United Nations

ESCAP/81/13

Economic and Social Council

Distr.: General
31 January 2025

Original: English

Economic and Social Commission for Asia and the Pacific

Eighty-first session
Bangkok, 21–25 April 2025
Item 5 (d) of the provisional agenda*
Review of the implementation of the 2030 Agenda for
Sustainable Development in Asia and the Pacific and
issues pertinent to the subsidiary structure of the
Economic and Social Commission for Asia and the Pacific:
disaster risk reduction

Advancing multi-hazard early warnings for all through regional cooperation

Note by the secretariat

Summary

> The 2004 Indian Ocean tsunami has highlighted the significant vulnerabilities of the Asia-Pacific region to coastal and other natural hazards. In the 20 years since that tsunami, substantial progress has been made in developing tsunami and multi-hazard early warning systems, including with the support of the ESCAP multi-donor trust fund for tsunami, disaster and climate preparedness. However, the region continues to face increasingly complex challenges related to disaster preparedness and climate resilience.

> In the present document, which was prepared in line with Economic and Social Commission for Asia and the Pacific resolution 79/1, the secretariat explores the region's varied risk landscape, highlighting successes and showcasing the transformative potential of strengthened regional collaboration in science, technology and innovation along the early warnings for all value chain as a cornerstone for the development of effective disaster and climate adaptation strategies.

> Furthermore, the secretariat provides targeted policy recommendations. The Commission may wish to take note of the findings and policy recommendations contained in the present document and provide further guidance to the secretariat in that regard.

---

*   ESCAP/81/1.

Please recycle

I. Introduction

1. Asia and the Pacific remains the world's most disaster-affected region and its populations experience a disproportionate share of all disaster-related fatalities and economic losses. The 2004 Indian Ocean tsunami served as a wake-up call, prompting concerted regional action to strengthen tsunami early warning systems. During the past two decades, progress in science, technology and data, coupled with more purposeful regional cooperation, has broadened the scope and effectiveness of early warning systems.

2. Today's risk environment, however, is more complex. Climate change is intensifying the frequency and severity of hydrometeorological hazards, while socioeconomic changes, rapid urbanization, environmental degradation and uneven development are creating new patterns, both in terms of exposure and vulnerabilities.

3. In the present document, which was prepared in line with resolution 79/1 of the Economic and Social Commission for Asia and the Pacific (ESCAP), the secretariat explores the region's varied risk landscape and ways to ensure that everyone is covered by multi-hazard early warning systems. It underscores the transformative potential of more purposeful regional collaboration in science, technology and innovation along the early warnings for all value chain as a cornerstone for the development of effective disaster and climate adaptation strategies. Finally, the secretariat provides targeted policy recommendations to address gaps and maximize opportunities for regional and subregional collaboration.

II. The disaster and climate risk landscape of Asia and the Pacific

4. The year 2024 was the hottest in history. It was also a year of unprecedented climate-induced disasters fuelled by rising atmospheric and ocean temperatures. Extreme heat- and water-related disasters proved deadly in many countries. Kerala, in India, was struck by catastrophic landslides following heavy monsoon rains that claimed more than 200 lives and caused significant property damage, testing disaster preparedness systems. When Kathmandu received one fifth of its average annual rainfall in just 48 hours, floods claimed the lives of more than 200 people and wreaked significant economic and social damages.

5. Sand and dust storms have emerged as significant transboundary hazards in the Asia-Pacific region, with far-reaching consequences for human health, agriculture, water resources, infrastructure and economic productivity. Sand and dust storms exacerbate desertification, reduce soil fertility and damage crops, further threatening food security in already climate-vulnerable areas. As highlighted in the Regional Plan of Action on Sand and Dust Storms in Asia and the Pacific,[1] the deposition of sand and dust on glaciers is of particular concern, as it accelerates the melting of ice and disrupts water cycles, contributing to long-term environmental instability.

6. Also in 2024, the large-scale floods triggered by Cyclone Yagi and monsoon rains severely affected the Lao People's Democratic Republic, Myanmar, the Philippines, Thailand and Viet Nam. In addition, significant earthquakes were felt in Japan (1 January) and Vanuatu (17 December). More

---

[1] ESCAP/78/12/Add.1.

recently, on 7 January 2025, hundreds of people lost their lives in an earthquake in Tibet, China, which also caused widespread damage to infrastructure, including housing. All these events are stark reminders that the region is at extreme risk of seismic disasters and that the impact of such disasters is felt disproportionately by millions of people who are already poor and who are thus pushed deeper into poverty and further marginalized.

7.   To increase understanding of this complex risk landscape, in 2024 the secretariat launched a series of reports highlighting the unique disaster-related risks, climate vulnerabilities and resilience needs of each subregion in Asia and the Pacific. The key findings from those reports are set out below.

8.   East and North-East Asia has borne a heavy economic burden, with disasters causing nearly 500,000 fatalities, affecting over 3 billion people and resulting in $2 trillion in damages over the past five decades (i.e. 68 per cent of all disaster-related losses in Asia and the Pacific). Each year, the subregion incurs an average annual loss of $510 billion, an amount that is projected to increase by 5 per cent to $538 billion under a 2°C warming scenario (i.e. should global temperatures rise by 2°C above pre-industrial levels). The risk of droughts is expected to intensify in northern and western China, while heatwaves are emerging as a critical threat in Mongolia and north-eastern China, with cascading risks for the Democratic People's Republic of Korea, Japan and the Republic of Korea. Adaptation costs are projected to account for 0.8 per cent of the gross domestic product (GDP), with China bearing a significant share owing to its vast geographical exposure.[2]

9.   In North and Central Asia, disasters have caused over 64,000 fatalities, affected 20 million people and resulted in $23 billion in damages over the past five decades. The subregion faces an average annual loss of $32.33 billion, an amount that is projected to rise to $32.55 billion under a 2°C warming scenario. Critical risk areas include the Aral Sea basin and northern Kazakhstan, where intensifying droughts, floods and heatwaves threaten agriculture, energy security and biodiversity. Moreover, in Turkmenistan and Uzbekistan, emerging climate hotspots are exacerbating vulnerabilities. Adaptation costs are expected to reach approximately 0.5 per cent of GDP, with countries, including Armenia and Azerbaijan, facing higher proportional adaptation costs compared to economic losses, emphasizing the need for transformative adaptation strategies.[3]

10.   In South-East Asia, disasters have caused over 435,000 fatalities, affected some 580 million people and resulted in $235 billion in damages over the past five decades. The current average annual loss of $150 billion is projected to escalate as global temperatures rise and as the risk of floods, heatwaves and tropical cyclones intensifies. Under a 2°C warming scenario, nearly all of the agricultural production of Cambodia and Myanmar will face high flood risks, while countries like the Lao People's Democratic Republic, Thailand and Viet Nam will experience increasingly severe heatwaves and droughts. Adaptation costs are estimated at 0.7 per cent of GDP, with

---

[2]   *Targeting Transformative Disaster Risk Resilience in East and North-East Asia: Asia-Pacific Disaster Report 2024 for ESCAP Subregions* (ESCAP/5-TR/25).

[3]   *Targeting Transformative Disaster Risk Resilience in North and Central Asia: Asia-Pacific Disaster Report 2024 for ESCAP Subregions* (ESCAP/5-TR/28).

Cambodia and Myanmar showing the highest adaptation costs as a percentage of GDP, reflecting their heightened vulnerability.[4]

11.   South and South-West Asia has suffered over 1 million fatalities and incurred $485 billion in disaster-related damages over the past five decades. As in the other subregions, the average annual loss (currently estimated at $240 billion) is projected to rise under a 2°C warming scenario. From 1970 to 2024, Bangladesh recorded over half a million deaths, the highest cumulative number of disaster-related fatalities in the subregion, followed by India, with over 190,000 deaths. During the same period, an average of 43 million people in India, over 8 million in Bangladesh and over 2 million in Pakistan were affected by disasters annually. The risk of floods in densely populated areas, including the Ganges and Brahmaputra river basins, remains significant, while heatwaves and droughts represent increasing threats in Afghanistan, Nepal and Pakistan. Vulnerabilities in terms of agricultural production and access to water are compounded by urbanization and economic disparities. In particular, the loss of mangrove cover is alarming, as mangroves act as a natural barrier, reducing the impact of coastal hazards such as storm surges, tsunamis and erosion, while also stabilizing shorelines and protecting vulnerable communities. Between 1992 and 2019, the South and South-West Asia subregion lost 6 per cent of its mangrove cover, with the highest losses recorded in Bangladesh and Iran (Islamic Republic of). Bangladesh, which contains one of the world's largest mangrove forests, lost 19 per cent of its mangrove cover owing to the expansion of urban areas, growing demand for agricultural land, sea-level rise and coastal erosion. Lastly, the ability to cover adaptation costs, which are projected at 0.6 per cent of the subregion's GDP under a 2°C warming scenario, remains critical for countries, like Afghanistan and Nepal, where the economic losses are disproportionately high compared to the available resources.[5]

12.   In the Pacific, disasters have caused over 6,000 fatalities, affected 28 million people and resulted in $185 billion in damages over the past five decades. The subregion's average annual loss stands at $20 billion and is projected to increase significantly under a 2°C warming scenario, in particular for small island developing States. Palau, Tonga and Vanuatu face the highest losses as a percentage of GDP, with the risk of floods and tropical cyclones expected to intensify under a 2°C warming scenario. Coastal erosion, sea level rise and mangrove cover loss further endanger livelihoods, with 80 per cent of mangrove cover projected to be exposed to significant risks from global warming. Adaptation costs are estimated at 1.2 per cent of GDP, which reflects the high vulnerability of small island developing States to climate-related hazards and the need for urgent international support.[6]

13.   In addition to highlighting subregional specificities, the reports underscore the critical importance of addressing transboundary hazards, which pose complex challenges requiring regional cooperation and integrated solutions. For instance, the Third Pole region,[7] which is home to the largest store of glacial ice except the north and south poles, is experiencing rapid glacial melt owing to climate change. This phenomenon threatens the water

---

[4]   *Targeting Transformative Disaster Risk Resilience in South-East Asia: Asia-Pacific Disaster Report 2024 for ESCAP Subregions* (ESCAP/5-TR/35).

[5]   *Targeting Transformative Disaster Risk Resilience in South and South-West Asia: Asia-Pacific Disaster Report 2024 for ESCAP Subregions* (ESCAP/5-TR/38).

[6]   *Targeting Transformative Disaster Risk Resilience in the Pacific: Asia-Pacific Disaster Report 2024 for ESCAP Subregions* (ESCAP/5-TR/31).

[7]   Also known as the Hindu Kush Himalaya region.

security and livelihoods of over 1.3 billion people in multiple countries, as it feeds major river systems like those of the Ganges, the Brahmaputra, the Yangtze and the Mekong. The cascading impacts of increased glacial melt include heightened risks of glacial lake outburst floods, disrupted hydrological cycles and increased flood and drought variability. The reports contain calls for coordinated, science-driven regional initiatives, such as those facilitated by the secretariat in partnership with the Third Pole Climate Forum, to monitor glacial retreat, enhance early warning systems and develop adaptive water governance frameworks that go beyond national boundaries. Without such collective efforts, transboundary hazards like glacial melt, riverine flooding and biodiversity loss will continue to undermine resilience and sustainable development across the region.

14.   Lastly, the recent ESCAP report entitled "Tsunami preparedness within a multi-hazard context: opportunity for enhanced regional cooperation" [8] highlights the persistent risks faced by over 20 million people in 13 States along the Indian Ocean basin, where the dangers posed by tsunamis are compounded by rising sea levels, cyclones and coastal flooding. Infrastructure vulnerabilities are stark: $203 billion in building stock, 1,213 education facilities, 1,450 health facilities and 140 power plants are in fact exposed to the risk of tsunamis. Although progress has been made since 2004, significant gaps remain in the areas of preparedness, early warning systems and risk assessments, particularly at the local level.

15.   Given these significant challenges, transformative adaptation measures are needed to address the escalating impacts of climate change. While incremental measures may be helpful in managing immediate risks, they fall short of addressing the systemic vulnerabilities and compounding hazards triggered by climate change. Achieving transformative adaptation, however, requires forward-looking strategies, including large-scale investments in climate-resilient infrastructure, comprehensive social protection systems for vulnerable communities and integrated policies that take into account future climate scenarios. Moreover, science-based, innovative technologies, predictive risk analytics approaches, ecosystem-based solutions and risk-informed development planning are urgently needed to safeguard lives, livelihoods and critically endangered ecosystems from the irreversible impacts of climate change.

16.   A critical component of transformative adaptation is the development and implementation of early warning systems, which are pivotal in minimizing losses and damages from climate-induced disasters. Effective early warning systems reduce disaster-related losses by providing timely, actionable information to at-risk populations and decision-makers. These systems are essential in high-risk areas, for example the drought-prone regions of North and Central Asia, the flood-prone urban areas of East Asia and the coastal zones in the Pacific, which are vulnerable to sea level rise and cyclones.

17.   Investing in advanced early warning systems infrastructure, addressing data gaps, enhancing forecasting capabilities and strengthening regional cooperation are key to maximizing the benefits of these systems. The secretariat has contributed to these efforts, notably through its timely, machine-automated impact-based forecasting and artificial intelligence-driven early warning tools.

---

[8]   ESCAP (Bangkok, 2024).

III. Persistent gaps and challenges in developing multi-hazard early warning systems

18. Despite a doubling in coverage since 2015, half of the world's population remains without access to early warning systems. To close this gap, in 2015 the General Assembly adopted the Sendai Framework on Disaster Risk Reduction 2015–2030, which includes the goal of substantially increasing the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030.[9] In Asia and the Pacific, 60 per cent of countries (that is, 26) have reported on progress made on this goal. Subsequently, the Early Warnings for All initiative of the Secretary-General and the United Nations action plan to ensure that every person on Earth is covered by early warning systems by 2027 were launched in 2022, and a call was made for investments in this area of $3.1 billion between 2023 and 2027. While the situation has greatly improved since 2015, access to information about the risk of disasters continues to be poor. The number of countries with accessible, understandable, usable and relevant disaster risk information and assessments at the national and local levels is small. In addition, although Asia and the Pacific has the highest levels of reporting on pillar 1 of the Early Warnings for All initiative (on disaster risk knowledge), with 38 per cent of countries in the region having submitted reports, far exceeding the global average of 22 per cent, the scores are especially low in South-East Asia, in South and South-West Asia and among least developed countries, landlocked developing countries and small island developing States. This suggests that more needs to be done to translate risk analyses to the national and subnational levels.[10]

19. Robust multi-hazard early warning systems rely on high-quality, real-time data. While meteorological and seismic data collection has improved, data gaps persist for slow-onset hazards like droughts and emerging risks such as zoonotic diseases. And while there has been significant progress in the development of observation networks to support tsunami early warning systems in the Indian Ocean since 2004, the sharing of seismic and sea-level monitoring data has seen a recent decline,[11] possibly because data-sharing protocols and interoperability standards vary widely across the region. Even where early warning systems do exist, more needs to be done to ensure that warnings reach vulnerable populations in an accessible and understandable format and in diverse languages. The integration of information on gender, age and literacy level, as well as of disability-sensitive approaches, is needed to ensure that early warning systems do not reinforce existing inequalities.

20. Lastly, emerging and compounding hazards – such as those resulting from climate extremes and biological hazards (e.g. pandemics), environmental degradation and socioeconomic fragilities – demand broader policy coherence. Moreover, the Asia-Pacific region's growing urban population is more exposed to extreme heat, flooding and pollution, while rapidly expanding coastal cities face these same risks in addition to seismic and tsunami threats, coastal erosion, mangrove degradation, sea-level rise and storm surges. Many countries have yet to fully integrate multi-hazard early warning systems,

---

[9] General Assembly resolution 69/283, annex II, para. 18 (g).

[10] United Nations Office for Disaster Risk Reduction and World Meteorological Organization (WMO), *Global Status of Multi-Hazard Early Warning Systems 2023* (Geneva, 2023).

[11] See ESCAP, "Tsunami preparedness within a multi-hazard context: opportunity for enhanced regional cooperation" (Bangkok, 2024), figure 17.

including seismic preparedness along the Pacific Ring of Fire, into national adaptation plans and climate strategies, limiting their potential as core components of plans to achieve resilient and sustainable development.

IV. Progress made in multi-hazard early warning systems in Asia and the Pacific

21.   Despite the challenges, good progress has been made in the region. In particular, to support the implementation of the Early Warnings for All initiative and the Executive Action Plan on Early Warnings for All, 2023–2027,[12] at the regional level, ESCAP members and associate members have requested the secretariat to develop early warning systems for all at the regional level, and support regional and subregional priorities to address climate-related challenges. [13] Moreover, the Committee on Disaster Risk Reduction reiterated, at its eighth session, that the secretariat should further develop a regional strategy to support the achievement of early warnings for all by 2027 by strengthening multi-hazard early warning systems in Asia and the Pacific in coordination with member States and relevant partners. At that same session, members and associate members were encouraged to make financial contributions to the ESCAP multi-donor trust fund for tsunami, disaster and climate preparedness as a means of accelerating efforts to achieve early warnings for all.[14]

22.   Towards this end, the secretariat, in collaboration with the United Nations Office for Disaster Risk Reduction, the World Meteorological Organization (WMO), the International Telecommunication Union and the International Federation of Red Cross and Red Crescent Societies, has supported activities under the four pillars set out in the Executive Action Plan on Early Warnings for All, 2023–2027.

A.   Pillar 1: disaster risk knowledge and management

23.   To meet the needs of countries and subregional and regional stakeholders for detailed and context-specific climate information, the secretariat is leveraging climate model downscaling, a cutting-edge methodology provided through the Asia-Pacific Climate Change Adaptation Information Platform.[15] This approach makes it possible to refine the coarse outputs of global climate models so that instead of providing information for an area of approximately 100 km^2 they are able to provide more granular data, for an area of 1 km^2. Traditional global climate models, which operate at a resolution scale of 100 km^2, lack the granularity needed for precise risk analysis at the local level. By employing this methodology, ESCAP, through its Risk and Resilience Portal, [16] is producing high-resolution climate projections that inform country-level and sector-specific analyses, ultimately enabling more targeted and resilient development planning.

---

[12]   WMO and United Nations, *Early Warnings for All: The UN Global Early Warning Initiative for the Implementation of Climate Adaptation – Executive Action Plan 2023–2027* (2022).

[13]   ESCAP resolution 79/1.

[14]   ESCAP/CDR(8)/6, para. 24 and decision 4.

[15]   See https://ap-plat.nies.go.jp/.

[16]   See https://rrp.unescap.org/.

24.   The secretariat has developed and provided downscaled climate and hazard projection data on, for example, temperatures, precipitation, heatwaves, floods, droughts, landslides and glacial lake outburst floods to Cambodia, Maldives, Nepal and Tajikistan. To integrate climate uncertainties into early warning systems and improve impact-based climate forecasting for critical sectors such as population, food and energy, the secretariat has also piloted downscaled models for use in Bhutan, Fiji and Vanuatu.

25.   In Bhutan, for example, with support from the sixteenth tranche of the Development Account, the secretariat and the United Nations Development Programme have assisted the National Centre for Hydrology and Meteorology in downscaling global climate models to a resolution of 1 km^2 in the 2024 *Climate Change Projection Report*.[17] This high-resolution analysis has enabled the assessment of climate impacts on critical sectors, such as agriculture and energy, providing granular insights into vulnerabilities and adaptation needs. The National Centre for Hydrology and Meteorology is now leveraging this analysis to develop the national adaptation plan of Bhutan, thereby ensuring that climate resilience is integrated into national development strategies.

26.   In addition, the secretariat has bolstered the resilience of Bhutan to disasters through the development of a pilot portal and the provision of relevant training.[18] Participants in the training were shown how to utilize the portal and integrate climate data into decision-making processes. The portal will soon be hosted on the website of the Department of Local Governance and Disaster Management of Bhutan.

27.   In Maldives, the secretariat has supported the downscaling of global climate data to assess vulnerabilities related to sea-level rise and extreme weather events. Localized climate models provide detailed insights into risks such as storm surges and flooding, which are critical for this low-lying island nation. High-resolution data inform national adaptation plans and coastal resilience strategies, focusing on protecting critical infrastructure and vulnerable populations. These efforts have been facilitated through the ESCAP Risk and Resilience Portal. The risk and resilience portal of Maldives, which is housed on the National Disaster Management Authority website,[19] also provides data on the risk of a tsunami occurring, thereby enhancing the availability of localized vulnerability and exposure analysis. This supports both national planning and community-level preparedness.

28.   Downscaled data have also been provided to Fiji and Vanuatu[20] to support the production of high-resolution climate projections in the Pacific and increase understanding of precipitation variability and its impacts.[21] The downscaled analysis shows that precipitation in Vanuatu is projected to increase significantly under a 2˚C warming scenario, particularly in the northern islands, and that 46 per cent of the population will be exposed to more intense precipitation by 2040. During the same period, rainfall is expected to rise in the central and western regions of Fiji, which means that the proportion

---

[17] Bhutan, National Center for Hydrology and Meteorology, *Climate Change Projection Report: Insights from CMIP6* (Thimphu, 2024).

[18] See https://unescap.org/events/2024/capacity-development-proposal-drr-and-cca-disaster-management-officials-and-dzongkhag.

[19] See www.meteorology.gov.mv/forecast.

[20] *Targeting Transformative Disaster Risk Resilience in the Pacific.*

[21] Ibid.

of the population exposed to rainfall-related risks is projected to rise from 17 per cent to 22 per cent by 2060.

29.   On sand and dust storms, the Asian and Pacific Centre for the Development of Disaster Information Management took important steps in 2024 towards the implementation of the Regional Plan of Action on Sand and Dust Storms in Asia and the Pacific, including by facilitating agreement on reducing the impacts of sand deposition on glaciers, at a meeting held in Dushanbe in September 2024. Furthermore, the Centre has further expanded its outreach on sand and dust storms to the global and interregional levels. For example, on behalf of the ESCAP secretariat, the Centre has assumed the role of Co-Chair, with the Economic and Social Commission for Western Asia, of the United Nations Coalition on Combating Sand and Dust Storms for the period 2025–2026. It is an important biennium that will see the Coalition focused on, among other issues, developing a plan for implementing the United Nations Decade on Combating Sand and Dust Storms (2025–2034).[22] The Centre has also facilitated, in collaboration with the Centre for Sustainable Agricultural Mechanization, a study tour on desertification control and on the prevention of sand and dust storms to China for officials from Iran (Islamic Republic of) and Mongolia.

30.   Finally, through the ESCAP multi-donor trust fund for tsunami, disaster and climate preparedness, the secretariat has supported the Governments of India, Iran (Islamic Republic of) and Pakistan[23] in developing a standardized risk profile for the Makran subduction zone, thus allowing them, as well as the Governments of Oman and the United Arab Emirates, to base their tsunami preparedness and evacuation plans on scientifically robust, area-specific data. Such unified probabilistic tsunami hazard assessments form the backbone of regional and local near-field tsunami risk mitigation strategies. Moreover, a tsunami preparedness in multi-hazard contexts analysis has been conducted for the Indian Ocean basin that incorporates geophysical data with information on climate hazards to better understand the complex riskscape in coastal zones.[24]

B.   Pillar 2: detection, observation, monitoring, analysis and forecasting of the hazards and possible consequences

31.   The secretariat has spearheaded efforts to develop innovative impact-based forecasting tools to bolster early warning systems. By integrating seasonal climate forecasts with geospatial vulnerability and exposure data, the secretariat's impact-based forecasting tools enable precise impact scenarios tailored to the needs of vulnerable populations and those operating in critical sectors such as agriculture, energy and infrastructure. The secretariat has provided hands-on training on these tools in Cambodia, Nepal and Tajikistan.

32.   The secretariat has also been actively supporting the use of impact-based forecasting methodologies through regional platforms, including the Association of Southeast Asian Nations (ASEAN) Climate Outlook Forum, the South Asian Climate Outlook Forum and the Forum on Regional Climate Monitoring, Assessment and Prediction for Asia. These efforts are bolstered by e-learning tools hosted at the ESCAP Risk and Resilience Portal, which provides accessible and scalable capacity-building resources to members and associate members. Furthermore, the secretariat has collaborated with WMO

---

[22]   In its resolution 78/314, the General Assembly decided to proclaim 2025–2034 the United Nations Decade on Combating Sand and Dust Storms.

[23]   Oman and the United Arab Emirates self-funded their participation in this work.

[24]   ESCAP, "Tsunami preparedness within a multi-hazard context".

and the WMO/ESCAP Panel on Tropical Cyclones to provide training on impact-based forecasting to support any preventive action needed to respond to cyclones in the Bay of Bengal and the Arabian Sea. This comprehensive approach enhances regional capabilities for climate risk assessment and proactive disaster response.

33. Other key advancements under this pillar include the automation of climate hazard assessments using data from the above-mentioned climate outlook forums, as well as the Third Pole Climate Forum.

34. Finally, the secretariat has also developed a large language model-powered tool called SatGPT[25] that automates flood hotspot mapping and enables users to generate historical flood maps in minutes. SatGPT provides a cost-effective way to quickly produce information that would otherwise require substantial financial, human and time investments. Asia-Pacific countries can use this tool free of charge and further develop it to meet their specific needs and on the basis of the data available to them. For example, the National Research and Innovation Agency of Indonesia has used SatGPT in collaboration with researchers to map the flood hotspots in Karawang City, Indonesia. SatGPT has been shortlisted for the Sustainable Development Goal Digital Game Changers Award under the "planet" category.[26]

C. Pillar 3: warning dissemination and communication

35. Through the ESCAP multi-donor trust fund for tsunami, disaster and climate preparedness, the secretariat has worked with the Regional Integrated Multi-hazard Early Warning System for Africa and Asia to build impact-based forecasting capacities in Bhutan, Cambodia, Fiji, the Lao People's Democratic Republic, Maldives, Papua New Guinea, Samoa, Sri Lanka and Timor-Leste. This has involved providing technical training for forecasters, developing digital tools to support decision-making in the agricultural sector and institutionalizing national climate outlook forums, also known as "monsoon forums", in which critical sectors work together with the national hydrological and meteorological services to prepare for predicted seasonal weather impacts.[27]

D. Pillar 4: preparedness and response capabilities

36. Through the ESCAP multi-donor trust fund for tsunami, disaster and climate preparedness, the secretariat has supported local governments and communities to improve their readiness to deal with disasters by facilitating tsunami drills and holding workshops on tsunami inundation and evacuation mapping with the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization.

37. The secretariat has also facilitated the timely transmission of approximately 60 gigabytes of satellite imagery and products from China, India, Japan, the Republic of Korea and Thailand to countries affected by cyclones, floods and landslides. These efforts, which are aimed at improving early warning systems, response capabilities and damage assessments, have benefited from the involvement of the Regional Space Applications

---

[25] See https://satgpt.net/.

[26] See www.itu.int/initiatives/sdgdigital2024/award/planet/.

[27] ESCAP, "ESCAP multi-donor trust fund for tsunami, disaster and climate preparedness: annual report 2023" (Bangkok, 2024).
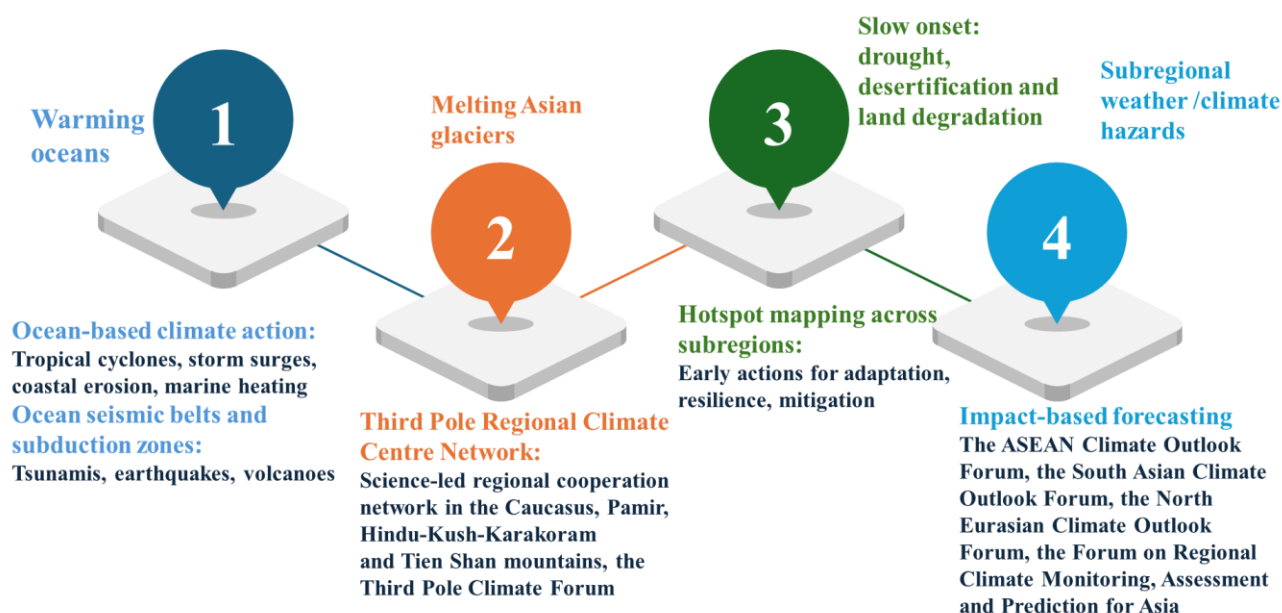
Programme for Sustainable Development and the United Nations Satellite Centre. The data were provided for free at the request of Bangladesh (affected by a cyclone); Nepal and Papua New Guinea (affected by landslides); the Lao People's Democratic Republic, Nepal and Thailand (affected by floods); and Vanuatu (affected by an earthquake).

V. Advancing regional cooperation for early warnings for all

38.   The secretariat is focused on strengthening early warning systems and resilience across the region by implementing collaborative initiatives, leveraging cutting-edge technologies and building the capacities of members and associate members to address a diverse range of climate-induced risks.

39.   The secretariat employs a multipronged strategy to ensure access to early warnings for all. In doing so, it also considers the transboundary elements of disasters and their impacts. The approach is based on emerging scientific knowledge and data on the diversity of weather and climate hazards such as warming oceans, melting glaciers and other slow-onset disasters, notably droughts, desertification and land degradation, all of which are expanding and intensifying.

Building blocks of early warnings for all: understanding transboundary disasters and impacts

Warming oceans

1

Melting Asian glaciers

2

Slow onset: drought, desertification and land degradation

3

Subregional weather /climate hazards

4

Ocean-based climate action:
Tropical cyclones, storm surges, coastal erosion, marine heating
Ocean seismic belts and subduction zones:
Tsunamis, earthquakes, volcanoes

Third Pole Regional Climate Centre Network:
Science-led regional cooperation network in the Caucasus, Pamir, Hindu-Kush-Karakoram and Tien Shan mountains, the Third Pole Climate Forum

Hotspot mapping across subregions:
Early actions for adaptation, resilience, mitigation

Impact-based forecasting
The ASEAN Climate Outlook Forum, the South Asian Climate Outlook Forum, the North Eurasian Climate Outlook Forum, the Forum on Regional Climate Monitoring, Assessment and Prediction for Asia

40.   Under pillars 1 and 2 of the Early Warnings for All initiative, the secretariat addresses gaps in scientific understanding and knowledge about climate-related risks. Notably, most of the climate models available to Pacific small island developing States are based on insufficiently granular data. Through its Risk and Resilience Portal, for example, the secretariat provides downscaled climate risk scenarios to support the Government of Maldives to implement better-informed policies aimed at ensuring early warnings for all and improve spatial planning and land use in the country. Furthermore, the secretariat encourages the integration of data and the adoption of collaborative solutions, for example through the Asia-Pacific Climate Change Adaptation Information Platform, the Global Infrastructure Resilience Index of the Coalition for Disaster-Resilient Infrastructure, the Third Pole Climate Forum and other regional initiatives.

41.   Specifically, the secretariat's collaboration with the Asia-Pacific Climate Change Adaptation Information Platform, made possible by the support provided under the sixteenth tranche of the Development Account, has been instrumental in providing high-resolution climate data and adaptation resources that are used in the planning processes of members and associate members to bolster their resilience to climate change. Similarly, the secretariat's collaboration with the Coalition for Disaster-Resilient Infrastructure has made it possible to assess infrastructure vulnerabilities together with social, economic and environmental vulnerabilities, thereby offering actionable policy insights to safeguard critical systems against climate-related disasters. Linking such platforms with the secretariat's Risk and Resilience Portal ensures that the region has a robust, integrated knowledge base to support decision-making and enhance the effectiveness of early warning systems.

42.   In addition, the secretariat serves as a knowledge partner to regional climate forums, scaling up the automation of impact-based forecasting through platforms such as the North Eurasian Climate Outlook Forum, the South Asian Climate Outlook Forum, the ASEAN Climate Outlook Forum, the Forum on Regional Climate Monitoring, Assessment and Prediction for Asia, the Third Pole Regional Climate Centre Network and the Third Pole Climate Forum.

43.   Specifically, the secretariat is part of the Third Pole Regional Climate Centre Network, led by the Governments of China, India and Pakistan, which provides critical seasonal forecasts and supports transboundary collaboration. Its first seasonal outlook, issued in June 2024, highlighted temperature and precipitation anomalies across the region, enabling the early identification of risk hotspots. With funding from the regular programme of technical cooperation, the secretariat contributes to the programme by translating seasonal forecasts into impact-based scenarios that enable countries to prepare for cascading hazards such as glacial lake outburst floods and water scarcity.

44.   By supporting the above-mentioned forums, the secretariat builds capacities and provides the tools necessary for tailored, science-based forecasting, helping members and associate members to transition from a hazard-based to an impact-based approach for risk-informed decision-making.

45.   The regional dialogue on ocean-based climate action held in Bangkok and online on 19 September 2024 was jointly organized by the secretariat, the Governments of Fiji, Indonesia and Maldives, as well as the Coordinating Body on the Seas of East Asia, the United Nations Development Programme and the United Nations Environment Programme, as a collaborative effort to strengthen coastal resilience and mitigate the impacts of climate change. Oceans play a key role in mitigating greenhouse gas emissions and increasing resilience to climate change. To increase community resilience to ocean and coastal risks by 2030, [28] two specific actions have been identified: (a) establishing comprehensive people-centred early warning systems capable of addressing multiple hazards; and (b) devising adaptation strategies that specifically target risks associated with the ocean, including those linked to climate change.

---

[28] Challenge 6 of Vision 2030, developed in the framework of the United Nations Decade of Ocean Science for Sustainable Development (see General Assembly resolution 72/73).

46. With funding from the Government of the Russian Federation, the secretariat has partnered with institutions in that country to strengthen resilience to slow-onset disasters such as drought, desertification and land degradation in Central Asia. A project implemented with the Governments of Kazakhstan, Kyrgyzstan and Tajikistan is addressing critical knowledge and capacity gaps through partnerships with the North Eurasia Climate Centre (which focuses on seasonal impact forecasting) and the Institute on Global Climate and Ecology (which provides climate projections for long-term adaptation planning). These efforts enable Governments in pilot countries to make strategic, cross-sectoral decisions for disaster risk reduction and climate adaptation. The secretariat is building on the project outcomes to establish a subregional cooperation framework for fostering the exchange of scientific evidence and expertise to address shared challenges.

47. Finally, through the ESCAP multi-donor trust fund for tsunami, disaster and climate preparedness, the secretariat has been supporting regional and national initiatives to strengthen multi-hazard early warning systems for greater resilience to ocean- and climate change-related disasters in the region. The opportunities emanating from advances in climate and ocean science, risk analytics and the digitalization of early warning products can substantially address the threats of sea level rise and extreme weather events through regional cooperation.

48. Moving forward, regional cooperation will be critical to achieving the Early Warnings for All initiative in Asia and the Pacific. Initiatives like the secretariat's downscaled climate models and the Indian Ocean Tsunami Warning and Mitigation System highlight the importance of accurate assessments and shared seismic and sea-level data. However, recent declines in data sharing underline the need for stronger agreements and interoperability standards. Subregional mechanisms such as the ASEAN Agreement on Disaster Management and Emergency Response and the Pacific Resilience Partnership can facilitate the integration of multi-hazard risk data across borders.

49. Investments in cutting-edge technologies such as artificial intelligence-powered monitoring systems, satellite-based detection tools and geospatial analytics are necessary to strengthen observation and forecasting capabilities. Similarly, investments in inclusive and accessible communication will ensure that vulnerable populations and critical sectors receive and act on early warning alerts in a timely manner. Regional cooperation efforts should focus on implementing standardized protocols for communication, such as the Common Alerting Protocol,[29] which allows for dissemination of consistent, multi-channel warning alerts across borders.

50. Achieving these goals requires the development of integrated policies and sustainable financing mechanisms. Regional frameworks should align early warning priorities with global agreements such as the Sendai Framework for Disaster Risk Reduction and the Early Warnings for All initiative. The ESCAP multi-donor trust fund for tsunami, disaster and climate preparedness has been instrumental in financing these initiatives by facilitating donor coordination through a pooled funding mechanism. Innovative financing mechanisms, including climate resilience and thematic bonds and

---

[29] United Nations Office for Disaster Risk Reduction, "The Common Alerting Protocol (CAP): the international standard format for emergency alerting". Available at www.undrr.org/early-warnings-for-all/common-alerting-protocol (accessed on 27 December 2024).

public-private partnerships, can be used to mobilize additional resources for technological upgrades, capacity-building and long-term system sustainability.

VI. Issues for consideration by the Commission

51. Considering how critical it is to ensure early warnings for all by 2027, especially those in risk hotspots in least developed countries, landlocked developing countries and small island developing States, the Commission may wish to take note of the findings and policy recommendations contained in the present document and provide further guidance to the secretariat on its work, including on the priority areas and partnerships related to the following:

(a) Ensuring predictable, long-term financing for the operationalization and maintenance of early warning systems, including by exploring the use of new financial mechanisms such as climate resilience and thematic bonds;

(b) Strengthening cross-border cooperation to share knowledge and data on risks, particularly risks associated with emerging hazards such as glacial melt and cascading risks emanating from climate and geophysical hazards;

(c) Enhancing regional platforms, including the secretariat's Risk and Resilience Portal and SatGPT, to better integrate local hazard data into national and regional strategies;

(d) Scaling up the implementation of inclusive community-based early warning systems by leveraging innovative technologies so that early warnings reach marginalized communities in a timely manner;

(e) Promoting the alignment of early warning strategies with global frameworks such as the Sendai Framework for Disaster Risk Reduction and the Early Warnings for All initiative, thereby fostering coherence in disaster risk reduction policies and actions across the Asia-Pacific region.

————————