China – UK, WRDMAP
Integrated Water Resources Management Document Series

2. IWRM

Thematic Paper 2.5: Drought Management for Water Resources Managers

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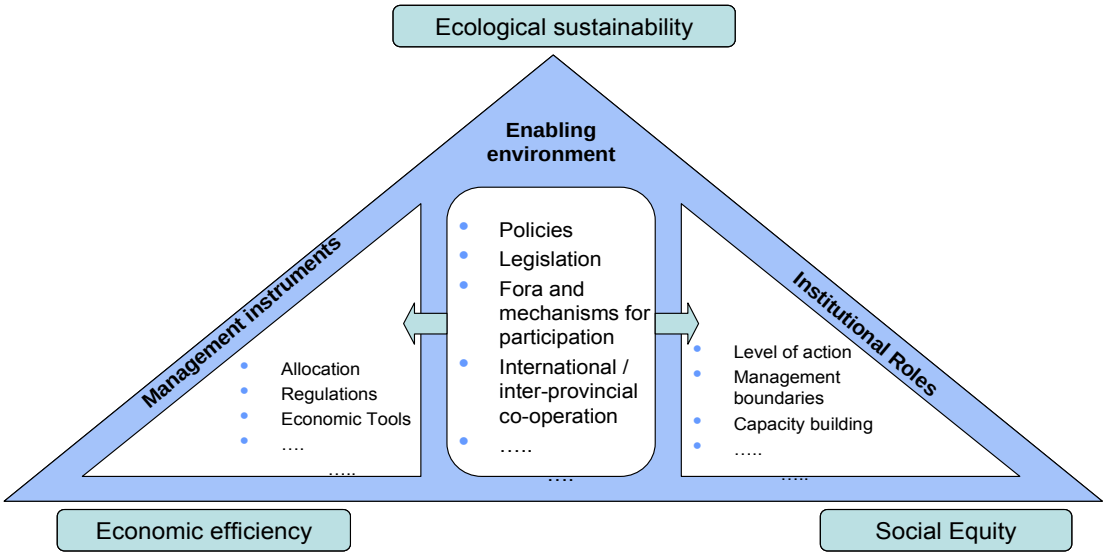
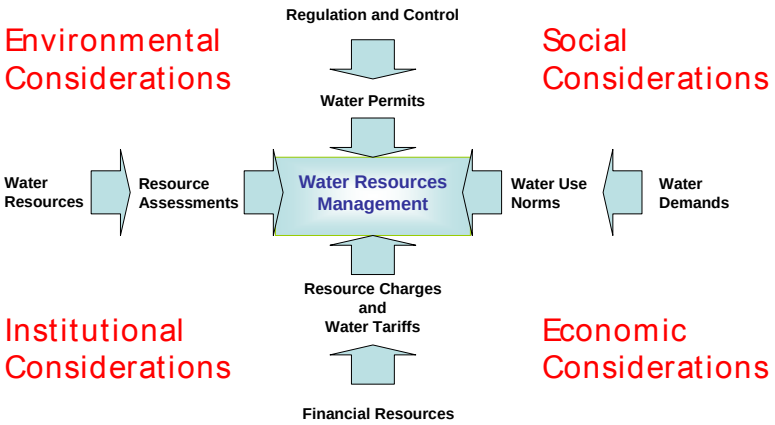
Integrated Water Resources Management (IWRM)

(Basics after Global Water Partnership)



Driving Elements of Integrated Water Resources Management



(Second figure after WRDMAP)

Summary: Drought is a normal climatic feature. That it is also a serious and continuing worldwide water issue is more due to lack of effective water planning and management than to climate.

This thematic paper describes a **risk management-based approach to drought planning for water resources managers.** The impacts of drought, like those of other natural hazards, can be reduced through mitigation and preparedness (risk management). Planning ahead to mitigate drought impacts gives decision makers the chance to relieve impacts at the least expense. Current approaches to drought management by water resources agencies in China are described and comparison made with international examples, highlighting the progress that is being made in implementing risk management based drought planning. The paper covers:

- Drought conceptual framework
- Types of drought
- Drought indices and triggers
- Drought risk management approaches
- Risk reduction strategies
- Developing a drought management plan
- Drought management plans – international examples
- Drought management in China

This document is one of a series covering topics on sustainable water resources planning, allocation and management. Details are given in the bibliography.

The Ministry of Water Resources have supported the Water Resources Demand Management Assistance Project (WRDMAP) to develop this series to support WRD/WAB at provincial, municipal and county levels in their efforts to achieve sustainable water use.

1 Introduction

1.1 Drought management - the wider perspective

This Paper focuses on drought management from the **perspective of water resources managers**, but it is important to bear in mind that preparing for, and dealing with, the consequences of drought on the human population involves a much wider range of stakeholders than just water sector institutions. In this wider context, **drought management can be clearly seen as a cross-sector issue requiring close collaboration between key institutional stakeholders**.

For example, rain fed agriculture is often the most sensitive sector to drought but falls outside the scope of most water resource planning and cannot really be addressed by water engineers/managers. This highlights the importance of cross-sector links in drought management planning and drought management.

Indeed, stakeholder participation is central to the concept of integrated water resources management (IWRM).

Throughout the Paper brief references are made to social and economic aspects of drought planning, management and recovery where the role of water resources managers is of less significance than that of other institutional stakeholders, this is to set the role of the water resources manager in context and to emphasise the importance of information sharing and other links.

Other documents in this series cover IWRM, stakeholder participation, and means of improving cross-sector sharing of information (see

bibliography at the end of the Paper for details).

This document series has been prepared under the WRDMAP (2005-2010) which addressed IWRM and water demand management issues particularly related to dry season conditions in northern China. As part of the activities the issue of drought management was explored in Chaoyang Municipality of Liaoning Province. A specific drought management plan was developed that was officially approved by the Municipality in 2008. A sample survey of drought management approaches in China was also undertaken. These activities have informed the content of this paper.

1.2 Water resources context

Drought is a normal climatic feature. That it is also a serious and continuing worldwide water issue is more due to lack of effective water planning and management than to climate. No region is immune to drought problems but some have more serious droughts than others.

Failures in water supply can have serious consequences to cities, industries and other water users such as irrigation, hydropower, recreation and wildlife, and the **risk of failure is increasing with the interdependence and vulnerability of water systems**. While it is not possible to completely prevent water shortages, effective water resources management can minimise problems and mitigate impacts.

Climate change is likely to make matters worse in some areas.

Planning ahead to mitigate drought impacts gives decision makers the chance to relieve the most suffering at the least expense. **Preparedness** is based on good scientific understanding of the **local 'climatology of drought'** and how drought impacts on the population and economy, strong institutional arrangements that clearly identify which organisation will do what and when, and finally a widespread awareness in society of the need for water saving and the part that they play in achieving it.

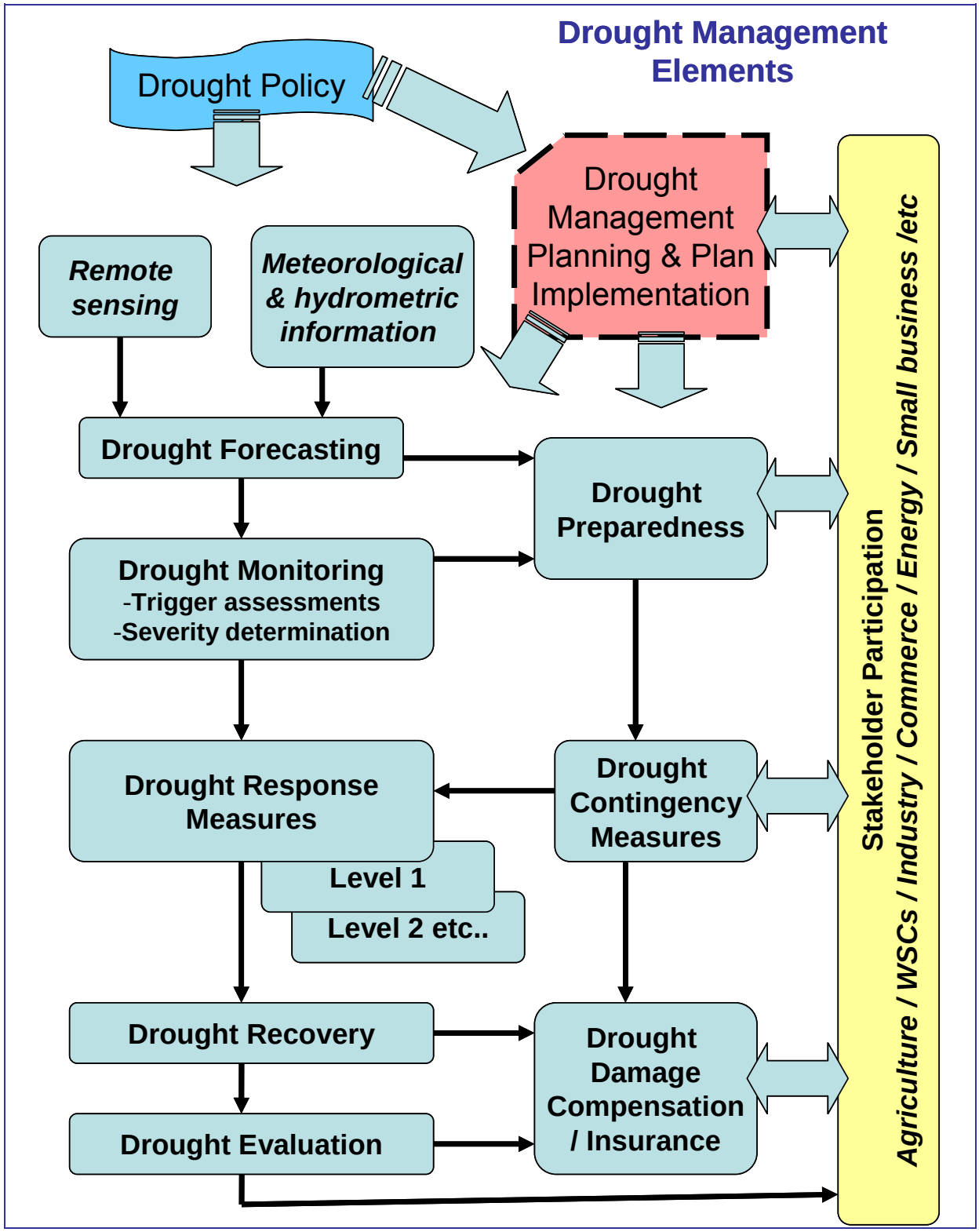
Water resources planning and management for drought preparedness and mitigation starts by an assessment of the potential and available water resources and the vulnerability of the existing supply systems to drought. The essence of a drought management plan is a determination of which drought response actions will be implemented under what conditions of water shortage. Figure 1 illustrates the many aspects that must be considered.

Further guidance on practical drought management planning by water resources managers is available through other documents in this series: Advisory Note 2.5 'Developing a Drought Management Plan – Guidance for Water Resources Managers'; and an example of the preparation of a drought management plan (DMP) in the document Example 2.5 'Preparation of a Drought Management Plan for Chaoyang Municipality, Liaoning Province'.

1.3 Policy and legislation

The essential prerequisite to successful drought management planning for reduced societal vulnerability is the development and adoption of a policy on drought.

Figure 1: Drought management elements



Such a policy, which should have the support of all decision-making levels (national, local, etc.), and should also be a key element of national development strategies, particularly the aspects related to water and other natural resources development and management.

To avoid fragmentation of activities between several institutions, with no, or limited, coordination, additional regulations, mechanisms and structures for implementing and enforcing the policies are also needed. The regulations should spell out in a clear fashion all aspects related to drought, such as the institutional set-up and their mandates, coordination of the programmes and activities, etc.

The development of national drought policy should be built on discussion among, and consensus of, all concerned sectors, institutions and groups of interest to achieve effective stakeholder 'buy in'. Box 1 illustrates how in the federal system of the USA coordination and collaboration are essential to reducing the nation's vulnerability to the impacts of drought.

Box 1 Drought policy example from the USA

In 1998, Congress passed the National Drought Policy Act. The Act stated that the nation would benefit from national[1] drought policy based on preparedness and mitigation to reduce the need for emergency relief. The Act created a National Drought Policy Commission to advise Congress on how best to:

- Integrate federal drought laws and programmes with ongoing state, local, and tribal programmes into a comprehensive national policy to mitigate the impacts of and respond to drought.
- Improve public awareness of the need for drought mitigation.
- Achieve a coordinated approach to drought mitigation and response by governments and nongovernmental entities, including academic, private, and non profit interests.

The experts of the National Drought Policy Commission held public hearings across the country and invited written comments on the draft of their recommendations. Comments were received from non federal governments, citizen groups, and individuals.

The National Drought Policy Commission recommended that the guiding principles of national drought policy should be:

1. Favour preparedness over insurance, insurance over relief, and incentives over regulation.
2. Set research priorities based on the potential of the research results to reduce drought impacts.
3. Coordinate the delivery of federal services through cooperation and collaboration with non federal entities.

Preparedness—including drought planning, plan implementation, proactive mitigation, risk management, resource stewardship, consideration of environmental concerns, and public education—must become the cornerstone of national drought policy.

[1] In the USA the government system places many limitations on the powers of the federal (national) government. Thus the National Drought Policy Act directed the Commission to avoid recommendations that might diminish the rights of states to control water through state law, or interfere in any way with state, local, and tribal sovereignty.

Source: National Drought Policy Commission Report (see bibliography)

Stakeholder involvement should also feature strongly in subsequent planning activities after the drought policy is adopted.

2 Drought Conceptual Framework

Drought is a normal, recurrent feature of climate, although many erroneously consider it a rare and random event. It occurs in virtually all climatic zones, but its characteristics vary significantly from one region to another. Drought is a temporary aberration; it differs from aridity, which is restricted to low rainfall regions and is a permanent feature of climate.

Drought is an insidious hazard of nature. Although it has many definitions, it originates from a deficiency of precipitation over an extended period of time, usually a season or more. This deficiency results in a water shortage for some activity, group, or environmental sector. Drought should be considered relative to some long-term average condition of balance between precipitation and evapo-transpiration in a particular area, a condition often perceived as “normal”.

It is also related to the timing (i.e., principal season of occurrence, delays in the start of the rainy season, occurrence of rains in relation to principal crop growth stages), and the effectiveness (i.e., rainfall intensity, number of rainfall events) of the rains. Other climatic factors such as high temperature, high wind, and low relative humidity are often associated with drought in many regions of the world and can significantly aggravate its severity.

Drought should not be viewed as merely a physical phenomenon or natural event. Its impacts on society result from the interplay between a natural event (less precipitation than expected resulting from natural climatic variability) and the demand people place on water supply. Human beings often exacerbate the impact of drought. Recent droughts in both developing and developed countries, and the resulting economic and environmental impacts and personal hardships, have underscored the vulnerability of all societies to this “natural” hazard.

There are two main kinds of drought definitions: **conceptual** and **operational**. **Conceptual** definitions, formulated in general terms, help people understand the concept of drought. For example: “Drought is a protracted period of deficient precipitation resulting in extensive damage to crops, resulting in loss of yield.” Conceptual definitions may also be important in establishing drought policy.

Operational definitions help people identify the beginning, end, and degree of severity of a drought. To determine the beginning of drought, operational definitions specify the degree of departure from the average of precipitation, or some other climatic variable, over some time period. This is usually done by comparing the current situation to the historical average, often based on a 30-year period of record. The threshold identified as the beginning of a drought (e.g., 75% of average precipitation over a specified time period) is usually established somewhat arbitrarily, rather than on the basis of its precise relationship to specific impacts.

An operational definition for agriculture might compare daily precipitation values to evapo-transpiration rates to determine the rate of soil moisture depletion, and then express these relationships in terms of drought effects on plant behaviour (i.e., growth and yield) at various stages of crop development. Such a definition could be used in an operational assessment of drought severity and impacts - by tracking meteorological variables, soil moisture, and crop conditions during the growing season, and continually re-evaluating the potential impact of these conditions on final crop yield.

Operational definitions can also be used to analyse drought frequency, severity, and duration for a given historical period. Such definitions, however, require weather data on hourly, daily, monthly, or other time scales and, possibly, impact data (e.g., crop yield), depending on the nature of the definition being applied. Developing a 'climatology of drought' for a region provides a greater understanding of its characteristics and the probability of recurrence at various levels of severity. Information of this type is very beneficial in the development of response/mitigation strategies and preparedness plans.

Water managers require operational definitions for drought to fulfil their responsibilities for:

- Water abstraction permitting;
- Water allocation;
- Water quality management; and
- Environmental allowance control.

All of which require response/ mitigation strategies to address the impacts of drought.

3 Types of Drought

3.1 General

Droughts are commonly classified as meteorological, agricultural, hydrological, and socio-economic.

Meteorological drought is a natural event that results from climatic causes, which differ from region to region. Agricultural, hydrological, and socio-economic drought, however, place greater emphasis on the human or social aspects of drought. They highlight the interaction between the natural characteristics of meteorological drought and human activities that depend on precipitation to provide adequate water supplies to meet societal and environmental demands.

3.2 Meteorological drought

Meteorological drought is usually defined by a precipitation deficiency over a pre-determined period of time. The thresholds chosen, such as '50 percent of normal precipitation over a six-month time period', will vary by location according to user needs or applications. Meteorological drought is defined usually on the basis of the degree of dryness (in comparison to some "normal" or average amount) and the duration of the dry period. Definitions of meteorological drought must be considered as region-specific since the atmospheric conditions that result in deficiencies of precipitation are highly variable from region to region. Some definitions of meteorological drought identify periods of drought on the basis of the number of days with precipitation less than some specified threshold.

3.3 Agricultural drought

Agricultural drought is defined more commonly by the lack of availability of soil water to support crop and forage growth than by the departure of normal precipitation over some specified period of time. The relationship between precipitation and infiltration of precipitation into the soil is often not direct. Infiltration rates vary depending on antecedent moisture conditions, slope, soil type, and the intensity of the precipitation event. Soil characteristics also differ. For example, some soils have a higher water-holding capacity, which makes them less vulnerable to drought.

Agricultural drought links various characteristics of meteorological (or hydrological) drought to agricultural impacts, focusing on precipitation shortages, differences between actual and potential evapo-transpiration, soil water deficits, reduced ground water or reservoir levels, and so forth. Plant water demand depends on prevailing weather conditions, biological characteristics of the specific plant, its stage of growth, and the physical and biological properties of the soil.

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. Deficient topsoil moisture at planting may hinder germination, leading to low plant populations per hectare and a reduction of final yield. However, if topsoil moisture is sufficient for early growth requirements, deficiencies in subsoil moisture at this early stage may not affect final yield if subsoil moisture is replenished as the growing season progresses or if rainfall meets plant water needs.

3.4 Hydrological drought

Hydrological drought is normally defined by deficiencies in surface and groundwater supplies relative to average conditions at various points in time through the seasons.

Like agricultural drought, there is no direct relationship between precipitation amounts and the status of surface and groundwater supplies in lakes, reservoirs, aquifers, and streams because these hydrological system components are used for multiple and competing purposes, such as irrigation, recreation, tourism, flood control, transportation, hydropower production, domestic water supply, protection of endangered species, and environmental and ecosystem management and preservation.

The frequency and severity of hydrological drought is often defined on a watershed or river basin scale. Although all droughts originate with a deficiency of precipitation, water resource managers are more concerned with how this deficiency plays out through the hydrologic system. Hydrological droughts are usually out of phase with or lag the occurrence of meteorological and agricultural droughts. It takes longer for precipitation deficiencies to show up in components of the hydrological system such as soil moisture, river flow, groundwater, and reservoir levels.

Hydrological droughts are also a function of the robustness of the water resource systems, eg presence of large capacity dams with inter-annual storage or good quality aquifers that provide long term buffers against drought.

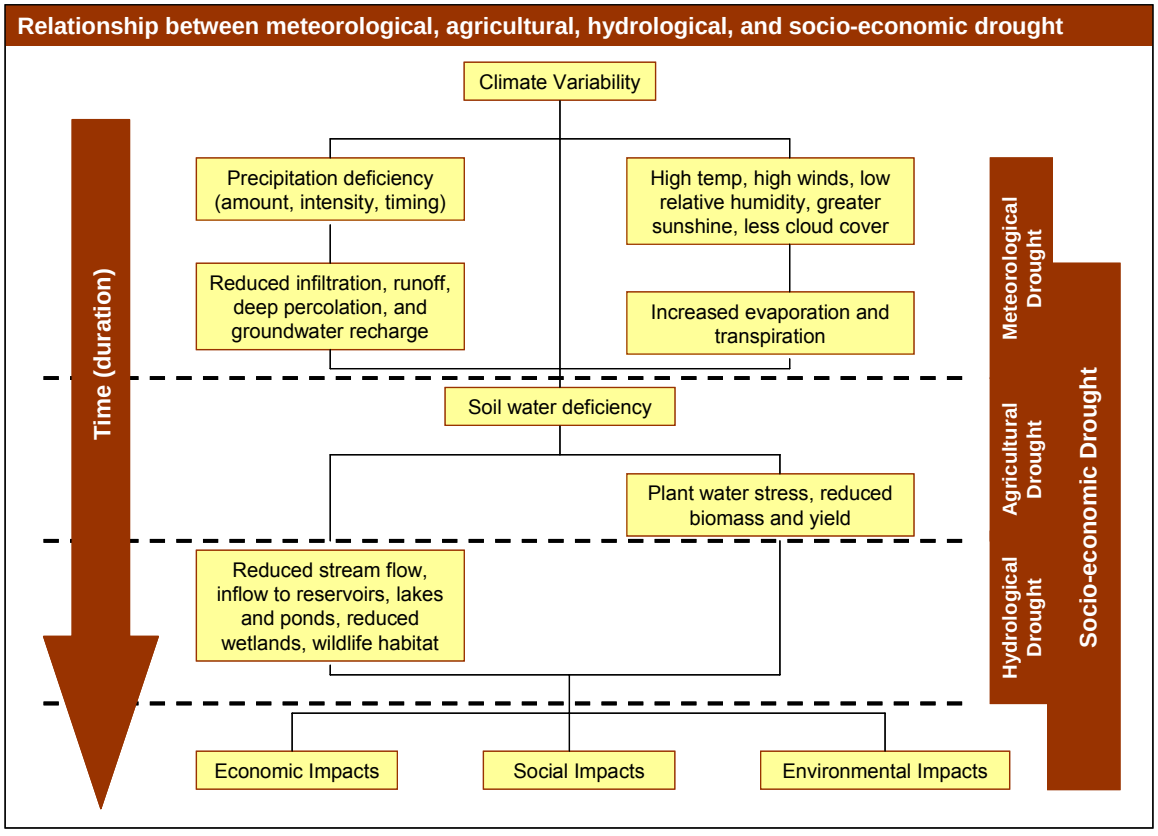
3.5 Socio-economic drought

Socio-economic drought differs markedly from the other types of drought because it reflects the relationship between the supply and demand for some commodity or economic good (such as water, livestock forage, or hydropower) that is dependent on precipitation. Supply varies annually as a function of precipitation or water availability. Demand also fluctuates and is often associated with an increasing trend as a result of population growth, development, and other factors.

3.6 Relationships between the types of drought

The relationship between these types of drought is illustrated in Figure 2. Agricultural, hydrological, and socio-economic drought occur less frequently than meteorological drought because impacts in these sectors are related to the availability of surface and subsurface water supplies. It usually takes several weeks before precipitation deficiencies begin to produce soil moisture deficiencies leading to stress on crops, pastures, and rangeland. Continued dry conditions for several months at a time bring about a decline in river flow and reduced reservoir and lake levels and, potentially, a lowering of the groundwater table.

Figure 2 Relationships between different drought definitions



Source: National Drought Mitigation Center, USA

When drought conditions persist for a period of time, agricultural, hydrological, and socio-economic drought occur, producing associated impacts. During drought, not only are inflows to recharge surface and subsurface supplies reduced, but demand for these resources increases dramatically as well. The direct linkage between main types of drought and precipitation deficiencies is reduced over time because water availability in surface/subsurface systems is affected by how the systems are managed.

Changes in the management of these water supplies can either reduce or aggravate the effects of drought. For example, the adoption of appropriate tillage practices and planting more drought-resistant crop varieties can diminish the effect of drought significantly by conserving soil water and reducing transpiration. Therefore, the effects of drought are a product of both the physical nature of the hazard and our ability to manage risk.

3.7 Elements of droughts

The following are common elements of droughts and respective definitions:

- Intensity - deficiencies in precipitation, surface and groundwater supplies.
- Duration - seasonal, multi-season, multi-year.
- Impacts on human activities/environment - individual, sector and region specific
- Thresholds – explicitly defined for operational controls.
- Severity - best described through multiple indicators and indices (early warning systems)
- Impacts are non-structural in nature (unlike floods which typically cause a lot of damage to structures, eg embankments, buildings) and spread over large areas (which makes assessment and response difficult; mitigation actions less obvious)

4 Drought Indices and Triggers

4.1 Development and need for indices

In principle, drought indices provide a measure of the difference between needed and available water resources and can be part of the "decision support systems" relating to drought.

Indicator statistics can be developed for the four drought types (Figure 2). When developing a decision support system the indicators should be chosen and weighted to suit the local situation. Therefore indicators should be chosen on the basis of a basin-wide resource assessment, an understanding of the ‘climatology of drought’ in the basin, the operation of existing water control infrastructure, and an understanding of the socio-economic importance of precipitation, surface water and groundwater to the population and to different sectors.

To water managers, drought means problems in meeting demand. In that sense, drought means not having sufficient water to meet demands because supplies fall below expected levels. The "expected levels" are socio-economic because expectations can be adjusted – this is the basis for mitigation and conservation measures discussed later.

Different users of indices will have different decision support requirements. In general, water managers need indices to measure

climatic and hydrologic trends and fluctuations.

Box 2 Example of drought indicators

The drought early warning index in Bengbu City is expressed by the estimated water supply guarantee rate, i.e. the forecast water supply volume from all water sources in a certain period in future versus the normal water demand volume in the corresponding period.

Drought Early Warning Index	Estimated Water Supply Guarantee Rate (T)
Slight drought	90%< T <95%
Moderate drought	80%< T ≤90%
Severe drought	70%< T ≤80%
Extreme drought	T ≤70%

Drought thresholds are also assessed based on the storage available at Bengbu Gate.

Source: Drought management plan for Bengbu City, Anhui Province, China.

4.2 Setting triggers

The threshold value of an index marking the boundary between one drought condition and the next more serious state is often referred to as a 'trigger' because it triggers or initiates actions. Depending on the operational procedures the trigger might initiate an early warning procedure, bring in rotational cuts in supply to conserve water, or take emergency actions to alleviate the consequences of drought.

4.3 Examples of indices

Meteorological indices

As the fundamental driver for the onset of drought, decision support systems for drought management at all geographical scales usually track indicators of meteorological drought. There are a number of tools that are in widespread usage around the world.

Percent of normal precipitation

The percent of normal is a simple calculation well suited to the needs of TV weather forecasters and general audiences. Figure 3 illustrates the use of this index in China to define drought severity.

It is calculated by dividing actual precipitation by 'normal' precipitation - typically considered to be a 30-year mean. This can be calculated for a variety of time scales - usually from a single month to a group of months representing a particular season, to an annual or water year. 'Normal' precipitation for a specific location is considered to be 100%.

One of the disadvantages of using the percent of normal precipitation is that precipitation on monthly or seasonal scales does not have a normal distribution and therefore the results may be misinterpreted. Further, the method assumes that climate is fixed ("stationary") for the purposes of short term planning.

Standardized precipitation index

The Standardized Precipitation Index (SPI) was developed in the USA to quantify the precipitation deficit for multiple time scales. The purpose is to assign a single numeric value to the precipitation which can be compared across regions with markedly different climates. Technically, the SPI is the number of standard deviations that the observed value would deviate from the long-term mean, for a normally distributed random variable. Since precipitation is not normally distributed, a transformation is first applied so that

the transformed precipitation values follow a normal distribution.

The Standardized Precipitation Index was designed to explicitly express the fact that it is possible to simultaneously experience wet conditions on one or more time scales, and dry conditions at other time scales, often a difficult concept to convey in simple terms to decision-makers.

These time scales reflect the impact of drought on the availability of the different water resources. Soil moisture conditions respond to precipitation anomalies on a relatively short scale. Groundwater, stream flow, and reservoir storage reflect the longer-term rainfall anomalies.

The SPI calculation for any location is based on the long-term precipitation record for a desired period, eg SPI(24) for 24-months, SPI(18) for 18-months etc. The original SPI research categorised both wet and dry periods as in Table 1, Figure 3 shows that in China an additional drought category has been introduced between the 'near normal' and 'moderate' in Table 1.

Table 1 Original SPI Categories

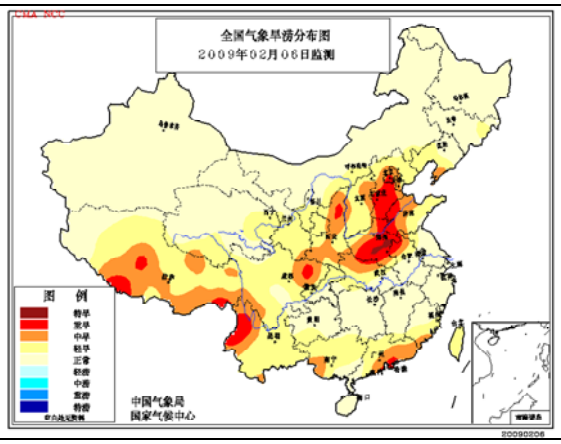
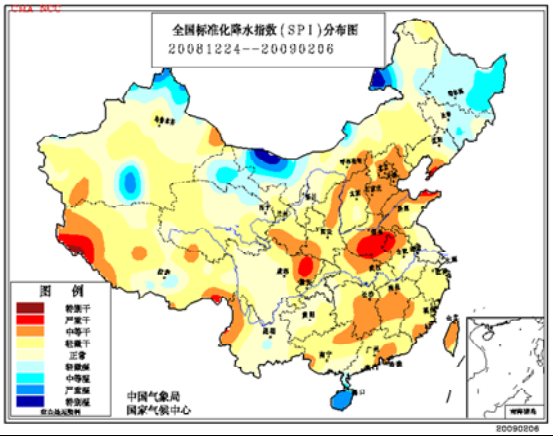
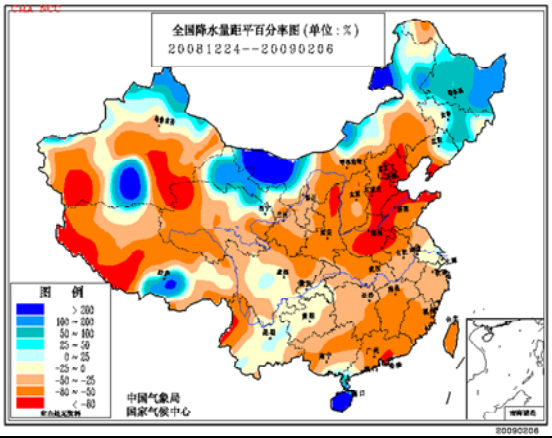
SPI value for chosen period	
2.0 and above	extremely wet
1.5 to 1.99	very wet
1.0 to 1.49	moderately wet
-.99 to .99	near normal
-1.0 to -1.49	moderately dry
-1.5 to -1.99	severely dry
-2 and less	extremely dry

The SPI index is widely used internationally and software for its calculation is freely available on the internet.

Figure 3 China drought monitoring

Drought Class	China Index	SPI	Percentage of Precipitation Anomalies (%)
Extreme Drought	CI≤-2.4	-2 and less	< -80
Severe Drought	-2.4 ~ -1.8	-1.5 to -1.99	-80~ -50
Moderate Drought	-1.8 ~ -1.2	-1.0 to -1.49	-50 ~ -25
Slight Drought	-1.2 ~ -0.6	-0.5 to -0.99	-25 ~ 0
No drought	-0.6+	-0.49+	0 +

Example (6th-Feb-2009)

CI	
SPI	
Percentage of Precipitation Anomalies (%)	

Source: China Meteorological Centre http://ncc.cma.gov.cn

Hydrological indices

Hydrological indicators are more locale-specific than meteorological indices – they are relevant to the particular characteristics, natural and man-made, of a river basin. Therefore whenever an indicator method is transferred from its original location to another basin care is needed to 'recalibrate' the method to ensure that it is relevant and will give reliable guidance.

The development of hydrological drought indicators will depend on the nature of the historical drought problems and the water use infrastructure present in the basin.

The simplest indicators are based directly on field measurement of river flow, reservoir storage, groundwater level, and soil moisture content. The monitoring points to be used need to give results representative of the area of interest. Indicators based on physical values at these chosen monitoring points should be designed to have local significance in terms of assessing water availability to users. For example, a specific depth to groundwater that has local significance in terms of well depths and pumping costs.

Standard hydrological analyses can be carried out on long river flow records to assess the frequency, magnitude, start and end dates and duration of low flow periods. Such parameters are frequently used as indicators particularly in basins where there is no significant natural or reservoir storage to buffer the effects of lower flows.

Hydrological simulation models are often used by water resources planners to model complex systems. Once built and calibrated such models provide an opportunity to obtain estimates of river flows and groundwater levels at points where there is no field measurement, and to run forecast inflows to predict consequences within the system. There is considerable scope for using such modelling tools in setting up, and in using, indicators for drought management.

In basins where there is natural storage in the form of snow pack, information on water equivalent volume at the end of the winter accumulation period could be tracked with a temperature index to forecast melt rate.

Where a basin has significant provision of reservoir capacity indicators based on available storage in reservoirs at critical dates would obviously be important. Mathematical models of reservoir operation are normally used to develop indices based on historical records and operating rules for drought conditions.

Composite indices

Since drought is such a complex phenomenon decision support systems for drought management usually use a number of indices in combination.

It is important to **review** the chosen trigger values for all indices **after a period of operation**, and to make adjustments to try to make the system of triggers more appropriate to the local conditions. Such a process of progressive adjustment to improve performance is common in modern management practices and is referred to as '**adaptive management**'.

4.4 Monitoring to support operational drought management

Drought monitoring is based on basic weather, water, soil moisture, snow amount, and climate observations, supplemented by various forecasting tools. Increasingly this is becoming more accurate and more comprehensive. The use of satellite imagery and remote sensing, the use of telemetry and other real time data transmission systems, all tied through the internet to GIS and drought management decision support systems, can all contribute to making drought management more scientific and efficient/effective.

Problems remain at smaller spatial scales and in more remote areas – such aspects are typically not well served by existing monitoring networks. Remote sensing techniques may provide a solution, but there is still a need for local ground checking to confirm the results from the remote sensing analysis.

However, in many situations data collection is fragmented between several institutions, incomplete and often not treated in the required manner for drought monitoring, nor linked to a decision support system that allows managers and users of water resources to take decisions. In these situations it is essential to improve collaboration among institutions, and between scientists and managers, to enhance the effectiveness of observation networks, monitoring, prediction, information delivery, and applied research.

5 Drought Risk Management Approaches

5.1 Risk management

Droughts are usually managed after the fact by “crisis management” as a response to problems, providing relief as a safety net for the affected population to survive the bad times and rebuild their livelihoods thereafter. There is however a new recognition that a risk based management approach can make society more resilient to the impacts of drought.

Figure 4 shows the relationship between “risk management” acting ahead of a disaster to minimise impacts, and “crisis management” acting only after the disaster is manifest to recover the situation.

The components of drought for risk management are:

RISK = HAZARD x VULNERABILITY

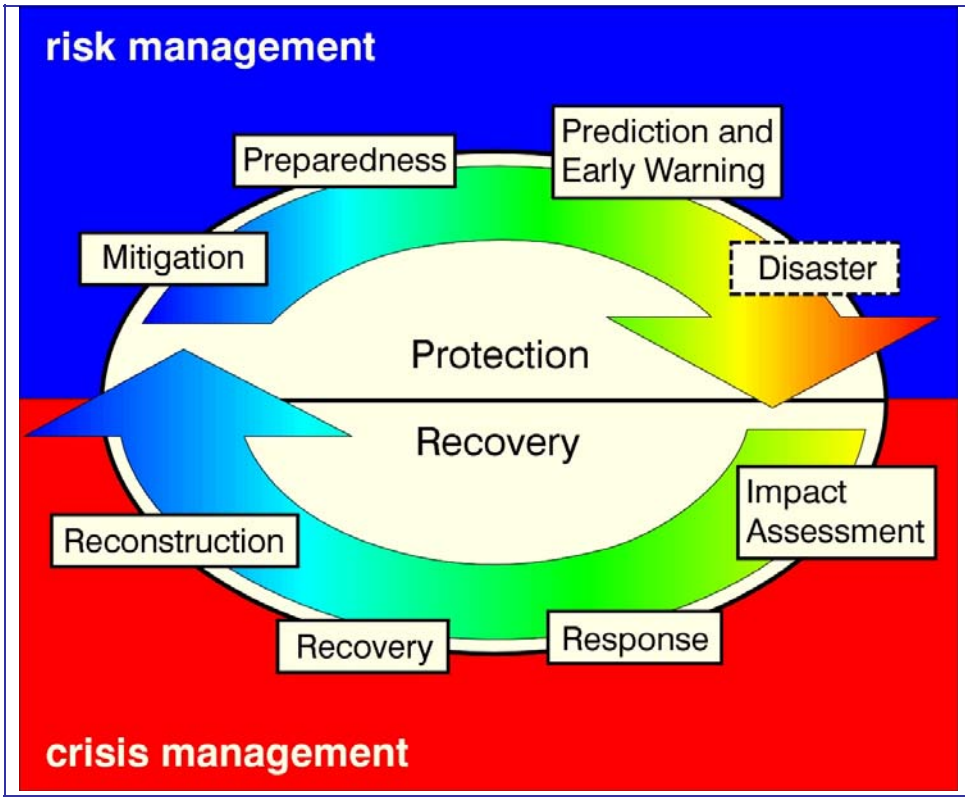
Where **hazard** is the result of natural factors and **vulnerability** is the result of social factors.

5.2 Drought hazard – natural factors

A “Hazard” is a natural event defined under any of the definitions of drought in Section 3, and consists of the following aspects:

- Severity or magnitude
  - Intensity and Duration
- Frequency—probabilities
- Spatial extent

Figure 4 Comparing risk and crisis management approaches



Risk management covers the **entire cycle** and starts from Mitigation and Preparedness

Crisis management has four stages:

Impact assessment
Response
Recovery
Reconstruction

- Trends
  - Historical
  - Future projections
  - Impacts

5.3 Drought vulnerability – social factors

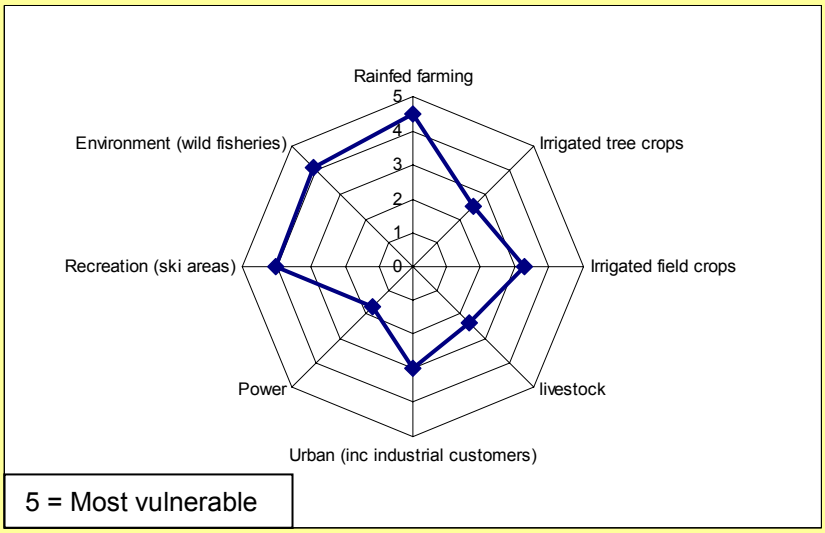
The primary impact of drought is due to the real or feared interruption of supplies, because water supply is critical to the economy and the natural environment.

People's vulnerability to drought is complex. Drought results in substantial effects in both developing and developed countries, but the characteristics of these effects differ considerably. The ability to cope with drought also varies considerably from country to country and from one region, community, or group to another (Figure 5). Therefore, a **vulnerability profile**, including analysis of vulnerability factors, is an invaluable tool in assessing local risk. The vulnerability profile is a cornerstone of drought risk reduction planning. Box 3 shows an example from the USA.

Vulnerability analysis provides a framework for identifying the social, economic, and environmental causes of drought impacts. It directs attention to the **underlying causes** of vulnerability rather than to its result, the negative impacts, which follow triggering events such as drought. For example, in drought conditions, the **direct impact** of a lack of precipitation may reduce crop yields. The **underlying cause** of this impact, however, may be that farmers did not plant appropriate crops because there was no drought warning. Mitigation measures should aim to address the underlying causes because this will reduce the risk in future.

Box 3 Assessing vulnerability to drought in Washington State, USA

The study assessed vulnerability of five sectors in six regions across the state. The agricultural sector was further sub-divided to reflect diversity and differences in vulnerability. The figure below uses the results to present vulnerability by sector for the state as a whole.



Source: Fontaine and Steinemann, 2009

"Vulnerability" consists of a variety of social factors such as:

- Population growth
- Population shifts
- Urbanization
- Technology
- Land use practices
- Environmental degradation
- Water use trends
- Government policies
- Environment awareness

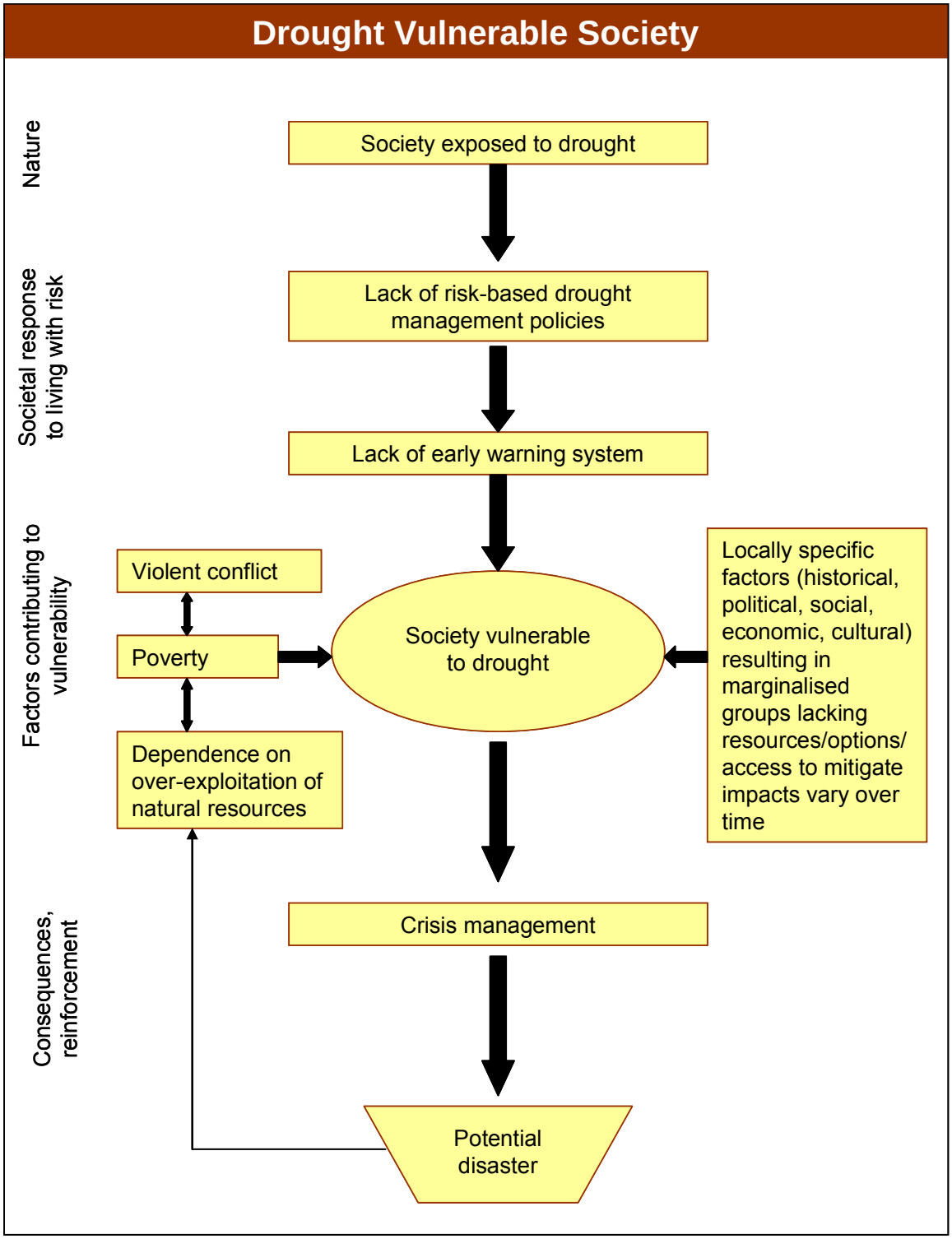
5.4 Drought planning and risk assessment

Although drought is a natural hazard, society can reduce its vulnerability and therefore lessen the risks associated with drought episodes. The impacts of drought, like those of other natural hazards, can be reduced through mitigation and preparedness (risk management).

Planning ahead to mitigate drought impacts gives decision makers the chance to relieve the most suffering at the least expense. Reacting to drought in "crisis mode" decreases self-reliance and increases dependence on government and donors.

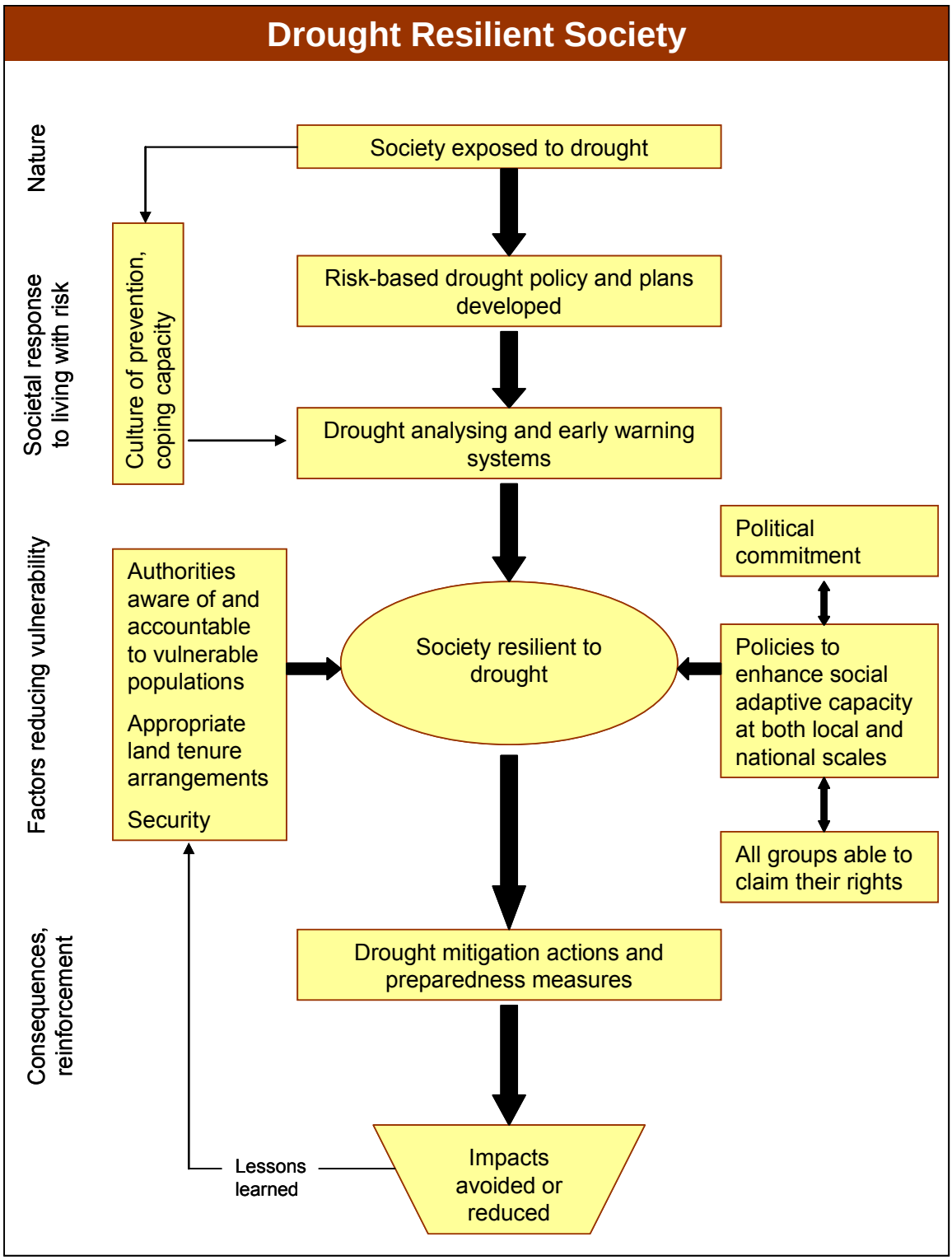
Overall, drought risk assessment must consider both an improved understanding of the natural hazard and human exposure to this climatic extreme, as well as a better understanding of the micro and macro context of people's vulnerability to drought. It must also consider trends that might increase risk such as population pressure, or the increasing interdependence of water systems.

Figure 5a Characteristics of drought vulnerable societies



Source: modified from Drought: Living with Risk, UNISDR, 2003 at http://www.unisdr.org/droughts-doc in Drought Risk Reduction Framework and Practices

Figure 5b Characteristics of drought resilient societies



With this understanding, enhanced drought mitigation, preparedness, and response measures can be identified and implemented to create a more drought resilient society.

Planning for drought is essential, but it may not come easily. There are many constraints to such planning:

- Politicians, policy makers, and the general public may lack an understanding of drought.
- In areas where drought occurs infrequently, governments and the public may ignore drought planning, or give it low priority.
- Governments and the public may have inadequate financial resources.
- No single definition of drought works in all regions.
- Lack of technical knowledge or data to enable drought planning.
- Responsibilities are divided among many governmental jurisdictions.
- Most countries lack a unified philosophy for managing natural resources, including water.
- Policies such as disaster relief and outdated water allocation practices may actually deter good long-term natural resource management.

One of the major impediments to drought planning is its cost. Officials may find it difficult to justify the costs of a plan, which are immediate and fixed, against the unknown costs of some future drought.

5.5 Benefits of drought planning

Some of the benefits of drought planning to a region can be summarised in generic form as follows:

- Proactive, emphasises mitigation and response
- Improves coordination between and within levels of government which enhances organisational structure of responses
- Enhances early warning through integrated monitoring efforts
- Involves stakeholders
- Identifies areas, groups, and sectors at risk
- Reduces economic, environmental, and social impacts (i.e. risk)
- Reduces conflicts between water users
- Improves information dissemination for better delivery of drought management actions
- Builds public awareness

The essence of drought planning is the reduction of risks due to the potential for drought from a variety of aspects, as outlined in the following sections.

6 Risk Reduction Strategies

6.1 Assessment

The assessment stage of drought planning offers a variety of methods for risk reduction such as:

- Develop criteria - “triggers” - for drought-related actions

- Develop forecasting and early warning systems
- Improve the accuracy of seasonal runoff and water supply forecasts
- Establish new data collection networks
- Monitor vulnerable public water supplies
- Establish alert procedures for water quality problems
- Evaluate water quantity and quality from new sources
- Study public willingness to pay more for more reliable water supplies
- Study effectiveness of conservation measures
- Evaluate the continued use of marginally productive farm and rangelands
- Conduct public surveys on environmental, economic, and cultural beliefs for appropriate policy formulation

As shown in Figure 5b, forecasting and early warning systems are crucial elements in increasing resilience.

6.2 Legislation and public policy

Risk reduction strategies under legislative and public policy could involve the following:

- Examine water allocation policy and regulations to improve resilience
- Examine statutes governing water rights for possible modification during water shortages
- Establish a water accounting ("bank") and trading system to give greater flexibility to users to manage their water use
- Pass legislation to protect in-stream flows
- Pass legislation to protect and manage groundwater
- Impose limits on urban development
- Enact legislation to facilitate water recycling
- Establish standards for safe residential use of recycled wash water ('grey water')

6.3 Water conservation and demand reduction

Water conservation and demand-side measures for risk reduction could include:

- Good water allocation planning to accommodate drought scenarios
- Implement water metering and leak detection programs
- Support local development of conservation programs
- Improve water scheduling
- Reduce consumptive use by changing the type of water application system or using water meters
- Institute conjunctive use of surface and ground water
- Changes in water consumption promoting subsidies.
- Reduction of leakages in the distribution networks (pipes and canals).
- Improvement of irrigation technologies by improving agricultural management, optimizing soil water utilisation and irrigation, and setting up new

programmes of practical research in order to reduce water consumption (e.g. crop rotation, genetic variety).

- Promotion of improved waste water reuse where appropriate.
- Wise use of water resources (use of new technologies and changing processes in industry and agriculture), natural storage improvement and water saving.
- Water abstraction permits to have drought reduced permit levels (by water use type/type of permit holder)
- Evaluation of the advantage of setting up water banks and quota systems.
- Setting up an adapted tax and price policy system to encourage investments or demand management approach development, and to develop financial mechanisms to internalize external costs and anticipate profits on water savings.
- Development of education and awareness campaigns.

6.4 Increasing water supplies and/or augmentation

Risk reduction can be accomplished also on the supply side of the equation using methods such as:

- Issue emergency permits for water use
- Propose and implement programmes to rehabilitate reservoirs to operate at design capacity
- Undertake water supply vulnerability assessments
- Inventory of self-supplied industrial water users for possible use of their supplies for emergency public water supplies
- Inventory and review reservoir operation plans to allow for 'contingency storage' that can be drawn upon during drought
- Provide funds for water recycling projects
- Cloud seeding
- Emergency boreholes
- Provide on-stream storage of excess water
- Implement water quality management and wastewater reuse
- Use carryover storage in a reservoir to "bank" a conserved water supply, other water banking concepts
- Preservation of the functioning of natural catchments, aquifers and restoration.
- Improvement of an efficient use of existing water infrastructures.
- Artificial recharge of aquifers.
- Setting up an obligation for using a costs/needs/ advantages/ alternative solutions analysis with economic, environmental and social impact for every project of new water resource creation.
- Evaluation of effectiveness and efficiency of the proposed measures.

6.5 Public education and participation

Public education and participation are very important risk reduction methods using methods such as:

- Establish a public advisory committee and include public participation in drought planning
- Organise drought information meetings for the public and the media
- Implement water conservation awareness programs
- Publish and distribute pamphlets on water conservation techniques and drought management strategies
- Organise workshops on special drought-related topics
- Prepare sample ordinances on water conservation
- Establish a drought information centre with demonstrations of water saving techniques and technologies.

6.6 Timeframes

The various risk reduction strategies and the particular associated actions all address the problem of drought, but not all are appropriate to immediate drought management. That is to say that some strategies are longer term in nature and are therefore more appropriate to longer term planning processes such as the development and updating of river basin plans, integrated water resources management plans, water allocation plans, water saving plans, etc.

A drought management plan should address strategies for early warning, temporary cuts in supply (linked to abstraction permit system), temporary support pumping or augmentation of supply by transfers where the infrastructure exists to do this, practical advice to users on conservation measures.

Table 2 illustrates the distinction between temporary or short term measures and longer term actions to reduce potential impacts of drought.

Refer to Overview Document 2 and Thematic Papers 3.1 ‘Water Saving in Irrigated Agriculture’ and 3.2 ‘Urban Water Supply Demand Management’ for further discussion of water demand management tools as part of long term water resources planning.

Table 2 Examples of possible mitigation measures to reduce drought impacts

Short Term Mitigation Measures (suitable for consideration in drought management plan)	Long Term Mitigation Measures (suitable for river basin plan, integrated water resources plan etc)
Improve the accuracy of seasonal runoff and water supply forecasts	Reduction in leakage in canals and main pipelines
Develop early warning systems	Reduction in leakage in distribution pipe network
Establish new data collection networks and data sharing arrangements	Agricultural extension to advise farmers on more efficient irrigation, more drought resistant crops, rotations, deficit irrigation etc.
Emergency limitation on abstraction permit holders (prioritised list of users) in accordance with SCD 460	Introduce more efficient water use in industrial processes by introduction of new technologies
Rotational cuts in water supply	Introduce new technology for clean up of process effluent to improve quality of return flow
Public education and awareness of water saving actions	Take marginal land out of production
Advice to farmers on cropping before planting based on drought forecast	Implement waste water re-use where water quality permits
Avoid high water use crops	Review development plans to avoid new industry with high water use unless committed to new technologies for recycling etc
Revise reservoir operating rules	Establish protection zones above reservoirs to maintain runoff potential and minimise sediment ingress
Waste water reuse where water quality permits	Artificial recharge
Maintain and use cloud seeding capability	Conjunctive use of surface and groundwater
Emergency borehole drilling	Water transfer from outside (inter-basin transfer)
Step up leakage control activities in urban areas	Construct new storage (dam) or transfer infrastructure
Change any subsidies that promote greater water use (eg subsidised electricity for pumping)	Develop water grid to allow internal transfers between sources
Inventory of industrial users with own source of supply to see if this supply could be used for domestic water supply in an emergency	Establish charging mechanisms that discourage wasteful use of water but protect low income users' water for living

7 Development of a Drought Management Plan

Under the risk management approach the aim is to develop a structured and flexible framework of drought management to deal with droughts of different types and changing severity, to reduce potential effects on local communities, economy and environment.

The US National Drought Mitigation Centre has developed a 10-step drought planning process as shown in Table 3.

Table 3 The '10-step process'

1	Appoint a drought task force or committee
2	State purpose and objectives of the drought mitigation plan
3	Seek stakeholder involvement and resolve conflicts
4	Inventory resources and identify groups at risk
5	Prepare and write the drought mitigation plan
6	Identify research needs and institutional gaps
7	Integrate science and policy
8	Publicise the plan and build awareness and consensus
9	Develop education programme
10	Evaluate and revise the drought mitigation plan

These steps provide a "checklist" that should be considered and may be completed as part of the planning process.

In brief, the following is an overview of the process:

- Steps 1–4 focus on making sure the right people are brought together, have a clear understanding of the process, know what the drought plan must accomplish, and are supplied with adequate data to make fair and equitable decisions when formulating and writing the actual drought plan.
- Step 5 describes completion of the tasks necessary to prepare the drought management plan. The plan should be viewed as a process, rather than a discrete event that produces a static document. A risk assessment is undertaken in conjunction with this step in order to construct a vulnerability profile for key economic sectors, population groups, regions, and communities.
- Steps 6 and 7 detail the need for ongoing research and coordination between scientists and policy makers.
- Steps 8 and 9 stress the importance of promoting and testing the plan before drought occurs.
- Finally, Step 10 emphasizes revising the plan to keep it current, and evaluating its effectiveness in the post-drought period.

Although the steps are sequential, many of these tasks are addressed simultaneously under the leadership of a drought task force.

The task force should reflect the multidisciplinary nature of drought and its impacts, and it should include appropriate representatives of government agencies (state, provincial or municipal) to address all the local characteristics of drought impacts in the geographical area to be covered by the drought management plan.

Box 4 Generic statement of purpose for a Drought Management Plan

"The purpose of the plan is to reduce the impacts of drought by identifying principal activities, groups, or regions most at risk and developing mitigation actions and programmes that alter these vulnerabilities. The plan is directed at providing government with an effective and systematic means of assessing drought conditions, developing mitigation actions and programmes to reduce risk in advance of drought, and developing response options that minimise economic stress, environmental losses, and social hardships during drought."

The drought management plan should set out in some detail what activities should be undertaken at each drought severity level. However each instance of drought has unique characteristics so it is essential to tailor the actions for the specific circumstances to be most effective in mitigating impacts. Therefore within the drought management planning process there should always be a stage where a specific action plan for this particular drought situation is drawn up based on the guidance already prepared and presented in the drought management plan.

The relationship between the pre-prepared standard set of actions presented in a drought management plan and the tailored set of actions built from these to suit the current circumstance is explained in Box 5.

Box 5 Drought Management Plan vs Drought Management Action Plan

Drought Management Plan

A risk management tool prepared in advance of drought situation which sets out a process for identifying and warning of impending drought, and promptly addressing impacts once a drought is declared.

Drought Management Action Plan

Is used to set out what is to be done during the drought that is occurring NOW. It will contain elements of a generic plan set out in the Drought Management Plan but will be modified to suit the particular circumstances of the on-going drought situation.

The drought management action plan should be developed and issued promptly once a trigger threshold has been passed. One or two days should be sufficient. A standard format is advisable for a drought management action plan to enable it to be prepared relatively quickly.

8 Drought Management Plans – International Examples

8.1 UK drought management plans

The Environment Agency for England and Wales (EA) is responsible for the issue of abstraction licences, and the sustainable management of water resources.

The contents of an EA Drought Management Plan cover how to plan for and manage drought in the particular region of interest – the operational unit within the EA is the 'Area Office'. The plan sets out:

- The Area's drought management structure;
- The drought monitoring that will be undertaken by the Area;
- The drought management actions that the Area Drought Team may need to take and the triggers for these actions;
- How the Area deals with Drought Permit and Drought Order applications;
- The Area's drought communications actions, including reporting during a drought.

The EA works with water companies and other users to reduce drought effects on people and the environment. A Drought Management Plan sets out the measures that a particular Area will take to plan for and manage droughts.

The drought plan's main aims are to:

- Give a structured and flexible framework to deal with droughts of different type (for example groundwater or surface-water) and changing severity;
- Set out a system of monitoring and reporting to identify and track the onset, progress and recovery from droughts.

The EA checks drought plans annually to make sure they are up to date. They review their plans fully every three years. They also undertake drought exercises to make sure that water managers are ready for drought. These exercises will be based on information from historic droughts and will test the actions in their plans.

One of the prime management techniques used during droughts by the EA is the issuance of drought orders and drought permits. The 'order' is a temporary government measure which forces restrictions on specific water users during emergencies, i.e. reduces demand. The 'permit' is a temporary EA authorisation for abstractors to over-ride their license conditions during water shortages i.e. increases supply at the expense of the environment.

The EA expects water companies to develop and agree Drought Contingency Plans that confirm measures to be taken during a drought. The EA will not issue a temporary drought permit unless the water company demonstrates that reasonable measures have been taken to reduce demand.

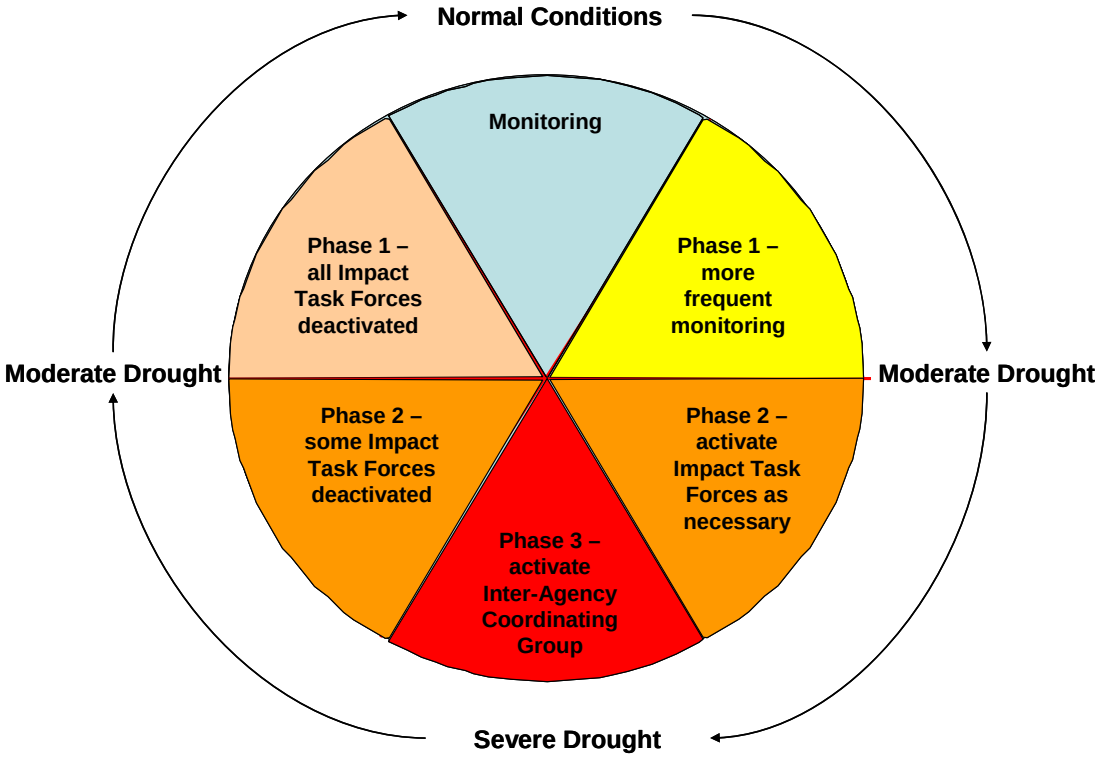
8.2 Colorado State, USA

In the USA drought management planning is predominantly undertaken at the State level or below. Colorado was one of the earliest states to move from a crisis management emergency response to a risk management based planning approach, based closely upon the recommendations of the National Drought Mitigation Centre (as described in Section 7).

The Colorado **Drought Mitigation and Response Plan** was developed to provide an effective and systematic means for the State of Colorado to reduce the impacts of water shortages over the short or long term. The initial Drought Response Plan was completed in 1981 and revised in 1986, 1990 and 2001.

The plan consists of four components: monitoring, assessment, mitigation and response. These four actions are designed to work within the existing framework of government, pulling together key personnel from both federal and state levels. The general sequence of activities is shown in Figure 6.

Figure 6 Colorado Drought Mitigation and Response Plan implementation cycle



Drought mitigation is an ongoing activity in Colorado through emergency preparedness planning and evolving water resources policy and management.

9 Drought Management in China

9.1 Current roles and responsibilities

The State Flood Control and Drought Relief Headquarters (SFCDRH), with its office established within the Ministry of Water Resources, is responsible for leading and organising flood control and drought relief work in the country.

Its major responsibilities include:

- Strategy development.
- Developing regulations and administrative procedures.
- Developing mitigation measures at the national scale (eg flood control measures for major rivers and water transfer schemes between provinces, autonomous regions and municipalities).
- Monitoring floods and droughts.
- Controlling water usage of hydropower facilities.
- Organising relief work and coordinating reconstruction after disaster.

To achieve this, the SFCDRH is supported by the State Flood Control and Drought Relief Headquarters Office. The 'Office' is the technical management unit and is based within the Ministry of Water Resources.

Basin-oriented flood control and drought relief headquarters have also been set up in major river basins such as Yangtze River, Yellow River,

Songhua River, Huaihe River, etc. Representatives from the governments of relevant provinces, autonomous regions and municipalities are members. The supporting Office is usually established within the basin management authority (that is itself responsible to the Ministry of Water Resources).

This structure is replicated at each tier of local government that has flood control and drought relief assignments as shown in Figure 7.

Figure 7 China flood control and drought relief organisation

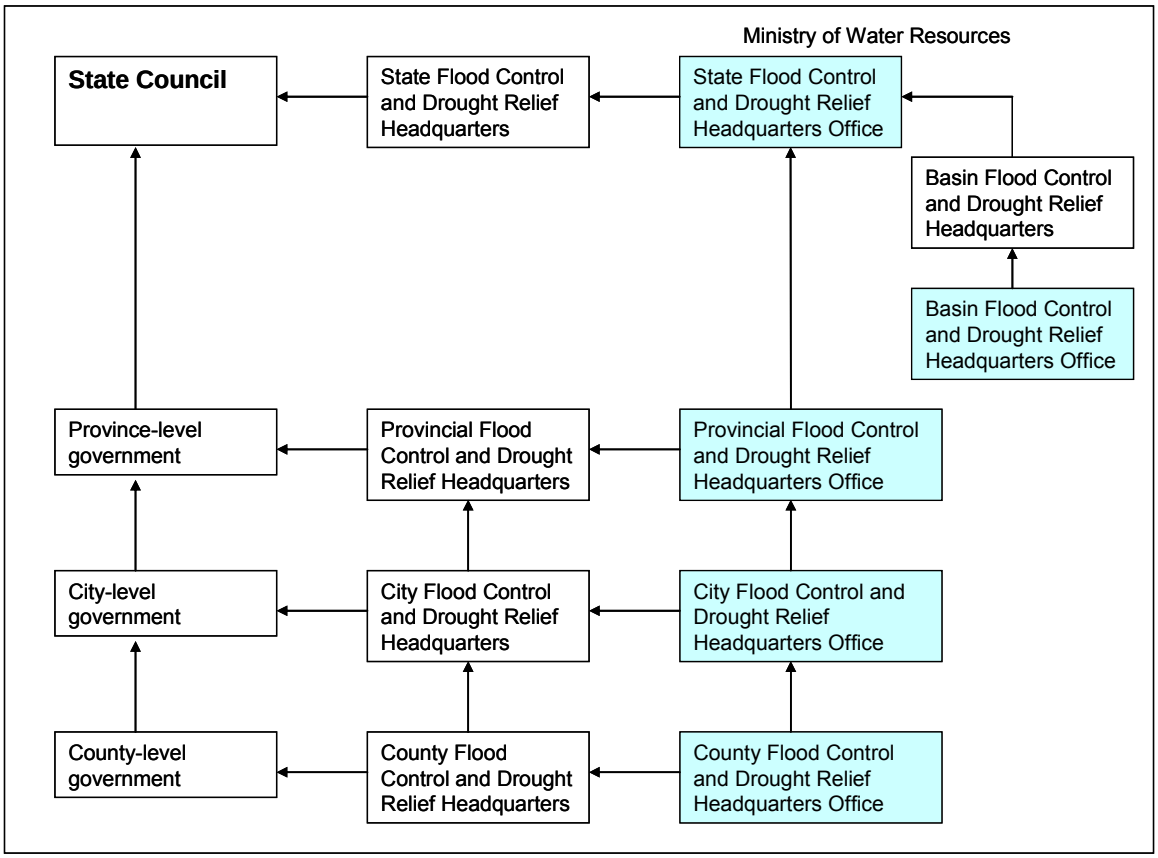


Figure 7 shows the management structure whereby at each level the Control Headquarters is required to organise local flood control and drought relief work under the leadership of upper-level authorities and the local government. Figure 8 gives details of the drought management structure agreed in 2008 for Chaoyang Municipality, Liaoning Province.

Table 4 shows the roles and responsibilities of all the organisations contributing to the SFCDRH operations.

Figure 8 Example of drought management hierarchy from Chaoyang Municipality, Liaoning

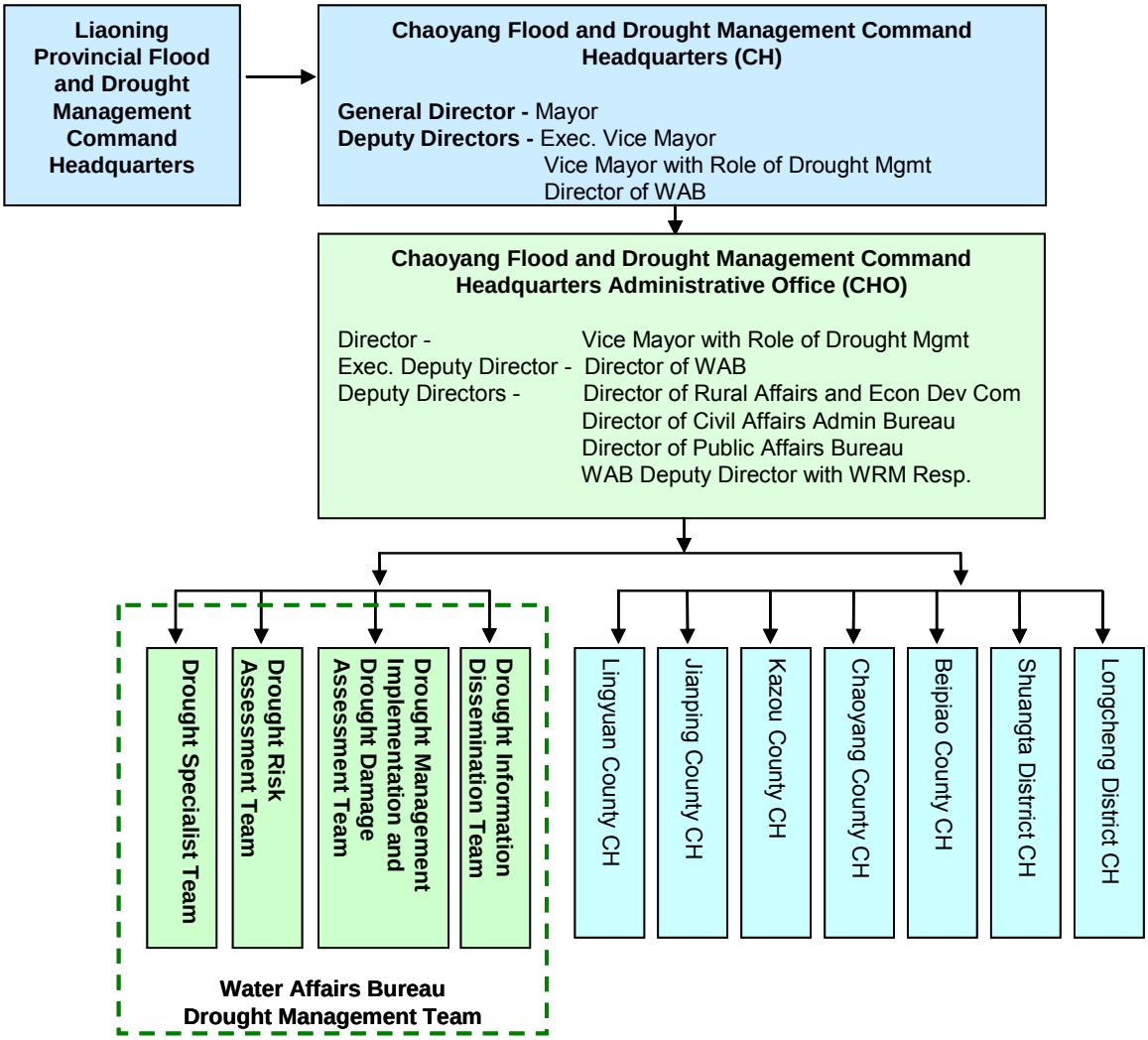


Table 4 Flood Control and drought relief organisation and responsibilities of member unit

Unit	Major Responsibilities
Flood control and drought relief direction agency	Carry out guideline, policy, regulation and rules re drought relief work; organise formulation of drought response plans and supervise their implementation; obtain information of rainfall, flood, drought, disaster and weather analysis/forecast in a timely manner; start up emergency plans as necessary; organise drought relief work inspection; responsible for storage and management of drought relief materials and management of specific funds; responsible for statistics and familiarity with drought hazard; organise and manage construction of drought relief communications and alarm system; disseminate drought relief knowledge and organise relevant training; promote advanced relief resistance technology and products etc.
Propaganda agency	Ensure correct drought relief guidance; coordinate and guide the media for proper reporting.
Development and reform agency	Lead the drought relief plan and construction; coordinate and supervise construction and planning of drought relief facilities and major infrastructure.
Public security agency	Safeguard social order; prevent/punish those spreading rumours, stealing and robbing drought relief materials and destroying infrastructure; assist relevant

Unit	Major Responsibilities
	authorities to properly handle group public order incidents arising out of drought relief; assist with evacuation.
Civil affairs agency	Organise and coordinate drought relief work; conduct hazard checking and report to the flood control and drought relief headquarters in a timely manner; responsible for organising/coordinating reconstruction and subsistence assistance to the victims; manage and allocate fund/materials to help victims and supervise its use; organise, guide and collect donations.
Finance agency	Organise budget/fund for drought relief operation and responsible for timely appropriation and supervise its use.
Land resources agency	Monitor and prevent geological disasters.
Construction agency	Assist with guidance on formulation of urban drought relief plan.
Railway agency	Organise transportation of supporting staff, materials and equipment.
Transportation agency	Coordinate local authorities to ensure adequate transportation of supporting staff, materials and equipment.
Information industry agency	Ensure proper communication and coordinate/arrange emergency communication facilities as necessary.
Water resources agency	Responsible for organising, coordinating, supervising and guiding daily work in relation to drought resistance; manage drought resistance infrastructure; responsible for organising and guiding the construction and management of drought relief infrastructure; responsible for monitoring and management of drought hazard; responsible for supervision of the safety of drought resistance infrastructures.
Agricultural agency	Collect, compile and report information re drought hazard and disasters; guide agricultural relief and after-disaster recovery; guide agricultural restructuring of disaster stricken area and promote water saving technology and livestock disease prevention; responsible for distribution and management of special subsidiary fund/materials, e.g. fertilizers and diesel oil, seed, forage grass, livestock epidemic prevention medicine etc.
Commercial agency	Strengthen supervision and control of major commodity market and balance of supply and demand of the disaster stricken area; responsible for coordination of supply of materials for disaster relief and reconstruction.
Health agency	Responsible for disease prevention/control and rescue work; report to the Flood Control and Drought Relief Headquarters on epidemic situation and prevention in a timely manner after disaster happens; organise health care agencies and staff to arrive at disaster stricken areas to conduct medical work, prevent/control epidemics.
Aviation agency	Coordinate to guarantee transportation of staff, materials and equipment; secure necessary aviation for emergency response and rescue.
Broadcast agency	Guide reporting on drought relief work by radio and television stations; report to the flood control and drought relief headquarters on the situation of drought, disaster and relief work in a timely and accurate manner.
Meteorological agency	Responsible for weather monitoring and forecast; analyse and forecast situation of drought; provide rolling forecast on critical weather situation and extreme weather and provide information to the flood control and drought relief headquarters and its member units.

Unit	Major Responsibilities
Army, armed police	Responsible for organising armies, armed police force to conduct drought relief operation; participate in emergency recovery work of major infrastructure in case of major disasters; assist local public security bureaus in safeguarding order of the relief work and social stability of disaster stricken area; assist local government with evacuation of the victims.
Environment agencies	To advise on all environmental issues

9.2 Regulation system

China has produced a series of systems and measures in relation to drought relief since the 1990's. Table 5 provides details of the national level measures. As the table shows the pace of developments in this area has quickened since the enactment of the new Water Law in 2002.

Table 5 Regulations in relation to drought relief

Name	Date/agency	Major content
Provisional Rules of the Use of Subsidy for Major Flood Control and Drought Fighting	Dec 1994 Ministry of Finance, Ministry of Water Resources	Sets forth the use of subsidy for major flood control and drought resistance, the approval and application procedure, supervision methods etc. The subsidy will mainly be used for purchase of materials for construction of simple drought relief facilities and tools for water pumping and transfer.
Provisional Rules on Management of Organisation and Construction of Drought Fighting Organisations	10th May 1996 Ministry of Finance, Ministry of Water Resources	Defines the nature of drought relief service organisation, its function, goal, service method, capacity building etc, to guide the drought relief organisation to develop in a formal way.
Losses caused by Drought Disaster and Benefit of Drought Relief Calculation Measures (Provisional)	1997 The State Flood Control and Drought Relief Headquarters Office	Gives the following simple formula for calculation of losses and drought relief benefits: (1) Losses caused by drought = average unit product of past three years * [(covered area*0.1) + (affected area*0.4) + (non-product area*0.8)]; (2) Drought relief benefits = (unit product of farmland taking drought relief measures – unit product of that not taking drought relief measures)*area of farmland taking drought relief measures.
Rules of the Use of Subsidy for Major Flood Control and Drought Resistance (Revision)	1st January 1999 Ministry of Finance, Ministry of Water Resources	It makes amendment to the Provisional Rules of the Use of Subsidy for Major Flood Control and Drought Resistance and expands the usage of the subsidy. The subsidy will be used to support construction of emergency drought relief facilities, purchase of water pumping and transferring equipment and to cover the running costs.
Flood and Drought Hazard Statistical Form System	1999 The State Flood Control and Drought Relief Headquarters,	Defines the purpose, tasks, scope, content, timing, method and content of forms etc. The statistical forms include: drought trend statistical form, drought relief situation statistical form, losses and drought relief

Name	Date/agency	Major content
	The State Statistics Bureau	benefits statistical form.
Guidance on Drought Relief Plan Formulation	2003 The State Flood Control and Drought Relief Headquarters Office	Provides guidance on the principle of drought relief plan, basic work, classification of drought category, regional water transfer principle, drought risk plan, emergency response system and drought relief measures, plan management etc.
Flood and Drought Hazard Statistical Form System (Revision)	2004 The State Flood Control and Drought Relief Headquarters The State Statistics Bureau	It makes amendment to the 1999's Flood and Drought Hazard Statistical Form System and adds regulation on urban drought hazard statistics. The additional statistical forms include: statistics on status of urban water shortage and water sources, statistics on urban water shortage and drought relief situation, basic information of water shortage cities and water usage statistics and basic information of water sources of water shortage cities.
China National Flood Control and Drought Relief Emergency Plan	11th Jan 2006 The State Council	Sets forth the structure and function of flood control and drought relief organisation, prevention and alarm system (prevention and alarm information, prevention and alarm actions, alarm supporting system), emergency response (four-level emergency response start up, action and completion, information release etc), emergency security (communication and information exchange security, emergency support and equipment security, technology security etc) and after-disaster work etc.
Terms of Reference for Drought Relief Plan Formulation	27th Feb 2006 The State Flood Control and Drought Relief Headquarters Office	Provides guidance on principle and scope of drought relief plan, organisation system, prevention and alarm, emergency response, guarantee measures, approval and revision of plan.
Drought Hazard Assessment Criteria (Provisional),	April 2006 The State Flood Control and Drought Relief Headquarters Office	Presents assessment indicators, method and classification criteria for agricultural drought situation, stockbreeding drought situation, agricultural drought hazard, urban drought etc.
Classification of Meteorological Drought Category	1st November 2006 China Meteorological Bureau	Presents the calculation method and classification criteria of some meteorological drought indicators such as precipitation anomaly percentage, relevant humidity index etc, and identification of drought process and evaluation method.
Soil Moisture Monitoring Standards	1st June 2007 Ministry of Water Resources	Presents the monitoring elements, plan and spread of soil moisture monitoring station network, site visit to and construction of the monitoring stations, monitoring method of soil moisture, soil moisture measurement system and reporting method, aiming at standardising soil moisture monitoring.
Standard of Classification for Drought Severity	29th December 2008 Ministry of Water Resources	Presents the drought assessment indicators and corresponding classifications for agricultural drought, pasture drought, urban drought and drinking water

Name	Date/agency	Major content
		difficulty caused by drought. Regional drought can also be evaluated.
Drought Mitigation Regulation of the People's Republic of China, Decree No.552	26th February 2009 The State Council	Presents the requirements (Article 14) for the development of drought management master plans with mitigation measures for different severities of drought. Sets out activities, roles and responsibilities in the event of drought and post drought restoration. Sets out the legal obligations and responsibilities of organisations and individuals in complying with the regulations for drought mitigation and penalties for non-compliance.

Note: There are some difficulties in translation from the Chinese - in the table the literal translation has been adopted, eg 'drought fighting organisation' (responsible for preparedness, response, and post drought recovery)

It takes some time for national decrees and regulations to be adopted at each of the administrative tiers of government and in all parts of the country. It can also take time for all administrative bodies to complete the required actions because of a lack of capacity and/or technical guidance.

For example, by the end of 2006, 50% of the provinces (here including autonomous regions, special districts, and municipalities), over 49% of cities and 35% of counties had completed a drought relief plan; by the end of 2009 most had done so.

However, pilot experience of alternative approaches at provincial level, say in particularly water short basins, can be ahead of the development of national guidance.

Under the Water Law (2002) water supply companies, industries, and irrigation use requires a permit to abstract. State Council Decree No. 460 'Regulation for Water Abstraction Permit and Collection and Management of Water Resources Fee' sets out the requirements for abstraction permits and how these may be restricted during a drought (see Box 6).

Box 6 Emergency Limitation on Abstractions

State Council Decree No. 460 'Regulation for Water Abstraction Permit and Collection and Management of Water Resources Fee' states the following:

Article 41: In any of the following cases the competent authority may put limitation to the amount of water abstraction by a water abstraction unit or individual:

1. Water resources are inadequate to sustain the normal water supply in the area due to natural conditions;

2. Water abstraction or discharge has created significant impacts on the functions, ecology and environment of water bodies in a water function zone;

3. Groundwater over-abstraction is serious or geological hazards such as land subsidence have been induced by groundwater over-abstraction;

4. Any other special cases needing limitation to water abstraction amount.

If a major drought occurs, the competent authority may implement emergency limitation to the amount of water abstraction by units and individuals.

9.3 Summary of existing situation

In February 2009 State Council Decree No 552 'Drought Mitigation Regulations of the People's Republic of China' was issued. This section briefly describes a 2007 survey and its findings; then outlines the picture going forward with 'SCD552' in place.

2007 survey

In October 2007 a survey was carried out, largely by telephone interviews, in five locations where the local government authority had established a drought management plan. To explore the actual situation of drought management in China, five cities of different sizes were chosen, including Tianjin, Liaocheng in Shandong province, Qiqihaer in Heilongjiang province, Bengbu in Anhui province and Baishui County in Shaanxi province.

The objective was to assess best practice in this area given the reportedly slow progress being made across the country in developing such plans. The surveys were informative and the conclusions on the progress of these early adopters had lessons for wider implementation.

Technical findings

Monitoring the information necessary for drought planning and management is less well established compared with flood monitoring. Reported problems included weak drought information collection systems, inadequate monitoring sites, and poor information processing and analysis methods.

At the time no standard drought evaluation system had been set up - those surveyed had used the provisional standard issued in April 2006. This made it hard to conduct a scientific evaluation, analysis and forecast of drought severity; and hard to have an objective assessment on impacts on agriculture, industry and domestic users. (This situation should have been resolved by the issue in December 2008 of a standard evaluation procedure, see Table 5).

Findings on institutional issues

At the time no national drought relief regulation had been issued, although some provinces had issued regulations. Those surveyed reported that there was a lack of clarity over roles and responsibilities of different divisions and agencies. This resulted in ineffective coordination between divisions and regions which hampered the organisation and implementation of drought relief work. (This situation should have been clarified by the issue of SCD552 in 2009).

State Council Decree No 552

SCD552 sets out the roles and responsibilities of all levels of government for drought relief (mitigation) led by the SFCDRH.

It sets out the requirement for drought mitigation master plans and for the coordination of such plans with other plans for water resources development and utilisation. It also requires the preparation of contingency plans (drought action plans), and for public awareness campaigns aligned with Water Saving Society.

It sets out a hierarchy of measures for different drought severity and the adjustment of water allocation, ensuring supply for key needs, prioritising domestic use, and making a rational distribution between water users and the environment.

The issue of SCD552 demonstrates a commitment to improving the effectiveness of drought planning and management across the country. By clarifying roles and responsibilities SCD552 should make it far easier for water resource planners to develop risk based drought management plans for their resource base, and for all departments and agencies to cooperate more effectively in both short term (disaster) and longer term (relief) planning and implementation.

10 Conclusion

Despite advances in our scientific understanding of the nature of drought, societies around the world are vulnerable to significant disruption, or worse, when drought occurs. It is clear that societies everywhere need to develop strategies to minimise the potential impact of drought. This review of international and Chinese experience indicates the direction of the latest thinking.

- There is a clear trend away from the reactive approach to dealing with natural hazards including drought. Some countries have moved to an entirely risk-based management approach while others have begun to change in this direction.
- Many systems for dealing with natural hazards place responsibility for all types (eg. flood, earthquake, tsunami, drought, etc) under one 'disaster preparedness' agency with multi-sectoral linkages.
- Some jurisdictions have found that the complexity of drought definition and socio-economic impacts mean that drought is better handled by a specialist team rather than bundled in with rapid onset natural hazards like floods.
- China is in the middle of a transition to a risk-based management approach. National policy points strongly in this direction.
- Terminology for drought definition and for management responses is often confusing especially when trying to compare between jurisdictions.
- There is a clear recognition that some societies are more resilient in the face of drought than others, and that they share certain characteristics that others can emulate.
- Drought insurance is becoming more common.
- In many places population growth and economic development are already at, or are fast approaching, unsustainable levels of water use. This is a major challenge for society. Water can no longer be taken for granted and demand management approaches take on far greater importance. Water demand management should be an integral part of longer term water resource planning to reduce vulnerability to drought.
- Drought management planning is, like the higher level river basin planning and integrated water resources management (IWRM) planning, multi-sector in nature. It shares IWRM principles. Drought management needs to encompass short term actions and longer term mitigation measures or policies.

Document Reference Sheet

Glossary:

EA	Environment Agency for England and Wales
IWRM	Integrated water resources management
SCD460	State Council Decree No 460 (see bibliography)
SCD552	State Council Decree No 552 (see bibliography)
SFCDRH	State Flood Control and Drought Relief Headquarters
SPI	Standardized precipitation index
WAB/WRD	Water Affairs Bureau/Water Resources Department
WRDMAP	Water Resources Demand Management Assistance Project
WSC	Water supply company

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Document Reference Sheet

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Advisory Note 8.4	Inter-agency Agreements for Collaborative Water Quality Management

Where to find more information on IWRM – recommended websites:

Ministry of Water Resources: www.mwr.gov.cn

Global Water Partnership: www.gwpforum.org

WRDMAP Project Website: www.wrdmap.com

China – UK, WRDMAP

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