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International Centre
for Water Resources and Global Change
under the auspices of UNESCO

Training Guidelines on Integrated Flood and Drought Management

Biljana Radojevic, November 2015

Photo: Neryl Lewis, RRT

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Executive summary

There are many ways to cope with flood and drought situations. Countries have different strategies of managing flood and drought. Based on their experiences, integrated flood and drought management plans and policies are developed at the country level. Since flood and drought risks are defined based on the vulnerability of the affected areas, preparedness and anticipation are the key actions to limit hazard risk. Preparedness plans can be developed depending on the regional climate conditions, economic conditions, social conditions and other factors.

These guidelines on integrated flood and drought management aim to provide all necessary elements needed for successful flood and drought management at country level particularly in developing and in the least developed countries. The guideline of integrated flood and drought management is based on the inputs from the case countries and their best practices on integrated flood and drought management.

The inputs from the particular countries are provided based on the original outline and the discussion document, which was distributed among selected countries. The aim was to incorporate the regional and national experiences. The discussion document comprised of all elements related to integrated flood and drought management, which had to be elaborated within the selected countries having the independent forum of stakeholders working and discussing together with the governments. The guidelines comprise all necessary elements for integrated flood and drought management from the selected six countries: Myanmar, Cambodia, India, Thailand, Vietnam, Laos and Bangladesh. These elements are:

- Scientific basis for flood and drought management
- Assessment of the current stage of flood and drought management
- Flood and drought monitoring
- Flood and drought forecasting
- Risk assessment
- Developing of flood and drought management plan
- Flood and drought policy development
- Education
- Awareness raising
- Review and evaluation

The core outline was sent to the particular stakeholders within the selected countries seeking their feedback on flood and drought practices. The contribution was received from Myanmar National Hydrological and Meteorological Service, from Cambodia from Mekong River Commission, from Indian Institute of Technology, from the Bangladesh National Hydro Meteorological Service and National Agency for disaster management and from the National Meteorological service of Thailand.

The first chapter of guidelines is dedicating to rational explanation of flood and drought disaster and their consequences for the humanity in case of mismanagement.

The second chapter consists of the scientific basis for sustainable integrated flood and drought management. This chapter covers flood and drought generation processes, flood and drought modeling with the particular emphasis on frequency analysis and utilization of statistical models. Ungauged basins are included and elaborated together with the regionalization procedures.

The third chapter of the guidelines related to monitoring, early warning and prediction was improved by the practices of drought monitoring in India. Particularly, drought forecasting and early warning in India was elaborated. In the same chapter flood-forecasting practice in Bangladesh was presented and the most frequent types of flood in Bangladesh were described.

Also, dissemination of early warnings in Thailand, Cambodia, Vietnam and Laos is explained including the different alert levels. Climate change impact on drought in India was elaborated also.

In the fourth part of guidelines related to risk assessment and flood and drought management strategies, drought risk and impact of drought were elaborated for Indian case. Also drought risk analysis and drought indices in India were presented. In the same part, flood risk assessment in Bangladesh is elaborated. One part of chapter four is dedicated to transboundary cooperation in flood management in Thailand and Vietnam.

Chapter five describes flood management strategies in Bangladesh, Thailand and Vietnam using structural and non-structural measures.

There are many challenges in flood in drought management. In chapter six the challenges in flood management in Thailand and Vietnam are presented as well as the actions for national drought management plan in India.

Two chapters seven and eight are describing the importance of perspective shift in flood and drought management and the national management policies structured towards idea: from crisis management to risk management. These chapters elaborate the important measures to manage flood and drought risk.

Part of the guidelines related to the institutional set up related to flood and drought management is improved in chapter ten with the best practices from Cambodia and presenting the case study of institutional framework for flood and drought management in Cambodia. National flood and drought policy development was elaborated further in chapter eleven with the case study from Myanmar. In that case study, drought management policy in Myanmar was presented together with the drought hazard and management assessment strategy. Flood management policy and preparation of flood forecast and warning in Myanmar were elaborated also. Institutional framework for flood management in Bangladesh and flood management policy in Bangladesh was stressed also in the chapter eleven.

The guidelines part related to national preparedness plan and public awareness is based on the flood mitigation and preparedness experience in Myanmar and flood preparedness experience in Cambodia. Public awareness campaign in Myanmar served as a country case with the best practice of raising public awareness on flood and drought threat seeking their prompt actions. The best practice on education of stakeholders on flood and drought management was obtained from Cambodia case study on resources mobilization and community empowerment. Drought preparedness and community awareness on drought in India is also reflected in the text. National training and capacity-building on drought management in India is one of the important parts of the third guidelines draft. In the chapter twelve public participation for flood management as well as the strengthening the community awareness were presented for Thailand, Vietnam and Cambodia.

One of possible further activity of guidelines improvement can be the MasterClass course with the aim to reach a common knowledge basis for the selected countries.

The MasterClasses will be each time based on a regional case study and will provide the necessary material for guidelines improvement. The MasterClass participants are supposed to ensure the efficient knowledge transfer.

The other activity which can follow the guidelines development is discussion with people in charge of flood and drought risk management in order to feed guidelines with the concrete experiences of dealing with extreme hazard situations. The exchange with the local authorities is of high importance. The aim is to provide questions, answers and examples from the region and from the selected countries.

1 Rational for training guidelines on integrated flood and drought management

One cannot avoid flood and drought but hydrological extremes can be managed in a sustainable manner. The responsible institutions have developed two main approaches so far: the prevention actions and the (post-) crisis management.

The prevention approach includes hydraulic works for flood defense and reservoirs to store water both for flood and drought control, and also meteorological and hydrological modeling to forecast the possible hazard evolution and to issue information and recommendations for the exposed population.

The crisis management approach relies on emergency plan development and post crisis management. That requires a deep implication of governing institutions in adequate policy development and in a good coordination between services.

The final objective is to limit the consequences of flood and drought hazard for the exposed population and for the economy, but also to recover and to establish a normal situation as soon as possible after a crisis.

Flood and drought hazards are different, both in their duration and in their intensity. Therefore, their management strategies are different.

Statistical regional analyses are important tools for modeling the frequency distributions of flood and drought events in terms of intensity and duration, which are the two components of the hazard severity. They are used to design hydraulic works and refer to a mean recurrence period of time.

1.1 Drought

Drought affects millions of people worldwide on an annual basis. Economically, it is the most devastating of all natural disasters. Drought are difficult to predict due to their slow onset. And in the aftermath, the long-term effects are often long lasting and widespread, making them difficult to recuperate from quickly. Some of these effects include loss of human and animal life, reduced crop and forest productivity, water scarcity and rationing, increased risk of fires, and damage to animal and fish habitats. Only a few countries have in place adequate drought mitigation strategies, instead relying on post-impact management strategies to deal with the effects of drought once the worst has transpired. One essential element to changing the discourse on drought is to incorporate it into our language and policy as an expected and natural part of climatic activity.

Planning and mitigation can curb many of these costs. However, mitigation also requires a complete infrastructure of information and actors in order to function most efficiently.

A drought often covers a large area and then impacts a many of people and activities. Water storage capacities for people, livestock and agriculture are the main concern. The trend evolution in water resource can be predicted from field observations based on the water level evolution in rivers, ground water and reservoirs in combination with statistical data on monthly rainfall occurrence for example.

Prediction of trend evolution of the water resource at a large basin scale requires enough long time series of data that are necessary to fit hydro(geo)logical models. From this modeling both real time actions, based on simulated trend evolutions, and also predefined scenarios of actions build with authorities can be implemented. Time is not a limiting factor and the efficiency of authorities to inform and provide support to the population and the economic sector becomes crucial. This is the base of the mitigation action for drought.

1.2 Flood

One flood can impact a limited area with a very short period of time. Flood hazard severity cannot be really predicted in real time in the case of intense rainfalls. However, some experiments intend to use meteorological radar data to predict within the few hours the effects of intense rainfall when the vulnerability is high. That mostly happened in the large cities. Meteorological forecasting can issue alert messages to population and emergency services in order to predict the coming crisis and to limit its consequences. Long rainfall can impact the larger areas generating large runoff. Monitoring of the river flow increases at the upstream of a large basin and can be used to calculate level, severity, and the arrival time of a flood at a given location downstream. In that case there is often more than a day to implement prevention actions.

In this document, one intends to present the key elements for developing a national flood and drought policy. This document is open for discussion. The elements can be tailored to fit the particular needs of each individual country. However the main elements, presented in this document, must be incorporated in order to achieve an effective flood and drought integrated management plan.

2 Science – policy interface, the role of research in flood and drought management

2.1 Scientific basis

One key to national water management is a thorough understanding of the domestic sources of water, such as rivers, lakes, or glaciers. Another key is monitoring. Monitoring of the above-mentioned water sources grants policymakers an understanding of the current status of resources, future changes and trends in those resources, and the information to develop early warning indicators. Moisture "excess" is also responsible for intense overland runoff and flood generation. Time of flood transfer from an upstream to a downstream part of a basin is also of great interest when developing warning systems.

Ideally, monitoring will cover atmospheric conditions, namely precipitation, hydrologic conditions, surface and groundwater levels, and soil and vegetation conditions (Redmond, 2011). The development of indices is another useful, and easy-to-understand, way to monitor flood and drought conditions. Drought lack a standard definition, and the use of indices allows for easy comparison of drought across regions. The primary drought index presently used is the Palmer's Drought Index, which considers precipitation, evapotranspiration, soil moisture loss and recharge, and runoff. Most other indices are a variation on this one (Heim Jr., 2011).

2.2 Drought

Drought is a complex phenomenon which must be described in terms of several variable taking into account the wide range of social, environmental and economic impacts of drought. There are different definitions of drought:

Great Britain Meteorological Office, 1951: "drought is a period of more than some particular number of days with precipitation less than some specified small amount"

Beran and Rodier, 1985: drought is "a decrease of water availability in a particular period over a particular area"

The final report of U.S. National Drought Policy Commission, 2000: "drought is a persistent and abnormal moisture deficiency having adverse impacts on vegetation, animals or people"

Tallaksen 2004: "Drought is a sustained and regionally extensive occurrence of below average natural water availability, and can thus be characterized as a deviation from normal conditions of variables such as precipitation, soil moisture, groundwater and stream flow."

2.2.1 Drought generation processes

Drought is a complex natural hazard that impacts ecosystems and society in many ways. Many of these impacts are associated with hydrological drought (drought in rivers, lakes, and groundwater). It is, therefore, crucial to understand the development and recovery of hydrological drought and how does drought develop exactly. Drought is closely related and depend on the water balance components and fluxes in hydrological systems. There are differences between quickly and slowly responding hydrological systems. Drought in any case presents deficit of water within the system comparing to the normal conditions. In applying such definition, the following questions arise. What are normal conditions? Does one consider water in all components of the hydrological cycle or only in some? How large must be a water deficit or how long is it to last, in order to be called a drought? Does such definition only refer to natural processes or do human influences play a role as well? What should be regarded as the 'normal' situation depends on what the water is used for. In drought research, one generally focuses on the atmospheric and terrestrial components of the water cycle and the linkages between them, i.e., precipitation, evapotranspiration, snow accumulation,

soil moisture, groundwater, lakes and wetlands, and stream flow. It is also important to note that drought is a relative, rather than absolute, condition of the hydrological system. Drought climate and catchment control is crucial for drought generation processes.

Climate variability can be described due to Climate Moisture Index - CMI and discharge. Climate Moisture Index (CMI) definition is: CMI = P – PET (units in cm/year) where P is mean annual precipitation which (includes water input as both rain and snow) and PET is annual potential evapotranspiration (loss of water vapor from well-vegetated landscape). Recharge depends on precipitation and other factors. In general, recharge depends on: PET, land use, soils and precipitation. Part of catchment control is relation between recharge and type of soil. Catchment control comprises relation between groundwater and recharge. Groundwater level depends on the region. It is different for cold region in comparison for the tropics and humid-tropics. Part of the catchment control is the aquifer response. Drought spatial pattern is covered and elaborated by catchment control. Catchment control is particular for the lakes. Clearly lack of precipitation causes hydrological drought. Potential evapotranspiration has smaller effect and not very significant effect. Lower precipitation reduces both actual evapotranspiration and groundwater recharge. Aquifer characteristics strongly determine groundwater discharge and consequently drought development. Drought derived from groundwater levels are clearly related to lack of recharge. Overland flow and interflow can separate one severe drought in many minor drought. Lake characteristics determine outflow and thereby drought development.

2.2.2 Types of drought

There are different types of drought: meteorological, hydrological, agricultural and socio-economic drought. Drought should not be confused with: aridity, desertification and water scarcity.

2.2.3 Drought indices

Meteorological, agricultural and hydrological drought are often represented in sense of drought indices (simple to use, they absorb great amount of data about precipitation, snow pack, ground water regime…). There is the importance of time scale when accessing different types of drought. Meteorological drought depends on precipitation deficit and duration of period with precipitation deficit. Agricultural drought refers to situations with insufficient soil moisture level to meet the plant needs for water during vegetation period. Hydrological drought occurs after longer period of precipitation deficit. Choosing appropriate drought index depends on:

- available information
- drought specific
- can we reproduce drought events (impact on vegetation, agriculture, water levels)
- spatial scales (continental, national, regional)

There are large numbers of drought indices. Meteorological drought is simply expressed in terms of a rainfall deficit in relation to some average amount and duration of drought period. Definitions must be considered as region specific (some definitions identify as number of days with precipitation less than some threshold value). One needs longer term rainfall time series available for meteorological drought identification. The most common meteorological drought indices are:

- Standardized precipitation index (SPI),
- Palmer drought severity index (PDSI),
- Surface water supply index (SWSI),
- Rainfall anomalies,
- Foley drought index,
- Effective precipitation

Important information for general public is how long the drought has lasted, how long the drought will last (seasonal weather forecasting) and how much rainfall is needed to return to normal conditions.

Agricultural drought links various categories of meteorological and hydrological drought to agricultural impacts, focusing primarily on soil water deficits and differences between actual and potential evapotranspiration. Situations with insufficient soil moisture level to meet the plant needs during growing season are considered. A good definition of agricultural drought should be able to account for the variable susceptibility of crops during different stages of crop development, from emergence to maturity. Common interpretation of agricultural drought as physiological drought (water deficiency in plant cells when the soil and air contain the water in insufficient quantities) caused by an abrupt and marked increase in air temperature while soil temperature remains low. Temporal variability of water availability and precipitation distribution during growing season influences agricultural drought. Assessment of agricultural drought requires calculation of water balance on weekly scale during growing season. One needs:

- tools for calculating water balance
- tools for quantitative analysis of the growth and production of annual field crops

Indices, used in agriculture are:

- Agro hydro potential (AHP)
- Dry day Sequences
- Generalized Hydrologic Model
- Crop Moisture Index,
- Moisture Availability Index

Hydrological drought is characterized with the effects of periods of rain shortfall on surface and subsurface water supply. They lag behind meteorological and agro meteorological drought. Groundwater drought is outlined by lower than average annual recharge for more than one year. Groundwater levels are good indicators in an aquifer area.

The main considerations for drought indices are the following:

- Suitability for drought types of concern
- Data availability and consistency
- Clarity and validity
- Temporal and spatial sensitivity
- Temporally and spatially specific

2.3 Flood

2.3.1 Flood generation processes

Flood generation processes are depending on flood causes and on the impact of global change factors on flood. Climate change factor, land use change and human impact, have significant influence on flood generation processes. Following different flood causes, flood can generate as: flash flood, rapid on-set flood and slow on-set flood.

Flash flood happens within a very short time (2 – 6 hours, and sometimes within minutes) and are mostly result of heavy rain, dam break or snow melt.
Sometimes, intense rainfall from slow moving thunder-storms can be cause of such flood generation. Flash flood are the most destructive and can kill many people, as people are usually taken by surprise. There is usually no warning, no preparation and the impact can be very heavy, unpredictable and devastating.
Rapid on – set flood are similar to flash flood. For such generation process, it takes slightly longer to develop and the flood can last for a day or two only. It is also very destructive, but does not surprise people in the same way like flash flood. With rapid on-set flood, people can quickly put a few things right and escape before it becomes very dangerous. Slow on-set flood are generated mostly as a result of water bodies over flooding their banks. They tend to develop slowly and can last for days and weeks. Flood generated in such way are usually spread over many kilometers and occur more in flood plains (fields prone to flood in a low-lying areas). The effect on population of flood generated in this way is more likely to be due to disease, malnutrition or snakebites.

2.3.2 Types of flood

Fluvial or riverine flooding, happens when excessive rainfall over an extended period of time causes a river to exceed its capacity. It can also be caused by heavy snow melt and ice jams. The damage from a river flood can be widespread as the overflow affects smaller rivers downstream, often causing dams and dikes to break and swamp nearby areas.

There are two main types of riverine flooding:

1. Overbank flooding occurs when water raises overflows over the edges of a river or stream. This is the most common and can occur in any size channel – from small streams to huge rivers.
2. Flash flooding is characterized by an intense, high velocity torrent of water that occurs in an existing river channel with little to no notice. Flash flood are very dangerous and destructive not only because of the force of the water, but also the hurtling debris that is often swept up in the flow.

The severity of a river flood is determined by the amount of precipitation in an area, how long it takes for precipitation to accumulate, previous saturation of local soils, and the terrain surrounding the river system. In flatter areas, floodwater tends to rise more slowly and it usually remains for days. In hilly or mountainous areas, flood can occur within minutes after a heavy rain. To determine the probability of river flooding, models consider past precipitation, forecasted precipitation, current river levels, and temperatures.

A pluvial, or surface water flood, is caused when heavy rainfall creates a flood event independent of an overflowing water body. One of the most common misconceptions about flood risk is that one must be located near a body of water to be at risk. Pluvial flooding debunks that myth, as it can happen in any urban area – even higher elevation areas that lie above coastal and river floodplains.

There are two common types of pluvial flooding:

1. Intense rain saturates an urban drainage system. The system becomes overwhelmed and water flows out into streets and nearby structures.
2. Run-off or flowing water from rain falling on hillsides that are unable to absorb the water. Hillsides with recent forest fires are notorious sources of pluvial flood, as are suburban communities on hillsides.

A coastal flood happens in areas that lie on the coast of a sea, ocean, or other large body of open water. It is typically the result of extreme tidal conditions caused by severe weather. Storm surge – produced when high winds from hurricanes and other storms push water onshore – is the leading cause of coastal flooding and often the greatest threat associated with a tropical storm. In this type of flood, water overwhelms low-lying land and often causes devastating loss of life and property.

Coastal flooding is categorized in three levels:

- Minor: A slight amount of beach erosion will occur but no major damage is expected.
- Moderate: A fair amount of beach erosion will occur as well as damage to some homes and businesses.
- Major: Serious threat to life and property. Large-scale beach erosion will occur, numerous roads will be flooded, and many structures will be damaged. Citizens should review safety precautions and prepare to evacuate if necessary.

2.4 Flood and drought modelling

2.4.1 Flood and drought frequency analysis

There are two types of frequency analysis: at site-frequency analysis and regional frequency analysis. Philosopher: It is likely that something unlikely will happen! Scientist: What is the probability that such an extreme event will occur; in any one year, or in the next 50 or 100 years? The objective one giving lectures and when transferring knowledge is to give a statistical background to frequency analysis for hydrologists, including: at-site and regional procedures. One also needs to present several applications of frequency analysis to time series of hydrological drought characteristics to: demonstrate the procedures and to highlight methodological concerns and international experience. The estimates of the probability of occurrence of extreme events are obtained by the method of frequency analysis, which involves: the definition of the hydrological event and extreme characteristics to be studied, selection of the extreme events and probability distribution to describe the data, estimation of the parameters of the distribution and calculation of extreme events or design values for a given problem.

In order to do the frequency analysis one needs to start from the basic probability concepts and with description of the simple and population.

Population (sample space) presents all possible observations (all possible outcomes of an experiment). Sample presents the data set collected (the actual outcome of the experiment). Event is realization of an experiment (in environmental sciences the nature performs the experiment).

It is important to understand how the properties of a sample relate to the properties of the population. The range of values observed within a sample can be displayed by a histogram and quintile plot.

The cumulative distribution function (cdf) of X, F(X) = P{X≤x} = p is the non-exceedance probability for x and describes the probability of the event $A=\{X\leq\chi\}$.

The percentiles or quintiles of a distribution, χ_p, are often used as design values.

In hydrology empirical distribution functions are commonly labeled flow duration curves.

The probability density function, f(x) is the derivative of F(x) and is the relative likelihood that X takes on different values. The quantile χ_p is the value with a cumulative probability of p and an exceedance probability of 1-F(x) = 1-p

Return period is the important characteristic for frequency analysis. For the maximum values the return period is defined as: T=1/1-p where (1-p) denotes the exceedance probability and T is the average time between occurrences of an event $X>\chi_p$

For the minimum values the return period for the non-exceedance probability is here the quantity of interest: T=1/p and T is the average time between occurrences of an event $X\leq\chi_p$

Traditionally, hydrologists think in terms of return periods and return levels. The return period T is calculated as T = 1/p. The return levels x_T are calculated for return periods of 10, 100 and 1000 years, and are the quantiles corresponding to values of 0.1, 0.01 and 0.001 for p.

The following statistics will have to be considered when doing at site frequency analysis:

- Central tendency
- Mean (first moment)
- Median (50 % quantile)
- Mode (peak)
- Sample properties
- Variance / Standard deviation
- Coefficient of variation
- Quantile (and sample) range
- Skewness and kurtosis
- Autocorrelation and cross-correlations

For the frequency analysis one needs data and for the data there are basic assumptions. Frequency analysis requires that the data are: *independent* (no serial correlation or trend in the data), *identically distributed* (from the same population, i.e. homogeneous – the same generating processes have caused the extreme events) and the time series have the same population characteristics independent of time, i.e. there are no seasonality in the series.

Selection of extreme event can be done from the time series. Selection of extreme events from a time series based on the annual maximum/minimum series (AMS) and partial duration series method (PDS) where r are the largest values.

Selection of extreme event can be done by two methods:
Block Minima/Maximum (BM) method when the smallest/largest values within a sequence of adjacent blocks are selected. If a block size of one year is used, we call the extreme values an Annual Minimum/ Maximum Series (AMS).

The Peak Over Threshold (POT) method
Excesses over an upper limit (threshold) are selected. In hydrology the selected extremes are often called a Partial Duration Series (PDS). Annual exceedances can be calculated provided the average number of event each year larger than the upper limit is known.

Block minima method can be used for the selection of extreme event from the time series when the minimal values within a block are selected. But also, Block maxima method is used for the selection of extreme event from the time series when the maximal values are selected within a block.

For the frequency analysis one needs to determine the probability distribution. In statistical terms our problem is to estimate the tail of a unknown distribution F based on a limited set of data X_1, X_2, X_n. There are few extreme data so estimation is difficult. One often requires estimates beyond the largest/smallest observation so extrapolation is necessary. A distribution fitted to all data will not necessarily fit well for the extremes.

In the Block maxima method, for example, one does not consider the parent distribution F, but one can fit maximum values from time blocks directly to the GEV distribution.

The choice of block size is a trade-off between having enough data for statistical inference and having a large enough blocks for the GEV to be a good approximation. In environmental sciences a block size of 1 year is a natural choice.

The Partial Duration Series approach provides generally a larger sample size than the BM method with a block size of one year. The selected events will always be extreme, provided the upper limit is selected sufficiently high. It is necessary to consider the selection of upper limit and the selection of independent values.

There are different types of distributions. Extreme value distributions area: Y Reduced variance, Y Generalized extreme value distribution (GEV), Generalized Pareto distribution (GP) and other distributions. Selection of distribution function is important part of at site frequency analysis.

The extreme value theory forms a theoretical basis for procedures used to estimate the extreme behavior of a process and for a probabilistic extrapolation beyond the range of observations.

The generalized extreme value distributions (GEV) are a limit distribution of normalized maxima and thus suited to model AMS.

The generalized Pareto distribution (GP) is a limit distribution of scaled excesses over an upper limit and thus suited to model PDS:

- The selection of distribution function can be done in different ways. Traditionally, statistical judgment and best fit is used in combination with knowledge of the phenomenon studied, e.g. for minimum flows the distribution should be skewed and have a finite lower limit (≥0).
- For extreme events it is recommended to base the choice on its theoretical background, i.e., the GEV distribution is adopted to model AMS and the GP distribution is suited for the PDS.

Estimation methods are:

- The methods of moments relates the theoretical moments to the sample estimates:
- Product moments
- L-moments (functions of PWM)
- Maximum Likelihood estimators are obtained by maximizing the likelihood function

2.5 Catchment characteristics

A catchment is a land area surrounded by hills or mountains. Surface water and groundwater flows from the catchment into the rivers and streams. Based on the catchment topography, water is

collected at the lowest areas of the catchment. Catchment has its drainage network, which is formed from the water streams within the catchment area. Catchment is getting water from precipitation and through the drainage network water is going to a common outlet which is the mouth of the mainstream river. The mouth can be a place where stream empties into a lake, wetland and ocean or to another river. Streams are affected by the physiographical characteristics of the catchment.

Catchment characteristics, which are the most influential for streams are: catchment area, shape, orientation, elevation, slope, relief, stream morphology, land cover, soils and geology. Catchment characteristics can be obtained from the paper maps or digital spatial data. The necessary scale, or spatial resolution, of maps depends on the study requirements.

Catchment characteristics are used for the regionalization procedures, which are the techniques of relating river flow summary statistics to the physical and climatic characteristics of the catchment.
(www.waikatoregion.govt.nz/PageFiles/5949/04understanding.pdf)

2.5.1 Regionalisation procedures

Regional drought studies have two main categories: regional methods for estimation at the ungauged site or at sites with short records which includes the regional frequency analysis and the regional regression methods and the regional methods to characterize the spatial aspect of drought.

2.6 Regional frequency analysis

2.6.1 Regional methods for at-site estimation

Combination of flow records from different sites in a region that can be assumed to have similar drought characteristics reduce sampling uncertainty (space substitutes time) and present the basis for estimation at ungauged sites.

2.6.2 Index method

When one is using the index method, it is condition that the data at different sites in the region follow the same distribution except for scale. The individual time series in the region is divided by an at-site parameter (index parameter). In the next step, the normalized data are then jointly used to estimate the parameters of the regional distribution (simple pooling of the data).

The at-site quantile estimator is subsequently obtained by multiplying the normalized quantile estimator with an estimate of the at-site index parameter.

L-moments (Hosking, 1990) can be used to characterize sample properties and to estimate distribution parameters.

L-moments are weighted as the linear sums of the expected order statistics. L-moments can also be written as functions of PWM and procedures based on L-moments and PWM are therefore equivalent.

If X is for example a random variable and X(1:n) ≤ X(2:n)… ≤ X(n:n) the order statistics of a random sample of size n from the distribution of X, The first three L-moments are then defined as:

$$\lambda 1 = E\{X(1:1)\}$$
$$\lambda 2 = \tfrac{1}{2}\, E\{X(2:2) - X(1:2)\}$$
$$\lambda 3 = 1/3\, E\{X(3:3) - 2X(2:3) + X(1:3)\}$$

It is common to standardize moments of higher order to make them independent of unit of measurements of X

$$\tau 2 = \lambda 2/\ \lambda 1; \quad \text{L-CV (coefficient of variation)}$$
$$\tau 3 = \lambda 3/\ \lambda 2; \quad \text{L-skewness}$$
$$\tau 4 = \lambda 4/\ \lambda 2; \quad \text{L-kurtosis}$$

L – Moments analysis is part of regionalization procedures. One can analyze the L-moments thought the regional homogeneity when L-CV and higher order L-moments are constant and through the regional distribution when one compare the regional L- moment statistics with theoretical relations.

L-moment index method consists of few parts. One can calculate L-moment ratio estimates at each site. After, one can calculate regional average L-moment ratio estimates (weights are assigned to each site).

Next step is to determine the regional distribution and estimate the parameters of the normalized regional distribution, F(x) and then to calculate normalized regional T-year event estimate by using the inverse of the regional distribution. Finally, multiply the normalized estimate with the at-site sample mean to get T-year event estimate at a site.

The regional modeling components are the following:

- Delineation of homogenous regions
- L-moment analysis
- Test of regional homogeneity
- Identification of regional distribution

Generalized least squares regression (procedure that explicitly accounts for sampling uncertainty and intercity dependence).

- Assessment of regional homogeneity
- Estimation of regional parameters
- Modeling of regional heterogeneity

For the regional frequency analysis the prerequisite is that the sites comprise a definite heterogeneous region with respect to both deficit volume and drought duration. Division of sites into wet and dry catchments, and a further division based on average hydraulic conductivity provide usually few of different acceptable homogeneous regions.

The two-parameter Gamma distribution is adequate for describing both deficit volume and duration. The regression equations are established for the index parameter (mean annual flow). The resulting models allow estimation of T-year event of deficit volume an duration for both gauged and ungauged sites in the chosen region.

2.7 Conservation of water

Conservation should be practiced both during and outside of drought events, on the supply and demand sides. Conservation strategies include metering and pricing incentives, use of indigenous methods like rainwater collection, use of grey water, building of reservoirs and dams, leak reduction, switching to drip irrigation, and reforestation. Roughly 70 per cent of abstracted water goes toward agriculture and almost 70 per cent of that water goes to waste due to leaky irrigation or runoff into ground or surface water. Repairing leaks or installing drip irrigation systems can bring major savings. Agricultural and household conservation should be the first priority in putting together a drought plan. That includes Conservation Agriculture (CA). CA refers to a range of integrated soil management practices that aim to minimize the negative effects of intensive farming practices such as direct sowing, zero-tillage or minimum tillage, and the establishment of cover crops help to protect organic matter and soil fertility. CA is not a technology but a wide array of specific technologies that are based on applying one or more of the three main conservation agriculture principles (IIRR and ACT 2005): reduce the intensity of soil tillage, or suppress it altogether; cover the soil surface adequately – if possible completely and continuously throughout the year; and diversify crop rotations.

In the case of reservoir that is used both for irrigation and flood control, decision rules must be stated to know when and what amount of water must be release from the reservoir after the irrigation period. Several scenarios must be provided and the choice is guided by the water resource level status at the time of decision. The objective is to keep enough storage capacity to store part of a big flood event.

2.8 Changing crop varieties – drought effect mitigation

One conservation method aside from simply saving water is to shift to drought-tolerant crops. In Namibia, researchers have developed early maturing varieties of millet and sorghum, which, in 1998, recouped half of their initial investment in just a year. Other options are high-protein grains, like cowpea, which are nourishing, can be used as livestock feed, and restore nutrients to the soil. Crop rotation can also be beneficial during drought to boost production. The University of Pennsylvania found that corn yields increased by 5 to 7 per cent following a soybean harvest and 10 to 15 per cent after hay. Crop rotation also increases nitrogen in the soil and decreases the need for pesticides.

3 Monitoring, early warning and prediction

3.1 Modelling and forecasting capabilities of flood and drought

The key purpose for monitoring water levels and precipitation is to produce flood and drought forecasts. The more data that is available, the more precise the forecast for the next drought or flood will be. The specific areas that should be monitored are detailed in the following chapters including the particular country caseses.

3.1.1 Drought monitoring in India

In India drought is monitored based on the withdrawal of the southwest monsoon. Weather forecasts are done for different time lengths: (1) short forecast (validity for less than 3 days), (2) medium forecast (validity from 3–10 days) and (3) long forecast (validity for more than 10 days). Such forecasts are provided by the Indian Meteorological Department. The forecast is disseminated through the All India Radio, and various Newspapers. The National Centre for Medium Range Weather Forecasting in the Department of Science and Technology disseminates weather information through its network of Agro-MetAdvisory Service units which is part of the State Agricultural universities. There is a need for establishing a centralized data base for drought management. One would need to generate the information in amore objective manner, reducing the subjective view in data interpretation. The raw data should be made accessible to the organizations concerned in order to help indecision making. Such information system maintenance, monitoring and information dissemination is already in place in Karnataka and Andhra Pradesh.

3.1.2 Early warning and forecasting of drought in India

The Indian Remote Sensing Satellite (IRSS) was launched in 1988. From that time, the thrust has been given to the remote sensing applications to key sectors of development such as land and water resources management, coastal and marine resources, forest management, flood and drought disaster management etc. The satellite application with the active public participation provides crucial contribution to decision making at Central andState level. The satellite derived vegetation index and wetness index information arethe main indicators for the monitoring of crop condition. Ministry of Earth Sciences has set up eighty nine centers for short and medium term monitoring and weather forecasting. In order to overcome the limitations of drought monitoring, a project titled 'National Agricultural Drought Assessment and Monitoring System (NADAMS) sponsored by the Department of Agriculture and Cooperation and the Department of Space (DoS) was taken up by the National Remote Sensing Agency in collaboration with the Indian Meteorological Department (IMD), Central Water Commission (CWC) and concerned State Government agencies. Real time agricultural drought prediction is done at district level for nine states and sub district level for four states. One is assessing drought in terms of severity and persistence during kharif season (June-Nov) and submission of monthly drought reports to the Ministry of Agriculture and State Departments of Agriculture and Relief of different States is done regularly. There is a need to use additional vegetation related parameters (derived from satellite generated products for estimation of agro meteorological parameters such as rainfall, soil moisture and evapo-transpiration. This is due to the very poor density of the network of ground-based observations in the country. Efforts will be made to integrate the ground-based information with the space-based information for comprehensive reporting. The role of all departments working on drought management should be clarified. There is also a need to develop ways and means to obtain soil moisture data and also the evapo-transpiration rates to forecast accurately the

crop health at different phonological stage sin a season. There is a need to analyze soil samples to measure the moisture level for an assessment of actual crop conditions. Automatic weather stations which are setup by different agencies will also include moisture sensors in order to obtain information about the soil moisture level sunder natural environment. Remote sensing applications are providing on a weekly basis the findings on the crop health.

3.2 Dissemination of Flood Early Warning in Thailand, Vietnam, Cambodia and Laos

In Thailand, Vietnam and Laos, within the Flood Management and Mitigation Programme (FMMP), one intends to reach to the community level through reliable early warning initiatives and through improving the forecasting system. In the last five years, the Mekong River Commission with the Department of Hydrology and River Works (DHRW), supported the implementation of community based early warning initiatives in Cambodia, spreading over six provinces along the Mekong: Stung Treng, Kratie, Kampong Cham, Prey Veng, Kandal and Takeo. The initiatives were executed as part of FMMP priority. The initiative was also supported by U.S. Foreign Disaster Assistance (OFDA), European Commission Humanitarian Aid department (ECHO) and GIZ. The community based early warning activities provided crucial flood forecasting information to the communities. The involvement of Cambodia Red Cross (CRC) in these projects was crucial since it has far reaching network of provincial, district and village volunteer teams of volunteers that work closely with the disaster management structures at respective levels. The Early Warning System projects shared a common goal of "through improved warnings, vulnerable communities in Cambodia will reduce their risk to higher-than-normal flood" and the activities are implemented in three major phases: installation of flood reference tools, management enhancement and community empowerment. In addition to flood marks installed by the DHRW, community, home flood marks are also created for easy access where flood level markings are painted on school walls, along the ladders of pagoda, pillars of the houses of women headed households. To facilitate the information flow, the provincial hydrology departments, Provincial, District and Commune disaster management offices are equipped with two way communication devices. In some villages where houses are widely spread out, loud speakers exist. The village chiefs and village volunteers are trained to efficiently perform their tasks as flood mark operators to read and record flood water level in the log-sheets, to understand the flood information flow and how to take care of flood marks. To feed into the two way communication system, the local authorities cooperate with the hydro met services to read and record the water level from the flood marks and communicate with DHRW regularly. DHRW then fed the data into the forecasting model and the flood bulletin for the next three days is prepared and transmitted to the local authorities. Such a system help build community owned "flood Information Billboards". These billboards provide updated information on water levels and forecast for next three days.

3.3 Flood forecasting and warning process in Bangladesh

Flood forecasting is the main non-structural measure in flood management. The Flood Forecasting and Warning System (FFWS), established in the 1970s, now cover all the flood prone areas of the country and provide real time flood information with early warning for lead-time up to 120 hours (FFWC, 2014).

FFWC issues flood bulletin twice in day at 9.00 AM and 3.00 PM based on the available water level across the country. It uses the state-of the art modelling technique in preparation of forecast. *Figure 1* shows the flood forecasting network currently covered by FFWC.

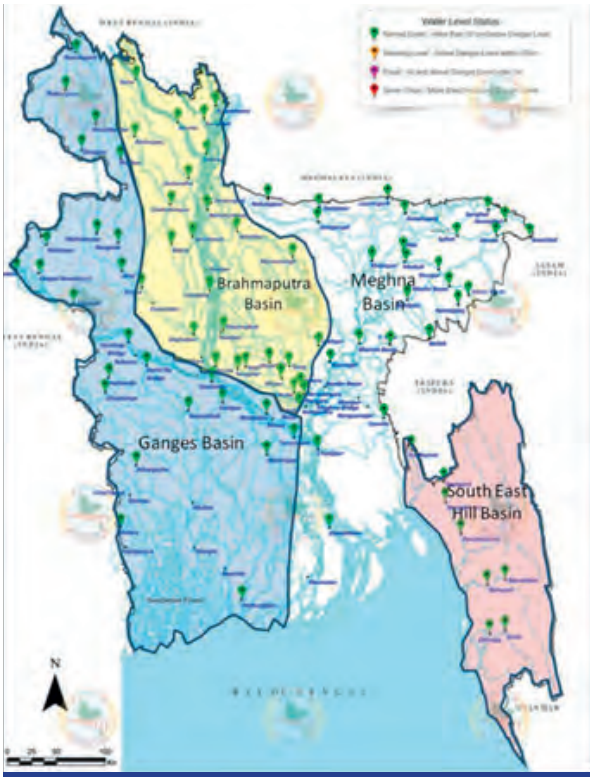


Figure 1: *Flood forecasting network in Bangladesh (Source: FFWC)*

Major Flood Forecasting Activities:

- Short-term forecast
- Medium-range flood forecast using ECMWF rainfall forecast
- Qualitative flash flood forecast
- Flood inundation map
- Short-term Forecast

A 5-day deterministic daily forecast, based on a 7-day hindcast is generated by FFWC daily during the monsoon. FFWC uses MIKE 11 hydrodynamic model for flood forecasting purposes. The simulated water levels are being assimilated with observed water levels (3 hourly values, 5 times a day, 84 locations). The observed water levels are sent to FFWC every morning, by mobile SMS. BWDB collects water level of the major rivers mostly manually.

Figure 2: *Typical water level gauge in the River (Source: FFWC)*

Medium range forecast

A 10-day probabilistic forecast, which is also provided by FFWC. This forecast is produced by Regional Integrated Multi-Hazard Early Warning System (RIMES) at the FFWC office. For this, ECMWF (European Center for Medium Range Weather Forecasting) provides a 10-day precipitation forecast each day. The rainfall run-off model, which also includes the total GBM basin, is simulated using ECMWF forecast precipitation. The simulated discharge at the boundaries is used to run Flood Forecasting Model in FFWC. The 10-days forecast is given by maximum, minimum and mean forecast. *Figure 3* shows 1–10 days probabilistic flood forecast hydrograph.

FFWC uses several modes for dissemination of flood forecast and early warning. The flood warning messages are distributed by printed copy, email, website (www.ffwc.gov.bd), fax, media, NGOs & Development partners, local disaster management

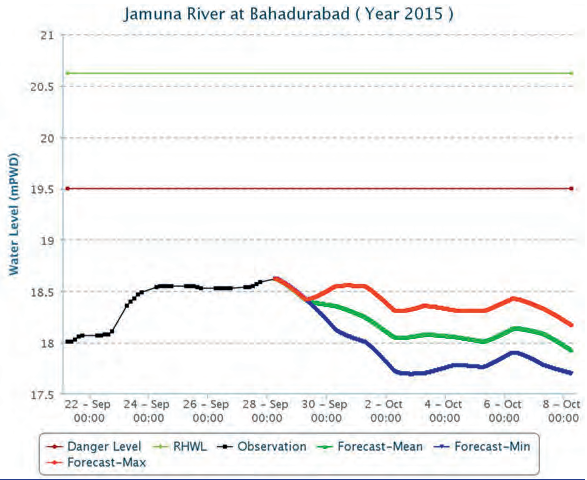


Figure 2: *10 day's probabilistic forecast using ECMWF data*

committee, IVR. FFWC has started an Interactive Voice Response (IVR) system on flood situation for mobile phone users with the support of Comprehensive Disaster Management Program-II (CDMP-II). Anyone can dial 10941 to hear voice message on flood situation.

Flood forecasting and warning activities in Bangladesh are carrying on by the Flood forecasting and warning centre (FFWC) of Bangladesh. Water development activities are priority for the Government of Bangladesh due to severe water hazard events which happened in the last fifty years.

Flood forecasting and warning projects in the country have been supported by different UN Agencies, notably World meteorological Organization and United National Environment Programme. During the period 1991–1995 the flood forecasting centre was assisted by DANIDA through the Flood Action Plan (FAP), to improve and expand the flood forecasting and warning services. Currently, most of the activities in the country, hazard related, are towards strengthening and consolidation of flood forecasting and warning services. During early period till 1999, the centre used to forecast flood by Co-axial correlation, gauge to gauge relation and Muskingum-Cunge Routing Model.

From 2008 onwards the forecasting activities at FFWC have been based on the flood modeling technology developed by the Danish Hydraulic Institute with the support service from the Surface Water Modeling Centre based in Dhaka. Today the forecasting and warning services are carried out by the expertise and staffs of FFWC using the MIKE 11 and FLOOD WATCH modeling systems.

3.4. Levels of alert

Based on local conditions and water resource levels derived from monitoring data, different alert levels should be defined to trigger different reactions from authorities.

In Spain, four alert levels have been defined for drought: Normal, Pre-Alert, Alert, and Emergency. Normal refers to the absence of water abundance risk for the near future. Pre-Alert refers to the beginning of drought conditions in which there is a greater than 10 % risk of encountering water scarcity. Alert refers to drought currently occurring in which measures need to be taken immediately to curb water shortages. And Emergency suggests that major steps should be taken to mitigate continuing shortages (Iglesias and Garrote, 2011). Such a system gives citizens enough information to make preparations, and signals to policymakers when to take action.

In France the national flood risk warning service delivers four levels of alertness through its web page (http://www.vigicrues.gouv.fr/) for 1 400 rivers which are given different colors depending on their risk level. Data are updated twice a day. The red color indicates a major flood risk. It indicates a direct threat and widespread security of persons and property. The orange color is for flood risk generating large spills that may have a significant impact on community life and for the safety of property and people. The yellow color is for risk of flooding or rapidly rising waters not causing significant damage but requiring special alertness in the case of seasonal activities and / or exposed. Green color indicates that no particular alertness is required.

3.5 Analysis of water sources for flood and drought

Usable fresh water is derived from surface and ground-water, which includes rivers, lakes, aquifers, and glacier runoff. Monitoring allows countries to understand the cyclical changes that affect their water sources by recording fluctuations in precipitation and water levels and observing long-term trends.

3.6 Analysis of the effects of climate change on flood and drought

Climate predictions show that precipitation and river runoff will increase in northern latitudes and decrease in lower latitudes by the middle of the 21st century. These changes will mean a decrease in moisture in arid and semi-arid zones and an increase in wet tropical zones. To aggravate this, water demand and use has also been steadily increasing over the last century and increasing over the last years, leading to water stress (http://www.ipcc.ch/pdf/technical-papers/climate-change-water-en.pdf). To counter these issues, drought policies will need to include careful monitoring of existing water conditions and the use of forecasting technologies to gain a sense of any changes in water resources for the coming years.

3.6.1 Classification of drought in India

As a result of continued dry weather and very seldom rain with little quantity, drought appears. Drought causes loss of soil moisture, depletion of underground water supply and insufficiency of stream flow. Drought is defined according to disciplinary affected. In India, The National Commission on Agriculture in defines three types of drought: meteorological, agricultural and hydrological. Meteorological drought is defined as a situation when there is significant decrease from normal precipitation over an area (i.e. more than 10 %). Hydrological drought results from long period of meteorological drought when starts depletion of surface and sub surface water resources. Hydrological drought can occur even when the rainfall is normal, if there has been a substantial reduction in surface water holding capacity. Agricultural drought is a case when soil moisture and rainfall are inadequate to support healthy crop growth. Drought proofing measures are taken before the crop is planted such as Improving Water Holding Capacity (WHC) of soil through organics/ silt, land configurations etc. Drought management measures are mostly initiated during the crop growing period (reduction in plant population, supplemental irrigation etc.)Most drought classifications emphasize physical aspects of drought, since its impacts are widespread across several sectors including non-farm sector. The impact, response and interventions would vary depending on at what point of time in a crop calendar there is a water or soil moisture deficit. Generally, three situations are recognized:

- Early season: Delayed rainfall (delayed monsoon)
- Mid-season: Inadequate soil moisture between two rain events
- Late season: Early end of rains or insufficient rains

In terms of climate variability the Meteorological department recognized different periods:

- A drought week when rainfall in a week is less than half of its normal amount
- An agricultural drought; when four drought weeks occur consecutively during mid-June to September
- A seasonal drought when seasonal rainfall is deficient by more than the standard deviations from the normal

- A drought year when annual rain fall is deficient by 20 % of normal or more
- Severe drought year; when annual rainfall is deficient by 25–40 % of normal or more.

The Ministry of Water Resources of India has set up in 1972 The Irrigation Commission. At the same time Government of India has defined those areas that face meteorological drought in twenty percent of years as drought prone areas and those experiencing meteorological drought in more than forty percent of years as chronic drought prone areas. The National Commission on Agriculture defines an agricultural drought when at least four consecutive weeks receive less than half of the normal rainfall (<5 mm) during six consecutive weeks. In 1994 it was suggested that the climatic variables with the irrigated area and source of irrigation can be used to redefine drought prone districts. Some climatic variables are interrelated and may not necessarily be distributed uniformly within the district. Therefore the complex methods need to be used in deriving a composite picture using such multiple criteria. For the preparation of drought vulnerability maps for Districts and State in India, a combination of the climatic variables is used. Developing vulnerability profiles for regions and communities provides critical information on who is at risk, the nature of risk and the reasons for such risk. A drought atlas for India is being prepared by the National Atlas and Thematic Mapping Organization (NATMO). The information from drought atlas, integrated in the planning process, helps in identifying and prioritizing specific areas, where progress should be made in drought risk management.

3.6.2 Climate change impact on drought in India

Climate change makes more difficult to forecast weather information. The debate of Intergovernmental Panel on Climate Change has shifted from the reality of climate change to the reaction to climate change. There are two groups of questions to be considered: how serious does one expect climate change to affect different parts of India; and how resilient will the society be in its response. Climate change and agriculture are interrelated processes taking part at the global scale. Global warming is projected to have significant impacts on agriculture, including temperature, carbon dioxide, glacial run-off, precipitation and these elements interaction. These conditions determine the carrying capacity of the biosphere to produce enough food for the human population and animals.

In 2008 the National Action Plan on Climate Change was made in India. The plan "identifies measures that promote Indian development objectives while also yielding co-benefits for addressing climate change effectively," and outlines existing and future policies and programmes addressing climate mitigation and adaptation. The core "national missions" are running through to 2017. One of the missions is the National Mission for Sustainable Agriculture. This mission aims to develop the strategies in order to make Indian agriculture more climate change resilient. Within such strategy is identifying and developing new varieties of crops and especially thermal resistant crops and alternative cropping patterns, capable of withstanding extremes of weather, long dry spells, flooding, and variable moisture availability. Climate change issues affect cross sectors and represent an additional stress on ecological and socioeconomic systems due to decrease in yield of cereal crops and increased risk of natural disasters. Temperature rise and humidity change are also affecting human health due to increased vector borne diseases, heat stress and other communicable diseases.

3.6.3 Types of flood in Bangladesh

Bangladesh experiences all kinds of flood almost every year. Flood types depend on the hydrology and physical characteristics of the region. *Figure 4* shows the locations of flood in different parts of the country.

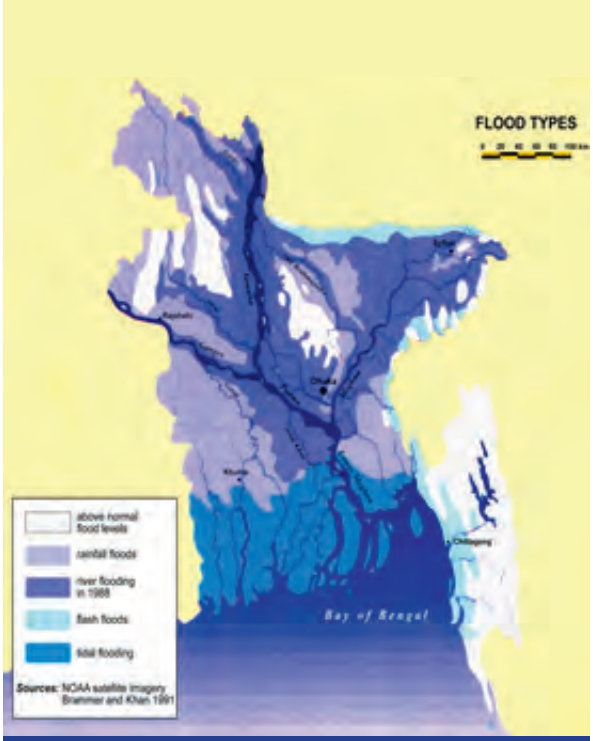


Figure 4: *Different Flood Types in Bangladesh (Source: FFWC)*

The following are the major Flood Types in Bangladesh:

- Flash Flood
- Rain-fed Flood / Water Logging
- River Flood
- Flood due to Cyclonic storm surges / Coastal Flood

Flash flood occurs in northeastern and southeastern hilly part of Bangladesh due to sudden heavy rainfall. Some areas are very much vulnerable to flash food. Heavy rainfall in southeast region aslo triggers landslide and causes death of lives. Flash flood occurs in pre-monsoon period usually mid April to mid of May.

River Flood

River flood is the most common phenomenon in Bangladesh. In normal flooding year around 20–25 % area is inundated where as in extreme flooding area 50–70 % area of the country is inundated. *Figure 5* shows percentage area inundated in different years. The country experienced extreme flood events in 1998 with 68 % inundated area (FFWC, 2014).

Rain-fed Flood / Water Logging

This type of flood occurs due to rainfall along with drainage congestion. South-west part of the country usually experiences water logging due to drainage congestion. This flood also occurs due to human intervention in flood plain such as unplanned embankment, road and illegal encroachment of river. The rain-fed flood occurs in urban areas due to improper drainage system.

Flood due to Cyclonic storm surges / Coastal Flood

Flood due to storm surge occurs in coastal areas of Bangladesh. The country has 720 km long coast line. Bay of Bangle is the hot spot for the generation of tropical cyclone. Shallow continental shelf and conical shape coast have made the coast most vulnerable to Cyclonic storm surge. It causes severe damage to human lives, infrastructures in the coastal area. For Example, cyclonic storm surge in 1970, 1991, 2007, 2010 are the worst cyclone hit at Bangladesh coast. Besides storm surge, coastal flooding also occurs due to high tide during monsoon months.

Causes of flood

Geographical location makes the country most vulnerable to flood. Bangladesh is location at the foothill of world highest mountain – Himalaya range and Bay of Bengal is located to the south of the country. Moreover, around 93 % catchment is located outside Bangladesh which generates huge runoff and pass through Bangladesh. *Table 1* shows the catchment areas of Brahmaputra, Ganges and Meghna in Bangladesh, Bhutan, India and China.

The following can be considered as major causes of Flood:

- Unique Geographical Location
- Excessive run-off from upstream catchment
- Low/Flat topography
- River siltation
- Sea swell during monsoon
- Hydraulic Characteristics
- low gradients of major rivers
- Ganges: 4 cm/km, B. Putra: 8 cm/km, Meghna: 3 cm/km
- Different kinds of flood have various hydrological characteristics and following section describes in more specific way the causes of flood.

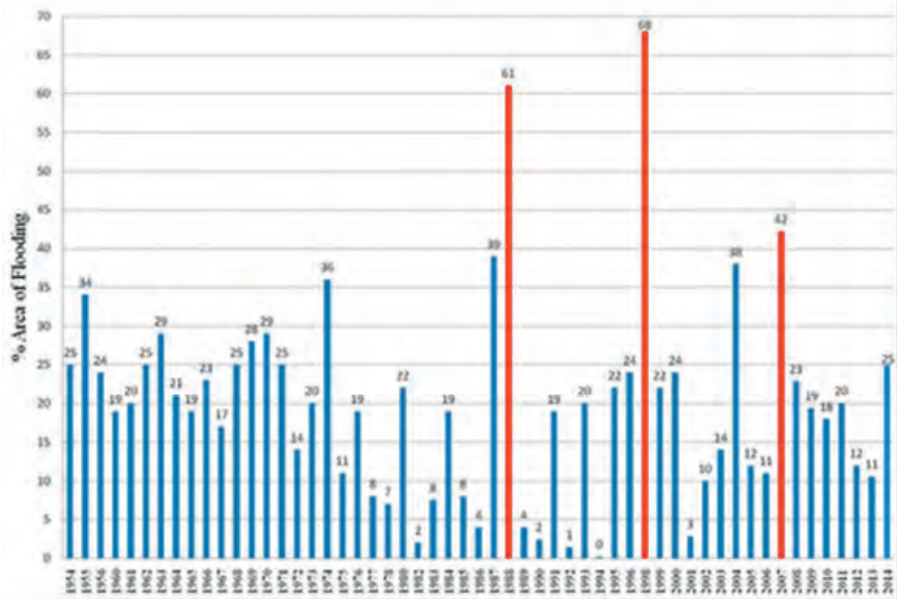


Figure 5:
Percentage of area flooded in different year

Table 1: *Catchment Areas of Brahmaputra, Ganges and Meghna River (Source: Joint River Commission Bangladesh)*

River Basin	Total catchment area (km²)	Catchment Area (km²)				
		India	Nepal	Bhutan	China	Bangladesh
Brahmaputra	552 000	195 000	—	47 000	270 900	39 100
Ganges	1 087 300	860 000	147 480	—	33 520	46 300
Meghna	82 000	47 000	—	—	—	35 000

In Bangladesh there are four types of flood which country can experience:

- Flash Flood
- Rain fed Flood
- River Flood
- Flood due Cyclonic Storm Surges

Flash flood happens with rapid rise and fall of water levels. Flash flood in most of the cases occurs within a time frame of between few minutes to few hours. This type of flood occurs mostly in northern part of the country, north-central part, north eastern part and southeastern part of the country. Northern, north-central and northeastern parts land areas are mostly at foothills with the hilly catchments in India. If the rain is extreme in the Indian parts of the catchments the run-off quickly accumulates and flow to Bangladesh. Flash flood starts happening in these areas from mid-April just before the start of the south west early monsoon.

The rain fed flood occurs in the moribund Gangetic deltas in the south-western part of the country where most of natural drainage systems are being deteriorated due to fall in up-land inflow from the main river Ganges. Such flood happens in the flood plains where natural drainage systems have been disturbed due to human influences due to construction of unplanned rural roads and illegal occupation of the river courses. When important rainfall happens, natural drainage system can not carry the run-off generated by the rain and causes temporary inundation in many places. This kind rain induced flood is important in the urban areas. Urban population is increasing very fast and to making their houses and infrastructure low lying areas and natural drainage systems are being filled up permanently. When new settlements are constructed, the issue of drainage is not always considered seriously. Consequently, in the urban areas flood has become very common phenomenon.

River flood is a most common phenomenon in the country from time immemorial. Normally, 25–30 % of the area is inundated during monsoon season along the river. In case of extreme flood events 50–70 % of the country is inundated even in the areas out and around

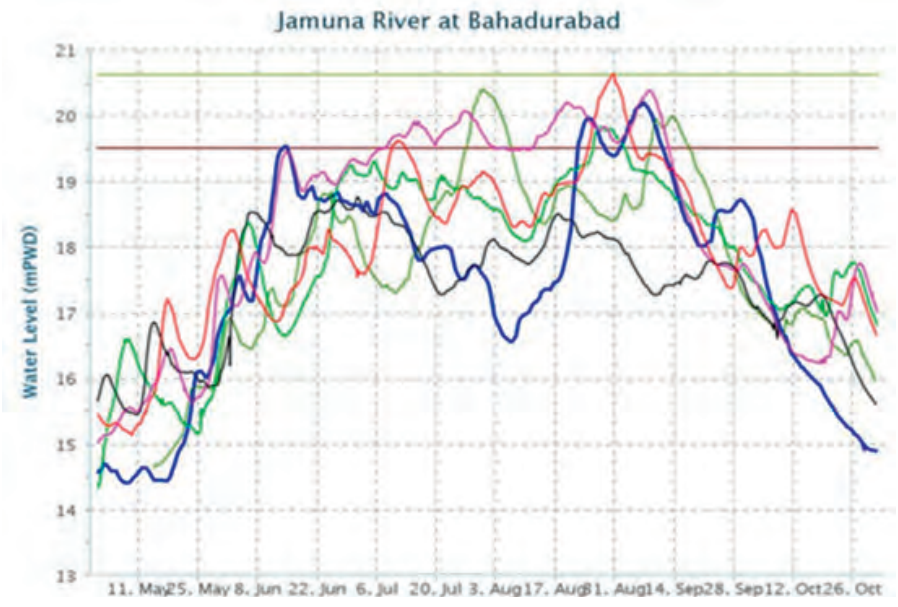


Figure 6: *Flood Hydrograph of Brahmaputra River at Bahadurabad*

Figure 7: *Community Level Flood Forecasting (Source: CEGIS)*

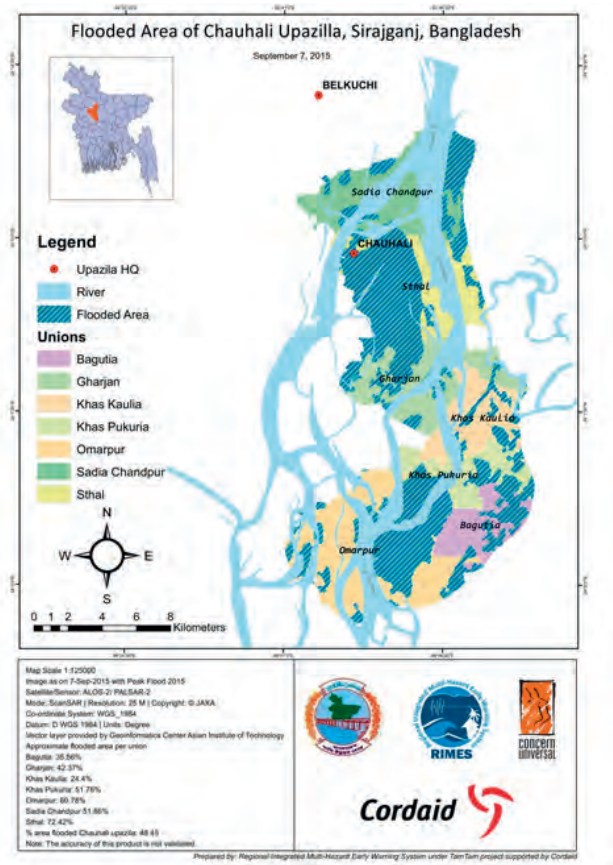


Figure 8: *Satellite based local level flood map (Source: FFWC)*

the riverbanks. The worst flood experienced by the country were in 1987, 1988 and 1998. Flood of1998 was the severest one in terms of magnitude and duration.

Flood due to storm surge in most of the cases occurs along the coastal areas of Bangladesh with the total coast line of 800 km along the northern part of Bay of Bengal. Continental self in this part of the Bay is shallow and extended to about fifty kilometers.

The coastline in the eastern part is conical by the shape. Because of these two factors, storm surges generated due to any cyclonic storm is comparatively high compared to the same kind of storm in other parts of the world. When the super cyclones hit the coast of Bangladesh maximum height of the surges can be even fifteen meters, which causes flooding in the entire coastal belt. Worst kind of flooding occurred in 1970 and in 1991.

The coastal areas are also exposed to tidal flooding during the months from June to September having important monsoon wind. Occurring of this kind of flooding is increasing now days.

3.7 Case studies of flood management in Bangladesh

Case Study 1

Flood message has been disseminated to community people by making correlation with forecast of Main River and water level gauge at floodplain with the financial support from Canadian International Development Agency (CIDA) and Technical assistance from Center for Environmental and Geographic Information Services (CEGIS). *Figure 9* shows the flow diagram of dissemination flood message to the community people by using mobile sms.

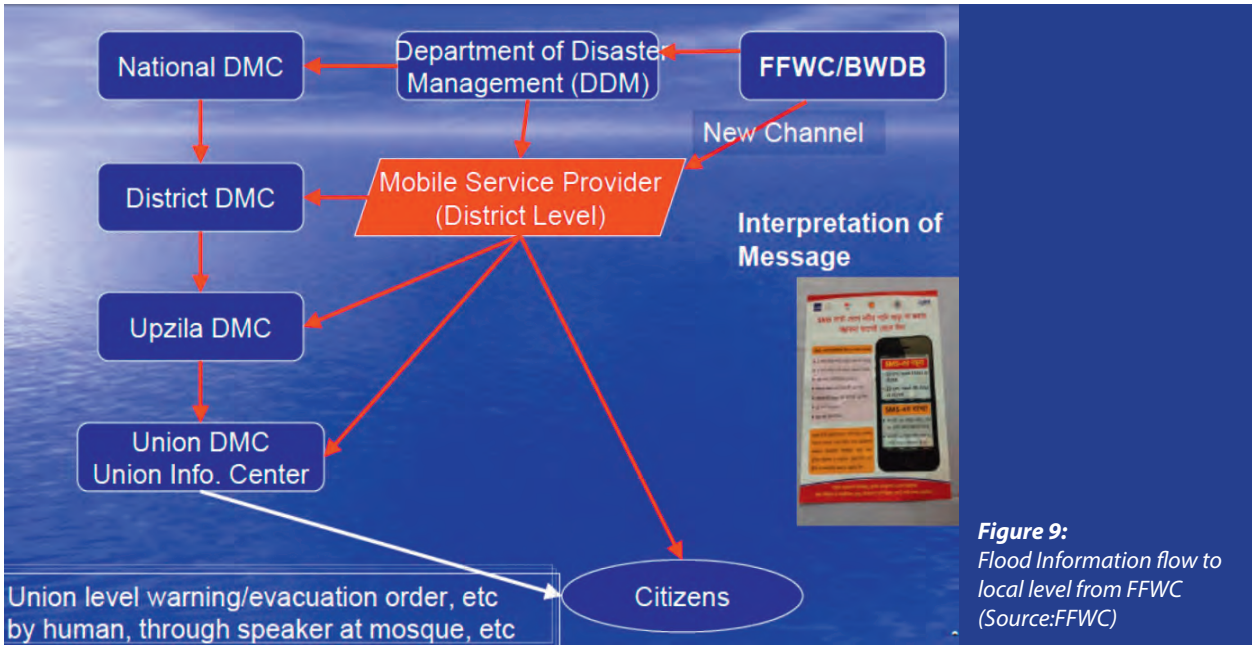


Figure 9: *Flood Information flow to local level from FFWC (Source:FFWC)*

Typical voice message is as follows:

Local level message: *"Welcome to the FFWC of BWDB. Today Friday 15th August 2014. As per the observations of 6 AM this morning Jamunariver at Sirajgnaj is flowing 30 cm below Danger Level. According to the latest flood forecast water may rise 22 centimeters in Ghorjan union, Chowhaliupazila and 29 centimeters in Rajapurnion, Belkuchiupazila in next 5 days."*

Case study 2

FFWC has also taken an initiative to provide community based flood forecast using mobile sms with the technical assistance from RIMES, Deltares and other NGOs and funded by Netherlands Enterpise Agency and CordAid. The pilot site is located at Chowhali and Belkuchi Upazilla of Sirajganj District. Voice message has been prepared based on the flood forecast and the SMS has been sent to selected volunteers of the pilot areas. The volunteers then disseminated to local community.

Case Study 3

FFWC with the help of Department of Disaster Management and financial support from Asian Development Bank (ADB) has experimented another pilot project to disseminate flood warning message to community level by using web based GIS and Mobile technology. The pilot site is located at Islampur and Raumariupazilla of Jamalpur and Kurigram district respectively.

Under this initiative, FFWC has sent mobile SMS directly to local level instead to send it at national level. FFWC prepared flood map with very course resolution Digital Elevation Model (DEM). So, an attempt has been taken to prepare high resolution DEM by topographic survey to develop flood map at local level.

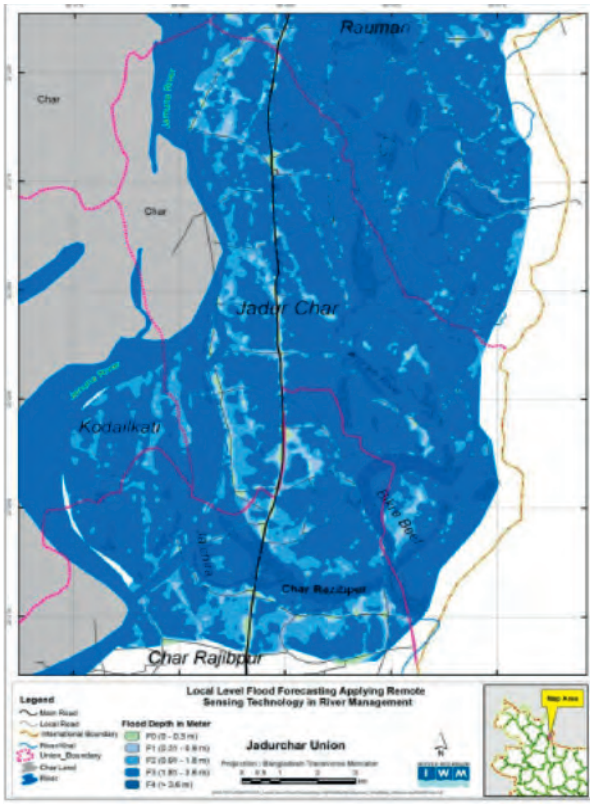


Figure 10: *Local level flood map (Source: FFWC)*

River Bank erosion is a serious issue during flood season. Almost every year several hundred hectors land have been engulfed in to the river bed by erosion which is one of the major disasters in Bangladesh. According to National Water Management Plan (NWMP), Government has focused food management in an integrated way which includes Integrated Water Resources Management (IWRM). Moreover, Community involvement has also encouraged in implementing flood management project for its sustainability.

4 Risk-based national flood and drought management-risk evaluation, goals, state of national flood and drought management

The preparation of national flood and drought management plan needs clear objectives and steps at the very beginning. The national responsible body and the government must discuss the following issues and goals before starting the process of creating the management plan:

- What is the role of government in flood and drought mitigation?
- What is the scope of the flood and drought management plan?
- In which sectors the country is the most vulnerable in economic and social aspects?
- What have been the most important impacts of flood and drought in the past?
- What has been the government's response to flood and drought and how effective it was in the past?
- What is the role of the flood and drought management plan in addressing and resolving conflict between water users when the flood and drought happened? Between companies and habitations, do they both require protection?
- What current trends (e.g. climate, flood and drought incidences, land and water use, population growth) can increase vulnerability and conflicts in the future?
- What human and financial facilities can the government have in the planning process?
- Does the government have other resources or funds related to drought and flood issues?
- What are the legal and social implications of the flood and drought management plans in neighboring countries and in the region?

4.1 Drought risk

Drought risk is defined as a mix of drought vulnerability and drought hazard. Drought hazard varies due to weather and climate variability and drought vulnerability depends on the population exposure and drought prone areas exposure.

4.1.1 Drought risk and impact of drought in India

Drought vulnerability is increasing in the regions with the risk of water shortage and with the important community exposure. In order to reduce drought vulnerability one must improve the understanding of the hazard and the factors that influence vulnerability. The frequency of occurrence of meteorological drought at various levels of intensity and duration defines the drought hazard for drought-exposed regions. One needs to understand the hazard and its developing through the time and space. Establishing of integrated drought early warning systems is crucial. These early warning systems should take into account climate, soil and water supply factors such as precipitation, temperature, soil moisture, snowpack, reservoir and lake levels, ground water levels and stream flows.

There are few different strategies to cope with drought population related. These include diversification of activities, reducing and modifying consumption, reducing expenditures on non-essential goods. In different drought affected regions in India, these strategies are not the same. Severity of drought influence the strategy adopted by the concerned population. Also, different parts of the society in the same drought affected area can have different strategies. In India, for example, small farmers and landless laborers tend to migrate if they face drought situation. Large farmers may diversify their crops so as to reduce the risk.

People in some drought prone areas adopt long term strategies to develop natural resources, soil, water and vegetation by following the watershed development approach, which could minimize severity of drought. That is clear that in the absence of effective government intervention, drought with medium intensity could cause catastrophe and big disaster.

Drought vulnerability assessment in most of the cases is done using the multiple criteria. For such multiple criteria the variables are:

- Meteorological – rainfall, temperature etc.
- Soils - depth, type, available water content
- Surface water use – percent irrigated area, surface water supplies
- Ground water – ground water availability/utilization
- Crop – cropping pattern changes, geo spatial land use, crop condition, anomalies of crop condition etc.
- Socio-economic – population of weaker sections, size class of farm holdings

4.2 Early warning and risk analysis

4.2.1 Early warning and drought declaration in India

Early warning in India is ensured through the immediate measures which have to be taken when drought appears and through regular drought declaration. With a view to ensuring timely declaration of drought, having the priority objectives, the following steps are taken:

- The drought monitoring cell in the States will receive and collate the weather data from multiple sources across the state like Meteorological Department, Irrigation Department, Department of Agriculture, Ground water Department;
- Data on water levels in reservoirs/tanks, ground water etc. are received weekly from the concerned departments.

The data collection at district level is done by the existing departments and the information is transferred to relevant departments. All data received from sub-district level through District and State level will be made available online. The drought monitoring cell is preparing weekly status of weather and crop condition on the following indicators:

- Rainfall deviations
- Number and length of the dry spell
- Progression of crop area at district level
- Satellite derived indicators such as Normalized Difference Vegetation Index.
- Declaration of drought is done in a timely manner often in three phases (1) end of July, (2) end of September and (3) end of November.

4.2.2 Drought assessment and risk analysis in India

In India, in order to improve drought management and reduce drought risk, sustainable strategy was developed. The basis of such strategy is improving the awareness and understanding of the drought and the causes of societal vulnerability. The principles of drought risk management in India are based on the building strong institutional capacity. The improvement and application of seasonal and shorter-term forecasts is done at country level. Integrated drought monitoring and drought early warning systems and connected information delivery systems are put in place. Preparedness plans are developed at all governance levels. Mitigation actions and programmes are also created. For each indicator thresholds it is possible to define intensity of the drought. A normal rainfall succeeding a few years of drought would not wipe out the cumulative effect the earlier drought. From the social and economic point of view, many data have still be updated and taken. For example data related to: trends in agricultural commodity prices, land distribution, copping pattern, and changes in copping calendar, sown area, productivity, livestock density etc. The agricultural sector is the first affected when drought happens. Agriculture depends on stored soil water. Soil water is rapidly depleted during extended dry periods. If precipitation does not come, people dependent on other water sources begin to feel the effects of the shortage.

4.2.3 Drought indicators – Indian case

Like in all other cases, in India, drought indicators are related to drought impact and to drought type. The impacts of drought can be environmental, economic or social. Among the environmental indicators rainfall, water level in the reservoir sand other surface storage systems, ground water depth and soil moisture can be included. A data basis has to be built and regularly updated with the values. For each indicator thresholds need to be fixed, to define problem intensity.

4.3. Independent stakeholder participation; water conflicts, transboundary water issues

4.3.1 Stakeholder input

In drafting a national flood and drought management plan, it is crucial to consider the needs of all stakeholders affected by drought or flood. The primary stakeholders will be farmers in the case of drought, members of industry, representatives from the various sectors that are impacted (energy, tourism, agriculture, etc.), policymakers, decision makers, education sector, average citizens and scientists. The, sometimes competing, interests should be balanced with present and future available water resources and land planning for industrial-economic development, based on

forecasts. It is also important to collect stakeholder input after the implementation of a flood and drought policy to gather feedback on the success of the plan and to improve the next iteration of the plan.

4.3.2 Cooperation between sectors

Within any country, multiple sectors are affected by flood and drought. These sectors include, but are not limited to, energy, agriculture, tourism, and industry. Each relevant sector should be given the opportunity to voice their concerns and should be engaged in negotiations as water resources become scarcer and hazard more intense.

4.4 Transboundary cooperation in flood management in Thailand and Vietnam

The Mekong River Commission (MRC) offers such mechanism with its officially recognized role to address differences and to facilitate bilateral agreements between its Member Countries with respect to trans-boundary issues. For instance, the MRC is playing a role of neutral facilitator to the Member Countries on land-use or structural flood mitigation measures. MRC holds the unique position to build confidence among the neighboring countries through its ongoing programmes such as Water Utilisation Programme, the Basin Development Plan and the Environmental Program and also assist in coordinating floodplain management aspects of national programmes. In strengthening trans-boundary collaborations, existing mechanisms were utilized in creating awareness between the neighboring provinces between Cambodia and Viet Nam as well as Thailand and Lao PDR for exchange of flood information and cooperation in flood response. Between Kandal and Prey Veng provinces of Cambodia and An Giang and Dong Thap provinces of Viet Nam, prospect of promoting trans-boundary flood emergency assistance has been set in motion with bilateral meeting and initiation of a joint planning on flood preparedness and resource sharing. Building on this existing mechanism, the provincial disaster management authorities in conjunction with national counterparts worked on the inclusion of trans-boundary emergency assistance and flood preparedness into the regular meeting agenda. A similar intervention of flood risk reduction cooperation between provinces of Lao PDR (Khamamoune) and Thailand (Nakhom Phanom) has also been initiated under the component 4 of the FMMP. A preliminary activity for the development of a detailed joint plan has been initiated in the form of a provincial meeting. It is anticipated that the upcoming meeting will also address to a considerable extent the strategy for integration of trans-boundary issues into development planning at the provincial levels.

4.5 Data for drought and flood management

4.5.1 Information delivery

Scientific data should be easily accessible to any interested stakeholder. Therefore, an internet-based delivery system is ideal, allowing even remote farmers or small cities to access the latest forecasts and meter readings. Furthermore, information must be made immediately available to policymakers so that in the event of a drought or a flood, appropriate and timely action can be taken to mitigate negative outcomes.

5 Need for national flood and drought management plan

Since recent years, a number of countries have suffered from a series of natural hazards, especially severe drought and flood which have an impact on people, food production, water resource security, economy and finally livelihoods. The majority of people are dependent on agriculture, which is highly vulnerable towards climate conditions on a seasonal basis.

Climate change increases the vulnerability of agriculture towards extremes. The main reason is the reinforcement of the hydrological cycle that will lead to an increase in the frequency and intensity of the extremes such as flood and drought. In order to adapt to the impacts of climate variability and change, there is a need for tools to be used to monitor and forecast drought and flood.

Global environmental change has a differentiated gender impact, with women assuming more work and responsibility. Women are the main producers of agricultural products in least developed countries, which make them more vulnerable to climate change and drought. Drylands involve specific problems for women because of gender-based roles and different levels of access and control of resources between genders.

Agricultural and environmental policies are a crucial contribution in the management of dryland resources, but fail to attend to women's needs. When land becomes scarce, the situation of women deteriorates, together with the food security of their households. As women have the task of finding and providing evermore-scarce water resources for the subsistence of their families, their livelihoods are the most affected with the creation of irrigation systems for agricultural production, better water resources management and better access to rivers, waterbeds and waterways.

Mitigating the impacts of drought and famine, of flood and their economic consequences, is one of the primary aims of many governments and humanitarian organizations. Mitigation, however, cannot be effective if the causes and characteristics of flood and drought events and the indicators of their realization are not well understood. The first action in getting a better understanding is to have an effective monitoring system that is capable of measuring various characteristics of the processes as objectively as possible. To treat the problem and to mitigate its impacts, proper National policies are needed in the countries, at the country level.

5.1 Flood management strategies in Bangladesh

Flood management can be considered from different points of view in respect to the life improvement, environmental and socio-economic impacts. In various parts of the world flood management techniques are practiced in different ways. All the methods and techniques for flood management are classified into three main categories and they are as follows:

5.1.1 Structural measures

In Bangladesh one can find that exist structural measures such as flood embankment, channel improvement, river training, coastal embankment etc. to combat the flood disasters. Among these structural measures, construction of embankment is most popular and very old practice in Bangladesh. This is indeed a very cheap method compared to other structural measures. With the experience over the last few decades, it was observed that the structural measures are basically not done only blessings. They also have bad effect. The negatives effects do not appear shortly after their construction, they appear after some time.

5.1.2 Structural cum non-structural measures

The engineering constructions, improvement or change in agronomic practices and watershed management are now applied in Bangladesh to mitigate the flood and to combat the negative flood effects. Some of this method is very cheap compared to other methods. Adoption of agronomic practices change or watershed management requires very high level of community participation. Community awareness campaign is very important to achieve good results with such flood measures.

5.1.3 Non-structural

Non-Structural measures consists the flood plain zoning and management, infrastructure planning policies and development in the flood plains, flood proofing, disaster preparedness and response planning and flood forecasting and warning. Due to the fact of increased population it is a typical scenario in Bangladesh that the human habitat is expanding and moving more and more towards flood plains, which are vulnerable to frequent flood. Moreover, more lands of the flood plains are being occupied and converted to habitat and agricultural lands, which were mostly, back swamp. Flood plains are considered as the extended part of the main river channel. During high flows, the flood plains usually act as temporary detention basin and also are transmitting excess water to the downstream. Due to increasing occupation of the flood plains for the known reasons, the areas for temporary detention basin and conveyance of the flood flow is very much restricted. As a result, the recurrence of flood is increased and the flood damage becomes important. Flood plain zoning and management is the effective means of regulating habitat construction and agricultural use with minimum environmental damage in the flood plains. Due to the population in increase the flood plains, the governments are obliged to carry out more and more development projects in the flood plains. Having the construction of the infrastructure in the flood plains, it is obvious that flood vulnerability increases. It is now much noticed that appropriate policy formulation is needed for infrastructure planning and development in the flood plains to avoid negative environmental impacts and to lessen the flood vulnerability. Policy formulation should be scientifically and research based. Bangladesh Government has already finalized Flood Management Strategy in 1995, National Water Policy in 2004 and National Water Management Plan in 2011. Flood proofing is a measure, which has been found to have less negative environmental effects. In most of the flood prone areas in Bangladesh, the people used to flood proofing technique in such a way that people build their houses on the built-up earthen mounds. This is being in practice for centuries. Community participation and awareness are very important in the flood proofing measures. Many of the damages of the flood can be reduced to a great extent through a proper Disaster Preparedness and Response Planning, which is, in spite of many efforts, lacking in most of the LDC's (Least Developing Countries) and the Developing Countries. With the increased awareness on this issue, Disaster Preparedness and Response Planning in many countries are being improved. For the Disaster Preparedness regarding the flood, the most important tool is the Flood Forecasting and Warning System. If the flood depth and duration can be forecasted well in advance, the community vulnerability can decrease. That helps the disaster managers and the communities to formulate their own strategies to mitigate flood. With the current advancement in the information technology and hydrological and hydraulic sciences, it is possible to provide most accurate advance warning. It is now found that if advance warning is not sufficient, the dissemination of information to the people in the flood prone areas is also very useful and important. The assessment of the people response to the flood warning is very important element for the planning process. Disaster Preparedness programme cannot be made successful without proper response planning.

5.1.4 Modification in flood management strategies in Bangladesh

After many disastrous flood in Bangladesh the Government brought many flood management strategies changes. Most important change was in the policy development for different infrastructures. The Government decided to build all structures of strategic importance above the flood level of 100 yr frequency. Government also decided to construct in the flood prone areas school buildings having the option to use them as temporary flood shelters. As are result all the national high ways were raised to meet the new standards. The Government also decided to stop encroachments on the flood plains and adopted the legislation which is controlling constructions within the flood plains and wet lands. Even, such legislation took place, the Government could not effectively control the encroachments in the flood plains. Consequently, the Government has taken very strong measures to implement the legislation especially in and around the capital Dhaka city because of important population movement to protect the environment. Government is also seriously

considering further legal instruments to implement the legislation effectively all over the country. The Government of Bangladesh to measures to strengthen the flood forecasting and warning system in the country. The new concept was introduced to control flooding as per desire of the stakeholders instead of making some areas completely flood free. The pilot project is constructed on the basis of this concept, which is known as Compartmental Pilot Project(CPP), Tangail. The project is divided in to several units on the basis of land topography and micro-hydrological zoning. In this pilot project flooding is allowed in each unit as decided by the stakeholders through consultation among themselves in the Water User Groups. This group has responsibility to operate flood mitigation facilities by themselves. It is being thoroughly studied for its replication in all future projects and in other areas. After 2004 flood the Government adopted a policy of IWRM. Government is now putting more emphasis on non-structural measures for flood mitigation. Specially, the Government of Bangladesh indorsed a policy of community involvement in flood management. Flood management is now considered as an indispensable component of poverty reduction strategy.

5.2 Flood management and mitigation in Thailand and Vietnam

5.2.1 Flood causes in Thailand

In October 2011 the most severe flood happened in Thailand. One very long and heavy monsoon season caused flooding from Bangkok's Chao Phraya River and several other neighboring river systems. Long time inappropriate planning and management of water resources, together with the pressure from rapid urban growth, compromised the efficacy of both natural and built drainage courses from Bangkok to the Gulf of Thailand.

More than fifty provinces were affected by the severe flood, and those immediately north of Bangkok faced total crisis, experiencing a substantial share of flood-related fatalities, economic losses, and the resulting humanitarian crisis. Flooding devastated the seasonal rice crop vital to the agricultural region, affected thousands of small- and medium-sized businesses, and submerged at least seven large industrial parks in Ayutthaya and Patumthani that are home to major international and domestic industrial operations. These large-scale factory closures left more than two hundred thousand industrial workers without regular income for several weeks, and interrupted the supply of computer, automotive, and other components to global supply chains.

5.2.2 Flood management in Thailand, Vietnam and Cambodia

In the Lower Mekong River Basin (Cambodia, Lao, Thailand and Viet Nam) nearly sixty million people are leaving. Along the Mekong River, every year flood damage directly human lives. Millions of dollars is the damage to the property. Livelihoods and crops are destroyed. People have increased risk of poverty, malnutrition and disease. At the same time, flood are an important and essential natural process, bringing water, nutrients and other benefits to floodplains, wetlands and ecosystems. Climate, and particularly the Southwest monsoon, is the immediate cause of the annual flood. Most basin inhabitants are poor rural farmer and fishers. Most of them are rich in resources. One third of the population lives on less than a few dollars per day. Being poor make them more vulnerable to flood since the cheapest places to live are those which are mostly damaged by flood. Flood damage in the lower Mekong basin comes from a combination of direct losses due to the fact of inundation and secondary losses due to the suspension of normal economic activities in the commercial and service sectors. That happened many weeks after the end of the flood event and until the damage is repaired and the inventory replaced. Assessing these figures in dollars requires detailed survey of pilot areas. One is then apply such survey to the flood affected region on a loss per unit area basis. This is the methodology endorsed in each country in the basin. Relevant data are available from the relevant National Disaster Management Agencies.

The most devastating flood happened in 2000 in the south of the basin and in 2008 in the northern parts. If one knows the causes and the impacts of the Mekong flood, it needs to be solved how to get people ready for flood before the flood come and how to help people cope with flood. The current status of flood management and mitigation in Thailand, Vietnam and Cambodia has improved considerably from response to flood when they occur and crisis management to prevent major damage or to be prepared in advance for disaster. The preparedness level has to be improved from the institutional coordination point of view. To deal with the Mekong flood more effectively there is a need for continued support of local disaster management authorities in flood preparedness, disaster risk reduction activities and the capacity-building.

The Flood Management and Mitigation Programme (FMMP) of the Mekong River Comission is a ongoing programme which started in January 2005.

The FMMP provides technical and coordination services to the four countries in the Lower Mekong Basin to prevent, minimize or mitigate the civil and socio-economic losses due to flood and flooding, while preserving the environmental benefits of flood. Forecasts, flood data, technical standards, capacity-building and training packages are key outputs of the programme. The programme has five components:

- Establishment of a Regional Flood Centre
- Structural Measures and Flood Proofing
- Mediation of Transboundary Flood Issues
- Flood Emergency Management Strengthening
- Land Management

5.3 Drought management in Bangladesh

Drought conditions prevail in Bangladesh due to shortage of rainfall (10 days) during pre-monsoon and post monsoon. In drought situation soil moisture level in the agricultural lands become very low and river water also gets very low flow. Similarly, ground water level becomes extremely low at many places especially northwest Barind region of Bangladesh. Bangladesh is located in sub-tropical monsoon climate with annual average precipitation is 2,300 mm, varying from 1,200 mm in the north-west to over 5,000 mm in the north-east (FFWC, 2014).

Though drought are not always continuous in any area, they do occur more frequently in the low rainfall zones of the country. Occurrences of drought as a major water deficiency related issue is most profound in the north-west region of Bangladesh (WARPO, 2005), which has the lowest average annual rainfall in the country (1450 to 1800 mm). Irrigation is very important during dry conditions due to lack of water availability. Sometimes surface water irrigation is very difficult due to insufficient flow of the major river system.

The major causes of drought are shortage of rainfall during dry period which includes absence of sufficient moisture in the air. Global or regional oceanic and atmospheric circulations (El Nino/southern oscillation) influence the rainfall in various regions of the earth like monsoon rainfall in Bangladesh. The correlation between sea surface temperature and rainfall is considered as a potential cause of long dry regimes.

Bangladesh is located at the downstream of Ganges-Brahmaputra-Meghna (GBM) basins and receives abundant water during monsoon period and less water during dry period. There are 57 transboundary rivers (BWBD, 2011) which carry water through Bangladesh. Due to decrease of flow in dry period of those rivers is one of the reasons to prevail water scarcity for surface water irrigation.

Historically Bangladesh had experienced several severe drought. For instance, between 1949 and 1991, drought occurred in Bangladesh 24 times. According to WARPO (2005) very severe drought hit the country in 1951, 1957, 1958, 1961, 1972, 1975, 1979, 1981, 1982, 1984 and 1989. Past drought have typically affected about 47 % area of the country and 53 % of the population (Mirza and Paul, 1992). Drought severity varies from place to place based on water availability both ground and surface water. Northwest part of the country is the worst drought affected area in Bangladesh. Drought caused 25 to 30 % loss of crops in northwest region of Bangladesh (Rahman et al., 2008). Percentage area is affected by drought from 1951 to 1979 is shown in *figure 11*.

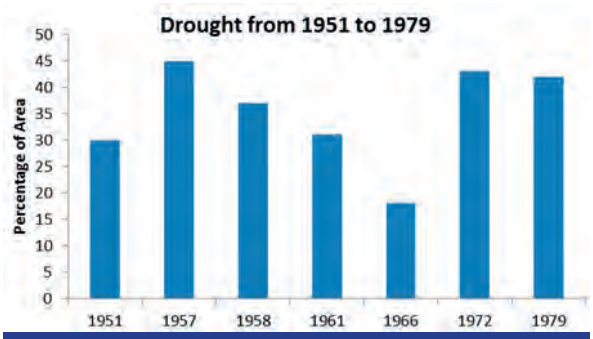


Figure 11: *Drought affected areas of Bangladesh in different (1951–1979) years (Source: Bangladesh State of Environment, 2001)*

Impact of Drought on Agricultural crops

In Bangladesh, drought has impact on various sectors- agricultural crops, livestock, fisheries, ground-water resources and environment (U. Habiba et al., 2011). Agricultural crops are mostly affected due to drought in Bangladesh. Agricultural seasons in Bangladesh are divided into primarily two types: i) Khraif and ii) Robi (BBS, 2012). Moreover, Kharif is further classified in two parts i) Pre-kharif and Kharif. There are possibilities of getting affected of crop in Pre-Kharif and Rabi by drought due to late monsoon

Table 2: *Cropping seasons in Bangladesh)*

Cropping seasons	Time period	Remarks
Pre-kharif	March–July	Early monsoon cropping season
Kharif	July–October	Monsoon cropping season
Rabi	October–March	Post monsoon/dry period

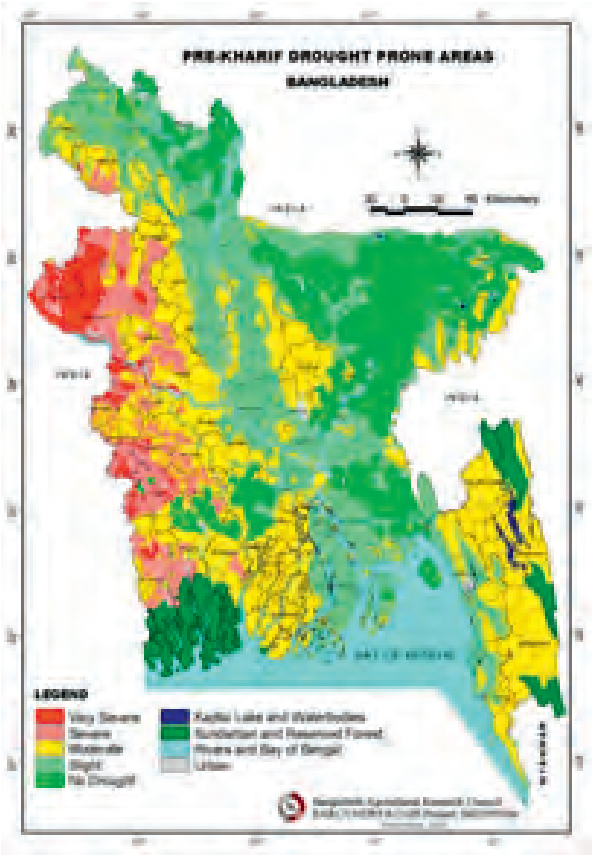


Figure 12: *Pre-Kharif Dorught prone areas in Bangladesh (Source: Bangladesh Agricultural Research Council, BARC)*

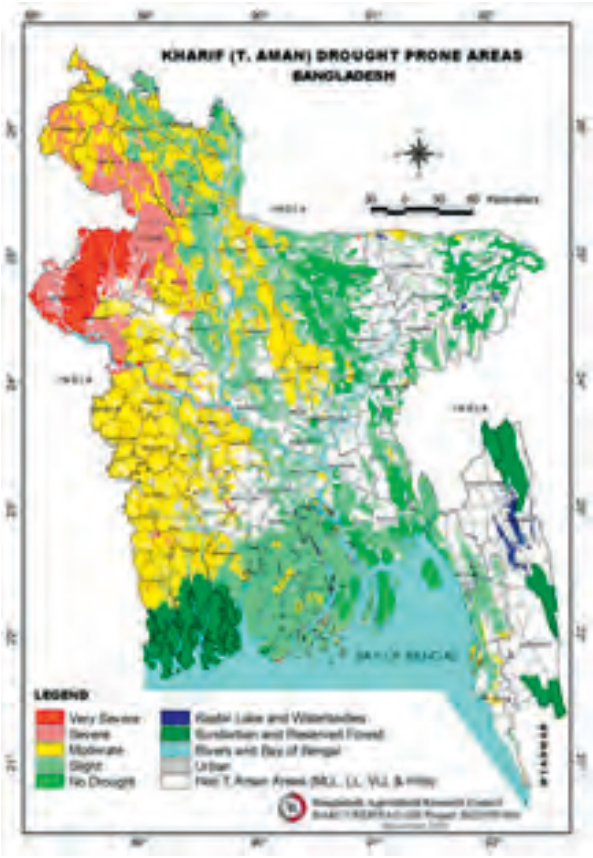


Figure 13: *Kharif drought prone areas in Bangaldesh (Source: Bangladesh Agricultural Research Council, BARC)*

and low river water flow. *Table 1* shows the cropping seasons and their timing periods in Bangladesh. Different cropping seasons get various degrees of drought which are classified as very severe, severe, moderate and slight.

Figure 2, 3 and 4 show the drought prone areas in three different cropping seasons, and *Table 2* shows the severity of affected area for different cropping seasons.

Different study reports show the severity of drought on agriculture in Bangladesh and among them rice is mostly affected. Iqbal (2001) calculated crop damaged between 20 to 60 % and in some cases more than 60 % based on drought severity for T. Aman and other rice varieties both in Pre-Kharif and Kharif. According to Climate Change Cell (2007) about 2.18 million tons of rice was damaged due to drought and 2.38 million tons due to flood during the period 1973–1987.

Table 3: *Drought Severity Areas in Million ha for different parts of Bangladesh (U. Habiba et al., 2013)*

Drought Class	Rabi Season	Pre-Kharif Season	Kharif Season
Very severe	0.446	0.403	0.344
Severe	1.71	1.15	0.74
Moderate	2.95	4.76	3.17
Slight	4.21	4.09	2.90

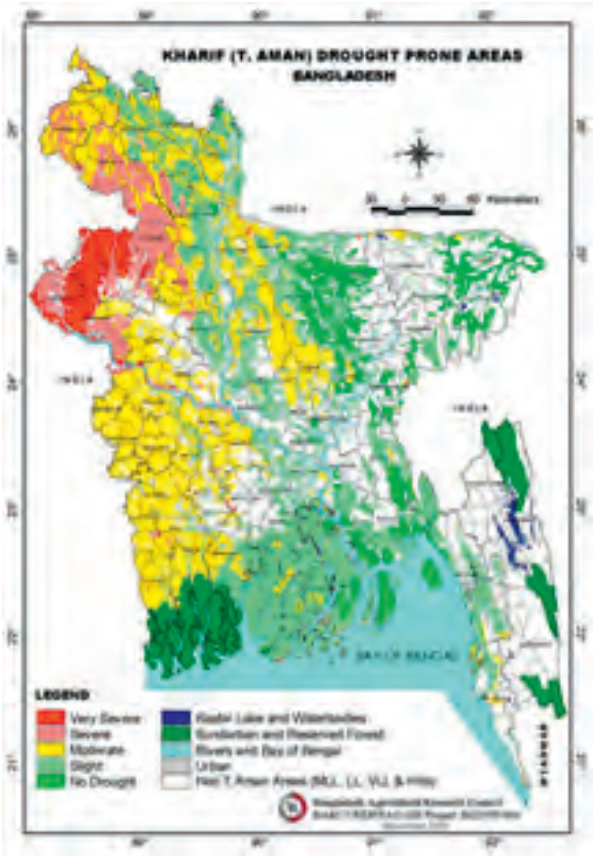


Figure 14: *Rabi drought prone areas in Bangladesh (Source: Bangladesh Agricultural Research Council, BARC)*

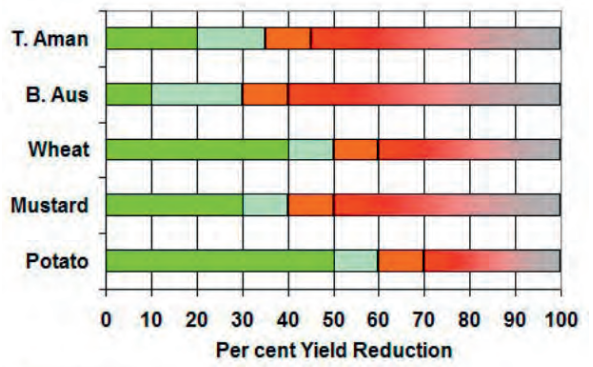


Figure 15: *Impact of drought on crop production (Source: Climate Change Cell, 2006)*

Drought affects annually about 2.32 million hectares and 1.2 million hectares of cropped land during the Kharif (summer) and Rabi (winter) seasons respectively. Such as rice other crops also affected by drought like wheat, jute, potato, different oil seeds and pulses, vegetable etc. (Ahmed, 2006).

Figure 15 presents the reduction of crop yield in percentage due to drought in Bangladesh.

5.4 Drought management

Institutional arrangements and capacity development of local community are required for drought management to adapt the situation. Drought management focused mainly water and soil management at the field level to maximize food security in drought conditions. Structural intervention like increase water storage capacity by digging ponds or constructing small reservoirs or rehabilitation of the existing wetlands or retaining water in the river reach can play important role in drought management. Similarly, drought monitoring and warning can reduce damage significantly by taking suitable measures in ahead of drought.

5.5 Act, policy, plan for drought management aspect in Bangladesh

Department of Disaster Management (DDM) in Bangladesh is responsible to implement various rules, regulations in connection with disaster management as well as well as the national disaster management principles and planning. The regulatory framework provides the relevant legislative, policy and best practice framework under which the activity of Disaster Risk Reduction (DRR) and Emergency Response Management (ERM) in Bangladesh is managed and implemented". The regulatory framework includes – Disaster Management Act-2012, National Water Management Policy (NWMP), Bangladesh Water Act. (2013), Standing Order on Disaster (SoD), Disaster Management Plan-2010-15, Disaster Management Policy, Guidelines for Government at all Levels (Best Practice Models), National River Conservation Act 2013 etc. SoD of Bangladesh outlines the disaster management arrangements in Bangladesh and describes the detailed roles and responsibilities of Committees, Ministries, Divisions, Departments and other organizations involved in disaster risk reduction and emergency response management, and establishes the necessary actions required in implementing Bangladesh's Disaster Management Model, e.g., defining the risk environment, managing the risk environment, and responding to the threat environment.

5.6 Institutional role in drought management

Different organizations are working in agricultural sectors; water management and disaster management organizations are involved in drought risk management activities in Bangladesh.

Table 3: *Major Agencies in Drought Risk Management*

Sl. Nr	Agencies	Role
1	Bangladesh Water Development Board (BWDB)	Surface and Ground Water Management- Surface Water Irrigation, Dredging of major river systems, Flood Control, Drainage, Irrigation, River Training, Coastal Polder Management and Salinity management, Wetland Management, Mitigation of Climate Change, Hydrology and meteorological, River Morphology, and Water Quality data collection and management
2	Bangladesh Agricultural Development Corporation (BADC)	Agricultural Development and Minor Irrigation
3	Department of Agriculture Extension (DAE)	Agricultural Extension Activities- Introduce crop diversification
4	Barind Multipurpose Development Authority (BMDA)	Work in Drought prone areas- Rajshahi, Naogaon and Chapai Nawabganj. Major activities-Installation of DTWs, Re-excavation of ponds, Afforestation, drinking water supply through the DTWs
5	Bangladesh Rice Research Institute (BRRI), Bangladesh, Agriculture Research Institute (BARI) Bangladesh institute of Nuclear Agriculture (BINA)	Research and Development on new varieties (e.g. drought tolerant crop) for drought conditions
6	Department of Disaster Management (DDM)	Co-ordinate among different organization to reduce drought risk. Operation of emergency activities during drought conditions
7	Bangladesh Meteorological Department (BMD)	Meteorological Data sharing with respective organizations for detecting the drought forecast and warning.

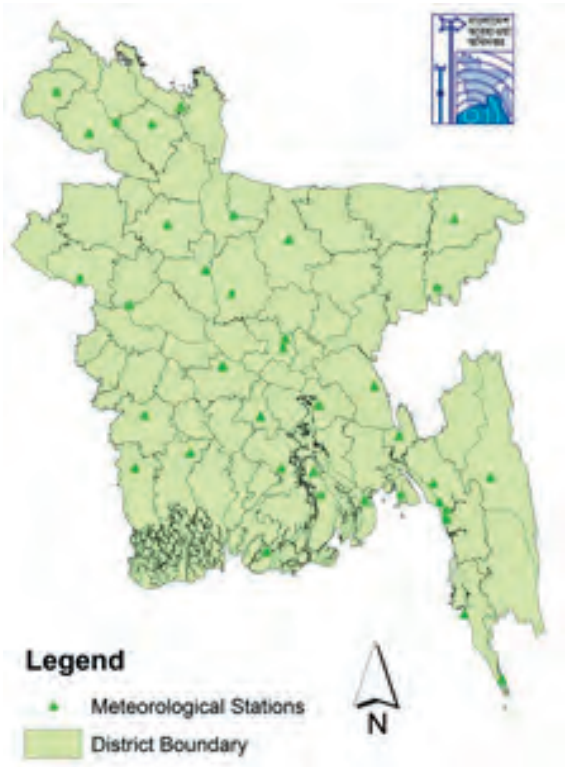


Figure 16: *Surface Observatory of BMD*

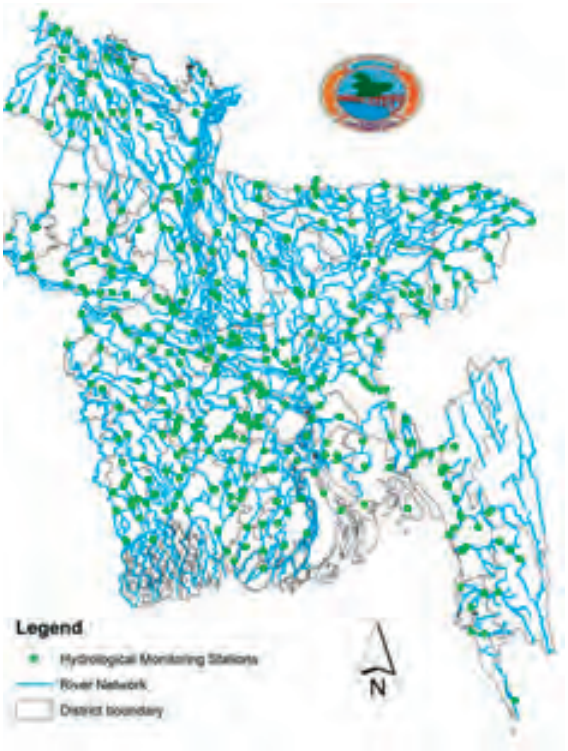


Figure 17: *Hydrological observation of BWBD*

5.7 Hydrology and meteorological monitoring

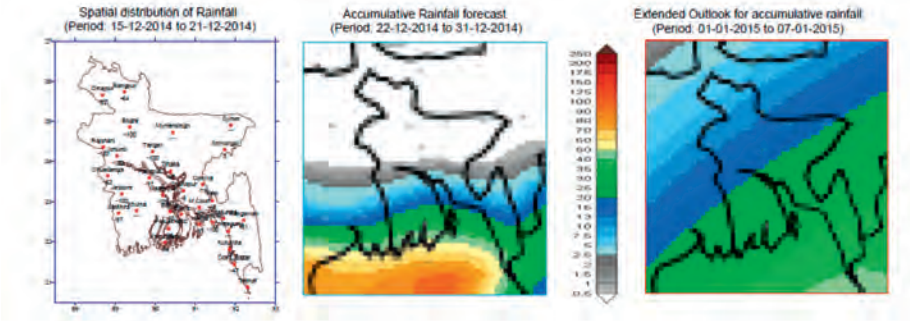
Hydrology and meteorological data has vital roles in drought monitoring and warning. Bangladesh Water Development Board (BWBD) is responsible for collection and archiving hydrology and meteorological data like water level of surface and groundwater, river flow, rainfall etc. The BWDB surface water, meteorology, and ground water network have designs all very mature and have excellent spatial coverage throughout Bangladesh (Innovate, 2012). Bangladesh Meteorological Department (BMD) weather related data like rainfall, temperature, evaporation, winds speed, pressure etc. It also maintains a network of surface and upper air observatories, radar and satellite stations, agro-meteorological observatories. Figures show hydrology and meteorological network of BMD and BWDB respectively.

5.8 Meteorological forecast

BMD is responsible for monitoring as well as issuing forecasts and warnings of all meteorological extreme events like tropical cyclone, severe thunderstorm/ tornadoes, heavy rainfall, drought, cold and heat wave along with daily routine forecasts round the clock. The forecast related to occurrence of rainfall help to take measures against incipient drought situation. BMD also issues one month and three months climate outlook which may be useful in agricultural planning.

Agrometeorological forecast

Agriculture sector is mostly affected due to drought situation in Bangladesh. Therefore Agro meteorological Forecast is very important for the farmers to farming activities. BMD issues weekly agrometeorlgical forecast for the farmers.



Highlights:

Country average of bright sunshine hour was 6.30 hours per day during the last week.

Country average of free water loss during the previous week was averaged 2.49 mm per day.

Weather forecast and Advisory for the period of 22.12.2014 to 31.12.2014.

Bright sunshine hour is expected to be between 5.50 to 6.50 hours per day during this week.
Average of free water loss during the next week is expected to be between 1.50 mm to 2.0 mm per day over Northern part and 2.0 to 2.50 mm/day over the Southern part of the country.

- Ridge of Sub-continental high extends up to West Bengal and adjoining area. Seasonal low lies over South Bay.
- Weather may remain mainly dry over the country during the first half of this period. Light rain (4-10 mm) may occur at Southern part of the country during the end of this period.
- Light to Moderate fog may occur from mid-night till morning over northern to middle part and river basin areas of the country during this period.
- Day and night temperatures may remain nearly unchanged over the country during the first half of this period and slight fall in day temperature and slight rise in night temperature are expected over the country during the second half of this period.
- Fungicides may be applied on potato crops during the first half of this period to save it from early blight diseases.
- Weather condition of this week may be favourable for preparing Boro seed bed.

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Deputy Director
For Director
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Figure 18: *Agrometeorological forecast Bulletin issued by BMD*

Figure 8 shows a typical agrometeorlgical forecast issued by BMD available at *http://bmd.gov.bd/?/p/=Agromet-Forecast*

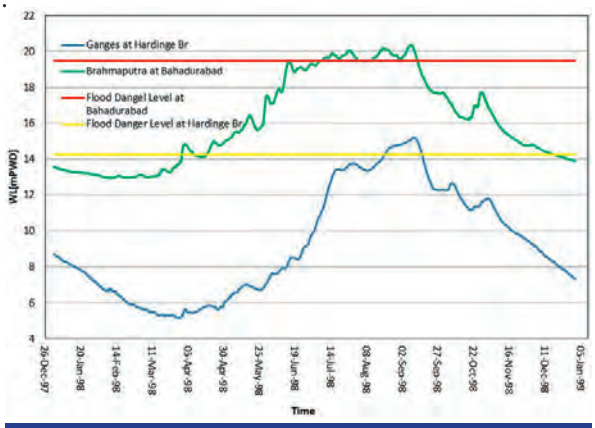

Figure 19: *Water level Flow Hydrograph of the Ganges River at Hardinge Bridge*

5.9 Hydrological information

Hydrological information is most useful to estimate water availability during dry period. Hydrology wing of BWDB regularly collect water level, discharge/river flow for the major and all important river systems of the whole country. Processing and Flood Forecasting Circle of BWDB processes, disseminates and archives of those data. A water level hydrograph of the Ganges River at Hardinge Bridge is shown in *Figure 9*. Relevant Departments or Agencies can easily collect data from BWDB and analyze the hydrological situation during drought period and recommend some measures.

Flood Forecasting and Warning Center (FFWC) of BWDB gives flood forecasting for the major river system during monsoon period. Low flow forecasting is essential in dry season to combat with drought situation. FFWC should take necessary steps to provide low flow forecasting in Bangladesh.

5.10 Action plan for drought under NPDM

Government of Bangladesh has prepared National Disaster Management Plan (NDMP) 2010 – 2015 for mainstreaming of disaster risk reduction and climate change adaptation. It has focused on the professionalism disaster management system, institutional strengthening, empowering risk communities and expanding risk reduction programming across hazards and sectors etc.

Operational practice for drought management
SoD describes role and responsibilities of different agencies in disaster management before, during and after disaster. According to SoD (2010), BMD will issues warning regarding meteorological disaster like drought, cyclone etc. In addition to that other agencies will perform some special duties during disaster like drought.

SPARRSO
Supply analyzed information on drought, flood, cyclone, tornado, storm surge etc. near time satellite images to BMD, FFWC, DAE, Department of Food and Agricultural Information Service and DDM.

Agricultural information services (AIS) of DAE
Agriculture information service will collect early warning information on drought, flood, flashflood, salinity from different early warning center and disseminate to the community level and copy to DDM for possible mitigation and coping measures

Department of disaster management (DDM)
Risk Reduction: Conduct research on drought mitigation, livelihood support and disaster recovery funding etc.

Table 5: *Risk reduction for Drought (NPDM, 2010)*

Expected Outcome	Expected Outcomes	Action Agenda for 2010-2015	Lead Agency	Supporting Agencies
Update Drought Hazard Map	Local and national development plans are developed on the basis of the updated hazard maps and anticipated climate change induced hazards	1. Conduct Hazard Risk Analysis and produce updated hazard maps 2. Conduct climate change modelling, cyclone & Storm surge modelling, flood and drought modelling and produce anticipated hazards maps	DDM	Ministry of Defence/ MoWR/ Ministry of Science and Technology/ BUET/ IWM/CEGIS/NGOs / Development Partners

Duties of DRR Officials at Field Level (District and Upazila)
Ensure speedy and effective publicity of forecasts and warnings relating to disasters (tornado, cyclone, tidal surge, earthquake, landslide, river erosion, tsunami, heavy rainfall, no rainfall, drought, flood, water logging, high tide, cold wave, etc.) among all officials of the district, relevant individuals/organizations and take measures to send the messages to the concerned individuals at the union, Pourashava and Upazila levels.

5.11 Adaptation aspects for drought

Various adaptation approaches can be taken to adapt drought condition. Water resources and agricultural practices can reduce impact of drought significantly. Introduction of new varieties of rice which is drought tolerant can be a good option along the other agricultural practices. Similarly, water management strategies like supplementary irrigation, installation of deep well can also effective in drought management.

Different training programmes are essential for the capacity development of local farmers for drought management at field level. *Table 5* shows some of the options in case of drought management.

Bangladesh is vulnerable to climate change impact due to various reasons like geo-graphical location, socio economic condition and already it is facing different extreme climatic events. Agricultural sector will be more affected due to climate change. Bangladesh government has also prepared National Adaptation Plan and Bangladesh Climate Change Strategic Action Plan to combat climate induced various disaster including drought. Timely application of those action plans can make reduce loss and damage to drought. It is also important to apply innovative technologies in drought monitoring. Index based system and use of remote sensing are very useful for drought monitoring. Inter agencies cooperation specially water managers and agricultural extension officers very essential during drought situation. Emphasis should be given on use for both surface and ground water.

Table 6: *Example of some adaptation Options*

Sectors	Options	Remarks
Agriculture	Introduce New Drought tolerant Varieties Short duration crops Vegetable Garden	BRRI has introduced some varieties on drought tolerant BRRI dhan 42, BRRI dhan 43 , BARI dhan 56 and BARI dhan 57
Water management	Supplementary Irrigation Rainwater Harvesting Installation of Deep Tube well Increase water use efficiency	
Soil Management	Crop Rotation Conservation of soil moisture	
Capacity Development and Technology Transfer	Community Training Program on drought management	NGOS can play important role in capacity-building of local people

6 National flood and drought management plan – procedures with many actions

6.1 Sequence of actions-STEPS to create a national flood and drought management plan

Survey All Relevant Parties – It is crucial to conduct a wide-reaching survey of all stakeholders who are affected by flood and drought. This list should include: farmers, policymakers, public and private companies, education sector, hydrologists and climate scientists, and other sectors of the government like tourism and energy. The survey should discover the main challenges faced by these sectors during a drought and a flood, the mitigation methods they use before a drought or flood hits, and where they need the assistance from the government.

- Find Gaps and Overlaps – When the national government, various government agencies, local governments, international organizations, and NGOs are all independently tackling an issue, there is sure to be overlap. Prior to formulating the policy, it will be essential to determine which bodies are accomplishing which tasks and whether or not all bases are being covered. A key priority of the national policy should be to eliminate redundancy and streamline the mechanisms involved in managing a drought or a flood.
- Determine a Budget – Each country will have its own financial circumstances to consider in allocating funding for flood and drought mitigation and planning. In determining the budget, the essential elements above should be considered and modified according to the needs and abilities of the country, keeping in mind that a proactive national flood and drought policy will, in the long run, be more cost-effective than a reactive drought-flood management plan.
- Raise awareness among the stakeholders on national flood and drought policy development in order to get their input
- Draft the national flood and drought management plan – Using input from all stakeholders, craft a plan that focuses on self-reliance and risk management rather than crisis management.
- Review – After the flood and drought management plan has been implemented and tested, conduct another survey of stakeholders to assess government performance. Weaknesses in the policy should be amended and strengths should be expanded.

6.2 Challenges in drought management in India

6.2.1 Actions in national drought management plan – Indian case

India has a national drought management plan which was established and which applies to all states. Such national drought management plan in India has the following lines:

- Taking on board all contemporary knowledge, experience and information. Identify clear destinations and road maps. Involve all stakeholders.
- The standard procedures for drought declaration are established. The risk gravity and the vulnerability of various States are clearly defined.
- Development of standard procedures for drought vulnerability assessment and generation of vulnerability maps in each state are made.
- The critical areas for minimizing loss of lives, livelihood and property are identified.
- Measures are put in place for drought proofing.
- The India Drought Management Centre (IDMC) is set up.

Integrated drought management comprises development of a centralized data base at state level and at nation level related to drought intensity assessment and drought vulnerability assessment.

Drought declaration is taken as a priority. Information and communication technologies applications are promoted to create the databases and for effective monitoring. Effective use of e-mail, video conferencing, mobile phones is encouraged. Remote sensing technology is encouraged to study historical and future trends of the drought occurrence and its effects. There is institutional participation and use of collective expertise in the drought intensity assessment, drought vulnerability assessment and drought declaration. A common policy is needed to achieve the short-term relief measures. Long-term interventions from different Ministries and Departments are foreseen for drought management in India The best practices in drought management are identified and applied.

6.3 Challenges in flood management in Thailand and Vietnam

Flood preparedness and flood emergency management is the essential element of Mekong River Commission Management and Mitigation Programme (FMMP). This programme is responding directly to the needs of the flood vulnerable communities and guides the strengthening and operations of government agencies in the Mekong river basin countries at different levels: nation, provincial, district and commune level.

National and international NGOs are also strengthening through the programme. This is vital for enhancing communication, coordination and cooperation between these stakeholders, as well as the quality of national disaster management and mitigation policy implementation. The experiences nowdays show that increased capacity of the key officials of the provincial, district and commune Disaster Management (DM) committees has led to a better flood preparedness in the selected provinces in Cambodia, Laos, Thailand and VietNam. Active involvement of national government and local authorities at provincial, district and commune levels in the formulation and implementation of the Flood Preparedness Programmes (FPP) has been a major step to ensure consistency, ownership and sustainability, in addition to the activity of integrating Flood Risk Reduction (FRR) into local development plans. The flood preparedness and emergency management initiatives have helped vulnerable provinces be better prepared for flood. While the FMMP contributions is helping the Mekong river commission member countries, covering some of the vulnerable provinces and districts, and improving the competence in dealing with the Mekong flood, a longer term sustainable approach and regional scaling-up is needed for wider geographical area to ensure that the flood management and mitigation policy objectives are incorporated into the national disaster management strategies of Thailand, Vietnam and Cambodia.

The role and mandate of the Mekong River Comission, being an inter governmental regional organization, give to the commission important responsibility, which allows connecting the FMMP with national, provincial and district disaster management agencies, as the commission contribution through its Member Countries to implement programmes at the national, provincial and district levels. The MRC has thereby created a receptive environment for the implementation of a range of dedicated interventions at the commune level.

The flood management and mitigation tools developed by the MRC have a basin wide approach and can be applied to support local level interventions. With the current FMMP phase ending in 2016, the formulation of the next FMMP phase would seek a long term partnership with national stakeholders from Member Countries as well as donor communities to continue its focus on enhancing capacities on solution based flood risk management to the vulnerable communities. The lesson learnt from the various components of FMMP and particularly from Component: "Flood Preparedness and Emergency Management Strengthening", leads to the continuation of innovative flood focused activities as the crucial activities for risk reduction. Negative impact of flood on the livelihoods of the people living in Lower Mekong River Basin will have to be reduced using the comprehensive approaches.

6.4 The objectives for drought management in India

Drought management in India is under responsibility of the state government. Drought declaration criteria vary for each state government. The state government has no time limit for drought declaration. Also, the indicators and the methodology used for risk and drought vulnerability assessment are different among the state governments. Ministry and different departments involvement delays timely alert and coordination.

For drought management in India, available data are the most important concern for all state governments. The data required for drought assessment and drought declaration are available but in a scattered manner, with different organizations, in local formats which makes it difficult for quick analysis and appropriate

decision making. The availability of key data used for drought intensity assessment are: rainfall, crops own areas and reservoir levels.

They are different for each state. The procedures for data collection and data-base maintenance vary across states. This results in insufficient use of information and communication technology tools by various agencies in drought management. Lack of check dams in the rain exposed areas has as a consequence inadequate storage-water in drought times. Community participation in drought management activities at the village level has to be improved and that is one of the main objectives for drought management in India.

6.5 National flood and drought management plan – leading and responsible national body

National flood and drought management plan should be established under the leadership and oversee of the specific national body or commission. This particular body should do the monitoring, early warning, impact assessment, response, mitigation and planning and coordination of the activities among the crucial stake-holders The establishment of specific national body for flood and drought policy development, should be imposed and controlled by the government itself.

7 Essential elements of national drought and flood management plan

7.1 Perspective shift

We can learn from the national drought and flood policies, which have been established in some developed countries. An important element in their national policies has been incorporating flood and drought into the national discourse no longer as a natural disaster but as a normal part of the climate. This shift aims to change perceptions of these natural disasters as unexpected events to expected, predictable events, encouraging farmers and industry to plan for these events, easing some of the stress on the government to provide relief funds in the aftermath. This attitudinal shift extends to the government itself, encouraging proactive flood and drought planning and risk management rather than reactive crisis management after an event has occurred.

7.2 Greater emphasis on self-reliance

Another effective element of drought management plan has been to put power into the hands of water users to plan for drought occurrence, with a strong focus on farmers. Farmers can be empowered through training in water management, efficient irrigation methods, and financial planning. This allows national governments to steer away from drought-related aid and focus finances on risk management. For flood defense, authorities have to take the lead and plan protection work implementation because these works are often expensive. However the public consultation and involvement of exposed people-activities in the project planning is essential as to keep people concerned and aware of their role in the flood risk reduction because protection works are not enough all over.

7.3 Delineated responsibilities

For example in the case of drought, following the 1976–77 US drought, $5 billion of designated federal relief funds were distributed by 16 federal agencies through 40 different assistance programmes (Wilhite, 2011). Relief systems require clear delineation in order to avoid overlapping responsibilities and wasted funds.

By clearly laying out each government agency's role and responsibilities in a national flood and drought protection plan, funds can be better spent. Furthermore, responsibilities should be delineated along national, regional, state/province, and local lines. Depending on the water sources of different regions within a country, climatic conditions may vary region to region.

Therefore, empowering regional, state, and local leaders to create plans for their region both removes pressure from federal authorities and streamlines local drought mitigation efforts.

7.4 Levels of support

All national policies should define different levels of support based on the severity of the flood and drought.

The country policy can designate special funds for those affected by 'Exceptional Circumstances' in which for example farmers in a widespread area are incapable of adequately predicting or preventing the worst effects of a drought. Such support ought to be a last resort. Other, preventive, levels of support could include conservation efforts and water rationing such as limiting showers and outdoor watering and installing household meters.

China classifies drought severity as: severe, extreme, moderate, or slight, which are based on the number of provinces or metropolises affected (Zhang, 2011).

These levels allow policymakers to easily grasp the severity of the flood and drought and to take appropriate action.

8 From crisis management to risk management

Flood and drought policies can be implemented based on the philosophy of risk reduction and risk management, which replaces the event management through reducing their impacts. Risk management can consist on many actions like:

- Application of forecasts
- Development of the monitoring and early warning systems
- Development of preparedness plans at the government level
- Mitigation
- Putting in place emergency response
- Making an organization with the best communication and coordination between government bodies and stakeholders
- National flood and drought policies are for all regions, population groups and economic sectors and support sustainable development of one nation.
- Reducing flood and drought risks can be done through improving operational services related to water supply and sanitation, education, emergency and land planning. Successful flood and drought mitigation requires implication of all parts of disaster management.

Risk management: mitigation, planning, monitoring and prediction, disaster are part of protection. Crisis management: impact assessment, response, recovery, reconstruction are part of recovery.

In the past, little attention has been given to preparedness, prediction and early warning actions (i.e. risk management) and the development of risk-based national flood and drought management policies that could avoid or reduce future impacts and the need for government investments and interventions.
Crisis management only addresses the symptoms of flood and drought, as they manifest themselves in the impacts that occur as a direct or indirect consequence of these events. Risk management focuses on identifying where vulnerabilities exist (particular sectors, regions, communities or population groups) and addresses these risks through implementing mitigation and adaptation measures. Such actions diminish the risk associated with future flood and drought events.

8.1 National drought and flood management policies and preparedness plan

A very important part of national flood and drought policies is increased emphasize on the preparedness in order to build institutional capacity to deal more effectively with these events. One would need to achieve flood and drought resilient societies by using successful preparedness examples from particular countries. Consequently, several countries successful examples have to be discussed further in this document since this is a leaving document and open for discussion and input based on the experience.

A constraint to flood and drought preparedness has been the dearth of methodologies available to policy makers and planners to guide them through the planning process. Flood and drought differ in their physical characteristics between climate regimes, and impacts are locally defined by unique economic, social and environmental characteristics. The steps in developing national preparedness' policy should be adapted to each government, sub region and region.

8.2 Flood and drought risks identification and response

Flood and drought risk is linked with the numerous climatic factors and a wide range of societal factors that define the level of societal resilience. Population growth and redistribution and changing consumption

and production patterns are the factors that define the flood and drought risks of a region, economic sector or population group. The other factors, such as poverty and rural vulnerability, weak or ineffective governance, changes in land use, environmental degradation, environmental awareness and regulations, and outdated or ineffective government policies are a few of the factors that increases these risks.

Adequate response can be done by:

- Encouraging the improvement and application of seasonal and shorter-term forecasts
- Developing integrated monitoring and drought-flood early warning systems and associated information delivery systems
- Developing preparedness plans at various levels of government
- Adopting mitigation actions and programmes
- Creating a safety net of emergency response programmes that ensure timely and targeted relief
- Providing an organizational structure that enhances coordination within and between levels of government and with the stakeholders.

8.3 Flood and drought mitigations

Flood and drought mitigation share defined as actions taken in advance of the events to lessen their impacts. In particular, when the climate change impact is concerned, drought mitigation is focused on reducing greenhouse gas (GHG) emissions and thereby mitigating or limiting future temperature increases. Also with the climate change, flood mitigation effect will have also to concentrate on soil erosion management because more intense rainfall on more erodible soils will lead to a loss in soil production. Then while not occurring at the same time, flood and drought events can have cumulative and detrimental effects. Then a common national policy could be more efficient to ensure that actions are taken in coordination. The rest of the proposal is then based on this possibility.

9 Budget Prioritization

Depending on the political and economic situation of a given country, certain elements of the national flood and drought plans must take precedence over others. For example, while monitoring is essential, limiting the number of data collection sites could be a cost-saving mechanism. It is advised that each country work with neighboring countries, international organizations, and NGOs to coordinate action in order to avoid redundancies.

9.1 Finance drought mitigation mechanism in India

Finance mechanism for drought management in India is done through different Finance Commissions. Each finance commision has a particular role and mandat.

9.2 Finance commissions in India

The Finance Commissions are appointed under the Constitution of India every five years. Their mandate is to assess the funding need of the States, and to recommend grants to the States. The Finance Commissions make recommendations on the mechanisms by which the Indian Government assists all States in funding drought management and relief.

The First Finance Commission has the responsibility of handling natural hazards like drought. The Central Government however, was expected to provide financial support. The First Finance Commission provides assistance for relief works. This is in the form of loans and a grant. Further assistance is provided through advances. The Fourth Finance Commission has a Central Team which visits the affected States when drought happens. Emphasis is usually given on funding relief expenditure within the allocations plan. The Central Government is expected to fund only half of the expected expenditure. Since most States in India are under fiscal stress, a need was realized to make available recurring funds to States to fund immediate relief effort. Each State is sanctioned a certain amount based on its past expenditure on relief. Any amounts in excess of this margin money, after severe drought was to be assessed by Central Teams. Additional Central assistance is foreseen only when relief requirements of a severe drought could not be met from state resources. The Ninth Finance Commission is mandated to avoid cash flow difficulties in initiating relief operations. The contributions of the State Governments are credited twice a year. The Chief Secretary of the state operates this fund with the assistance of a committee and all expenditures are controlled.

10 Institutional set up

Institutional framework for flood and drought management is of extreme importance for successful flood and drought preparedness and mitigation. The institutional gaps, which certainly exist in flood and drought management, have the bad impact on the policy development and on the planning process. If there are gaps in monitoring station networks or in the existing meteorological, hydrological and ecological networks, they need to be improved in order to do the timely early warning system. Flood and drought impacts determination is the crucial factor for the process of policy development.

10.1 Institutional framework for flood and drought management in Cambodia

An integrated approach is needed to address different action within the flood risk management. Therefore multi-agency involvement is necessary. Agencies must work together at all stages of the management cycle to prevent or mitigate, respond to, and recover from the effects of flooding disasters. The most difficult institutional challenge is to establish effective working partnerships between the many agencies involved.

In Cambodia, the National Committee for Disaster Management (NCDM) has a coordinating function that is generally limited to flood and drought preparedness and emergency relief. During a disaster, NCDM is responsible for the immediate actions and coordinating role between the different line ministries, and the donor community. The sector ministries have responsibility for the implementation of specific structural interventions for flood risk reduction, and for restoration of damaged infrastructure. In Cambodia general policies and strategies for flood risk reduction are in place, the law on Disaster Management is pending approval, and has been for some years now.

Lack of a law to govern flood and drought management remains a constraint to developing strong coordination among the involved stakeholders.

10.2 National Committee for Disaster Management (NCDM) of Cambodia

The intended function of NCDM can be summarized in its mission statement: "to lead the disaster management in Cambodia." It is chaired by the Prime Minister and comprises ministers of each government agencies, plus the Royal Cambodian Armed Forces, Cambodian RedCross and Civil Aviation Authority.

More specifically it functions and responsibilities include:

- To coordinate with the line ministries, UN agencies, IOs, NGOs, International Communities, National Associations, and Local Donors in order to appeal for aid for Emergency Response and Rehabilitation.
- To make recommendations to the Government on issue and policies relating to disaster preparedness and emergency responses.
- To disseminate information and strengthen coordination on disaster management from national down to community level, including the necessary capacity development.
- To recommend to the Government on the needs for adequate disaster prevention, emergency response, and rehabilitation (eg, funds, human resources, equipment etc).

Given NCDM's mandate, and its composition with the most senior government decision makers, it is the most appropriate organization to take the lead in disaster management. A review of NCDM's capacity was undertaken in recently. It was agreed by both government ministries, development partners, and the

NGO community that the key areas with regards to flood and drought management which have to be strengthen are:

- Policy and legal development and implementation – this is to provide official guidance and clarity to the disaster management actions needed at all levels (central down to commune). Both the policy and draft law on disaster management are yet to be approved by the Council of Ministers.
- Flood and drought preparedness and emergency response – fiscal constraints continue to hamper disaster emergency management activities by NCDM
- Flood and Drought Management Information System (DMIS) – lessons from previous flood, highlighted the need for improving inter agency or inter organizational coordination to deal with flood and drought. NCDM needs assistance to improve its systems, procedures and capacity to prepare reports on damage and needs assessment. Such information is important if coordination is to be achieved.
- Public Awareness and Early Warning System – while local communities and authorities are already aware of flood disasters, little has been done to develop a systematic preparedness strategy. NCDM has not been engaged in a public awareness program and does not have a public awareness strategy or plan which is a fundamental requirement.
- Comprehensive Flood and Drought Management Strategy – this needs involve the analysis and planning for a wide range of issues corresponding to all aspects of flood and drought management. Despite a number of key government policies there is only limited adoption in practice due lack of resources and capacity. While some government ministries are already implementing flood and drought risk reduction activities and projects, their efforts are largely uncoordinated. This highlights the need to develop the capacity of NCDM to take the lead in strong coordination.

10.3 Institutional framework for drought management in India

In India, drought is monitored from different aspects according to different national agencies. Indian meteorological department monitor drought as rainfall and aridity anomaly. Reservoir storage position is a value from which is drought monitored by the Central Water Commission. At State-level, departments like agriculture, irrigation, economics and statistics monitor crop evolution. Drought management comprises institutional, legal, financial and coordination mechanisms at the national state, district and local levels. These institutions are not parallel structures and will work in close harmony. The new institutional framework is expected to achieve a paradigm shift in drought management from crisis management approach to a proactive approach which puts emphasis on preparedness, prevention and mitigation.

National Disaster Management Authority (NDMA) has a leading role in drought management. The head of NDMA is the Prime Minister. NDMA has the responsibility for policies development, plans and guidelines for drought management and coordination of drought response.

Institutional framework for drought management needs to be addressed in a holistic manner and the present status of drought has to be analyzed. Indian Government has brought about a paradigm shift in the approach to drought management. The new approach is based on the principle that development cannot be sustainable unless drought mitigation is built into the process. The drought early warning surveillance and early response system prepared by the Department of Agriculture and Cooperation (DAC), involves at least eleven Ministries and Departments looking at different aspects of drought management. Effective and timely coordination among these agencies is an important factor which needs full attention. The data required for drought assessment and drought declaration are available but there are not enough data. The emphasis in drought management in India is put on prevention, mitigation and preparedness, which has resulted in minimizing loss of lives and livelihoods on account of drought.

10.4 Institutional framework for flood management in Bangladesh

In Bangladesh fifty three government organizations and thirteen ministries are involved in flood and water management. Principal national institution responsible for flood management is the Bangladesh is the Bangladesh Water Development Board. Many other organizations are also involved in the flood management activities. Each of organization is involved in particular stage of flood management process. The responsibilities of different organizations are given below:

- *Water Resources Planning Organization:* Macro planning of water resources management;
- *Bangladesh Water Development Board:* Feasibility studies, implementation, operation and maintenance of flood management projects, real time data collection for flood forecasting and warning services, dissemination of flood information at national and regional levels;

- *Joint River Commission:* To conduct negotiation for data and information exchange on trans-boundary rivers;
- *Bangladesh Meteorological Department:* Long, medium and short term weather forecasting and dissemination.
- *Local Government Engineering Department:* Implementation. Observation and monitoring of small scale flood mitigation projects;
- *Disaster Management Bureau:* Dissemination of all information on natural disaster including flood information at community level, flood preparedness awareness building etc.
- *Directorate of Relief:* Conducting relief and rehabilitation operation in flood hit areas;
- *Local Government Institutions:* Implementation and Operation and management of small scale flood management project, flood information dissemination, relief and rehabilitation of flood victims;
- *Non-Government Organizations:* Advocacy for flood management, Relief and rehabilitation of flood victims.

The Joint River Commission and Bangladesh Water Development Board (BWDB) carry out international and regional data and information exchange. BWDB disseminate all kinds of flood information to all related Governments, departments, organization. Over all coordination during the flood event is the responsibility of the Ministry of Disaster Management and Relief and Inter-Ministerial Disaster Management Committee. The changes as regards the organizational policies and behavior are very much Forecasting and Warning Center of BWDB has updated its flood forecast model and opened a web page. Flood Forecasting and Warning Center is disseminating the flood information in user-friendly manner. Disaster Management Bureau is now putting more efforts on the community level dissemination of flood information and on preparedness. Both the print and electronic media are very concerned with publishing and broadcasting flood information nearly every day during flood season. With the experience the Government has realized that complete flood control may not be possible and has taken policy of near real time flood management in case of extreme events where some areas will be allowed to be flooded to save areas of high investments and large population. Flood management has two different aspects, one relating to national water management and the other relating to national disaster management. Flood management relating to water management at national level is co-coordinated by the National Water Council and particularly by the Ministry of Water Resources. Flood management relating to disaster management is co-coordinated by National Disaster Management Council particularly by Ministry of Disaster Management and Relief. Both activities are also coordinated at local levels by appropriate bodies. Several ministries and agencies are responsible flood management at different stages. Bangladesh Water Development Board (BWDB) is responsible for major activities in flood management work both structural and non-structural. Besides BWDB, other agencies are also involved flood management according to their mandate.

Table 7: *Flood Management related organizations and their responsibilities (APFM, 2003)*

Sl. No.	Name of Organizations	Major role in Flood Management
1	Water Resources Planning Organization (WARPO)	Macro level planning for water resources management (e.g. National Water Management Plan, National Water Management Policy , Water Act etc.)
2	BangladeshWater DevelopmentBoard (BWDB)	Feasibility Studies, Implementation, Operationand Maintenance (O&M) of Flood Management Projects, Hydrological Data Collection, FloodForecasting and Warning Services, Dissemination of Flood information at national and regional levels
3	Joint River Commission (JRC)	To conduct negotiation for data and information exchange onTrans-boundary rivers with the neighboring countries;
4	Bangladesh Meteorological Department (BMD)	Long, medium and short range weather forecasting and dissemination.
5	LocalGovernment Engineering Department (LGED)	Implementation. O&M of Small Scale Irrigation projects;
6	Department of Disaster Management (DDM)	Dissemination of all information on naturaldisaster including flood information at community level, Flood Preparedness awarenessbuilding etc. Conducting Relief and Rehabilitation operation in flood affected areas
7	LocalGovernment Institutions (LGI)	Implementation and O&M of small scale floodmanagement project, Flood Information Dissemination, Relief and Rehabilitation of flood victims
8	Non-Government Organizations (NGO)	Advocacy for flood management, Relief andRehabilitation of flood victims.

11 National flood and drought policy development

11.1 Drought management policy in Myanmar

11.1.1 Drought conditions in Myanmar

Drought conditions in Myanmar are the basis for further actions on drought management and for the development drought management policy at the country level. The dry zone, central area of Myanmar is the area vulnerable to drought as compared to other parts of the country. This dry zone area covers 67,700 km^2 and 10 % of the total area. This area is characterized by low rainfall, intense heat and degraded soil conditions, affecting social and economic situations of the communities living in the region. There are about 35 % of the cultivable land in dry zone within the 3regions (including 54 townships under 13 districts). The temperature is very high and hottest is in April and May. The precipitation in dry zone is controlled by the monsoon circulation system. Annual rainfall is less than 750 mm(national average precipitation is 2353 mm). In Myanmar, drought years were observed as 1972, 1979, 1982, 1983, 1986 and 1987.

General description of drought conditions in 2010–2015 is crucial for drought studies and drought policy development. In this period the extreme temperature was recorded 47.2 °C on 14.5.2010 at Myinmu in dry zone area. The highest temperature was recorded at 20 stations during May. Inle Lake, which is the major tourist destination in Shan State of Myanmar, has been dried up in many parts. Water shortage was most severe in Ayeyarwaddy, Sagaing, Yangon, Mandalay and Bago Regions and Mon, Rakhine and Shan States in 2010. Most of the wells were dried up due to the depletion of underground water supply because of late of Monsoon onset and so the scarcity of drinking water problems occurred in Myanmar.

According to the Drought Annual Report of Department of Meteorology and Hydrology, the drought mostly occurred in dry zone area during Pre and Peak Monsoon period of 2010, the drought slightly occurred in Myanmar during 2011 and during 2012 & 2013, the severe and moderate drought occurred in dry zone area, some regions and states and mild drought occurred in some regions and states. The drought mainly impact to the agricultural fields, farmers, drinking water scarcity and also impact to social, economic, health, public, livestock and environment of Myanmar.

11.2 The observations, warning, bulletin, forecast and news in Myanmar

The observations, drought forecast and bulletin are the responsibilities of National Meteorological and Hydrological Service.

National Meteorological and Hydrological Service is providing regularly the following information:

- Cyclone Warning
- Storm Surge Warning
- Flood Warning
- Untimely Rainfall Warning
- Fog Warning
- Heavy Rain Warning
- Aviation Weather Warning
- Low flow water level
- Tsunami Warning
- Port Warning
- Agro-meteorological Bulletin
- Bay Bulletin
- Flood Bulletin
- Special Weather Bulletin

The observations which are also available are the following:

- Daily Weather/Water Level
- 10 Days Weather/Flood
- Monthly Weather/Flood

- Seasonal Weather/River Flood Forecast
- Aviation Weather Forecast
- Marine Weather Forecast
- Special Forecast
- Earthquake News
- Rainfall / Temperature Records
- Cyclone News

11.3 Drought monitoring and early warning systems in Myanmar

The Department of Meteorology and Hydrology of Myanmar has some additional responsibilities related to monitoring and early warning. The Department of Meteorology and Hydrology also issues the agro-meteorological bulletins to support the agriculture. The Department of Meteorology and Hydrology established the drought-monitoring center at the upper Myanmar office (Mandalay office) locating in dry zone area in 2010. This center is now preparing and issuing the seasonal and annual drought reports based on the rainfall conditions. The Department of Meteorology and Hydrology cannot issue the warnings for drought. The Department of Meteorology and Hydrology needs to upgrade the drought-monitoring center such as capacity-building and also forecasting techniques etc.

The Department of Meteorology and Hydrology is trying to upgrade the data observation networks, the forecast techniques, capacity-building and the early warning system cooperating with international organizations.

Particularly, the forest department was carried out dry zone rehabilitation activities during 1973–1993. Forest Department also implemented for the land rehabilitation and development of central dry zone during 1993–2002. During 1994–96, 9 and 13 District Greening Project in dry zone area was carried out by Forest Department. About 21,320 hectare (52,680 acres) was planted during the project period. Watershed Mountain Greening Special Project of Myingyan district was also implemented in 1996–97.

In July 1997, Dry Zone Greening Department (DZGD) was constituted under Ministry of Environmental Conservation and Forestry. Its working covers central dry zone of Myanmar including 3 regions (Sagaing, Mandalay and Magway Regions), 13 districts and 57 townships, covering 21.557 million acres of dry land forests.

11.4 Drought vulnerability assessment in Myanmar

The vulnerable sectors of society and economy due to drought in Myanmar are agriculture and food production, drinking water supply, health, livestock and fisheries, industry and environment. The largest vulnerable area is the dry zone area of Myanmar and the effected societies are farmers, people and livestock in rural areas.

11.5 Emergency relief and drought response in Myanmar

The National Disaster Preparedness Central Committee under the Vice President has been re-established in May 2013 (22 members include). National Disaster Preparedness Management Working Committee under the Minister of Ministry of Social welfare, Relief and Resettlement has also been re-established in May 2013 (10 sub-committees)

Also, it was established the Disaster Management Committees at State/Region, District, Township and sub-township levels. Committees, the concerned departments and organizations are cooperating and working for disaster management in Myanmar. These disaster management committees and the Ministry of Social welfare, Relief and Resettlement are the main responsibility of emergency relief and response for disaster and also other concerned departments and organizations are cooperating. These committees, concerned ministries and departments and organizations carry out the activities for relief and drought response. There are needs to upgrade the emergency relief and drought response in Myanmar

11.6 Practices/activities to alleviate drought impacts

Department of Meteorology and Hydrology issues the daily, monthly weather and river water level forecasts, news, warnings and bulletins for storms, flood, untimely rainfall, temperature and minimum alert water level, agro-meteorological bulletins and seasonal and annual drought report. Agriculture department is also doing in cooperation with international seed research centers for seeking and identifying drought resistant crops in Myanmar, conducting research on cultivation methods to be employed at the time of drought. The Ministry has been importing seeds that can survive with less dependence on water, and trying to nurse the crops and produce them. The Ministry of Agriculture and Irrigation carry out the construction, repair and maintenance of dams, reservoirs and water supply facilities, has been implementing the river water pumping project, is also helping the people to build drinking water supply works. It does so by feeding water-to-water tanks from the dams and reservoirs, digging lakes and wells, installing water purifying systems and providing other technologies. Ministry of

Forest and Environmental Conservation has been implementing a forestation and land rehabilitation in dry zone area through the projects. The local governments, public and also NGOs are also implementing the digging lakes for getting the drinking water during drought period, distributing the drinking water during water shortage and also rainwater storage.

11.7 Needs for drought management in Myanmar

In general, there is a need to set up the warning system for drought in Myanmar. Particular actions, which need to be taken are the following:

- To develop the forecasting techniques and capacity-building for drought
- To set up a Task force including authorities and experts of Administration, Relief, Water resources, Agriculture, Forestry, Department of Meteorology and Hydrology, other concerned depts., NGOs, INGOs:
- To conduct Drought risk assessment
- To promote education and public awareness for drought mitigation
- To encourage community level plans for Drought Mitigation.
- To cooperate, coordinate and collaborate the concerned departments and organizations in Myanmar and also INGOs for drought management in Myanmar
- To develop the concerned department's activities for drought mitigation
- To develop the drought policy and strategies for drought management in Myanmar
- To set up the Drought Management System in Myanmar

11.8 The essential elements for drought management policy in Myanmar

Myanmar's drought conditions and the longue experience dealing with drought have encouraged the country to work on development of an integrated drought management system. This system consists of three essential elements:

A monitoring and early warning system: Myanmar has developed national institutional and technical capacities mostly in the areas of climate modeling and remote sensing. Also the crop forecasting is an important element. The national drought observations were established to improve forecasting, assess impacts and develop strategies and tools for decision support and drought preparedness.

Emergency operational plans to cope with the drought impact: Myanmar has the experience in the development and implementation of programmes to alleviate the impacts of drought. The interventions within these programmes are:

- securing safe drinking water for rural populations
- livestock preservation through feed distribution
- maintenance of rural roads and irrigation infrastructures
- forests and natural resources conservation.

To reduce drought vulnerability: This strategy is based on a risk management approach, which reduces the vulnerability to drought at the national level with a focus on agriculture vulnerability. It involves different and multidimensional policies that take into account the drought risk in its geographical diversity and economic and social aspects. The strategy has three pillars:

An integrated approach to water resources management based on the policy reinforcement and institutional reforms. One investment programme is established to capture most of the remaining runoff potential.

Improving access to water supply and sanitation and increasing wastewater treatment capacity through optimized financing strategies and increased budget support. A National Sanitation Plan has been established.

Conserving water and improving efficiency, productivity, cost effectiveness and the sustainability of irrigated agriculture are increasingly necessary if Myanmar's economic growth is to continue. In this context, an integrated approach has been developed with the aim to:

(i) improve the hydraulic efficiency of irrigation systems;
(ii) strengthen the managerial capacities of irrigation agencies; and
(iii) increase the productivity. A comprehensive National Plan for Conservation of Irrigation Water has to bedeveloped. Private-public partnership has to be promoted.

11.9 Monitoring, early warning and information delivery committee

Water availability assessment and its longue term projection is valuable information in both dry and wet periods. During drought, the value of this information is even more important. One monitoring committee should be established be a part of each state or provincial committee in order to interpret local conditions and impacts and communicate this

information to the national drought policy commission and to the representative from the national meteorological service. For the particular cases, a monitoring committee may be set up for certain regions with similar climatic conditions and exposure to drought, rather than for each state or province.

The main objectives of the monitoring committee are to define a workable definition of drought that could be used for national mitigation actions and emergency measures for drought conditions. It may be necessary to define more than one definition of drought to identify the impacts in various economic, social and environmental sectors. The committee would need to consider appropriate indicators (e.g. precipitation, temperature, soil moisture, stream flow) and indices as substantial part the water supply assessment process. Many indices are available and the strengths and weaknesses of each index should be carefully examined. The idea is to rely on multiple drought indices to trigger mitigation and response actions. The other actions at national level are:

Developing a drought monitoring system. The quality of meteorological and hydrological networks is highly variable from region to region within country (e.g. number of stations, length of record and amount of missing data). Responsibility for collecting, analyzing and disseminating data is divided between many government authorities.

Determination of the data needs of primary users for information and decision support tools. Developing new or modifying existing data collection systems is most reliable when the people who will be using the data are consulted early and often to determine their specific needs.

Developing and modifying current data and information delivery systems. People need to be warned of drought as soon as it is detected, but often they are not. Information must reach people in time for them to use it in making decisions. One needs to establish the information channels.

It is essential to bring together the right people and supply them with adequate data to make fair, efficient and informed decisions pertaining to drought risk. These people should be technically competent.
The drought impact assessment should be carefully examined. Drought impact assessments can be through identifying direct consequences of the drought, such as reduced crop yields, livestock losses and reduced reservoir levels. These direct outcomes can then be traced to secondary consequences (often social effects), such as, food security, reduced energy production, dislocation or physical and emotional stress.

11.10 Flood management policy in Myanmar

11.10.1 Description of catchment areas in Myanmar

For the flood management strategy and for the application of flood management policy in Myanmar, it is necessary to elaborate at first the catchment areas and the instrumentation networks within the country.

In Myanmar there are seven important catchment areas where flood management policy has to be applied. These catchment areas with the major rivers are presented in the *table 8*.

Table 8: *Catchment areas in Myanmar*

No.	River	Basin Area (km^2)
1.	Ayeyarwady	348064 (up to Zalun)
2.	Chindwin	110350 (up to Monywa)
3.	Sittoung	26758 (up to Madauk)
4.	Bago	2580 (up to Bago)
5.	Dokehtawady	45792 (up to Myitnge)
6.	Thanlwin	295270 (up to Hpaan)
7.	Shwegyin	1747 (up to Shwegyin
8.	Ngawun	3455

Myanmar has eight major rivers which generally flow from North to South.

Ayeyarwady – 1789 km
Chindwin – 901 km
Thanlwin – 1223 km
Sittoung – 407 km
Bago River – 331 km

Along these major rivers there are many runoff gauging stations relevant for flood forecasting and flood management processes.
The gauging stations are distributed in the following way:

Ayeyarwady – 15 stations
Chindwin – 5 stations
Sittaung – 2 stations
Thanlwin – 1 station
Dokethawaddy – 2 stations
Bago – 2 stations
Shwegyin – 1 station
Ngawun – 2 stations

Total number of gauging stations is 30 stations.

11.10.2 Warnings/forecasts/bulletins and news

National Meteorological and Hydrological department is giving different type of warnings:

- Cyclone Warning
- Storm Surge Warning
- Flood Warning
- Untimely Rainfall Warning
- Fog Warning
- Heavy Rain Warning
- Aviation weather warning
- Low flow water level
- Tsunami
- Port Warning
- Strong wind warning

National Meteorological and Hydrological Department is also making the forecast like: Daily Weather/water level, Monthly Weather/Flood, Seasonal Weather/River Flood Forecast, Aviation Weather Forecast, Marine Weather Forecast and the Special Forecast. There are different kinds of bulletins which are delivered on a regular basis:agro-meteorologicalbulletin, baybulletin, floodbulletin, special weather bulletin, significant water level, low flow bulletin. Newsis produced regularly as: earthquake news, rainfall/temperature records and cyclone news.

Types of forecast and warnings from hydrological division are:

- Daily water level forecast
- Dekad Forecast (10 days advance FC)
- Monthly Forecast Significant Water level Bulletin
- Flood Warning and Bulletin
- Minimum Alert Water Level and Bulletin (for low flow)
- Seasonal water level forecast
- General Long Range flood Forecast Flood Forecast for early monsoon
- Flood Forecast for Peak-monsoon
- Flood Forecast for Late-monsoon

Some catchments in Myanmar like the Chindwin catchment, receives very high rainfall at upper part of basin and consequently have a very high. For example, the Chindwin catchment has the annual rainfall, which varies from 800 mm to 4000 mm. This amount of heavy rainfalls in most of the cases is cause of severe flooding.

11.10.3 Causes of river flood

The most common reason of flooding in Myanmar is intense, heavy rain due to persistent monsoon, which can last over 3 days over the Northern Myanmar areas. There are also heavy rainfalls due to cyclonic storm crossing Myanmar and Bangladesh coasts during pre-monsoon and post-monsoon period.

11.11 Preparation of forecast and warning

The river forecasting methods such as river stage correlation and empirical model are used for computing daily water level forecasts as well as flood forecasts in Myanmar. Whenever heavy rainfall condition happen due to strong monsoon, presence of tropical cyclone near Myanmar coast, formation of trough near part of Myanmar for 3 to 4 days and crossing of Typhoon from the South China Sea to Myanmar, alert is taken for watching flood along those rivers. IFAS-Integrated Flood Analysis System is used for flood forecasting purposes. A Multiple Linear Regression Approach for 1 day ahead for the Rivers is applied. Early warning dissemination is done through the following channels:

- President office
- Chief Ministry State & Region Ministry of MSWRR
- Related
- Ministries
- Media Television
- Radio/FM
- Website/newspaper
- INGO, NGO

11.12 Flood management

For the flood management purposes in Myanmar, the heavy machines are used for strengthening the embankments before the floodwater arrives. Strong embankment after reinforcement works is a common practice. With such kind of preparation the communities are ready to combat against flood water. Using low coast local bamboos does protection from erosion. During the entire flood period, more than 35 000 people, comprising of: government employees, local residents, police and fire service staffs, red cross volunteers, students, etc., are watching the river water conditions and the stability of the river embankments day and night, for immediate response.

11.13 Flood mitigation and preparedness

Different responsibilities for flood mitigation ad preparedness are distributed within the country among the stakeholders:
Department of Meteorology and Hydrology (DMH) is responsible for Early Warning.
Department of Irrigation is doing reparation of embankment system using machine and manpower to fill up where the embankment is low and strengthening weak portions of the embankment by resectioning them Directorate of Water Resources and Improvement of River System (DWIR) River Training (Bed Regulation Method) is involved in flood mitigation and preparedness.

Department of Relief and Resettlement has important role in evacuation when flood happens.

11.14 Public awareness programmes

In Myanmar, the public awareness programme on flood is taken at different capacities:

- Workshop and Training Courses at Department of Meteorology and Hydrology
- Lectures to University/college/High School about weather and disaster mitigation and prevention
- Radio Talks and Television News for Public Education
- Distribution of pamphlets
- Articles in the Newspapers and Journals

11.15 Gaps, needs and challenges

There are still many gaps and challenges for flood management in Myanmar. The most important gaps and needs for improvement and enhancement of country capacities are:

- Lack of instruments for real time data observation such as rainfall, water level, etc
- Lack of real time data for utilization of flood forecasting
- No mobile Doppler Radar
- Lack of communication system
- No information from dam, reservoir and weir, etc.,
- Lack of co-ordination among government departments/organizations
- Insufficient flood related data and network
- No automatic flood related data collection Network
- Insufficient knowledge about flood hydrology (rainfall runoff estimation, flood volume estimation, flood routing etc.) in flood related departments.
- Lack of developing the early warning system for dangerous hydro-meteorological phenomena
- Lack of developing the flood risk maps

11.16 Flood management policy in Bangladesh

Cruge-Mission was formed in 1957 under guidance United Nations (UN) to increase food productivity by minimizing losses of flood damage and water resources development & management in Bangladesh.
East Pakistan Water and Power Development Authority (EPWADA) were established in 1959 as the principal agency for the management and development of Water Resources in the country. The major tasks were flood control, drainage and irrigation projects to increase productivity in agriculture and fisheries. After the independence of Bangladesh, the authority was restructured in 1972 into two different organizations to deal with water and power separately. BWDB was established under the Bangladesh Water and Power Development Boards Order 1972 (P. O. No. 59 of 1972) as a fully autonomous organization. Country's flood management started its journey in a new pathway after 1987 and 1988 flood. After devastating flood of 1987 and 1988 the Flood action Plan (FAP) was created. The core concept of FAP was "Controlling Flood" and a substantial part was involved in construction of embankment and subdividing the protected areas into compartment.

- Presently, Water and Flood management is guided by several rules and regulation-
- Water Act-2013
- National Water Management Policy 1999
- Water Management Plan 2001
- Guidelines for Participatory Water Management (GPWM,2000)
- Guidelines for Environmental Assessment of Water Management

Government of Bangladesh has adopted National Water Policy, which covers execution of all activities in the water sector. Government of Bangladesh has also prepared a National Water Management Plan (NWMP), which has been prepared considering long term need, management and utilization of water resources taking account all water sectors. NWMP includes the issue of management of water disasters like flood, erosion, drought etc. Government has recently prepared a Comprehensive Disaster Management Plan (CDMP). Some time ago, Government has circulated Disaster Management Guide. This guide give the main lines in which the responsibilities different agencies involved in disaster mitigation activities are delineated during pre-disaster preparedness, rescue and evacuation during flood and post-flood relief and rehabilitation. Since the previous year severe flood events, the Government is putting more emphasis on Flood Management issues especially on the early warning, preparedness and response activities. In NWMP flood management issues have been covered through IWRM.

12 National flood and drought management policy and preparedness plans – public awareness

One needs to create awareness among the stakeholders and especially the farmers and other vulnerable groups. There is a need to incorporate local knowledge in the policy formulation. The goal of awareness rising is to disseminate factual information to the people who are either affected by flood and drought or who are responsible for developing national flood and drought management policies and who are responsible for preparedness and recovery plans. Good awareness raising campaigns are optimistic and empowering. They relay responsibility and ownership of an issue to the target audience.

12.1 Drought preparedness and prevention in India

Prevention and Preparedness include the activities prepared to increase the level of resistance and improvement of operational and institutional capabilities for responding to a drought. Drought prevention and preparedness involve water supply augmentation and conservation (e.g. rainwater harvesting techniques), expansion of irrigation facilities, effective dealing with drought, and public awareness and education. Transport and communication links are a must to ensure supply of food and other commodities during and just after a drought. Successful drought management requires community awareness on the mitigation strategies, insurance schemes for farmers, crop contingency plans, etc. Basic to drought management in the Indian context is the delineation of drought prone areas.

12.1.1 Drought prone areas delineation

Drought prone areas are delineated according to the following criteria and data:

- Rainfall (long term average - 30 to 50yrs) (Short Term average – 5 to 10 yrs);
- Cropping pattern (3 to 5 yrs);
- Available supplement irrigation (well, tank, ponds, ground water etc.);
- Satellite derived indicators (last 10years);
- Soil map;
- Ground water availability map;
- Population and food demand;
- Socio economic data;
- Other water demands like for drinking, industrial use etc.;

Gradation of Drought Prone Areas can be: high, moderate and low. Areas should also be graded on the basis of degree of drought proneness since it would affect the steps required for better preparedness. This requires multiple criteria approach. Such approach includes:

- Sensitivity to Rainfall Variation;
- Frequency of Occurrence of Drought;
- Vulnerability of Community (people and livestock) to Drought

12.2 Monitoring of drought in India

Having delineated drought prone areas and their gradation one can describe the criteria for monitoring relevant indicators. The monitoring indicators are:

- Rainfall and other associated weather parameters;
- Crop health (based on satellites images and field reports);
- Available ground water (variation in ground water table) and surface water resources;
- Migration and impact on community;

12.2.1 Observation network

For the good monitoring quality one would require reasonably dense observational network.

- Automatic weather station (25 km × 25 km);
- Automatic rain-gauge (5 km × 5 km);

- Ground water table observation (5 km × 5 km in hard rock region and 10 km × 10 km in alluvial plains);
- Field report;
- Satellite data of 50 m × 50 m resolution

In Indian case there is a gap between the existing and desired meteorological and hydrological monitoring network. The State Governments has to increase efforts to increase the monitoring network. For integrated drought management on regional and all-India scales, present day information and communication technologies are playing a significant role.

Drought assessment starts with rainfall measurement. The spatial and temporal variability of rainfall is very high in the semi-arid and arid areas prone to drought. The rain gauges are placed for every 40 km^2. However, one finds it necessary to have a rain gauge for every 25 km^2. The rainfall data needs to be accurately measured, recorded and measured more frequently within a day and transmitted on real time basis. Telemetric rain gauges are useful in not only recording real time rainfall data but also transmitting the same to data centre which enables near time analysis. The availability of real/near real time rainfall/weather data helps in establishing drought early warning systems. The digital data obtained from telemetric rain help in developing and makes operational early warning systems. Meteorological, agricultural and hydrological models can be developed which provides decision support tools. Automatic weather stations and rain gauges are contributing to enable micro level analysis and forecasting.

12.3 Weather forecasting for community level advisory in India

Numerical weather prediction is important element of drought management in India. To have accurate weather forecasts one needs to overcome many challenges. Currently forecasting in India has many constrains:

- The information is too general space and time related while forecasting needs are at local level;
- The timing does not match user needs;
- Information received from different sources transmit conflicting messages;
- The language is not clearly understood by users.

State drought management department will harmonize the current efforts by various knowledge centers at the national and international levels.

12.4 Strengthening community awareness in Thailand and Vietnam

In order to reduce the flood risks very good public communication campaigns contributed to public educating in order to convey the targeted message over a large geographical area to a broad audience. The aim of the campaign is to raise the awareness of communities on hazards and risks they are exposed to and what they can do at the individual household level to mitigate or minimize those risks. In such way, the communities become the active participants of wider disaster risk reduction scenario. Since 2008 The Mekong River Commission has developed in a very good way awareness raising initiatives in different forms; IEC (Information, Education and Communication) materials development and distribution, organizing cultural shows and sector specific activities like school flood safety programmes. One of the most important factors which added to the acceptance of the public awareness campaign undertaken was the successful mobilization and collaboration of the key disaster management actors in the province. All major stakeholders from provincial government officials to community focal persons were involved in the process. The existing natural disaster management strategies of Lower Mekong Basin countries acknowledge the public awareness rising as powerful tool in flood management. The awareness campaign was a product of a collaborative effort of local disaster management officials (i.e., the provincial, district and commune disaster management committees), provincial line departments (i.e., the departments for Education, Women's Affairs, Cultural, Information, etc.) and NGO partners. Involvement of the provincial line departments from inception to implementation of the awareness campaigns ensures sustainability of such approaches. The School Flood Safety Programmes (SFSP) is one of the innovative activities being implemented successfully in all four MRC Member Countries with the objectives of supporting the school authority in implementing flood preparedness programmes. One needs to enhance the vulnerable group's capacity in dealing with flood via children. The key role is played by the provincial Education Departments. They have the instrumental role in implementing SFSP activities under the guidance of provincial and district disaster management agencies. Provincial working groups are established having the representatives from other member departments of provincial and district disaster management committees to facilitate coordinate and monitor the implementing activities. The initiative to educate the community on flood risk reduction through traditional art forms in Cambodia succeeded in enhancing the

understanding of roles and responsibilities of these line agencies as well as supporting the communities in their understanding of and ability to respond to and mitigate flood situations. The Royal University of Fine Arts was the key institution in developing the scripts; the provincial officials played the key role in the conceptualization and eventual conduct of the plays. IEC materials on flood risk management such as flood booklet and "Living with Flood" video were provided to the Royal University and the Department of Culture and Fine Arts for their preparatory works.

A similar initiative in changing the attitude of local communities on flood management using performance arts in VietNam has been quite successful utilizing the capacities of the Office of Information and Culture (OCI) including the development of scripts, conducting performance rehearsal, charting the schedule and organizing the shows. A similar initiative in Lao and Thailand has also been initiated recently. The availability of limited resources for public awareness has the replication of awareness campaigns over wide area beyond the project geographical coverage. In order to broaden the pool of resources, the idea of public-private partnership has been initiated in Lao, Thailand and VietNam. The advantages of the involvement of private agencies in public awareness rising are that they provide extended networking beyond disaster risk reduction sector and more efficient use of resources and funds. It is planned that the roles of private sector can range from sponsorships of awareness raising activities to acceptance of flood policies installed in strategic planning.

12.5 Community awareness in India

Developing community awareness and ensuring community leadership for effective drought management is the crucial need. Investments in disaster education, public awareness, community leadership development are priority in India. Making communities sensitive is the most important activity. Since low income groups are the most vulnerable to drought, the design and content of the education material is based on issues like alternate livelihoods, supplementing income, creating awareness of government schemes for them etc. Community has to understand the importance of drought preparedness and mitigation. The aim is to promote an informed, alert and self confident, motivated community that will cope with the drought. Drought mitigation aspects are disseminated through the local bodies which are linked to the Community Disaster Management (CBDM) initiatives. CBDM activities are included in the plans prepared at the district, town and village levels.

Documentation is given due importance in drought management because of a variety of reasons. Shortage of well trained and experienced staff is one of the reasons for lack of documentation. Documentation is helping the learning process and case examples which would help in a wider understanding. The state Drought Management department is preparing and revising the existing drought manuals. The Disaster Management departments are taking measures to collect data and digitize them from various sources and save and maintain them. The documentation is facilitating learning from past experiences and provide for improvement for effective planning for drought preparedness and mitigation measures. They are also:

- Formulating and implementing a comprehensive mitigation plan, covering all aspects of Drought Management training;
- Organize awareness Training Programmes on Drought Management

12.6 Public participation in flood management in Thailand and Vietnam

During the flood event in the Mekong Delta high level water can last up to two months in some areas. During this period, women have more responsibilities as even their daily household jobs require more concerted efforts. In order to secure food for the family they are travelling longer distances than usual and they have to be more alert to ensure the safety of the children. The burden is even heavier on women who do not have any male relatives in the family. Some really poor women having households are mostly affected heavily. Children, on the other hand, rely on adults to cope with any stressful situation including disastrous events like flood. In some cases they are many deaths of children. That can happened to either negligence of In the Mekong Delta, where high water level during flood season can last up to two months in some areas, women have to bear more responsibilities during that time as even their daily household chores call for more concerted efforts; for instance securing food for the family might require travelling longer distances than usual and they have to be more alert to ensure the safety of the children. The burden is even heavier on women who do not have any male relatives to rely on; such as poor women headed households. Children, on the other hand, rely on adults to cope with any stressful situation including disastrous events like natural flood. In many cases there are deaths of children and that can happened due to negligence or lack of knowledge on the parts of both children and adult to

react in flood situation. One way to establish a sense of control and to build confidence in children before a disaster is to raise their understanding of flood and their impacts and provision of life-saving programmes. That can be free swimming lessons which include knowledge sharing among adults on taking care of the children during flood. Led by agencies like Save the Children and World Vision, disaster risk reductions programmes that consider and incorporate perspectives of children and their needs during disasters have been in place in Me Mekong River Comission member Countries.

Currently, both, government and non-government agencies are working towards creating a safer environment for children. Even though still in the infancy stages, the national disaster management plans of the Lower Mekong Basin countries concede the gains of child-focused disaster risk reduction. In Cambodia and Lao PDR, formal education sector has been involved in crafting a culture of preparedness by mainstreaming disaster risk reduction into school curriculum.

Thailand has developed guidelines for integrating disaster prevention and mitigation activities into schools activities. In Viet Nam is established the emergency kindergartens child safety. The parents of poor families are supposed and encouraged to be able to devote more time to income generating activities. The swimming programmes in the Mekong Delta provinces in collaboration with other stakeholders significantly reduce the child drowning. Kids between six and fourteen years old considered most vulnerable in the districts are equipped with life jackets and swimming lesson.

Under the FMMP, a specific flood risk reduction activity targeting the women-headed households was implemented in Kandal and Prey Veng provinces in Cambodia in partnership with the Ministry of Women's Affairs (MoWA). A common recommendation which was agreed is to build the capacity of the commune women and children focal points in two major areas: enhanced knowledge of flood risk reduction, mainly the community based flood risk reduction, and planning on how to disseminate the flood risk reduction information to the target groups of poor women-headed households.

The main aim is to enable the poor women-headed households to adopt adequate and inexpensive flood mitigation measures in order to reduce the cost of recovery and stress. That will help in future to invest more time, money and efforts in income important activities.

12.7 Flood preparedness in Thailand

12.7.1 Flood preparedness of small entreprises in Thailand

When disasters flood happened in Thailand in 2011 over three percent of Thailand's GDP were affected. That decreased all economic growth during the year. In order to cope with the situation, the Government of Thailand launched initiatives such as a flood reinsurance scheme and infrastructure upgrades around industrial parks in place to help the large-scale industrial sector prepare, adapt, and respond to flood disasters. However, smaller businesses that comprise the greatest percentage of economic enterprises in the country and contribute 40 percent to the country's annual GDP typically do not benefit from these large government-supported programmes. Few small- and medium-sized enterprises (SMEs) have adequate access to information or capacity for disaster preparedness planning. To address this gap, the Foundation is conducting a survey to assess disaster preparedness among such small companies in Thailand The survey focuses on the specific challenges that small companies face, their understanding of disaster risk management, and their knowledge of emergency regulations for businesses. The survey results and recommendations serve as the basis for future disaster preparedness programming to support SMEs and business associations.

12.8 Flood preparedness and emergency measures in Thailand and Vietnam

Flood preparedness and strengthening flood emergency management in the four Mekong River Commission countries such as Cambodia, Lao PDR, Thailand and Vietnam is the crucial point for integrated flood management. The emphasis is on capacity-building, knowledge sharing and public awareness campaigns at the provincial, district and community levels. With the continued support from the Government of the Federal Republic of Germany, the major focus has been to strengthen practical skills of key officials at provincial, district and commune disaster management committees to develop and implement the Flood Preparedness Programmes (FPP). The core objective of the flood preparedness is to enhance technical capacities of relevant authorities and other stakeholders in all riparian countries in flood preparedness and emergency management. One need to develop a people centered approach towards integrated flood risk management.

The main activities are to develop and implement innovative flood preparedness and emergency

management activities at the sub-national level by addressing directly the needs of the flood vulnerable communities. This has increased communication, coordination and cooperation between these stakeholders, as well as the consistency of national disaster management and mitigation policy implementation of Mekong River Commission member countries.

13 Education of stakeholders on flood and drought management

13.1 Farmer Training – living with flood and drought

The national flood and drought policy includes farmer assistance provisions, which include farmer training and emergency aid. Farmer training includes business guidance to help farm owners create a strategic business plan, financial planning, resource management, work-life balance, and planning for climate change. National governments can also disseminate useful indigenous practices and special techniques in soil and water conservation, water harvesting, small-scale irrigation, and agro-forestry to farmers. Farmers could also benefit from discounts, loans, or other incentives to update old machinery or invest in new technology.

13.2 Community-based flood mitigation and preparedness in Cambodia

Cambodia is exposed to annual river flood during the monsoon season along two major watersheds, the Tonle Sap Lake and the Mekong River. Localized flood caused by monsoon thunderstorms presents a serious problem for the communities. The Community-Based Flood Mitigation and Preparedness Plan are crucial for the flood preparedness purposes, which decrease significantly flood damages. The major goal of the plan is building the capacities of communities to respond to flood emerging situations. The Disaster Management Committees (DMCs) is leading communities in protecting themselves from the impact of flood in their localities.

13.3 Resource mobilization for community empowering in Cambodia

The main issues to be considered when implementing mitigation solutions are:

- Does everyone agree with the mitigation solution?
- Where will one get funding?
- How do we mobilize resources?
- How do we mobilize people?
- How does one maintain the mitigation solution?
- Mitigation minimizes the impact of flood, but can one prepare for it?

Resource mobilization means that all stakeholders are working together to prepare for the emergency situations and to act when disaster happen. Private agencies cooperate together and work with the communities to organize and mobilize people and resources in order to develop and implement mitigation strategies. Responsible people have to be identified and one has to rely on the local authorities such as the chiefs of the communes and villages, village groups, temple committee members, monks, and village elders. They are supposed to have advisory role or organizing roles in order to mobilize community resources for flood mitigation. Volunteers also help villages to find solutions for the emerging situations. The mitigation solutions generally are focused on water control structures necessary for livelihood(repairing dams and dikes, cleaning out irrigation ditches, culverts and water gates)or access (raising road levels or constructing small bridges). Resource mobilization is not always an easy process. Material and financial resources are scarce as most villagers are poor in Cambodia. A large portion of financial support had to come from outside the community. Most of the communities had not previously received any form of financial aid for any community-based initiative, so fundraising has to be foreseen. Mobilizing resources effectively comprises the following principles:

- Work with existing community groups.
- Make activities credible.
- Gain the support of local authorities and respected individuals within and beyond the community.
- Use community festivals and other events to promote activities.
- Do not let money drive activities and actions.

- Focus on linking mitigation solutions with the needs and priorities of the majority of community members.
- Ensure transparency in fund management.
- Consider timing of activity implementation

13.4 Implementation of mitigation solutions

Mitigation solutions, which can be applied, are those that reduce the communities' vulnerability to flood and improve their leaving conditions enhancing safety and economic benefits. For example, the construction of an emergency evacuation route enhanced the safety of villagers and their livestock. Rising of roads and construction of bridges provided are liable transportation route and increased accessibility, allowing students to travel to school and traders to transport their agricultural produce to local markets. New, enlarged or rebuilt culverts increased the community's control over the water flow, enabling them to increase their rice crop yield. In mitigation measures, the role of NGOs, private sector and government is important. The primary requirement for success in mitigation is local leadership and local responsibility.

In the Cambodia case, villagers are asked to contribute according to their abilities both financially and with respect to labor and materials. However, there are some examples when the problems appear: when making a bridge during the flooding for the evacuation, it can happen that costs of transporting materials are not foreseen and there is no funding. Also, during the harvest season the busy schedule of the villagers during harvest made it difficult to mobilize people and secure a commitment causing delays in the completion of mitigation work. Furthermore, the lack of technical skills among the villagers led to the added expense of hiring a knowledgeable and skilled person.

Lessons learned from the Cambodia examples of resources mobilization for flood mitigation are:

- Limited resources, human, financial and material
- Introduce fundraising activities and seek donor-support.
- Conflicting needs of funding agencies and communities
- For the benefit of the communities, involve the main decision-making and handover project as soon as possible.
- Misinformed decisions resulting in un satisfactory project output
- Ensure broad-based participation of people in the community for advice and assistance.
- Poor timing of mitigation measures implementation leading to lack of commitment
- Ensure sensitivity to work patterns, religious rites and festivals in communities

Replications of flood mitigation solutions

Replication of a community's success is a powerful factor in continuing local initiatives.
To do so, it is important to:

- Replicating success
- Students help in the reconstruction and constructing.
- Raised roads and protect the roads during the monsoon season.
- Lessons learned:
- Involve and convince people.
- Work together with local authority.
- Use appropriate technology.
- Show immediate results.

13.5 Preparedness planning in Cambodia

Flood preparedness is crucial step in the flood management cycle. One needs to raise awareness on the importance of flood preparedness, supported by the plan of providing further training on disaster preparedness. Planning activities in advance for the prompt actions of evacuation when flood happen, is a step towards increased preparedness planning in Cambodian communities. In that respect, the flood warning system needs improvement. Early warning and people's participation in disseminating early warning messages is of particular importance in the overall preparedness plan of communities.

It is important to enhance and build people's capacities to take the responsibility in monitoring hazards and issue warning to save their lives. The Royal Government of Cambodia, in partnership with the Mekong River Commission, is working to make timely and relevant flood information accessible. This public access to information on local patterns of risk is empowering and facilitates community participation in decision-making. In that way the opportunities for responsible governance are increased.

Community-based approach increases development capacity for flood preparedness and mitigation. The primary purpose of a community-based approach should revolve around addressing vulnerable conditions and the main strategy is to increase the community's capacity, their resources and coping strategies. Cambodian`s experience on flood preparedness had

shown that community's increased managerial and technical capacities often led to further development initiatives within and beyond their own communities.

13.6 National training and capacity-building on drought management in India

Capacity-building is a long- term process which is needed at the implementation level, at institutional and individual levels. Development of tools for drought prediction and mitigation is also part of education. Capacity development comprises government, city and district authorities. Capacity-building is addressing the needs of all the target groups mentioned Components of the multi-layer capacity development framework include training, techno-legal framework, knowledge management and developing institutional and individual capacities. Training is crucial among all capacity development activities. Training needs have to be designed and are involving all groups of stakeholders to fully address the needs of knowledge management. The target groups identified for training and capacity development are including the government officials, scientific community, technical institutions etc.

13.7 Training on drought management

Training needs assessment of drought management is not done in a good way in India and the training needs are not identified. Training is an integral part of capacity-building as trained personnel respond much better to initiatives. The performance of the personnel will be improved by need based training in all institutions. Training and capacity-building is also needed for all communities and other private institutions which are involved in drought mitigation and management. Educational and training institutions are ensuring training in drought management strategies. Special focus is given to water resources, crop and soil management. Some institutions are executing pilot projects in a participatory mode with agricultural universities and organizations. They are intending to carry out research in various aspects of drought management to establish synergy between various aspects of drought including the science, institutional, policy, socio-economic, legal, water, soil, environment and ecology related issues.

13.7.1 Training of trainers

In India there are not many qualified and experienced trainers but there is a serious demand for training of government cadre in drought management and mitigation.

Identification of stakeholders at various levels including the communities is required. Since the number of personnel to be trained is very large, a pool of trainers is developed at district and city level to facilitate decentralized training. Efforts are made to fill the gap between the requirement and availability of qualified and experienced trainers familiar with natural hazards, especially with drought mitigation and management activities. If detailed training needs are not determined in drought management, one could consider a possible list of areas of intervention for training and capacity-building in drought management as following:

- Natural resources management with specific focus on water conservation and management , watershed development, creation and revival of water bodies
- Financial, social, legal rules and regulations
- Use of information technology and remote sensing applications
- Monitoring & Evaluation
- Special training for the public representatives and politicians
- Synergy between departments and institutions
- Ground water recharge management techniques
- Use of micro - irrigation and supplement irrigation using harvested water
- Re-vitalizing of existing facilities
- Livestock development and management
- Agro forestry, farm forestry and dry land horticulture
- Plan for Agriculture
- Drought assessment, prediction and weather based agro-meteorology

13.8 Building capacities of local authorities in flood risk reduction in Thailand and Vietnam

Mekong River Commission with the flood preparedness and management programme help and assist Thailand, Vietnam, Cambodia and Laos to adopt holistic flood management initiatives. That means that they are able to address the interaction between beneficial aspects of flood and the flood risks management. That results in development and implementation of flood preparedness programmes (FPP). The FPP assign equal emphasis on both preparedness and emergency interventions of flood management. They also insist on participatory approach in order to increase and to match the consensus and ownership among the provincial and district level stakeholders. Such approach defines clear roles and responsibilities of the member line agencies who are member disaster management committees and sort out the requirements for implementing preparedness, mitigation, response, recover and rehabilitation tasks.

The FMMP has played a key role in facilitating the development and implementation of flood preparedness programmes (FPP) through the most participatory process by the national, provincial and district disaster management committees to improve the coordination of many affected departments with clearly defined roles and responsibilities and to reduce flood risks by implementing priority action areas identified in the FPP.

The engagement of the Provincial and District Disaster Management focal points in the FPP development process offered them exclusive opportunities to increase their ability in other aspects of flood risk reduction beyond the emergency response phase and to utilize their knowledge obtained from the trainings.

Following the successful development of FPP, further capacity-building activities are supported to implement the priority actions of FPP, as a progressive movement towards building of local capacities. The provincial and district level FPP process also facilitated in collecting and compiling information on existing resources in their vicinity such as location and number of health centers and safe areas and related facilities, existing number of boats and communication equipment, etc., in their provinces and districts. These resource inventories were used in the existing provincial and district maps with help from Regional Flood Management and Mitigation Center (RFMMC) facilities situated at Phnom Penh, Cambodia. These maps incorporated information required for planning such as national, provincial and district road and railway networks, rivers and streams, district and commune boundaries, etc. Relevant authorities have provided with final products, and the information was also kept at the data basis for further use by other interested users.

The provincial and district level disaster preparedness planning process has helped in institutional capacity and confidence building in the local district management officials to deal with the annual Mekong flooding. The experiences of the provincial and district levels officials show that they are able to demonstrate their built capacities and coordinate better than before in recent disasters including the Ketsana Typhoon that struck Cambodia, Lao PDR and Viet Nam.

The flood preparedness manual and the template on which they have prepared the plans have been useful to performed their roles and responsibilities in coordinated way.

13.9 Developing the local capacity base on flood risk reduction in Thailand and Vietnam

Each of the Mekong River Commission member country has developed a manual on Flood Preparedness Program Planning and Implementation for provincial and district level authorities in the Lower Mekong Basin in local language. The manual serves as an effective guide for local disaster management authorities for planning and implementing appropriate measures at all stages; from flood preparedness to flood mitigation to response to recovery and long term rehabilitation. The manual marks essential elements including detailing of roles and responsibilities of all stakeholders to ensure that preparedness and response activities are undertaken and assigned to avoid duplication or oversight of the activities and maintaining a resource inventory for fast resources deployment in case of emergency. It also underlines such cross cutting issues as livelihood planning, environmental conservation, flood plain management and mainstreaming of flood risk reduction into local development planning process. The manual emphasis the importance of accountability within the process of disaster management and risk reduction and the need for the presence of a main agency in charge of overall supervision of implementation arrangements. Although the manual was intentionally developed to address flood preparedness in the Lower Mekong Basin countries, it can easily be adapted to suit other country contexts and alternative flood events. The significant number of trained human resources in all the thirty target districts has been created at the national and sub-national levels while implementing the flood preparedness and emergency management project activities. These key officials play an important role as trainers in further training and capacity-building activities at local levels. The Community Based Flood Management (CBFM) trainings for selected commune level disaster member officials intend to improve the practical skills in flood management and to strengthen their capacities in flood preparedness planning and implementation. Such approach is helping them to manage and mitigate the negative impacts of flood. These trainings were carried out across the eleven target provinces in the four countries: Thailand, Vietnam, Cambodia and Laos. To meet the challenges of drowning during flooding season, Search and Rescue (S&R) trainings in Viet Nam were provided to the officials and youth organizations. These on the job trainings improved human skills and strengthen the rescue abilities at strategic locations at the confluence of rivers and along the waterways which are dangerous locations during the flood season.

14 National flood and drought policy evaluation – "Spiral approach"

14.1 Review process

A review of the impact of existing policies that have been tested is essential for improving the effectiveness of any national flood and drought policy. The process should include an economic assessment of how allocated funds were spent as well as a social assessment to see how the policies affected relevant stakeholders, such as farmers and industry. This information should be considered when updating the policy and the policy should allow for this flexibility. Every time with the current policy is evaluated; the result should show positive improvement in integrated management of flood and drought.

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