

A systems approach for EWSA

Building effective EWSA is an interdisciplinary task requiring an integrated systems approach that includes incorporating climate change and adaptation in their development and processes (Fig. 1). To be effective, EWSA need to comprise four interacting elements: (i) risk knowledge, (ii) monitoring and warning systems, (iii) dissemination and communication and (iv) preparedness and response capability. This Science for Adaptation Policy Brief draws on examples from around the world and evidence-based science results to describe the challenges, lessons learned and pathways for each of these interacting elements.

Figure 1: **Systems approach to Early Warning System for Adaptation (EWSA).** Adapted from: Basher 2006



2. https://gfcs.wmo.int/what-are-climate-services
3. https://www.un.org/ohrlls/
4. The Multi-Hazard Early Warning System (MHEWS) definition is taken from the Multi-hazard Early Warning Systems: A Checklist. WMO (2018). https://library.wmo.int/index.php?lvl=notice_display&id=20228#.YS5TGdNKj0p

Risk knowledge is key to getting us ready for climate-related events

Learning how risks' exposure and vulnerability[5] are shifting with climate change is key to improving preparedness for future hazards. What worked in the past is no longer sufficient for addressing today's and future risks. Between 2010 and 2019, the percentage of reported disasters associated with weather, climate and water-related events increased by 9% compared to the previous decade – and by almost 14% compared to 1991-2000 (WMO 2020a). According to the recently released WMO Atlas of Mortality and Economic Losses from Weather, Climate and Water Extremes (1970 – 2019), there were more than 11,000 reported disasters attributed to these hazards globally, with just over 2 million deaths and $3.64 trillion in losses (WMO 2021). The situation is particularly acute in SIDS and LDCs.

EWSA have to focus on two types of climate events: sudden-onset and slow-onset. Sudden-onset events include heatwaves, heavy rainfall events, droughts and floods. For example, multiple cities in the Pacific Northwest of the United States and Canada experienced temperatures in June 2021 never previously observed, including the setting of a new all-time Canadian temperature record of 49.6°C in the village of Lytton. Although well forecasted, this heatwave[6] affected a large population unaccustomed to, and unprepared for, such extreme heat.

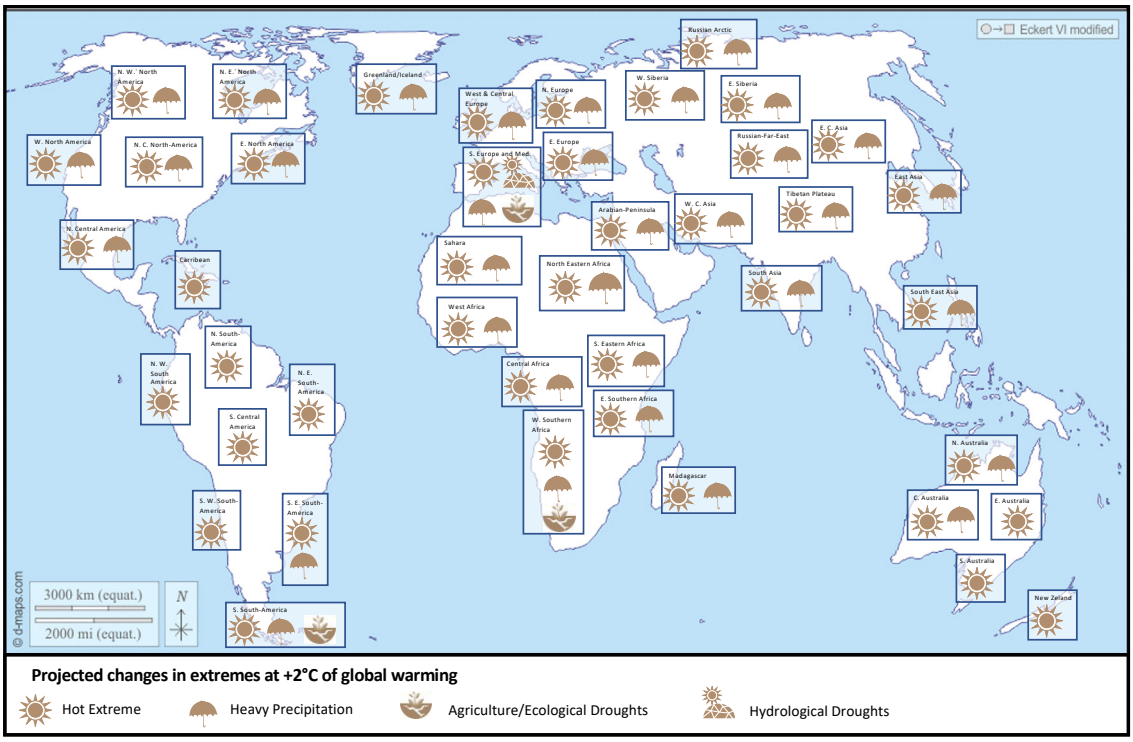
As global temperatures rise, extreme events are expected to become more intense and frequent (Fig. 2). The risk of compound events that combine multiple drivers or hazards, such as concurrent heatwaves and droughts, is also increasing in frequency.

Slow-onset events include sea-level rise, increasing temperatures, ocean acidification, glacial retreat, salinization, land and forest degradation, loss of biodiversity, and desertification which occur gradually. Vulnerable developing countries will be affected the most by slow-onset events due to their low adaptive capacity (UNFCCC 2012).

There is a growing awareness that both sudden-onset and slow-onset events can interact, creating a situation of cascading risks that concatenate through time and space. This causes impacts to worsen, spread, and last longer.

However, there is a great disparity in risk knowledge and response capacity among countries and regions in terms of responding to both sudden-onset and slow-onset events, as well as cascading risks. Knowledge needs to go beyond the provision of extreme weather, climate and water-related alerts to include information about trends in events, locations of climate hazards, types of associated impacts, who and what are likely to be affected, and how to be prepared.

Figure 2: **Projected changes of extreme events at +2°C of global warming. Projections are shown for the pre-industrial baseline 1850-1900. Only projected changes with a high level of confidence are represented.** Source: AR6 WG1 IPCC report, chapter 11, table A.11.2, pp 17-19.[7]



5. The definitions of risk, vulnerability, and exposure are set out in the IPCC Sixth Assessment Report (AR6) Chapter 1. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter_01.pdf
6. https://www.worldweatherattribution.org/western-north-american-extreme-heat-virtually-impossible-without-human-caused-climate-change/
7. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter_11.pdf

Monitoring and warning systems help anticipate climate risks

In a warming world, accurate short-range weather and climate forecasts are critical to trigger warnings and rapid anticipatory action, but can be complemented by information about the past, present and medium-range future (sub-seasonal, seasonal, interannual) to inform the development of more seamless adaptation and preparedness strategies.

Over the past 30 years, ever-increasing amounts of satellite and other data, along with the development of improved weather and climate modelling and deep learning techniques, have revolutionized the accuracy, timeliness and affordability of early warning systems. These are increasingly important for climate change adaptation and sustainable development.

Although reliable monitoring capability is a fundamental prerequisite for EWSA and effective climate actions, there are still significant data gaps in basic weather observations in some parts of the world such as Africa, the southwestern Pacific, South America and Antarctica (WMO 2020a). These gaps affect the quality of weather and climate forecasts, and more broadly, climate services and EWSA. Closing the data and adaptation finance gaps would require innovative approaches to financing such observations.[8] These approaches are designed and implemented by the Systematic Observations Financing Facility (SOFF).[9]

Monitoring and warning systems can also deliver significant environmental co-benefits. Increased availability and use of actionable climate information and early warnings can improve natural resource management, from climate risk-informed policymaking to conservation and arresting biodiversity loss. Impact-based forecasts tailored to natural resource-dependent sectors, such as agriculture and fisheries, can facilitate rapid identification of weather, water and climate hazards that pose environmental risks, and consequently inform actions that minimize impacts.

Box 1: Global Monitoring and Warning Tools in Aid of National Action

There are many global tools available to help countries bridge data gaps and strengthen EWS and its applications, including the Famine Early Warning Systems Network **(FEWS NET)**,[10] PreventionWeb.net,[11] the World Meteorological Organization's specialized Climate Risk and Early Warning Systems **(CREWS)** initiative,[12] the integrated Earth System observation network,[13] the United States National Oceanic and Atmospheric Administration **(NOAA)**,[14] the United States National Integrated Drought Information System **(NIDIS)**,[15] the Enhancing National Climate Services **(ENACTS)** initiative (International Research Institute for Climate and Society [IRI] 2014), the NextGen climate forecast approach (IRI 2020), and the Copernicus Emergency Management System **(EMS)**.[16]

Response capability requires significant improvement to build resilience

The overall goal of EWSA is to improve climate risk management and increase the resilience of sectors and communities likely to be affected by climate change. Building more resilient systems requires significant improvements in existing early warning systems, preparedness, and response mechanisms. To advance adaptation, anticipation and response mechanisms need to be integrated in a systemic and interdisciplinary approach incorporating information on the anticipated risks and impacts at different timescales, and a seamless response mechanism over time. Early warnings will not save lives if they are not translated into early actions. These actions will not be sustained if they are not integrated into national and local risk management plans and budget processes informed by up-to-date and locally relevant knowledge on climate risks and their evolution under climate change.

As a result, the existing response capability for adaptation urgently needs to expand by improving:

(i) the capacity of climate information providers to generate data and tools based on the best available science, understanding of sectoral needs and vulnerability, and improved communication and tailoring of information.
(ii) the capacity of disaster risk reduction practitioners, policymakers and vulnerable communities to appropriately understand, access and use climate information at different timescales and communicate their climate-sensitive needs

This two-way capacity-building approach is essential to support transdisciplinary collaboration on the co-production of EWSA by climate information providers and the meaningful

8. Petteri Taalas, Secretary-General of the World Meteorological Organization (WMO) at the fifth African Climate Resilience Infrastructure Summit (ACRIS5), June 2021
9. https://public.wmo.int/en/our-mandate/how-we-do-it/development-partnerships/Innovating-finance
10. https://fews.net/
11. https://www.preventionweb.net/
12. https://public.wmo.int/en/climate-risk-and-early-warning-systems-crews
13. https://public.wmo.int/en/our-mandate/what-we-do/observations
14. https://cpo.noaa.gov/Serving-Society/NIDIS
15. https://cpo.noaa.gov/Serving-Society/NIDIS
16. https://emergency.copernicus.eu/

participation of practitioners, policymakers and those at risk. To be effective, EWSA need to actively involve the people and communities at risk from a range of hazards over time.

Recognition and integration of local climate knowledge can improve preparedness strategies and increase the ownership, confidence and adoption rate of adaptation strategies in some communities.[17] Lessons learnt from research in sub-Saharan Africa show the benefit of integrating meteorological and indigenous knowledge-based seasonal climate forecasts for the agricultural sector (International Development Research Centre [IDRC] 2010).

The Global Framework for Climate Services (GFCS)[18] has an important role to play in supporting and facilitating transdisciplinary collaboration among researchers, producers and users of information to improve capacity for science-informed decision-making for adaptation worldwide, particularly in developing countries.

Forecast-based early action and financing (FbA/FbF)[19] is increasingly recognized by humanitarian and disaster risk management organizations to be useful in identifying pre-planned early actions based on forecast triggers and supported by pre-allocated funding. It enhances the impact of EWSA. Effective FbA improves the efficiency of interventions (UNEP 2020), minimizes loss and damage caused by climate-related hazards, and reduces the need for humanitarian assistance in their aftermath (World Food Programme [WFP] 2019).

Dissemination and communication are critical to ensure an effective and proactive response

Communication of key messages that link current and future timeframes and general information on possible responses can help to ensure an evolving state of preparedness.[20] Early warning information must also be provided in the right language and use the right communication channels. Dissemination of lessons-learned is also key to boosting future capacity.

A recent survey of potential users of climate risk information in Asia and Latin America (De Mel et al. 2021) found scientific reports, climate scientists, and online sources to be the most useful information sources on climate risk information. A smaller proportion found "media and news" a useful source of information. Maps and illustrations, scenarios, data tables, graphs and charts were identified as user-friendly formats. The main factors preventing the use of climate risk information in decision-making were unavailability of climate risk information, limited financial or human resources available to respond, lack of organizational mandate or support, or limited institutional incentives, linking to the capacity needs described above.

Stakeholder surveys conducted in West Africa (Sultan et al. 2020) highlighted the irrelevance or incompleteness of the information that current climate services often provide. The lack of high-resolution information, or high uncertainties, were the biggest barriers. The surveys also showed that the lack of training to understand available information was also an important barrier, implying the need for capacity-building activities to ensure the uptake of information by target audiences. Overall, the survey responses demonstrated the importance of stakeholder engagement in ensuring the usefulness of climate services in West Africa.

Box 2: Some Examples of EWSA

A report on ***Vulnerability and Climate Change Adaptation Planning: Heat and Floods in Portland, USA,***[21] analyses the intersections between climate vulnerability and resilience by creating a Social Vulnerability Index to map the geographic distribution of vulnerable populations. The report analyses resilience by mapping food, transit, water and green space access to identify neighbourhoods of concern.

Record-breaking flooding in Germany, Belgium, the USA, and China in the summer of 2021 highlighted the critical need of EWSA in providing timely meteorological reporting to help authorities and communities prepare. Effective resource mobilization and communication of relevant information and guidance are critical to building adaptive capacity in emergency responses.

UNEP's Pacific SIDS programme[22] will establish integrated climate and ocean information services and ***multi-hazard early warning systems (MHEWS) in the Cook Islands, Niue, Palau, the Republic of the Marshall Islands, and Tuvalu.*** The programme aims to effect a paradigm shift to risk-informed, evidence-based climate adaptation and disaster management underpinned by accurate, timely and actionable climate information and impact-based early warnings.

Nevertheless, warning dissemination and communication are consistently weak in many developing countries. There, "one person in three is still not adequately covered by early warning systems and risk-informed early approaches are not at the scale required."[23] Improved and more readily available communications media need to be fully exploited so that EWSA can reach as many at-risk people as possible.

17. https://theconversation.com/la-necessaire-preservation-des-savoirs-meteorologiques-traditionnels-en-afrique-163379
18. GFCS is a global partnership of governments and organizations that enhances EWSA.
19. https://www.forecast-based-financing.org/
20. https://climate-adapt.eea.europa.eu/metadata/adaptation-options/establishment-of-early-warning-systems
21. https://www.reed.edu/es/assets/es_300_2017_vulnerability-and-climate-change-adaptation-planning.pdf
22. https://www.greenclimate.fund/project/fp147
23. António Guterres, Secretary-General of the United Nations, speaking at the Climate Action Summit in January 2021. Climate Adaptation Summit: Invest in early warnings and early action | World Meteorological Organization (wmo.int)

Finance is key to bridge the gap in acquiring information

A lack of basic infrastructure, information and data contribute to the failure of effective adaptation and climate risk reduction. More resources for adaptation responses are needed: adaptation finance is only a small fraction (20%) of climate finance. The gap between the global South and the global North needs to be bridged by mobilizing earmarked financial support and resources.

A sustainable business model is needed for financing weather and climate services, particularly in LDCs and SIDS where the combination of very low GDP and large geographic territories makes it particularly challenging to operate and maintain a reasonable density of basic observation facilities in many parts of the world (Alliance for Hydromet Development 2021). To this end, SOFF is being developed to address the fundamental mismatch between the current country-based financing of basic observations and the value of these observations as a global public good.

Box 3: Which Organizations Fund Early Warning for Adaptation?

The **Green Climate Fund** helps fill capacity gaps in early warning; nearly three-quarters of GCF's US$877 million funding allocated to date for climate information and EWSA has been directed to African countries, LDCs and SIDS (WMO, 2020b).

The **CREWS Initiative** was launched in 2015. The initiative's aim was to raise US$100 million to build resilience, especially in LDCs and SIDS. EWSA is estimated to bring protection to some 10 million additional people, through 13 projects covering more than 50 countries. (Climate Adaptation Summit: Invest in early warnings and early action).

The **Adaptation Fund** provides funding to projects aimed at helping most vulnerable communities, with about 20% of its funding used to help countries build resilience through EWSA and DRR projects.

Conclusions and pathways forward

EWSA urgently needs interdisciplinary and intersectoral collaboration between policymakers and scientists, sectoral experts, humanitarian/disaster risk management actors and vulnerable communities. This collaboration, coupled with financial support, will enable the co-development of impact-based climate risk assessment and forecast-based early actions that can inform local strategies to effectively and efficiently respond to the increasing risks due to the changing climate.

EWSA is part of the wider Climate Services initiative[24] that highlights the adaptation process and the need to incorporate current climate extremes as well as future climate change into an integrated framework across timescales. Adaptation plans can combine EWSA with long-term adaptation strategies (e.g., water management plans, climate-resilient agriculture) in line with both the Sendai Framework and the SDGs. The IPCC advocates integrating DRR, climate change adaptation and sustainable development into economic planning (WMO 2020a).

Research on EWSA needs to analyse the interactions of climatic, environmental, and human factors that can lead to multi-sectoral options for managing risks posed by impacts and disasters; conduct cost/benefit evaluation of decisions that combine traditional early warning systems with adaptation; and focus on the important role that non-climatic factors play in determining impacts and responses.

Additional financial investments and resources should be directed to LDCs and SIDS to establish or strengthen EWSA, enhance preparedness and build systems capacity for the dissemination and communication of early warnings to the most vulnerable people now and in the future.

Supplementary information

Europe has considerable experience with early warning systems which have alerted people to flood risks, storms, forest fires, heatwaves and droughts, including Meteoalarm, Copernicus Climate Change Service, Risk Data Hub of the Disaster Risk Management Knowledge Centre, European Forest Fire Information System, EuroHEAT and European Drought Observatory.

WMO (2020a). 2020 State of Climate Services Report. Geneva. Available from: https://library.wmo.int/doc_num.php?explnum_id=10385. It provides six strategic recommendations to improve the implementation and effectiveness of EWSA.

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24. https://gfcs.wmo.int/

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