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Emerging CHALLENGES for EARLY WARNING Systems in context of Climate Change and Urbanization

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A JOINT REPORT PREPARED BY DKKV/ Platform for Promotion of Early Warning/ UNISDR WITH INPUTS FROM PARTNER ORGANIZATIONS AND COORDINATED BY HUMANITARIAN & DEVELOPMENT NETWORK,

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1. Introduction

This paper is a joint review undertaken by the Platform for the Promotion of Early Warning (PPEW), and the German Committee for Disaster Reduction (DKKV) to identify opportunities and implications for early warning systems in the light of changing climate. The study was the result of a review of the institutional learning gained from the work undertaken by PPEW since its creation, in particular in investigating linkages to emerging risk from climate change, expanding urban growth in risk areas, and in the context of the development of early warning systems needed to address the challenge of seasonal forecast for livelihoods' adaptation. The consultative workshop took place on 2-3 September 2010 to examine these issues with major stakeholders based in Bonn.

Contributions to the substantive sections of the study were purposely and specifically prepared by experts being member and/or cooperating with DKKV. The document aimed at demonstrating the importance of early warning: its various sections illustrated how it fits into and links with the areas covered by a number of other organizations, many of which are located in Bonn. The report highlighted the position of early warning in disaster risk reduction and in the ISDR system, and its direct relevance to the work of UNISDR. The critical value of early warning has grown with the strengthening of links between DRR and climate change, including specifically in the context of expanding urban development under stress from environmental changes. One important aspect that will require greater involvement in future is indeed the socio-economic aspects of early warning. Strengthening of climate monitoring capacities especially in Africa is another important aspect, as the regions that are most under threat of Climate Change lack the capacities to monitor future changes (see also p. 9 and 11).

At the same time a quick review of the National Adaptation Plans for Action (NAPA) of 24 countries which submitted proposals on Disaster Management and Early Warning, showed that nearly half of the projects submitted focused on Early Warning and another five on the strengthening of Met Services. Of the total requested budget (65 Mio USD) roughly half of the total (28.677 Mio USD) is on Early Warning and additional 10.5 Mio USD requested for strengthening of Met Services. It could be concluded that vulnerable countries see the need to strengthen their Early Warning and forecasting capacities as the most pressing one in order to adapt to Climate Change.

This extract[1] compiles the substantive sections of the report, illustrating the forthcoming challenges in the broad area of early warning, in the context of disaster risk reduction. The study was carried out through literature research and semi-structured interviews with a variety of stakeholders: UN agencies based in Bonn, federal ministries in Germany and major Germany-based stakeholders from the scientific community, agencies and institutions.

2. The concept of Early Warning

a. Definition

According to UNISDR, Early Warning is the provision of timely and effective information, through identified institutions, that allows individuals exposed to a hazard to take action to avoid or reduce their risk and prepare for effective response. In other words, Early Warning can be defined as the set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss. The definition does not include a reference to the time scale on which a warning is given. Early Warning Systems include a chain of concerns, namely: understanding and mapping the hazard; monitoring and forecasting impending events; processing and disseminating understandable warnings to political authorities and the population, and undertaking appropriate and timely actions in response to the warnings. The term “chain”, however, can be misleading as it implies a sequence in time of different actions. Given the findings of this study, it might be appropriate to discuss about a concept that captures the concomitance of the different elements of EW; this could be a subject for review with the stakeholders at the workshop.

[1] The original papers that were contributed to DKKV for the study, on the concept of early warning, on climate change, urban development, seasonal forecast, EW and livelihoods, and governance, can be obtained on request from DKKV. Appreciation and thanks are expressed to the authors.

b. Early Warning chain

A complete and effective early warning system comprises four elements, spanning knowledge of the risks faced through to preparedness to act on early warning. Failure in any one part can mean failure of the whole system. The “four elements of effective early warning systems”, the Early Warning Chain, include the development and operation of early warning systems in regard to: (a) knowledge of risks; (b) monitoring and warning services; (c) warning dissemination and communication; and (d) emergency response.

These four elements of an Early Warning System imply that early warning is based on the assessment of risk and vulnerability. Moreover, early warning should be communicated appropriately and ensure response capability of the people at risk, taking into account short and long-term measures.

Climate change, urban development, changing conditions for the livelihood concept due to new dimensions of natural disasters and global environmental change and the seasonal forecast approach will have implications on the different elements of the EW-chain. This review addresses parts of the chain that are affected by those elements. An underlying issue is the socio-economic dimension, and related frameworks. It also raises the question as to whether an adjustment of the conceptual understanding of early warning might be necessary in view of promising possibilities of long-term forecasts and predictions. Is long-term action still early warning?

3. Climate change: implications for Early Warning

a. Definition

The IPCC Glossary defines the term "climate change" as referring "to a statistically significant variation in either the mean state of the *climate* or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or *external forcings*, or to persistent *anthropogenic* changes in the composition of the *atmosphere* or in *land use*. Note that the *United Nations Framework Convention on Climate Change* (UNFCCC), in its Article 1, defines "climate change" as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." The UNFCCC thus makes a distinction between "climate change" attributable to human activities altering the atmospheric composition, and "climate variability"."

b. Evidence from past observations

The Fourth Assessment Report of the IPCC (Climate Change 2007: Synthesis Report) displays clear evidence that climate change takes place. This evidence becomes visible when one considers the changes of some important indicators of the global warming:

indicators			implications
increase in global average air and (sea temperature - not displayed)	increase of the sea level	extended melting of glaciers and the decrease of snow cover	frequency and intensity of extreme weather events (* last 50 years)
observed increase in air temperature between 1906-2005: +0.74°C	observed values between 1961-2003: +1.8mm/year or 75,6mm	e.g. average Arctic sea ice extent shrinking: -2.7% between 1978-2007 per decade	Hot days and nights more frequent (very likely)* More heat waves (likely)* More heavy precipitation (likely)*

"The observed widespread warming of the atmosphere and ocean, together with ice mass loss, support the conclusion that it is *extremely unlikely* that global climate change of the past 50 years can be explained without external forcing and *very likely* that it is not due to known natural causes alone. During this period, the sum of solar and volcanic forcings would *likely* have produced cooling, not warming." (IPCC, Climate Change 2007: Synthesis Report, p. 39). Due to the fact that none of the known external forces seems to be responsible for global warming it is very likely that the increase of anthropogenic Green House Gases (GHG) resulted in the increase of global average temperature during the last 50 years. This is supported by the fact that "the atmospheric concentrations of CO_2 and CH_4 in 2005 exceed by far the natural range over the last 650,000 years" (IPCC, Climate Change 2007: Synthesis Report, p. 37).

Assuming that anthropogenic emission of GHGs is the most important driver of recent global warming, it is crucial to consider future emission scenarios. The IPCC SRES-scenarios (Special

Report Emission Scenarios) represent a set of possible future global societal developments with different implications on the GHG concentrations and global warming. Regarding the findings of the report mentioned above the process of global warming will continue for the next few decades, even if the emissions of GHGs will stay constant at the level of the year 2000. Even more ecologically friendly scenarios predict an increase in average global temperature at the end of the century. In conclusion, Climate Change is not avoidable for the following decades and will furthermore change the frequency, spatial and temporal distribution and intensity of natural hazards. Hence it is reasonable to (1) assess climate change induced trends of natural hazard and (2) to detect and deduce resulting implications for and potentials of Early Warning Systems under changing climate conditions.

A number of areas and hazards have to be considered in the context of climate change and early warning, as the non-exhaustive list hereafter suggests:

Heat waves: with hot periods expected to multiply, it is likely that more frequent heat waves will occur in most parts of the globe, becoming a growing hazard of the changing climate, especially in cities. For instance, Central European cities may be confronted with more Mediterranean climate conditions. It is realistic to state that climate change will result in the expansion of heat waves northwards and pose additional risk for cities that do not implement appropriate DRR measures such as heat-health warning systems. Heat waves have adverse impacts on a variety of sectors: water supply, energy, transportation, agriculture, health and fire services etc., with extreme temperature conditions making society more vulnerable and endangering the health and life of people.

Heavy precipitation: an increase of heavy precipitation events is also likely to occur. Depending on environmental conditions, e.g. topography, vegetation cover, soil and other factors, heavy precipitation may result in flash floods and other hazards such landslides, increasingly so as the likelihood of heavy precipitation grows. The lead time for flash flood is about 15 minutes, thus the development of denser precipitation measurement networks, improved modeling techniques and the extension of lead times is necessary. With short lead times, dissemination of warnings has to be upgraded.

Floods: floods often have anthropogenic roots, caused by river bank straightening, ground sealing, bad settlement planning and other land use changes. Increased heavy precipitation will also affect the discharge of rivers. While some argue that a general increase of flood risk might not occur, the complexity of floods and regional precipitation and melting processes need to be considered.

Hurricanes: the uncertainty about an increasing pattern of tropical storm activities is due to historical classification and changes, inter-decadal variability and the only recent availability of reliable records (since the 1970s), making it difficult to detect long-term trends. Nevertheless, increasing sea surface temperatures related to climate change is a matter of concern: SSTs are one of the key factors enhancing tropical storms activity. Rising SSTs may introduce a spatial expansion of tropical storms; areas that until now have been not affected by tropical storm could be at risk in future. While discussing tropical storms in the context of EW, the ENSO-phenomenon may be regarded as an important indicator for tropical storm activity.

Droughts: drought modeling (based on Palmer Drought Severity Index- PDSI) depicts that some areas of the globe have become drier between 1900 and 2002 (Sahel, southern Africa, the Mediterranean, southern Asia) while other regions have become wetter (eastern North America, South America, northern Europe, northern and central Asia). Even if there are supra-regional differences, globally very dry areas have more than doubled since the 1970s.

Sea level rise: sea level is projected to rise between now and the end of this century (2090–2099) between 0.18 m and 0.59 m depending on the underlying SRES scenario. This will pose a challenge for coastal regions and especially for urban areas in Low Elevation Coastal Zones (LECZ). With some ten per cent of the world's population and 13 per cent of the urban population, LECZ count about 600 million people, of which 360 million are urban.

Health & diseases: heat and cold waves, floods, drought and other natural hazards may cause new impacts on health. Climate change related diseases may result from northwards expansion and redistribution of some vectors like ticks and (non-malarial) mosquito which has been observed in Europe and North America. The expansion of the primary malaria agent (falciparum) is likely to continue until 2050. Assuming that many regions will be increasingly affected by floods, the risk of cholera can rise, due to the faecal contamination of water supply. Water shortages during long drought periods may have an impact on the quality of water, resulting in sanitation problems and an increase of diarrhea diseases.

Wildfires: the occurrence, spread, controllability and impacts of wildfires are closely linked to weather and climate variability. While the predominant ignition risk of wildfires in a globally changed climate may remain unchanged, the increasing occurrence of extended droughts and heat waves will provide aggravating burning conditions. These may result in wildfires affecting larger areas, fires of increased intensity and severity. Extended regional smoke pollution episodes are likely to recur more frequently in countries in which extended organic terrain will be subjected to wildfire. Retreating glaciers and desiccating mountain ecosystems may affect fire regimes both in the mountains and lowland ecosystems, as changing water supply will influence the vulnerability of ecosystems to fire. The combination of the consequences of human interference in the world's vegetation cover, increasing occurrence of dry spells and heat waves, and changed fire regimes may interact with predicted occurrence of extreme rainfall episodes, events and droughts and will lead to secondary disasters and ecosystem degradation, e.g. landslides, mudslides, flash floods and soil erosion.

GLOF: with global warming, retreating glaciers increasingly fill the glacier lakes with more water. The lakes develop in front of the end moraine, constituting a natural dam. With high pressure from water or because of a landslide, the moraine fails, causing a Glacier Lake Outburst Flood, flooding communities and infrastructures downstream. Accurate and timely information and regular monitoring of the glacier lakes behavior is needed, to prevent and monitor the GLOF hazards and assess potential damages.

Permafrost degradation: the degradation of permafrost has been observed in different regions of the world (e.g. North America, Tibetan Plateau, Alps), in some regions further reinforced by the impact of increasing wildfire occurrence. This may have an impact on infrastructure resulting from subsidence of the ground. Thawing of permafrost will probably also increase landslide and rock fall. Climate-driven change of permafrost regimes may also lead to a release of paleo-gases, notably methane, currently trapped in permafrost and wetlands.

Other hazards: the melting and disappearance of glaciers will put additional stress on the availability of potable water for cities. This poses a huge problem for municipal administrations, power supply sector and agriculture, rendering communities and livelihoods more vulnerable to extreme events.

Early Warning Systems and Climate Change: climate change will not only adversely affect the resilience of communities, the environment, urban infrastructures, transportation, energy supplies and other sectors, but also Early Warning Systems. Beyond the need for mitigation, adaptation to climate change is itself an important task: existing and planned early warning concepts need to be checked against climate change.

c. Early Warning and Climate Change

It is important to stress that climate change will not only adversely affect the resilience of communities, environment, urban infrastructures, transportation, energy suppliers and other sectors but also Early Warning Systems. It is a common opinion that beyond the need for mitigation, adaptation to Climate Change is an important task. It should be highlighted here that in this context not only the exemplary listed sector above will have to adapt to Climate Change but also existing and planned early warning concepts need to be climate checked. The need for adapting EWS may reveal for all parts of the Early Warning Chain.

(1) Risk knowledge

In the context of Climate Change, natural hazards and risk will change with some generic changes of natural hazards. Changing of global hazard patterns can only legitimate the discussion of integrating CC considerations into EW concepts, but is insufficient for establishing climate proofed Early Warning Systems and concepts. The global indicators of global warming, the global climate models and even the IPCC regional models are inadequate in the context of Early Warning (EW), since they: (1) often describe changes in temperature and precipitation but are excluding the changes in natural hazards and (2) describe climate change for extended areas, like CAS (Central Asia) covering different countries, political systems, ethnic constellations and disregard sub-regional environmental, topographical and other differentiations.

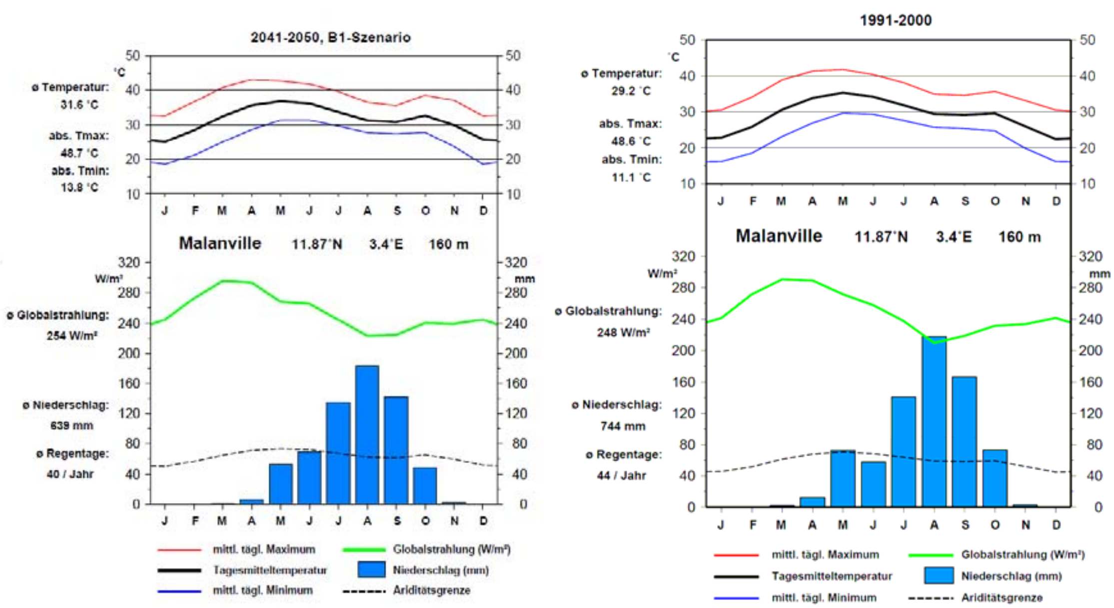
In most cases the implementation of EWS for climate related hazards requires: (1) local risk knowledge, (2) communication of warnings, which reach the local communities in a timely way, and (3) local disaster response capabilities. Hence knowledge of the sub-regional or even small scale impacts of Climate Change on communities and their livelihoods is required, to allow a useful conception of Early Warning Systems. Regional modelling results retrieved from projects like IMPETUS (An Integrated Approach to the Efficient Management of Scarce Water Resources in West Africa) provide an appropriate resolution (about 7 km grid) to handle Climate Change impacts on sub-regional scale. Within those projects, impacts of Climate Change are displayed for a specific sub-region (e.g. Atlas Mountains) and additionally socio-economic, agricultural and hydrological contexts are kept in mind. Those aspects are of importance since EWS must also incorporate the question of vulnerabilities. “Assessments of risks require systematic collection and analysis of data and should consider the dynamic nature of hazards and vulnerabilities that rise from processes such as urbanization, rural land-use change, environmental degradation and climate change” (Developing Early Warning Systems: A Checklist, 2006, p. 2). Regional differences of climate change impacts are obvious when one considers for example the regional modelling result for Germany provided by the Regional Climate Agencies. While for north

Germany an average increase of 3 storm days is predicted, there is only an average increase of 1.8 storm days for the whole Federal territory. A similar project considering Climate Change in a more integrated way is AMMA (African Monsoon Multidisciplinary Analyses).

Since EW is an integral part of the Disaster Risk Reduction framework, vulnerability on specific spatial and time scales needs to be taken into account, irrespective of resilience conditions, while discussing EW and Climate Change impacts.

Climate sensitive EW concepts have also to consider adaptation strategies and climate change related vulnerability assessments, which are in place for some regions. These are increasingly implemented by national adaption plans and by civil society and humanitarian organizations such as the International Federation of Red Cross and Red Crescent Societies (e.g. Vulnerability and Capacity Assessments - VCA). Those measures in place must be included into conceptual considerations to prioritize early warning systems' needs. In some cases adaption strategies and disaster risk reduction (DRR) measures may have reduced vulnerability of communities to a level that is not compelling for the implementation of an Early Warning System.

It is also crucial to readjust existing EWS in a way that follows the small scale impacts of Climate Change, especially in developing countries where often hydrological and meteorological data is lacking. According to the WMO World Weather Watch, "There are 1152 WWW stations in Africa giving a station density of one per 26,000 km2, eight times lower than the WMO minimum recommended level." Additionally, maps provided by the Global Runoff Data Center illustrate the uneven distribution of discharge monitoring stations worldwide. In many parts of Africa and Asia such stations are missing and if available in most cases do not provide long-term data (> 75 years). The missing information limits possibilities (1) to detect climate variability precisely, (2) to make reliable forecasts and (3) to make use of the data in the context of early warning (e.g. drought monitoring or discharge monitoring).



Source: IMPETUS modelling results for Malenville - north east Benin - indicating changes in precipitation and temperature (REMO – SRES B1)

(2) Monitoring and warning services

Monitoring and warning services may be affected by Climate Change due to several reasons depicted in the following examples:

> Spatial and temporal changes in risk patterns resulting from changed vulnerability and the "new dimensions" of natural hazards (intensity, frequency, distribution) may introduce the need for adapting the distribution of early warning systems. Beyond that, areas increasingly affected by droughts or other hazardous events may face the phenomenon of climate change induced migration; strong environmental changes may strengthen processes like rural exodus and urbanization. These processes can thus contribute to a changed distribution and vulnerability of people who have to be warned. Social changes (e.g. improper changes in land-use patterns in growing urban areas), environmental changes such as changes in vegetation cover may also alter the discharge of rivers and introduce flood events or facilitate hydrological droughts with consequences for irrigation, farming and livelihoods.

> Significant redistribution of population, changes in vulnerability and hazard patterns may necessitate changes in monitoring and warning services. It is thus important to monitor a CC-induced evolution of risks, to detect affected areas and to place early warning systems at appropriate locations at the right time.

Assuming that CC will lead to more frequent operations of EWS, due to more fast-onset events like flash floods, warning services will be challenged in terms of timeliness. (Note that the dynamics of urban floods are related to social changes more than to climate change.) New dimensions of risks will consequently make new monitoring methods and equipment necessary. Simultaneously, more frequent and more intense events will pose additional stress on technical equipment (maintenance and replacement of damaged equipment) and related personnel.

> Power supply shortages are a common problem in developing countries, while increasing industrialization and population growth will probably cause a rise in the demand for supply. Hydroelectric power generation may be negatively influenced by changes in precipitation patterns while rising temperatures will increase the demand for cooling water in industry and for household cooling. More frequent power supply shortages could increasingly become an issue in the context of electric driven warning services. In some regions, potable water comes from glaciers; the melting and gradual disappearance of glaciers may pose a huge problem in relation to drinking water.

> Global climate drivers like ENSO will change due to Climate Change and hence contribute to the complexity of the process. Since typical anomalies are observed during El Nino and La Nina phases, these correlations could change in future and complicate corresponding forecasting capabilities. Approved warning approaches in this context could temporary face the problem of becoming less reliable.

> Monitoring systems need to identify not only fast-onset events but also creeping processes caused by climate change (e.g. sea-level rise). The longer term prediction enables warning services to deliver more complex information to populations. Long term early warning can provide essential information to enable people to adapt their livelihoods to potential upcoming hazards.

(3) Dissemination and communication

The way of disseminating and communicating warnings will virtually not be affected by climate change. But should new areas be affected by a specific hazard (e.g. northward shift of tropical cyclones), the communication lines would need to be adapted spatially and eventually shifted to new regions and/or be extended.
Institutions in charge of dissemination and communication may face the problem of adapting their concepts for disseminating and communicating early warnings because of new risk patterns. Increasing magnitudes of events requires dissemination with a longer lead-time in order to enable people to get prepared. Changing/increasing regional scales of events requires a regional extension of dissemination and communication lines.
Migration flows could lead to the need to prepare new dissemination concepts (e.g. through standardized messages and pictograms) and information about population figures. Expanded communication of warnings could raise the costs for communicating warnings and consequently increase personal demand for the dissemination of warnings at national level.
To be effective, an early warning must be recognized as such by the community: it is thus crucial to raise the general awareness that CC-induced hazards may increase. The character of messages can be enhanced, as promising developments for longer term and seasonal early warnings materialize, including on information about impacts on livelihoods and ways to react.

It is expected that many African and other developing countries will be affected by climate change more adversely than developed countries. In many such developing countries, however, the capacity for adaptation is lacking and adaption strategies often are neither investigated nor prepared. For example, the world's regions where seasonal forecast skills are high (e.g. West Africa) in most cases do not have the appropriate knowledge or technological means to make use of its advantages for vital sectors like agriculture and health. This gap should be closed, through capacity building and international cooperation: seasonal forecast information can then be incorporated into communities' decision-making processes in the course of changing climate. Obviously, this can only be achieved if information reaches the affected population. Appropriate ways of communication and the presentation of forecast results need therefore to be tailored to the needs of the users. It is thus crucial to ensure that capacities for adaptation are strengthened, including the upgrading of measurement networks and the improved access to relevant climatological and remote-sensing information and seasonal forecasts. It is important also to link national adaption processes to the local level, to link NAPAs to the livelihood strategies and to integrate DRR into the climate change adaptation strategies.

(4) Response capabilities

Existing contingency and preparedness plans should be updated; they should consider climate change projections and vulnerability and capacity assessments. Existing information about climate change projections should be incorporated into existing plans (especially regional investigations but also national and international initiatives). Increasing frequencies/shorter return periods of events will pose a challenge to response capabilities and structures.

As longer term possibilities for early warning response capabilities move out of the sectors of preparedness and response and enter the area of development decisions, the number of actors to involve has to increase; emerging potentials have to be explored; and available tools have to be integrated.

4. Urban development: implications for Early Warning

a. Coastal Urban Areas in the context of Global Environmental Change

Urban areas are complex and dynamic systems of interaction between socio-economic, geopolitical, and environmental processes. Many of the most important and significant changes associated with the impact of globalization are taking place in urban areas. According to the United Nations (2004), the world´s urban population will grow from 2.86 billion in 2000 to 4.98 billion by 2030. The world´s annual urban growth rate is projected at 1.8% in contrast to the rural growth rate of 0.1%. About 60% of the world´s population will live in cities and a high proportion of this population growth is likely to occur in the developing countries.

Recent research has emphasized the linkages between rapid urbanization and disasters. Current urbanization processes play a key role in the context of population growth, inequality, political change, economic growth, technological innovation, global interdependence, etc. that are related to increasing disaster-related losses and damages.

High concentration of people and resources in urban areas result in high economic, social and environmental costs of disasters, where urban areas already deal with various environmental burdens, either environmentally-induced or human-induced. This situation is likely to be exacerbated in coastal areas, with the growing populations in coastal cities that are particularly vulnerable to sea-level rise, tsunamis and other hazards. Low Elevation Coastal Zones (LECZ), the continuous areas along coastlines with an elevation of less than 10 metres above sea level, represent 2% of the world´s land area but hold 10% of its total population and 13% of its urban population. There is a long history of human settlement in coastal zones and since the twentieth century, the globe's urbanized coastal population has grown rapidly due to economic opportunities and environmental amenities offered by such zones. This implies unprecedented pressure on the economic development of their resources.

Development in coastal areas, especially urban, may on the one hand increase vulnerability to coastal hazards or, on the other hand, weaken the resilience of the coastal population. Hazards in coastal areas often become disasters through the increasing erosion of resilience, driven by environmental change and by human action, shown for example in extreme events such as the 2004 Indian Ocean Tsunami and major recent hurricanes.

The situation in coastal areas will be exacerbated with climate change. Several main climatic drivers for coastal systems for climate change scenarios were considered in the IPCC Assessment Report, namely higher CO2 concentration, increasing sea surface temperature, sea level rise, increasing storm intensity, uncertain storm frequency and track, uncertain wave climate, regional variety of run-off with flood risks. These drivers are combined with the environment and socio-economic factors such as population, coastward migration, human-induced subsidence, terrestrial freshwater / sediment supply, aquaculture growth, infrastructure growth, extractive industries, adaptation response, hazard risk management, habitat conservation and tourism growth. The resulting impacts will affect various coastal socio-economic sectors as shown hereafter:

	Climate-related impacts (and their climate drivers in Figure 6.1)						
Coastal socio-economic sector	**Temperature rise (air and seawater)**	**Extreme events (storms, waves)**	**Floods (sea level, runoff)**	**Rising water tables (sea level)**	**Erosion (sea level, storms, waves)**	**Salt water intrusion (sea level, runoff)**	**Biological effects (all climate drivers)**
Freshwater resources	X	X	X	X	–	X	x
Agriculture and forestry	X	X	X	X	–	X	x
Fisheries and aquaculture	X	X	x	–	x	X	X
Health	X	X	X	x	–	X	X
Recreation and tourism	X	X	x	–	X	–	X
Biodiversity	X	X	X	X	X	X	X
Settlements/ infrastructure	X	X	X	X	X	X	–

X = strong; x= weak; – = negligible or not established.

Summary of Climate-Related Impacts on Socio-Economic Sectors in Coastal Zones (Nicholls et al., 2007)

It is indispensable to prepare for action and response to existing and changing environmental hazards; this includes effective early warning systems and taking necessary precautionary measures. UNU-EHS has chosen two case studies to illustrate early warning systems in the context of coastal hazards and climate change, aimed at identifying new challenges of early warning in the context of existing experience and global change. The studies address particularly the early warning system within an urban perspective, where dynamic development processes take place and various stakeholders are involved that influence the vulnerability or resilience of the cities, directly or indirectly.

The starting point of the analysis of the case studies is the ISDR concept of Early Warning, as outlined in section 3 above, stating that a complete and effective Early Warning System comprises four elements, spanning from knowledge of risk to preparedness to acting on early warning.

In the two case studies in LECZ cities, Padang and Semarang in Indonesia, both have a variety of economic sectors as well as dense settlement areas localized in low-lying areas; they both face multiple coastal hazards. The two studies provide a basis for drawing lessons or learning of new challenges for an effective Early Warning System for different hazard and risk profiles. The case of Padang is based on the experience of developing an early warning system for a sudden-onset hazard of tsunami, with a short warning time, based on different risk and vulnerability profiles. It emphasizes the necessity of linking early warning with long-term urban planning in terms of provision of evacuation infrastructures such as shelters and routes. The case of Semarang addresses creeping hazards of sea level rise, combined tidal waves, land-subsidence problems and urban dynamics. It shows the need to monitor a dynamic long-term urban vulnerability and risk profile and to develop early warning for creeping hazards in addition to sudden-onset hazard events. The necessity to involve long-term urban planning, such as water resources and land-use management in the development of early warning for creeping hazards is also outlined.

b. Case studies

Padang: the coastal city of Padang is one example of urban areas in Indonesia, where the tsunami early warning was installed and is currently being institutionalized at the local level. A local evacuation planning for the tsunami early warning was developed using information of tsunami hazard and vulnerability. The case study shows how important it is to link the establishment of an early warning system with the long-term urban planning at the local level.

Unequal distribution of information of an early warning as well as lack of supporting facilities and infrastructures for an appropriate response to early warning may lead to ineffectiveness of an early warning. It poses additional (perceived) risks for the people.

In the context of tsunami early warning in Padang, the vulnerability of the people is created by their unequal access to information, either due to limited access to the private and public warning dissemination media or lack of capability on how to interpret the strong earthquake events beside the various, sometimes unclear information they receive. This is combined with the awareness and knowledge background they have about tsunamis and what they have to do, and their perception towards it. Moreover, their vulnerability is shaped by the existing urban setting with high exposure to potential tsunamis due to concentration of settlements and activities along the coast and limited infrastructures to support evacuation to safe areas.

Establishment of an early warning entails development of effective risk communication, where the people become aware and clear about the danger they face and what they need to do to prepare themselves. However, preparedness at the community level cannot stand alone and should be supported by long-term measures, like in this case, appropriate evacuation infrastructures, such as evacuation shelters, sufficient evacuation roads, and in the long-term, control of urban activities in potentially affected areas. This means that an early warning should not be seen as relevant for solely emergency response, involving actors in community preparedness, but also the urban planning actors who should bear the task of necessary long-term intervention. It is therefore important to involve stakeholders related to urban planning and coastal management in the process of establishment of an early warning.

Further, vulnerability assessment is crucial as part of an early warning system and should enable the support of long-term infrastructures and planning for disaster risk reduction. The implementation of early warning in terms of detection of events, dissemination of warning and trigger for appropriate response cannot be seen as the final goal of an early warning; rather, it has to trigger long-term action for disaster risk reduction in wider sense.

Lessons: the following lessons can be learned from the case study in Padang for an effective early warning system:

- Early warning should include monitoring of vulnerability taking into consideration how properly the risk information is communicated to people at risk, with clear guidance for an appropriate response within a short timeframe
- Early warning should also ensure that the necessary supporting infrastructures needed for people's immediate response are identified and provided in the medium and long-term
- Establishment of an early warning system should involve not only actors in preparedness and emergency response, but also the relevant urban planning actors, to ensure implementation of early warning and evacuation requirements in the spatial or urban and economic development of a city or region.

Semarang: the coastal city of Semarang in the Central Java Province of Indonesia is one example of urban areas exposed to sea level rise in addition to other hazards, such as tidal flooding and land subsidence. The city is also interesting due to its multiple economic sectors, land uses and growing population along the coast.

A potential impact assessment was necessary for planning adaptation in the city. It provided a coarse overview on the potentially affected people and economic impacts due to future hazard scenarios under current urban development without adaptation ("status quo") that showed the costs of taking or not taking action, for the local government and the people. It also served as a starting point for further vulnerability assessment and differentiation of impact on various social groups or sectors.

Planned adaptation measures need incorporation of good basic data on future scenarios in the city planning; in the case of Semarang, this would be data and scenarios on sea level rise and land subsidence. Because of the uncertainty in climate change scenarios especially for an application at a local level, knowledge transfer and capacity building for the local government is needed, to allow interpretation and use of different scenarios for planning purposes.

Vulnerability assessment is crucial also: it reveals the existing (or future) susceptibility, coping and adaptive capacity of the community (social dimension), of the sectors (physical, economic, and environmental dimensions) and of institutions, such as local government. It also shows the limits of adaptation where interventions and external support may be needed. The vulnerability of people to sea level rise is shaped by the limited resources that they have, but also by low housing standards and lack in provision of infrastructure such as proper drainage to cope with rising inundation. In parallel to uncontrolled land use and over-extraction of groundwater for use in coastal areas, urban dynamics and population growth cause increasing land subsidence, adding to the vulnerability of the people living in the coastal areas. Long-term impact assessment and risk and vulnerability assessment, taking urban dynamics and planned adaptation measures into account, are needed to develop an early warning for a creeping hazard such as sea level rise in Semarang. It requires monitoring beyond the big flood events, and has to include continuous smaller inundations, providing an early warning for urban planners to adapt their urban plan.

In the case of Semarang, early warning should comprise two components: firstly, a hazard events warning at a very local level that outlines the areas that are flooded or provides help to identify alternative transportation routes; and secondly, a form of monitoring of the slowly increasing potential impact of the sea level rise, which is manifest in continuously inundated areas in the city.

In this case thus, an early warning system is not solely the responsibility of the Water Agency, which deals mostly with flood protection, and, as in the case of Padang, emergency response under the Local Disaster Management Agency. An effective people-centred early warning system has to be combined with long-term monitoring of urban dynamics such as population growth and development of coastal areas, so as to allow identification of the necessary long-term urban planning measures such as the necessity to control urban land use and improve infrastructures, particularly in terms of building a "safer places", to reduce the vulnerability to sea level rise and generated inundation.

Lessons: the following lessons can be drawn from the case study in Semarang for an effective early warning system:

- The function of an early warning system should be further developed to monitor both sudden-onset hazard events (short-term), e.g. tidal flooding, and creeping changes (long-term), e.g. sea level rise
- Risk and vulnerability assessment as part of an early warning for creeping hazards should take multiple-hazards into consideration as well as long-term urban dynamics (trend analysis and scenario development)
- Thus, early warning should allow to identify areas in urban planning where gaps exist and long-term intervention is needed to improve the level of security
- Establishment of an early warning system should involve not only actors in preparedness and emergency response, but also the relevant urban planning actors, to ensure implementation of short and long-term measures
- An Early Warning System for cities in LECZ has to consider the potential impact of creeping changes on sudden-onset hazards as well as the respective changes for anticipated responses (e.g. evacuation needs, evacuation capabilities, access to areas due to high water levels in transport networks).

c. Conclusions

These two case studies provide an interesting background to think about further enhancement of the early warning system for sudden-onset and creeping hazards. Both types of hazards – sudden-onset and slow-onset – are likely to appear with climate change. The linkage between early warning and urban adaptation particularly through urban planning is clearly demonstrated, even for sudden-onset hazards which are often more associated with short-term measures.

The necessity of involving actors related to urban planning rather than only actors from emergency response is emphasized through those studies. In practice however, those actors may not naturally coordinate their activities: they have different planning horizons, different instruments and approaches. Urban planners focus mostly on general development of the city based on medium and long-term investment priorities, with disaster risk reduction only a small part of their scope. Actors in emergency response such as a disaster management agency focus more on extreme events and how to handle community preparedness and emergency response, which a short-term response interest. Thus, it is important to involve all actors from the beginning and reach a common understanding on the necessity to monitoring short and long-term risk and vulnerability profiles as well as to establish an early warning system in an integrated manner.

The awareness of continuous risk and vulnerability profile monitoring was not yet visible in either case; it was rather shown as a snap-shot exercise. This could mean that there is a need to raise awareness on the role and use of such assessments in the development of effective early warning. In general, a clear understanding of what an effective early warning should consist of, based on the four elements, was not fully achieved in those case studies. Moreover, the value of early warning needs to be explored further in-depth for creeping hazards.

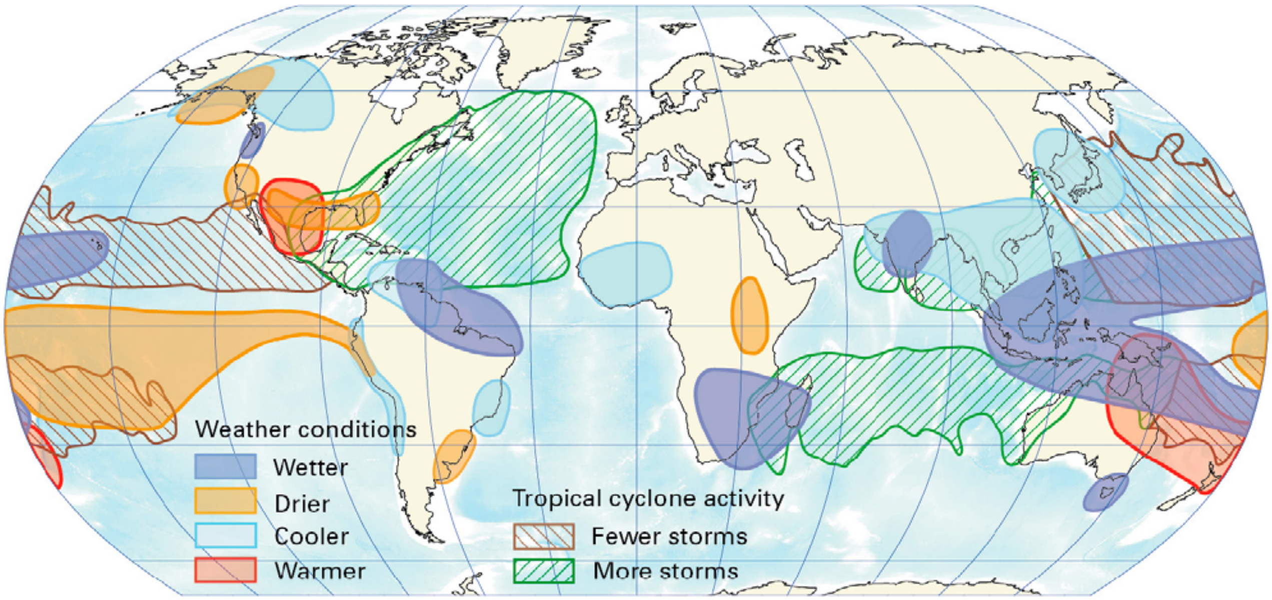
5. Seasonal forecasting: an old concept with new potential

a. Introduction to seasonal forecasting

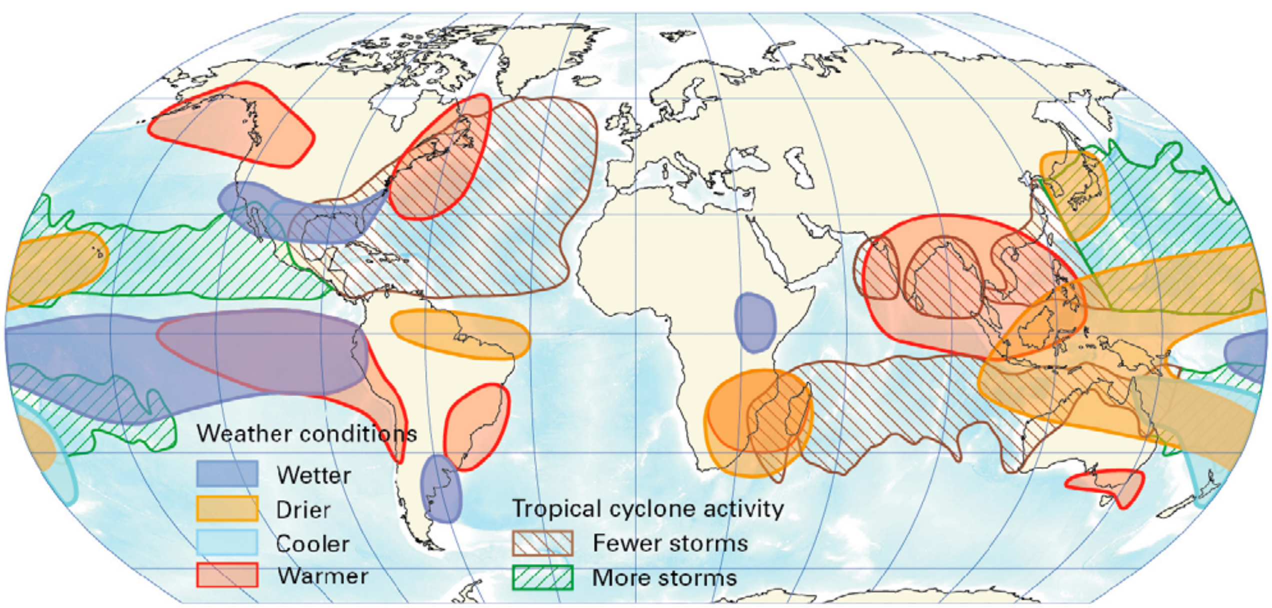
Seasonal forecasts have been part of coping strategies of ancient cultures and became an important component of indigenous knowledge. Climate variability and the El Niño phenomenon was recognised very early by the fishermen from the Gulf of Guayaquil who noticed that fish stocks seemed to disappear for several months at a time every few years, resulting in a decrease of food reserves. At those times, heavy rainfall would flood the areas, washing away crops and mud-built houses. The Incas adapted to climate variability and farmed diverse stocks at different altitudes in the Andes, experience having shown that there was rarely simultaneous failure of all stocks. Similarly, ancient Egyptians knew what to expect from the yearly flooding of the Nile delta. Records from the Pharaonic times show that one out of every five years saw an inundation that was either over-abundant, washing away much of the infrastructure in the flood plain, or fell short of expectations, leading to potential famine. The ability to predict the volume of coming inundations gave the priesthood, which held it through their knowledge of measuring the level of the Nile, an important political and administrative role.

Today, several methods exist that provide seasonal climate forecasts with lead times of up to several months (1-9 usually). Besides forecasts based on gridded physical models (atmospheric general circulation models and regional climate models - GCMs and RCMs) there are statistical approaches which either try to correlate/correct GCM output with past climate data or try to predict the near-future climate using purely statistical approaches. The most commonly used input parameter is the sea surface temperature (SST) anomaly. This anomaly is described as El Niño if unusually warm temperatures are measured across the eastern equatorial Pacific and as La Niña if unusually cool temperatures are given.

Several correlations exist between the ENSO status and global weather conditions. These are displayed in the following for La Niña and El Niño regimes.



Source: Munich Re 2009: Globe of Natural Hazards – La Niña



Source: Munich Re 2009: Globe of Natural Hazards – El Niño

The *physical models* are distinguished in:

- Coupled ocean-atmosphere-land models (CGCMs), which start off from one or more initial times and forecast the climate system “on their own“, i.e. without the input of estimated changes in SST. The model starts with an observed state of the land and sea temperature (preferably down to several hundred meters of water depth) and solves the model equations on a physical grid, hence producing a deterministic forecast for several weeks or months in advance. Since the oceanic and atmospheric processes can interact in these models, this model system is believed to be the most promising physically based approach. However, the model skill is limited not only due to deficits in the description of the physical processes but also due to uncertainties in the initial state (observation network density, data quality etc.). Therefore, a probabilistic approach is preferred, which provides a bandwidth of possible solutions. A varied initial state may be realized for seasonal or climate forecasts by starting the model from different initial times, e.g. several hours or even days apart. The forecast skill of CGCMs varies for different regions of the globe as well as for different seasons. The least skill is usually noticed for the March-May period, while it has become quite good for the period following July-September. Skill also depends on the SST measurements, especially on the sub-surface temperatures which are often not available, especially in the Atlantic and Indian Ocean.

- Purely atmospheric general circulation models (GCMs or AGCMs), which are driven by a guess/forecast of the evolution of SST anomalies. This is a traditional method which can simulate the inter-annual weather variability when the GCM is forced with an observed SST time series of different stations/buoys. For forecasting purposes, the SST time series is either provided by CGCMs or by statistical methods, with the simplest being the assumption of SST persistence. Since the skill of the latter methods varies for different regions, they can also be combined to drive the GCM in the end. An ensemble approach is considered most promising for GCMs as well. The skill of GCMs in predicting the tropical convective activity, for example, has been demonstrated in cases of observed SST time series and is currently monitored when driven by forecast SSTs.

- Higher-resolution regional climate models (RCMs) driven by the GCMs/CGCMs. A RCM is forced by the large-scale fields (temperature, wind, pressure, humidity etc.) from one or more GCM(s) or CGCM(s) and provides a higher-resolution, physically-based view of the regional climate. Due to their much finer horizontal grid (in the order of 10-50 km) they are able to resolve some crucial atmospheric processes, such as the interaction of air flow with the orography. Nonetheless, their skill depends greatly on the quality of the forcing model's forecast since the RCM mainly acts as a downscaling technique for the large-scale fields which are fed by the GCM. A regional climate model can be useful to quantify the effects of certain atmospheric pattern on the local/regional scale.

The *statistical methods* comprise:

- The correction of the physical models through comparison of past predictions with observations. Since all the above mentioned physical models involve systematic errors, it is necessary to correct those errors with statistical concepts. This may include simple bias corrections as well as more sophisticated methods, such as model output statistics. The latter comprises also the derivation of non-resolved properties, for example the 2-

metre temperature over complex terrain. All of those adjustments require a data set of observations and model output for an overlapping time period.

- The attempt to capture the physical behaviour of the climate system in a set of statistical relationships solely based on past (historical) data. The statistical methods comprise regression techniques, canonical correlation analysis and others, all aiming at finding a significant correlation between observed parameters (e.g. SST or pressure indices) and a forecast field (e.g. the sub-Sahelian rainfall). For these methods, it is important to find the relevant predictors, i.e. parameters that have some physical relationship with the predicted field. This might also be the case for fields which are co-varying with the predicted field. Statistical relationships can be regarded skilful tools in some regions and with some predicted fields. Forecasts of the ENSO are also based on statistical methods, which reveal some skill of those techniques.

Besides SST anomalies, there are other influential sources which can have an altering impact on the climate system:

- The land surface state (temperature and moisture content), which is suffering from a rather poor observing network as seen from a global perspective, can have an effect on following weeks/months if the soil is especially wet/dry or warm/cold, influencing the convective activity in the warm season for example.

- Anomalies of the large-scale circulation (e.g. a blocking high pressure pattern with repeating occurrence over weeks) that might themselves have their origin in SST anomalies, as they are more or less coupled. Significant skill is therefore depending on temporal delays or regional shifts of existing anomalous patterns.

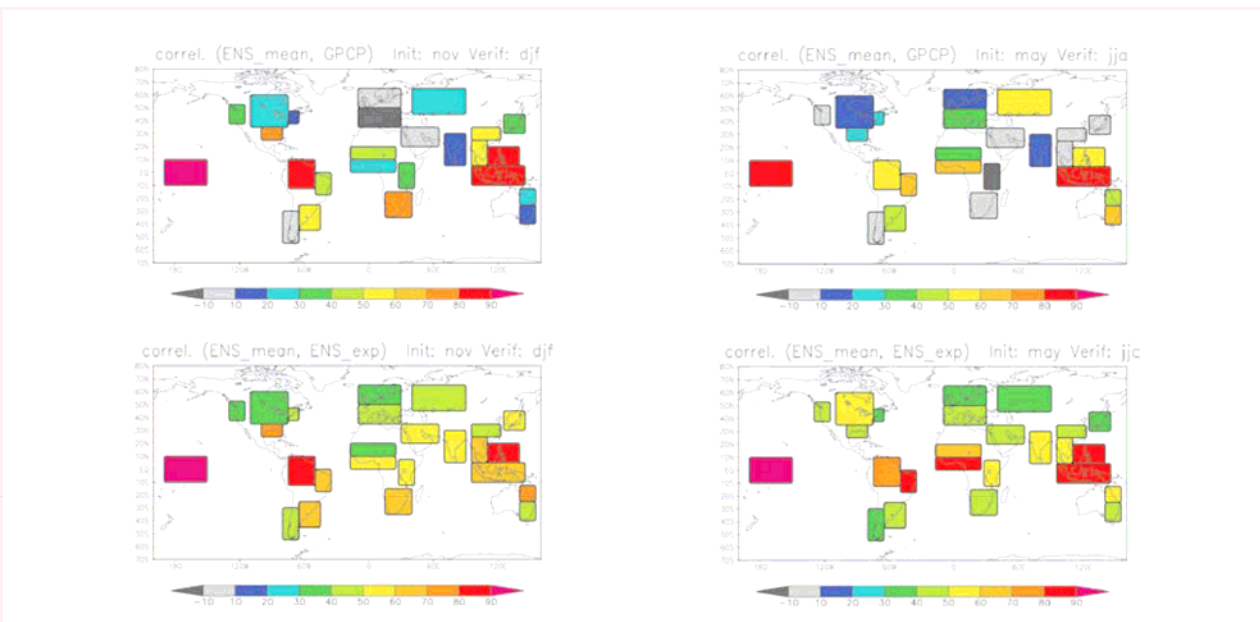
- The Quasi-Biennial Oscillation (QBO): the active weather is almost completely restricted to the lowest 8-16km of the atmosphere, called the troposphere. Above it follows the stratosphere, a layer which contains the atmosphere's ozone layer and where the temperature does not decrease further with increasing altitude. The winds exhibit a quasi-regular 2-year cycle, the quasi-biennial oscillation. The feedback or interaction between this large-scale circulation and the general circulation in the troposphere is not well understood so far. But it is believed that this middle atmosphere oscillation can influence the lower atmospheric circulation. A seasonal prediction might be possible if it can be proven than certain lower-atmospheric patterns follow the stratospheric winds with some delay.

<u>Note on observation network and quality for initial state of prediction</u>

The physical models rely on a good initial state which is the starting point of each forecast. This means that the measurements of land/sea temperatures as well as the atmospheric variables should have no systematic errors, if possible. Further, a dense network of observations is desirable but not feasible everywhere. The atmospheric variables are usually provided by the data assimilation system of an operational global numerical weather prediction model (e.g. by ECMWF or NCEP). The ocean data, however, requires a different analysis system, e.g. realized by a coupled ocean-atmosphere model which is fed with ocean temperatures (and in some cases salinity) from buoys, ships, satellites and others. Here, the sub-surface temperatures down to several hundred meters are valuable information which considerably increase the forecast potential since the memory effect of large water bodies is not only determined by the sea surface temperature. The adequate capturing of snow cover and sea-ice coverage and thickness is of great importance for local seasonal climate forecasts, but can also influence the global circulation for the same reasons as land and sea surface temperatures do.

b. Forecast skill – time of year and region

Since the quality of ENSO predictions has reached an appreciable level in the past years, it is possible to forecast rainfall anomalies some months in advance for certain regions of the globe.
The forecast skill of physical models is most commonly validated by comparing 2-metre temperature and precipitation forecasts with observations since these are the most important parameters in societal and especially agricultural contexts. While the temperature can be predicted quite well over large parts of the globe, especially over the ocean, the prediction skill of physical models for precipitation is rather poor even for one-day forecasts. This is partly compensated when precipitation is summed up over longer time periods, but the highly sensible and localized character of precipitation processes (mid-latitude cyclones, tropical convection etc.) limits prediction of the absolute amount over one point. Predictability generally tends to decrease further away from the Equator and from the oceans, although some areas, such as North America, are favoured in certain seasons because of stronger teleconnections. Despite these general tendencies, the quality of predictability differs strongly between different regions and depends additionally on the investigated season.

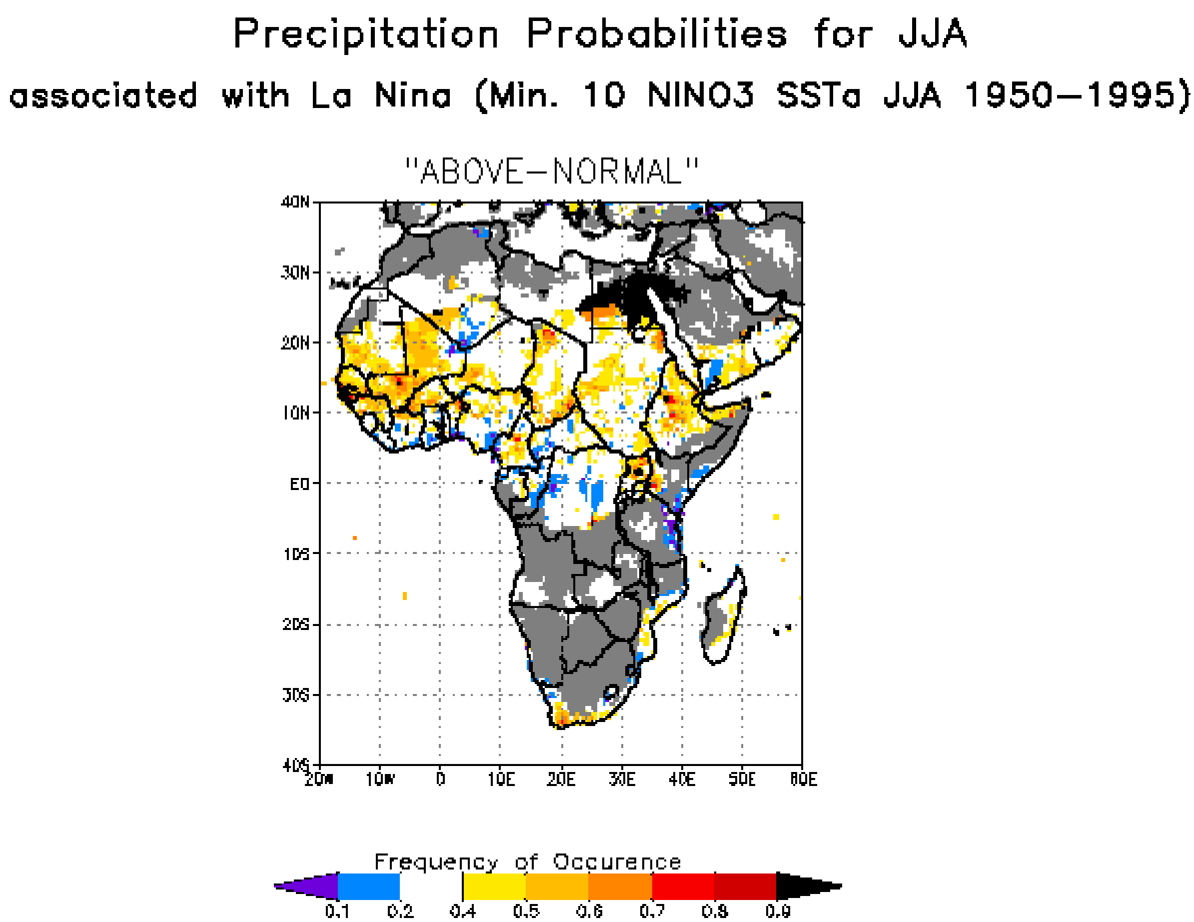


Anomaly correlation for area-averaged seasonal rainfall anomalies (December–February, left, June–August, right) in selected regions of the world for ECMWF System 3 seasonal forecasts (European Centre for Medium-range Weather Forecasts)

The upper panels of the above figure show the correlation between forecasts and observations. In some regions this is quite high, in others it is near zero. The lower panels show the model estimate of the predictability limit, in other words the correlation that would be obtained with a perfect model. In some places, the level of potential predictability is much higher than the skill presently achieved.

For some tropical areas, such as the Amazon basin, Southeast Asia, Southeast North America, relatively high forecast skills are available, while other regions such as Europe have a significantly lower skill allowing no better forecast than the climatological average. For large portions of the equatorial region, the seasonal rainfall can be forecast with considerable skill via CGCMs or statistical methods. This is demonstrated with an example from West Africa as follows.

While the probability for above normal summer precipitation in West Africa is about equal to the probabilities for normal or below normal rainfall during El Niño events, it is significantly higher (i.e. a wet period is likely) during La Niña events in West Africa and the Sahel zone as a whole. The probability for wet conditions reaches 60-70% in the western Sahel.



Beyond pure climatological forecast, seasonal forecast may be retrieved for some regions from the nival or glacial river discharges. Depending on the winter snow cover, spring melting intensity and onset, discharge may be highly variable and result in unexpected severe water shortages. Such shortages may negatively affect different sectors, from agriculture to health to power supply, and result in adverse implications on livelihoods. Thus, monitoring and forecast ability of nival and glacial river discharges are highly valuable for communities that might be affected, as a prerequisite to develop mitigation strategies and plans. Climate Change will affect the onset of the melting season, its duration and the intensity of discharge and thus will have an impact on different traditional livelihood strategies, both in rural and urban areas.

c. Decision making

Seasonal forecasts are becoming a more important element in some policy/decision making systems, especially within the context of climate change adaptation. Giving serious consideration to the management of risks posed by climate variability and of development in general on the seasonal to inter-annual scale is crucial to achieving the longer terms goals of climate change adaptation strategy.

Integrating available forecast information into decision making processes is especially critical for less developed countries where variability in precipitation and temperature may have significant impacts on rural and urban livelihoods and may threaten lives. The two beneficiaries of climatic information and seasonal forecasts are the private sector and the public sector, with the latter receiving and using information for the public good, facilitating sustainable development and contributing to the improvement of livelihoods.

Several applications of seasonal forecast in security issues are relevant in the context of livelihoods and have advantages for different sectors, such as:

- Disaster forecast and prevention
- Water resource management
- Agriculture management
- Food security
- Health planning

Beyond the question of forecast reliability, it should be noted that forecasts provide probabilistic information. Uncertainties should thus be communicated to the users who should take them into account when using forecasts for decision-making and coping strategies. Possibilities for forecasts vary from a region to another, and furthermore different users have different requirements. While in some cases the right direction of forecast is sufficient, in other cases more precise information is required for decision-making. Thus the utility of a forecast is user specific.

Example: Welthungerhilfe (German Agro Action)
An EU-funded project in Afghanistan for water management in the Kunduz River provides a good practical example of seasonal forecast. In this area of the country, irrigation systems are fed by melt water from the mountains. Satellite images provided the implementing agency with information about the amount of winter snowfall in the mountains. Thus, it was possible to get information about the availability of water for irrigation in summer. This information provided the background to discuss with the communities located at the irrigation channels at times of reduced snowfall which crop plants to be used in the next season. Farmers agreed to switch from water intensive cotton to wheat production. Through this seasonal forecast, the livelihood of the communities was improved. If farmers would have continued to grow cotton, only the

communities at the start of the irrigation channels would have had enough water. Unequal distribution of water often creates conflicts in Afghanistan. Seasonal information also served as a conflict prevention tool.

Example: Drought Management in Georgia (USA)
Teleconnection between ENSO and the south-eastern USA enables valuable forecast skills - 78% improvement compared to climatological values - up to a year in advance. The drought-prone US State of Georgia was hit by several droughts in 1998-2002 with losses estimated in tens of billions of dollars. It now incorporates seasonal forecasts for drought mitigation and decision-making: by 1st March each year, the State makes the decision on whether to implement the Georgia´s Flint River Drought Protection Act (FRDPA), which compensates farmers in the Flint River Basin who voluntarily suspend irrigating their crops with surface water during a severe drought year. The estimated overall benefit resulting from the forecast ranges from US$30 million to US$350 million per year depending on the correctness of the forecast.

d. Future perspective

The Third World Climate Conference concluded a global framework for climate services (GFCS) aiming at utilizing daily to decadal climate predictions. The framework will facilitate the usage of climate information for national climate-checked decision-making. Investments to improve climate projections on the 1-10 year time scale are rising and it is expected that seasonal forecast reliability will improve and become an increasingly important chain link in decision-making processes. Beyond optimizing computer models, the challenge remains to improve the utility of modelling results by incorporating the knowledge of different disciplines (natural and social science) into decision-making. Forecast products for decision-making will have to consider different backgrounds of decision makers (end-users) and will thus have to be tailored to the end-user's needs and views.

The position paper of WCRP (World Climate Research Programme) depicts some areas where seasonal forecast skills can be further improved:

- if the implications and influences of the cryosphere (sea ice, land ice and snow) on the predictability are better understood,
- if soil moisture implications on the rainfall variability and stratographic processes are better understood.

Recent efforts spent into remote sensing Earth Observation Systems (e.g. GMES - Global Monitoring for Environment and Security) will improve the access to data and amplify the understanding of the earth system. Additionally, satellite data coupled with in-situ data may advance the reliability of forecast.

6. Early Warning and livelihood

a. Long-term Early Warning: a new focus?

Early warning for any kind of potentially disastrous event is a scientific exercise that may require expensive technical means (sensors, gauges, sometimes computers...), data and know-how, excluding consideration of non-mainstream forms of early warning such as animal behaviour or cloud patterns that may not be sound methods of early warning. For the less developed countries, this means that at grass root level, people rely on (a) their traditional systems of early warning based on the wealth of generation-long knowledge and observations; and (b) the processed scientific information that is being passed on to them through various channels and means.

Despite modern ways of addressing early warning, traditional systems and coping mechanisms show that long-term planning and adaptation is not new to people whose livelihoods are exposed to climate-related risks. The Incas, recognizing the consequences of climate variations for their food security, farmed diverse stocks at different altitudes in the Andes, knowing from experience that there was rarely a simultaneous failure of all stocks.

In general the more immediate the event or scenario, the more precise the warning can be. The more long-term, the more time there is for the driving known and unknown parameters to take on an unforeseen course. That is particularly true for the chaotic system “climate/weather” which is so complex that it is not yet fully understood.

Early warning, be it long-term or short-term, always considers the likelihood of defined events, trends or scenarios. Hence, accountability of early warning is illusive. Any prediction or early warning necessarily deals with a level of probability. While there is no authoritative distinction between forecasting and prediction, there is a difference, for example between using historical statistics to make a prediction regarding potential events based on probabilities and making a forecast of a specific tsunami once an earthquake has taken place in a coastal area. This makes it difficult to act decisively upon information that is more or less probable, with correctness known only post-facto. While this characteristic must not lead to condemning early warning as a whole, it is important that it be known and accepted as a feature to be addressed in the ways EW messages are formulated and disseminated, and in the ways decision makers can or should react to a warning. Early warning remains an indispensable part of disaster risk reduction, climate change adaptation, sustainable development, and livelihood diversification. Connections between those concepts have to be established and/or strengthened.

When early warning is seen as an integral part of such concepts, long-term early warning is the most suitable since it operates on a similar time frame. An example is provided with the partnerships established by the IFRC with climate change professionals (in particular the African Centre of Meteorological Applications for Development/ACMAD and the International Research Institute for Climate and Society/IRI), allowing the International Federation to launch a pre-emptive emergency funding appeal in 2008 for flood preparedness based on seasonal forecasts, the first of its kind.

b. Implications for the Early Warning chain

Early Warning is not an end in itself. Much effort is invested in scientific aspects of Early Warning to improve its reliability, in the context of disaster risk reduction, climate change adaptation, sustainable development, livelihood diversification etc., with potentially threatening climate scenarios increasing the urgency of measures to be taken.

To make early warning an integral part of disaster risk reduction, climate change adaptation, sustainable development, and livelihood diversification widens the potential of early warning mechanisms at all levels, from household to national and international. It enables synergies to develop between existing achievements and mechanisms of implementation, reducing costs and time needed to establish sustainable EW systems particularly in high risk, high poverty areas.

Longer-term early warning gives target groups more time to act and prepare to react: a wider range of options for response can be considered over a longer period of time. Longer forecasts could also allow farmers, for example, to manage their work with a view to improve agricultural production and food security (as is the case with El Niño Southern Oscillation (ENSO)-based seasonal forecasts in South America, South Asia, and Africa). However, long lead times tend to reduce the sense of urgency to react to potential danger. To avoid this risk, early warning can be made into an iterative process. The repetition of warning messages can compensate for a potential lack of urgency.

c. Changing lead times: changing the flow of information?

Early Warning Systems are established to alert people at risk about imminent, threatening events. Besides reliability and scientific soundness, Early Warning strives to reach the right decision maker at the right place with the appropriate message, in a timely way. This principle is valid for sudden onset events such as hurricanes or tsunamis as well as for long-term, gradual events or trends, such as droughts or sea-level rises. What changes is mainly the response action. Diverse groups and numerous levels of decision makers usually require warning information to act upon, with often the individual household decision maker who decides about changes in livelihood, being the most difficult to reach. Too often, households do not get the information that is available elsewhere, and could save their livelihoods.

When focusing on livelihoods when developing EWS, some questions to address are:

- What are ideal early warning chains and which information should be directed at whom?
- How do differences in lead times affect early warning systems, chains and messages?
- Are people able and willing to react?
- Do they have appropriate equipment (and access to it) to react?

Additionally, the question has to be raised as to the level of acceptability of risk for different groups (national, local authorities, households). EW messages have to be formulated taking into account their understanding by the target groups; often households will have a blurred concept of probability and risk. Responding to an early warning alert requires trust in the information received – especially when the reaction involves a heavy investment and a drastic change in livelihood. This trust usually builds up with time and positive experience. Reliable and dependability-proven early warning systems are hence crucial for successful early warning.

People react to early warning messages if they contain information on the probability of a potential disaster occurring that allows them to make informed decisions. The capacity to adapt or react to early warning varies considerably between regions, countries, socio-economic groups, and with time. Information has to be tailored to the needs of the people, in their specific environment. The most vulnerable regions and communities are those that are highly exposed to hazardous climate change effects and have limited adaptive capacity. Countries with limited economic resources, low levels of technology, poor information and skills, poor infrastructure, unstable or weak institutions, and inequitable empowerment and access to resources have little capacity to adapt and are highly vulnerable.

d. Links to livelihood

While from a scientific and policy perspective, disaster risk reduction, climate change adaptation, disaster mitigation, and sustainable development are different disciplines, overlaps and common concerns are increasingly being observed and taken into account. Distinctions are important on national or trans-/inter-national levels when they help to identify and assign budgets, responsibilities, and to introduce accountability. However, they can be artificial and irrelevant at the household level where individual livelihoods are the focus of consideration. Measures taken in a household to improve security or standards of living can be attributed any of those concepts. Diversification of income, for example, can be a desired response equally to disaster risk reduction, climate change adaptation, sustainable development, or simply the result of early warning. It appears that livelihood-based or people-centred early warning will increasingly become the focus of early warning and might even be a precondition for successful early warning.

In recognition of the interdependency between early warning and livelihood, an assessment of Ethiopia's 60 million farming livelihoods was carried out from 2006 to 2010 (funded by USAID, undertaken by FEG-consulting) that became the basis for the government's famine early warning system. Emergency Nutrition Network (ENN) reports that early warning systems in the greater Horn of Africa were compromised because they failed to incorporate information on the livelihoods: "Early warning systems need to be adapted to pastoral economies. It is now fairly widely accepted that part of the reason food insecurity in the Ogaden (…) escalated to a crisis was because the early warning systems in place were weak and not adapted to pastoral areas, i.e. did not monitor water, movement of livestock and people, livestock health, etc.".

Response to early warning and adaptation also has economic aspects. Adaptation costs and benefits are relevant for actors directly exposed to climate risks who need to make decisions about whether, how much, and when to invest in adaptation: individuals and households, farmers, project managers, and sectoral planners. At the national and global level, cost estimates can be used for budgets to be covered through international, domestic, and private funding sources. Estimating adaptation costs and benefits is challenging, though, because of the nebulous nature of many adaptation actions. It might not be feasible to cost the climate component of such decisions that are also simultaneously conditioned by a range of other, often more influential, factors.

Assuming that the warning message is clearly understood by the decision maker, the level of risk or the consequences of the foreseen event paired with self-interest should be incentive enough to trigger appropriate response actions. In this context, more information will be needed about the sustainable tools that can support individual households as they carry out responsive actions to EW alerts, including micro credits. There are however questions about the effect of microfinance and microcredit: while they can enable impoverished people to gain access to greater economic independence, they are no real substitute for social security systems, as they remain a debt rather than grant support.

7. Governance

a. Perspectives and notions of governance

Environmental governance was initiated in the 1980's with the release of the World Commission on Environment and Development's report *Our Common Future* (1984), followed in 1994 by the UNDP's Human Development Report that promoted "freedom from want" and "freedom from fear" as the best way to address global insecurity. The notion of global environmental governance based on sustainable governance incentives is closely linked to human security, which rest on three pillars: freedom from want, freedom from fear and freedom from hazard impact, reflecting the basic concerns of sustainable development.

Generally, governance can be understood as the body of rules, enforcement mechanisms, and the corresponding interactive process that coordinates and brings into line the activities of persons with regard to a concerted outcome. A more relevant notion of governance in the social sciences is the modern forms of steering that are often decentralized, open to self-organization and less hierarchical than traditional governmental policy-making (even though most modern governance arrangements will also include some degree of hierarchy). Governance usually includes non-state actors from industry and non-governmental lobbying groups to scientists, indigenous communities, city governments and international organizations.

MunichRe Foundation Project: Early warning communication system for the Kingdom of Tonga
2009 NGO + Gov
Early warning system in Tonga → fully operational but tsunami hit in the early morning when staff had not yet arrived;

Samoa Community Based Adaption (CBA)	GEF / AusAID	Global: 10 pilot countries including Samoa	Small Grants Programme (SGP) and United Nations Development Programme (UNDP)	Enhancing community resilience to climate change via community education and awareness, coupled with "hard solutions" such as shoreline protection.	Enhancing community resilience and the ecosystems upon which they depend via a "results based approach" including community adaptation priorities (United Nations Development Programme (UNDP), 2008).
Navua Local Level Risk Management	UNDP Pacific Centre	Navua, Fiji	UNDP, SOPAC, Red Cross, NDMO	Education and community awareness for pre-existing early warning flood system in addition to multi-stakeholder involvement in long term community awareness activities.	Using the Local Level Risk Management (LLRM) approach, capacity building with the community, NGOs and local authorities in terms of risk sensitisation and disaster risk sensitive development projects.
Building Disaster Response and Preparedness in the Pacific	AusAID	Fiji, Samoa, Kiribati, Vanuatu	Caritas Samoa and Australia, Caritas Oceania and Pacific	Education and community awareness with the aim being to change behaviour to incorporate better preparedness for disasters in everyday living.	To raise awareness and educate key Catholic people in disaster risk reduction in order to pass this information on to the wider community (Caritas Australia, 2008).
Samoa Disaster Risk Reduction and Awareness Workshops	UNESCO, SOPAC, World Bank	Samoa	NDMO, multitude of other government agencies, NGOs, Red Cross	Education and community awareness relating to disasters. Follow up activities with the assistance of government ministries, including potential "hard solutions" depending on the needs of the community.	To strengthen village understanding of current vulnerability and capacity, risk reduction measures and consequently formulating a village Response Plan Booklet for all households. To also have a village simulation to test the response of the village to a disaster.
Samoa Red Cross Community Based Health and First Aid (CBHFA) Program	Internation-al and National Red Cross societies	Samoa	Samoa National Red Cross Society and government partner ministries	Education and community awareness relating to the specific needs of the community, using Red Cross's Vulnerability and Capacity Assessment (VCA) tool. Specific attention paid to disaster and climate change related issues and needs. Inclusion of government ministries to allow for follow up of additional activities.	To assess the specific vulnerabilities of the village and develop a targeted response to educate people in ways to overcome and become more aware of the risks in their daily lives.

Example of governance (early warning communications system)

b. Potential

Governance is a foundation of EWS effectiveness, adaptability, resilience and sustainability, and offers a basis for a strategy to address challenges outside the scope and capability of an individual or institution. EWS governance has the potential to advance the institutional aspects of managing risk and disasters towards the reducing vulnerability and building sustainable resilience. EWS governance offers the opportunity to cope with increasing and uncertain risks in the context of climate change. It gains increasing importance in the international policy dialogue as it incorporates multi-level and cross-sectoral regulatory challenges by governmental and non-governmental stakeholders to reduce risk in complex societal and political environments.

In addition, in a specific situation, governance helps to assess which organization(s) can intervene or deliver services most effectively and efficiently by analyzing institutional and organizational set-up, and what institutional linkages and other organizational factors are critical to successful delivery. It provides opportunities for better policy-making and effective coordination processes at all levels and scales. It contributes to the design of the most appropriate institutional arrangements and to the strengthening of institutional capacities and performance. Multi-stakeholder participation helps to cope with multiple values and interests: inclusive governance assumes that all stakeholders contribute to the process of risk governance. Such inclusion improves the decision-making process without compromising the quality of scientific input. Stakeholder involvement is a function of the characteristic of a risk, needed both to ensure inclusiveness and responsiveness of the process and to maximize effectiveness and acceptability of decisions. Governance is needed to capture and sustain political commitment. The uncertainty of risks associated with climate change requires a balanced, precautionary and resilience-building approach to governance.

Strengthening institutional and legislative systems for disaster risk management remains a governance challenge. Such issues should be seen in the context of pervasive, dynamic cross-cutting interactions: a key question is how to link national and local levels to improve the governance of hazards and risks through EWS in the context of climate change.

c. The link between national and local levels

Environmental phenomena can be categorized in three levels: local, regional and global. By definition, global problems are of international concern; however, local problems can evolve into global problems. This implies that governance has different levels and interacts across boundaries: institutional structures, arrangements and architectures, and decision-making processes at all levels have to be linked to allow for the management of new EWS challenges due to extreme events arising from a changing climate. The discussion hereafter addresses multi-level and scale governance that can be improved through (1) technical links (i.e. systems, architectures, structures and frameworks) and through (2) decision-making links (actors, agents).

(1) Technical links

- Systems of governance (political, economic and socio-technological)

Political, economic and social systems of governance can be viewed as the driving forces for EWS effectiveness and sustainability. The specific indicators that define the political system of governance include political stability, absence of violence, government effectiveness, regulatory quality, rule of law, accountability, and corruption.
Decentralization is an important part of the political system of governance. Supporters point out that a decentralization process results in greater efficiency, equity and responsiveness centred on local people's participation in local decisions on programmes, projects, investment and management and ultimately more socially and environmentally sustainable development. Decentralization increases government decision-making processes closer to the citizens; it is fundamentally a strategy of governance to facilitate the transfer of power closer to the people. It is therefore closely linked to democratic mechanisms and processes allowing the people's

aspirations to be met, where local actors can exercise a certain degree of autonomy. Hence, effective decentralization is a key mechanism capable of enhancing the ability to solve regional and local problems while the central government has more time and energy to deal with global issues and promote the country's interests.
A socio-technological and economic system of governance includes indicators such as public health, education, income level, transportation, communications, innovation, growth of the GDP, local competition, and external debt. For example, societies with a higher level of education are less vulnerable to disaster while a good technological communication system results in an effective end-to-end EWS, from national to local level. Therefore, systems of governance and modern forms of decentralized steering are key foundations to support multi-level and scale links to deal with different risks and challenges.

- <u>Early Warning System as a system of systems</u>

The most common view of EWS is a linear top-down warning chain that is expert-driven and hazard-focused from observation to warning generation and transmission to users. An effective and sustainable EWS needs to have not only a strong scientific and technical basis, but also a strong focus on the people exposed to risk, with a systems approach that incorporates all relevant factors in that risk, whether arising from natural hazards or social vulnerabilities or from short-term or long-term processes. EWS is ideally a system of systems: it should no longer be viewed only as a linear chain process, but rather as a mix (or other model) approach depending on the characteristics and complexity of risks, especially under climate change conditions.

- <u>Architecture</u>

Architecture includes frameworks, institutional arrangements, norms, polycentric-multi-layered systems and structures.

Policy frameworks and platforms
A concept or framework with clear goals is required to stimulate policy and governance interest among the institutional actors and the community, which would result in improved environmental governance. For example, the global governance framework for disaster risk reduction (DRR) is the Hyogo Framework for Action (HFA). Its overarching goal is to build resilience of nations and communities to disasters and achieve a significant reduction of disaster losses by 2015. The HFA is a non–binding agreement based on a multi-stakeholder participatory system. A mechanism such as a global or national platform for DRR is required to implement its goals. Many regional bodies have formulated strategies of regional scale for DRR in line with the HFA. Over a hundred governments have designated official focal points for HFA follow-up and implementation. Some have taken action to mobilize political commitment and establish centres to promote regional cooperation in DRR.

Multi-institutional arrangements and norms
The term "institution" includes more than agencies and organizations: it covers rules imposing constraints on human behaviour to facilitate collective action. The main exogenous variable that influences the action arena are institutions, the *'rules of the game'* consisting of three worlds of action where every institutional arrangement is shaped by three layers of hierarchy institutions: operational, collective choice and constitutional types. Each level is arranged to serve different functions independently, but higher levels affect lower ones by dictating their boundaries of action. Operational institutions regulate activities that occur on a day-to-day basis. Accordingly, the operational level includes the rules and regulations that define actors' right and actions. Collective choice institutions regulate the decision/making processes that establish operational

rules. Constitutional institutions provide political and legal arrangements which 'officially' shape the rules and laws by which actors operate. Thus, it is important to clearly establish the three layers of rules to enhance vertical and cross scales links. This would entail, for instance, having a constitutional basis for environmental protection and human security, laws and supporting regulations, decrees, clear and detailed standard operating procedures for each institution and between multi-level and scale institutions. The main issue to highlight is that governance has been consistently debated around formal and informal institutions and their respective advantages and weaknesses. EWS designed for people at risk has to rest on plurality and a complex mix of institutions at multiple levels - state, public and private - involved in networks of environmental governance that deal with problems beyond the scope of one actor. Therefore, on the one hand, institutions could serve as the rational, collective choice and be geared towards utility maximization, economic and operational efficiency for deliberate ends in the upstream technical component of the EWS. On the other hand, depending on the specific hazard and risks in the downstream-culture component of the EWS, it is possible to cater for flexible informal processes that can be blurred and often overlapping, to respond to dynamic environmental uncertainties. Institutions designed with the community rather for the community should be flexible and contingent, and should have *ad hoc* and non-robust approaches, making use of public institutions characterized by social relations and networks. This requires not only an inclusionary, participatory decision-making process, but the creation of space for institutional learning that reflects and makes use of plurality of perspectives. This approach is particularly relevant when addressing the issue of people-centred warning systems, since institutions should be embedded in social interactions and social practices and everyday life for sustainability. There is thus close interaction between local, national and global levels and vice-versa. Such plurality and institutional mix between formality and informality may strengthen the vertical and horizontal links and provide the legitimacy for the EWS.

(c) Polycentric multi-layered systems and structures
Polycentric governance is particularly important for larger countries to improve governance for hazards and risks. Polycentric and multi-layered institutional arrangements are important to handle scale-dependent governmental challenges as well as cross-scale interactions. Polycentric institutions, by definition, have multiple centres or authorities. Such organizations' structures can enhance opportunities for understanding and servicing needs in spatially heterogeneous contexts. Polycentric systems are often multi-layered, but do not necessarily have neat hierarchical structures. Multi-layered governance facilitates vertical interplay among institutions.

(2) <u>Decision-making links</u>

The action arena is the decision environment of the actors; it is characterized by interacting individuals with decision-making abilities who affect the activities and outcome in the arena. Actors have the potential to influence a specific state of affairs or a process by act, intervention or by refraining from intervening or participation. Actors are considered to be constrained by their environment rather than acting in absolute rationality.

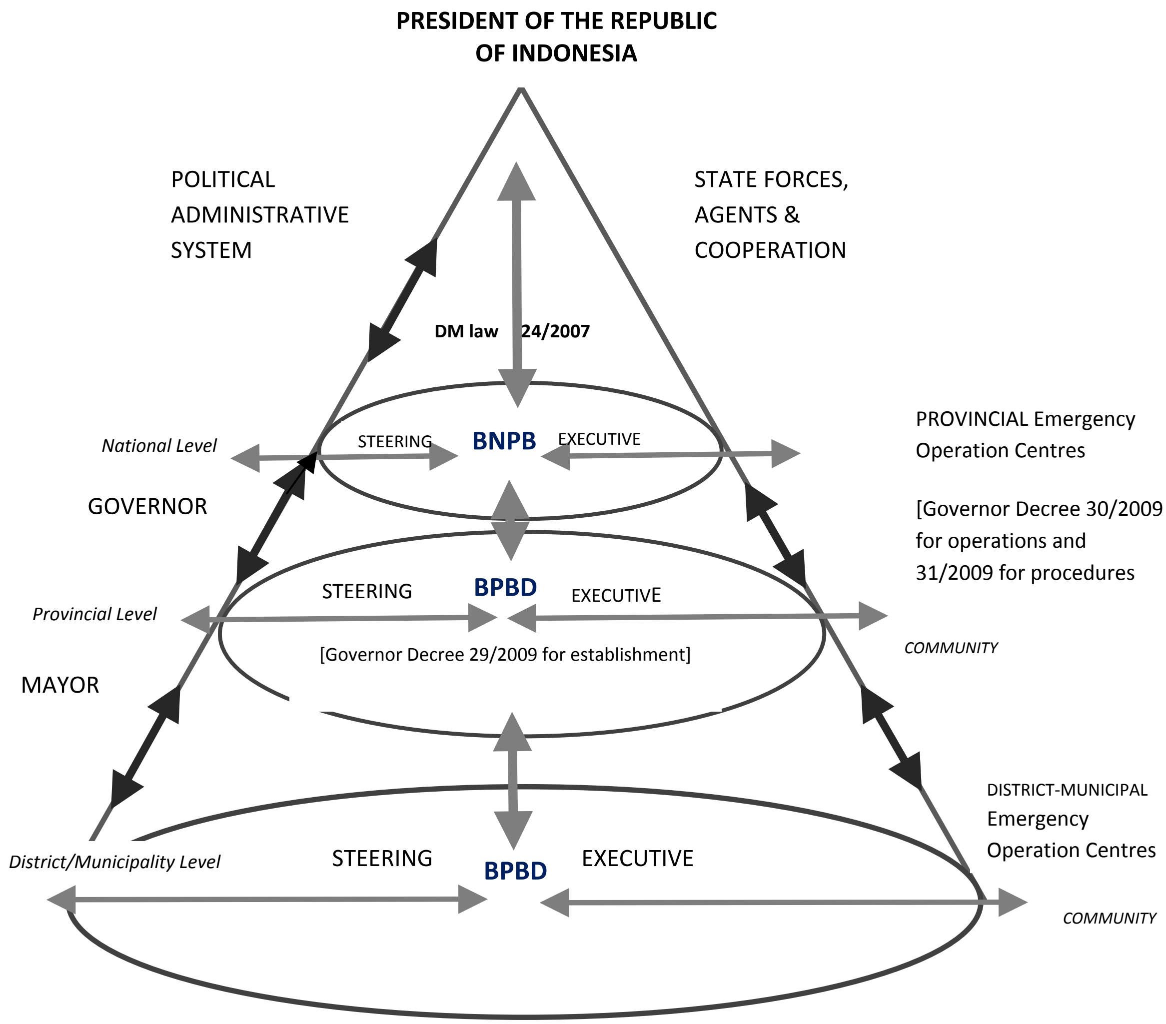
Understanding effective governance requires the understanding of the actors or agents that drive earth system governance and need to be involved. It is important to differentiate between actors and agents and what constitutes agency as a critical element of earth system governance. Agency is understood as the capacity to act in the face of earth system transformation or to produce effects that ultimately shape natural processes or processes between human and physical systems, e.g. in a multi-level context where actors have stepped in to fill the gap where the national government has not been able to effectively respond on its own. Agency in EWS is a critical element of the decision-making process.

Institutional actors have to relate and interact with the community characterized with the generally accepted norms of behaviour and common understanding. In this context, the attributes of "good'' governance are important, including promoting participation, networks, deliberation, negotiations, mediation, transparency, accountability, equity, justice between the multi-level institutional actors and the community. Therefore the dynamics and interaction of the actors and the community with the systems and architecture (i.e. institutional arrangements, structures) defines the decision-making processes and links. These issues influence the individual community members' motivation to cooperate, participate, and communicate with each other, obey rules, and use and manage local affairs in a 'positive' way. These are essential elements of EWS governance. For example, if participation, transparency, corporation and quality networks are lacking between institutional actors and between institutional actors and the community, there would be weak links and poor decision-making at different levels and scales.

d. Experience and best practice: Indonesia

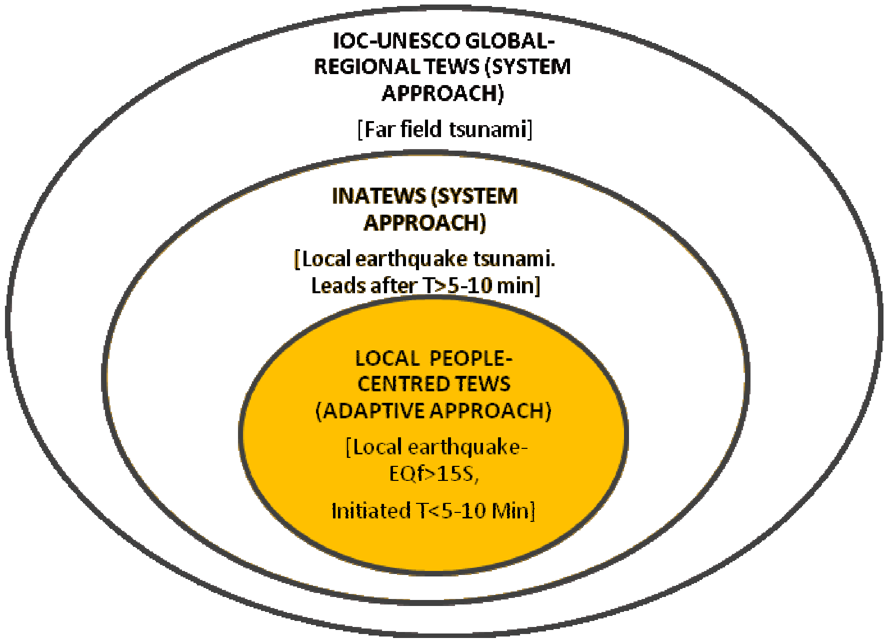
In terms of technical links, all countries in the Southeast Asia region, including Indonesia, agreed in 2005 that the HFA would enhance regional cooperation and nations' capacities in DRR. The establishment of a DRR platform in Indonesia was initiated in 2006 and was declared official in 2008 to operate as a national mechanism for multiple stakeholders, acting as an advocate of DRR and to improve links at different levels and scales

The 2004 tsunami disaster and the HFA provided the driving incentives for institutional change in disaster risk management. A major institutional legal arrangement was the Disaster Management Law 24/2007 and its supporting Government Regulations, Decrees to regulate disaster management arrangements, financing and external support, providing a comprehensive basis for rules in disaster management at multiple levels and scales in Indonesia. That law governs the EWS and its integration as part of the Indonesian Disaster Management System. An interim institutional Ministerial Decree, Sk21/2005 provided the momentum and coordination mechanism for developing the Indonesian Tsunami Early Warning System. A Presidential Regulation legitimized the establishment of the multi-level Disaster Management Agency (BNPB, BPBD at the national and sub-national levels) for improved links and coordination from the national to the local level (see figure hereafter). Furthermore, local authorities are legitimizing the establishment and operations of Multi-level Emergency Operations Centres as another critical and important architecture component and structure for improved decision-making and governance throughout the country.



Chang Seng, S.D., 2010: Disaster Risk Preparedness: The Role of Risk Governance, Multi-Institutional Arrangements and Polycentric Frameworks for a Resilient Tsunami Early Warning System in Indonesia

Institutionalizing and embedding the Indonesian Tsunami Early Warning System (INATEWS) within the Disaster Management Agency (BNPB) as a larger architecture is a key step towards a multi-hazard approach and improved inter-institutional coordination and performance. Furthermore, the global-regional governance framework for tsunami hazard and risks under UNESCO-IOC coordination, and the developing multi-level architectures and structures synchronized within the existing decentralization are ideal polycentric multi-layered architectures for optimum interlink between levels and improved hazard and sustainable risk governance in Indonesia, as shown in the figure hereafter:



Mix model of TEWS with polycentric-multilayered architectures

There was recently an increase and shift in the contingency budget from national to local level, an important step towards effective decentralization to manage hazards and risks locally. The growing economic system of governance promises to help sustain the TEWS in Indonesia (INATEWS).

In terms of decision-making links, the national disaster platform supporting the Hyogo Framework for Action and the new steering committee consisting of the state and professional citizens of the multi-level Disaster Management Agency gives legitimacy to multi-sector, multi-level participation and decision-making in Indonesia. In addition, the multi-level Emergency Operations Centres mandated by the local governments offer key local decision-making links both for hazard and non-hazard events. In this context, a key mechanism indicating the strength of the decision-making process is the emerging tsunami early warning chain backed with standard operating procedures especially in the study areas of Bali and Padang.

Actor participation in Indonesia is rather complex, and is characterized by a high degree of multi-stakeholder participation at various levels and scales having a profound impact on the decision-making process and final outcome. Furthermore, there are at least two national non-state actors who have emerged as agents and have exercised agency beyond the state where and when the state government was unable to respond effectively. The Indonesian Society of Disaster Management (MPBI) has emerged as an agent in driving and shaping governance and institutional change in DM at multiple levels and scales in Indonesia while the Tsunami Alert Community Foundation (KOGAMI) has emerged as an agent in exercising agency in community disaster preparedness in Indonesia. The agency exercised at different levels determines the decision-making links and actions across levels and scales.

An important issue to highlight is the actor's interaction with the technological systems for better and rapid decision-making at the national level for use at the local level: the novel expert Decision Support System (DSS) which is at the heart of the technical tsunami warning system in Indonesia. It will be used at the time of an earthquake to match and compare the signature and consequence of the real earthquake with the database of hypothetical earthquakes of different sources and its simulation scenarios, to decide whether to issue a warning or not, and to assess inundation and impact areas. A rapid overview is gained and a visual display of the situation is shown on several monitors, together with recommendations for action. The DSS is geared for application in a crisis situation to enable fast and reliable decisions to be made under high time pressure and stress conditions.

e. Constraints and challenges

The main constraints and barriers of governance in the context of EWS are as follows:

- Adaptive and resilience governance

Analysis, knowledge and experiences in adaptive and resilience governance in the context of EWS in a changing environment are lacking. Governance has mainly been addressed in the context of natural resources, new institutional economics and international relations. While recent increased attention has been given to risk governance, it addresses only certain elements of the EWS. Interestingly, the concept of governance and institutional arrangements is increasingly found in emerging documents, yet it remains vaguely defined, systematized, applied and understood in the context of EWS.

- Weak systems of governance

In many developing countries such as Indonesia, despite the strengthening economic systems of governance, the prevailing political-social systems remain weak, in comparison for example with Japan and the United States that have decades of operational Tsunami Early Warning System backed with a very strong governance system. This suggests that Indonesia will face tough challenges to implement and sustain an effective Tsunami Early Warning System.

- Adequate financial resources to support decentralization

The decentralization reforms in Indonesia to support EWS face various constraints and challenges that have profound impacts and define governance effectiveness at multi-level and scales. For example, budget allocation at sub-national level is spatially variable and there are opportunities for unjust allocation of funds and resources. This is also linked with institutional weaknesses in the disaster management budget mechanisms.

- Multi-level bureaucratic norms, commitment and specialized human capacities

In some cases, the on-call budget mobilization is very slow due to multi-level bureaucratic procedures and norms directly linked to the overall government effectiveness (i.e. systems of governance). Furthermore, there are many challenges in implementing the polycentric multi-layered architectures and structures throughout Indonesia. Few provinces and districts have actually completed the Disaster Management local regulation to allow the transformation to take place at the provincial and district levels. In most cases there is not only a lack of resources but also of multi-level commitment and specialized human resources. Consequently, institutional mandates and clear SOPs are also slow in being developed throughout Indonesia to strengthen links between levels and scales. The integration of the present Indonesian Tsunami Early

Warning system structure within the larger architecture of the Disaster Management Agency is also vulnerable to the prevailing bureaucratic norms in Indonesia.

- Legitimacy of formal and informal institutions and their boundaries

Ideally in Indonesia tensions constantly emerge and are contested about the actual primary mode of EWS governance contrasted between linear top down technocratic approach and the local people approach. The local people approach is often undermined and given less attention in terms of financial support and legitimacy. The other problem is that there is the difficulty to delineate an interface between the formal and informal rules throughout the EW chain and how to create a coordinated “system of systems” between the two.

- Institutional origin and path dependencies

Institutional arrangements, monitoring and enforcement at the local level are not well planned or organized, and their legitimacy is questioned as the origin of institutions significantly influences their stability and potential for change. The way new institutions function and their level of success depend on the commitment and priority given to the paradigm shift from response and relief to preparedness, mitigation and adaptation. Moreover, DM financing remains heavily focused on post-disaster response rather than on preparedness, including EWS. Hence, institutional change for improved coordination and performance is strongly affected by the origin and institutional path dependencies.

- Different hazard risks and different incentive mechanisms

Another constraint is that different hazards and risks have different incentives. These affect the behaviour of actors and the community and their responses (e.g. exclusion or rivalry). For example in Indonesia, evidence suggest that climate and climate change driven hazards and risks tend to stimulate greater interest and incentives among institutional actors than tsunami hazards and risks, more uncertain and infrequent. This influences the effectiveness and sustainability of EWS.

8. Conclusion

The various sections of this paper illustrate the importance of Early Warning and of its place in disaster risk reduction, hence in the ISDR system, and thus its relevance to the work of UNISDR. The critical value of Early Warning has grown in recent years with increased strengthening of links between DRR and climate change, including specifically in the context of expanding urban development under stress from environmental changes.

<u>Link long-term forecast and prediction with Early Warning</u>

While many stakeholders understand EW as a short-term process, scientists do not make this restriction. There are different certainties for long-term forecasting in different regions (as described above) that have to be analysed in relation to their usefulness for EW. This analysis has also to consider the various information needs of different groups of stakeholders. Uncertainties need to be communicated to the beneficiaries in a transparent way.

The challenge is to integrate a number of sectors into EW, such as agriculture, health, water management, land use planning, city planning, and thus involve relevant decision-makers and structures. This would link them with the traditional EW actors in civil protection and humanitarian assistance. It would facilitate the integration of potentially changing risk patterns into EW. Traditional knowledge should not be overlooked: it can provide added value to technical or scientific capacities. However, traditional knowledge should be assessed on the basis of its effectiveness, flexibility, equity, efficiency and sustainability. To effectively link long-term forecast with EW requires a set of skills which differs from those needed for short-term EW. Such skills have to be clearly identified and developed. The risk knowledge component of the EW chain has to be improved.

Link local to global
The limitation in certainty and regional scale of forecasts hinders their usefulness for a number of users and decision makers. Both aspects have to be improved. Demands have to be clearly identified at different regional scales, in different regions, from different communities and from diverse decision-makers. While capacities improve at the global scale, this development should be accompanied by research and development of socio-economic EW systems, the combination of both providing the linkage between local and global scale. Monitoring and warning services have to integrate the different regional and time scales.

Tailor EW to user needs
There definitely is a gap between needs for information at different regional levels, for users but also for decision makers. While this issue has been discussed in relation to short-term EW, the long-term time scale provides new challenges. What is the information need for users in the short-term as well as in the seasonal or long-term? How can the dynamics of changing hazard patterns and changing vulnerabilities integrate into EW? Such an exercise is important to ensure that EW reaches its objective and does not remain based on empirical evidence. The challenge will be to integrate the diversity of structures while simultaneously developing generic solutions. Good dissemination and communication are crucial for the successful transmission of warnings.

Enhance the EW message
To function effectively n these times of global, including climate changes, EW has to take account of hazard and society changes. Evolving demands of diverse communities have to be addressed; this has to be reflected in the development of livelihood-oriented EW messages, adjusted and designed to the needs of people and communities in an integrated and sustainable manner. Livelihoods differ from rural to urban environments, and they require different information, specific to their needs. The EW community requires additional expertise in the socio-economic area, to advise communities to adapt and prepare for changes in livelihoods. The capacity to respond to long-term forecasts has to be built that differs significantly from the capabilities that can deal with sudden onset hazards. The EW community has to engage in long-term governance aspects, with new expertise and new alliances.

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