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# Drought Preparedness and Mitigation in the Mediterranean Region

Atef Hamdy<sup>1</sup>

## Introduction

Drought is inevitable; it is a normal part of virtually every climate on the planet, even rainy ones. Analyses show that drought is one, if not the most, expensive of natural disasters in developed countries, and that, as a trigger for famine, it can devastate vulnerable population in developing countries. The impacts of drought hit hardest when people place too high a demand on water supply. Unrealistic expectations often contribute to overestimating the water supply. We can reduce the impact of drought by careful balancing demand with supply.

Drought is an insidious hazard of nature. Unlike many disasters which are sudden, droughts result when there is less than normal precipitation over an extended period of time, usually a season or more. The decreased water input results in a water shortage for some activity, group, or environmental sector. Drought can also occur when the temperature is higher than normal for a sustained period of time; this causes more water to be drawn off by evaporation. Other possible causes are delays in the start of the rainy season or timing of rains in relation to principal crop growth stages (rain at the “wrong” time). High winds and low relative humidity can make matters much worse.

Unfortunately, it could be generalized that in most developing as well as developed countries of the Mediterranean, we tend to focus on drought when it is upon us. We are then forced to react to respond to immediate needs, to provide what are often more costly remedies and to attempt to balance competing interests in a charged atmosphere. This is neither a good policy, nor a good source management.

To the contrary, we must take a proactive approach to deal with drought, to anticipate the inevitable ... that drought come and go, and to take approach that seeks to minimize the effects of drought when it inevitably occurs.

In the region, implementing drought control or drought preparedness measures and policies are receiving limited political attention in

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changing economic and social environment, where growing pressures on natural resources, and development of man-induced water stressed conditions are creating new priorities. Nevertheless, drought aggravates these problems and diminishes the carrying capacity of the ecosystems.

The vulnerability of agricultural activities to drought has not decreased but has increased both in developed and less developed countries. In less developed countries food shortages have become much more frequent.

Evidence shows that drought episodes occurred more frequently during the 1980s and 1990s than previous decades, with increasingly dramatic economic, social and environmental consequences, particularly in the southeastern countries of the region. Analysis of the drought management policies in these countries indicates that decision-makers have reacted mainly through a crisis-management policies approaches, declaring a national drought emergency programme to alleviate drought impacts on people, crops, livestock, pasture and forest. For example, in most southeastern countries, almost all national efforts and international assistance during the recent drought situation have been focused on drought relief operations and short-term costly response programmes. Relief packages generally include provisions of emergency drinking water and food supplies for the most seriously affected populations, emergency fodder supplies for livestock, as well as the government's procurement programmes to create job opportunities for jobless farmers and herders and to minimize crop and livestock losses.

In the Mediterranean, water scarcity due to drought needs appropriate approaches. These approaches are to focus on identifying and ranking the priority of relevant drought impacts, examining the underlying environmental, economic and social causes of these impacts. Carrying this process is fundamental to decide on the specific mitigation actions that can be taken to reduce short and long-terms drought risks. Such actions will differ from one place to other and have to be tailored to cope with the prevailing conditions with straightforward and practical tools for drought management and mitigation.

To successful cope with drought, there is a need to a better understanding the characteristics and consequences of those phenomena, which make water scarce due to drought very different from those caused by aridity. Dealing with drought requires the development and implementation of preparedness and emergency measures.

In the Mediterranean, to manage drought, it is necessary to shift from the crisis management approach where responses and actions are made during the event with no prior planning to the risk management. Indeed, the risk management is the opposite of crisis management where a proactive approach is taken well in advance of drought so that the mitigation can reduce drought impacts, and so relief and recovery decision are met in a timely, coordinated and effective manner during a drought. However, in drought management, making the transition from crisis management to risk management is still facing some difficulties in most countries of the region and, therefore, much more needs to be done to understand and address the risk associated with drought.

## Drought Recurrence in the Region

The causes of the drought in the Mediterranean region are very complex. Contrasting geographic locations and topographic variations (seaside, mountains, hills, flat lands, and desert) with their oceanic or continental influences, exposure to western and eastern wind systems and exposure to the Azores atmospheric pressure systems are among the physical determinants which explain the spatial scale and intensity of the drought in the region. On the other hand, demographic pressure and human activities have also led to wide ecosystem degradation over the past decades and have certainly exacerbated the vulnerability to drought in the region through increased cultivation of marginal and fragile arid lands, soil erosion, run-off and desertification.

Historical evidence corroborated by tree ring studies in North Africa clearly indicates that drought is a structurally recurrent phenomenon in the Mediterranean. In Tunisia, drought episodes have been traced back to the year 707 and in the period 1907-1997 alone, say the 20<sup>th</sup> century, 23 dry years were observed. In Morocco, the number of drought episodes as revealed by tree ring evaluation over 1000 years (Chbouki, 1992; Stockton, 1988) varied from century to century around an average of 22 dry years per century. For example, there were 31 dry years in the 14<sup>th</sup> century, 25 in the 15<sup>th</sup> century, 12 in the 16<sup>th</sup>, 22 in the 17<sup>th</sup>, 16 in the 18<sup>th</sup>, 19 dry years in the 19<sup>th</sup> century and in the 20<sup>th</sup> century 22 drought episodes, of which ten occurred during the last two decades and included the three successive dry years of 1999, 2000 and 2001. The drought is also a recurring event in the Middle East, where Jordan is a significant example. The country is predominantly arid; it has long ago experienced chronic water shortages and suffered from severe shortage since the 1960s. The droughts in Jordan, Syria, Palestine, the worst ever recorded in decades, have recently intensified and become more frequent. Drought

events have also been more frequent after the 70's in Mediterranean Europe. Examples are the dry episodes in Cyprus in the periods 1989-91 and 1996-2001, in Greece in the periods 1982-83 and 1988-90, in Italy during 1989-1991, in Spain in the periods 1982-83 and 1990-95, and in south France in 1976 and from 1989 to 1992.

## The Concept of Drought

Drought may be considered in general terms as a consequence of a reduction over an extended time in the amount of precipitation that is received, usually over a season or more in length. It is thus a temporary aberration, unlike aridity, which is a permanent feature of the climate. Aridity that is seasonal in nature also needs to be distinguished from drought. It should be noted that drought is a normal, recurrent feature of climate, and it occurs in virtually all climate regimes. Drought, however, have some unique characteristics that may require different approaches to reduce their impacts.

### **Drought Characteristics**

- Slow-onset, creeping phenomenon that makes it difficult to determine the onset and end of the event;
- Duration may range from months to years;
- No universal definition;
- No single indicator or index can identify precisely the onset and severity of the event;
- Impacts are generally non-structural and difficult to quantify;
- Spatial extent is usually much greater than for other natural hazards, making assessment and response actions difficult, since impacts are spread over larger geographical areas;
- Impacts are cumulative.

Drought differs from other natural hazards in several important ways:

- First, it is a creeping phenomenon, making its onset and end difficult to determine. The effects of drought accumulate slowly over a considerable period of time and may linger for years after the termination of the events,
- Second, the absence of a precise and universally accepted definition for drought adds to the confusion about whether or not a drought exists and, if it does, its severity; and
- Third, drought impacts are less obvious and spread over a large geographical area than are damages that result from other natural hazards. Drought seldom results in structural damage.

For these reasons, the qualification of impacts and the provision of disaster relief is a far more difficult risk for drought than it is for other natural hazards.

In general terms, drought could be defined as a deficiency of rainfall with respect to the normal, related to seasons or longer periods, insufficient to meet human and environment demand (activities and ecosystems functions). It should be considered as a normal, recurrent feature of climate. Drought is a relative, rather than an absolute condition that should be defined for each region and location. Each drought differs in intensity, duration and spatial extent.

Because drought affects so many economic and social sectors, scores of drought definition have been developed by a variety of disciplines. In addition, because drought occurs with varying frequency, in nearly all regions of the globe, in all types of economic systems, and in developing and developed countries alike, the approaches taken to define it should be impact and region specific. The lack of precise and objective definition in specific situation have been an obstacle to understanding drought which has led to indecision and/or inaction on the part of managers policy makers, and others. It must be accepted that the importance of drought lies in its impacts.

**Example of Drought Impacts**

**ENVIRONMENTAL**

habitats, ecosystem functioning, loss of biodiversity, insect infestations, water quality and quantity, air quality, fires, wind and water erosion, etc.

**ECONOMIC**

crop, timber, fishery, dairy, livestock production, navigability of rivers, hydropower production, income losses, price increase for food, energy, and other products, unemployment, etc.

**SOCIAL**

food shortages, poverty, public safety and health, migration, conflicts between water users, etc.

## Drought Definition by Types

Differences in the perception of drought lead to the adoption of different definitions, which do not have general acceptance, nor have worldwide applicability, as reviewed by Wilhite and Glantz (1987) and Tate and Gustard (2000). The controversy over perceptions of drought, and the consequent defining of them and their characteristics, does not help decision and policy makers to plan for droughts. Lack of clearly agreed definitions makes it difficult to implement preparedness measures, to apply timely mitigation measures when a drought occurs, or to adequately evaluate drought impacts.

Several authors point out that scientists, engineers, professionals, decision-makers often do not agree on whether to regard drought as a hazard or as a disaster. As stated by Grigg and Vlachos (1990), this difference in perception is one of the central problems of water management for drought. In fact, drought is a hazard and a disaster. It

is a hazard because it is natural incident of unpredictable occurrence, and it is a disaster because it corresponds to the failure of the precipitation regime, causing disruption of water supply to the natural and agricultural ecosystems as well as to human and social activities.

Drought has been grouped by type as follows: meteorological, agricultural, hydrological, and socioeconomic (Wilhite and Glantz, 1985).

Meteorological drought: is expressed solely on the basis of the degree of dryness (often 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.

Agricultural drought: it is concerned specifically with the effects of water shortages on crops and grasses and other forages. Therefore, agricultural drought is most closely associated with deficiencies that occur in soil moisture and lead to losses in yield. Agriculture is usually the first sector to experience the devastating effects of drought.

Hydrological droughts: they are concerned more with the effects of periods of precipitation shortfalls on surface or subsurface water supply (i.e., stream flow, reservoir and lake levels, groundwater ...) rather than with precipitation shortfalls. Hydrological droughts: they are usually out of phase or lag the occurrence of meteorological and agricultural droughts. Water in hydrologic storage systems (e.g., reservoirs, rivers) is often used for multiple and competing purposes, further complicating the sequence and quantification of impacts.

Socioeconomic drought: it associates the supply of and demand for some economic good with elements of meteorological, agricultural, and hydrological drought. Time and space processes of supply and demand are the two basic processes that should be considered for inclusion in an objective definition of drought.

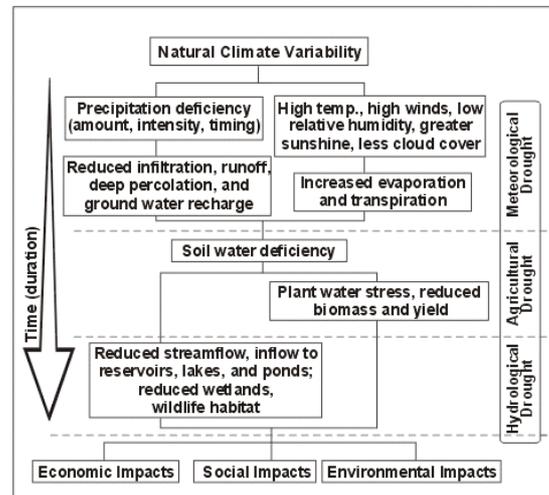


Fig.1. Definitions of drought categories as meteorological, agricultural and hydrological

In most instances, demand is increasing as a result of increasing population and/or per capita consumption. Therefore, drought could be defined as occurring when the demand exceeds supply as a result of a weather-related supply shortfall. This concept of drought supports the strong symbiosis that exists between drought and human activities, reemphasizing the importance of managing natural resources in a sustainable manner.

## Drought Characterization – the Use of Indices

### Drought indices

Drought indices assimilate thousands of bits of data on rainfall, snowpack, streamflow and other water supply indicators.

Meteorologists and hydrologists have developed indices which depend on hydrometeorological parameters and rely on probability. Several drought studies (Yevjevich *et al.*, 1983; Wilhite *et al.*, 1987; Vogt and Somma, 2000) gave examples of these indices. However, using indices is controversial and often contradictory. For instance, it is common that agronomists use the word drought to define a water stress condition affecting crop growth and yield (Maracchi, 2000). Drought could then be characterized by a crop-water stress index (Petrasovits, 1990).

In this regard, some researchers prefer to adopt an operational definition that distinguishes between meteorological, agricultural and hydrological drought. These usually focus on the indicator variable of prime interest, which could be the precipitation (meteorological drought), soil moisture (agricultural drought), stream

#### Drought Indices

**Percent of Normal:** this involves a simple calculation and is suited to the needs of general audiences. It is effective for analysis involving a single region or season.

**Standardized Precipitation Index (SPI):** it is based on the probability of precipitation for any time period. It can be computed for different time scale, and it can provide early warning of drought and help assess drought severity (McKee *et al.*, 1993).

**Palmer Drought Severity Index (PDSI):** it is a soil moisture algorithm calibrated for relatively homogenous regions. Palmer values may lag emerging droughts by several months, and it is not well suited to mountainous land or areas of climatic extremes (Palmer, 1965).

**Crop Moisture Index (CMI):** a palmer derivative; it reflects moisture supply in the short term across major crop producing regions and is not intended to assess long-term drought (Palmer, 1968).

**Surface Water Supply Index (SWSI):** it is designed to complement the Palmer in Colorado, where mountain snowpack is a key element of water supply. It is calculated by river basin based on snowpack, streamflow, precipitation, and reservoir storage (Shafer and Dezman, 1982).

**Reclamation Drought Index (RDI):** This index is also calculated at the river basin level. It incorporates temperature, precipitation, snowpack, streamflow, and reservoir levels (The Bureau of Reclamation U.S.A, 1988).

**Deciles:** Monthly precipitation occurrences are grouped into deciles, so that, by definition, "much lower than normal" weather cannot occur more than 20% of the time (Gibbs and Maher, 1969).

flow discharges or groundwater levels (hydrological drought or groundwater drought). Such alternative definitions result from the complexity of the hydrological processes that controls the temporal and spatial distributions of rainfall via the various paths within the large-scale hydrological cycle and the global circulation of the atmosphere.

In certain regions, where water supplies mainly depend upon river diversions, when dealing with a regional drought, it may be necessary to consider not only precipitation but also stream-flow. However, stream-flow is also a dependent variable, controlled by the current and antecedent precipitation. In many cases, where the river discharges are regulated by dams and other hydraulic structures, the drought definition may need to be more a reflection of the river management decisions than of the natural supply. Thus, the use of precipitation or stream-flow data may not be sufficient to characterize droughts at all scale, but the definition may need to reflect the supply conditions at the river basin scale.

From the analysis of the previous drought definitions as well as the alternative one, we can come to the conclusion that although there are clearly strong relationships between the three types of droughts especially during prolonged periods of rainfall deficiency, yet none of these operational definitions accommodates the variability of conditions and corresponds to the concepts of both hazard and disaster. However, operational definition often helps define the onset, severity and end of drought, but no single operational definition of drought works in all circumstances. This is a big part why policymakers, resource planners and others have more trouble recognizing and planning for drought than for other natural disasters. In fact, most drought planners now rely on mathematic indices to decide when to start implementing water conservation or measures in response to drought.

The interdependence between climate, hydrologic, geologic, geomorphic, ecological and sectorial variables makes it very difficult to adopt a definition that fully describes the drought phenomena and the respective impacts.

## Crisis Management Versus Risk Management Approach to Drought Management

The traditional mindset of most governments in the Mediterranean countries and elsewhere has been to react to drought (i.e. crisis management approach) by providing relief or emergency assistance to

the affected areas or sectors. By following this approach, drought only receives the attention of decision-makers when it is at peak level of intensity and spatial extent and when water management options are quite limited. This approach has been characterized as ineffective, poorly coordinated, and untimely (General Accounting Office, 1979; Wilhite, *et al.*, 1986; Riebsame, *et al.*, 1991; Wilhite, 1993). Not only is this approach extremely costly, relief provided through this process is often politically driven, programmatically misdirected, and poorly targeted. Relief often serves as a disincentive for the sustainable management of natural resources because it reinforces existing management practices, practices that may not be sustainable in the long term. The provision of relief has been the most common approach taken by several governments in the Mediterranean region to alleviate the impacts of drought. This reactive approach is not good policy and must be replaced by an anticipatory, preventive approach that reduces risk (i.e., risk management) through the adoption of appropriate mitigation programs and policies.

The question is how to overcome the difficulties and facilitate the shift from the crisis management approach to the risk management one?

The immediate answer to this question is fundamentally depending on our capability to manage water and other shared natural resources more effectively during periods of drought. The way to this implies not only introducing the available new technologies, but equally to monitor and get most benefit of such technologies.

For example, previous drought response efforts have been hampered by a lack of adequate early warning systems and insufficient information flow within and between concerned governments, scientific institutions and regional and international organizations involved in this field. Nowadays, such obstacle is mostly solved. Our ability to monitor and disseminate critical drought-related information has been enhanced by new technologies such as automated weather stations, satellites, computers and improved communications technologies (e.g. internet).

Simultaneously, an improved understanding of complex atmospheric-oceanic systems and the development of new computer models have improved drought forecast skills. These advancements and others can provide decision-makers with better and timelier data and information to facilitate the shift to risk management.

In this regard, it could be also added the important role of the collective experiences of the states in responding to recent years of

drought and particularly those with drought plans. Such experiences are very helpful to provide not only a more coordinated drought response effort, but also a significant record of lessons learned in mitigating the effects of drought.

## Plan For Drought

Across the Mediterranean, ongoing long-duration drought has highlighted the lack of a national drought strategy and action plans. In all countries, a clearly stated national drought management policy is essential to clarify the role of the central and provincial government ministries and agencies as well as the role of NGOs and water users themselves in implementing national drought preparedness and response programmes.

### Why plan for drought?

In the Mediterranean, having a regional plan to mitigate drought is essential, but not sufficient to cope with the sequences opposed by drought from one country to other. It is of paramount importance that each country in the region suffering the drought should have its own plan with the major objectives:

- to provide a dynamic framework to assess an ongoing set of actions to prepare for and effectively respond to drought, including periodic reviews of achievements and priorities, readjustment of goals, means and resources, as well as strengthening institutional arrangements, planning, and policy making mechanisms for drought mitigation;
- to reduce the impact of drought by carefully balancing the water demand with its supply;
- to practice risk management rather than crisis management;
- to give decision makers the chance to relieve the most suffering at least expense; and
- to develop drought policy that anticipates and resolves conflicts between different water users.

Country planning for drought is the key point for a successful mitigation policy, but it doesn't come naturally due to several obstacles related to:

- No single definition of drought;

- Responsibility is divided among many governmental jurisdictions;
- The absence of a unified authority for managing natural resources including water;
- Risk reduction is not always treated as an integral part of water resources management;
- The political will to take adequate risk reduction measures is lacking;
- Risk reduction is perceived as a technical problem ignoring both social and economical factors;
- Inadequate policy and institutional capacity and resources; and
- People automatically swing into action when crisis strikes, freely funneling time and money into alleviating suffering and property damage. This is crisis management. But, once the crisis is over, it seems like too much trouble to invert the time and resources in planning that could ease effects of the next drought.

## The basics of drought planning

For the Mediterranean countries, the primary step to be carried out is the establishment of a national drought authority including the following major committees:

- ❖ Climatologists and others who monitor how much water is available now and in the foreseeable future (**Monitoring Committee**);
- ❖ Natural resources managers and others who determine how lack of water is affecting various interests such as agriculture, municipal supplies, industry, etc. (**Impact Assessment Committee**); and
- ❖ High level decision makers often elected and appointed officials who have the authority to act on information they receive about water availability and drought's effects (**Drought Task Force: DTF**).

Bringing and working together, the above-mentioned committees are the core of a successful drought plan. It is also one of the planning's biggest challenges to get these groups to communicate effectively with one another.

## Country Drought Working Plan: Major Considerations

Drought planning and response framework are summarized in figure 2.

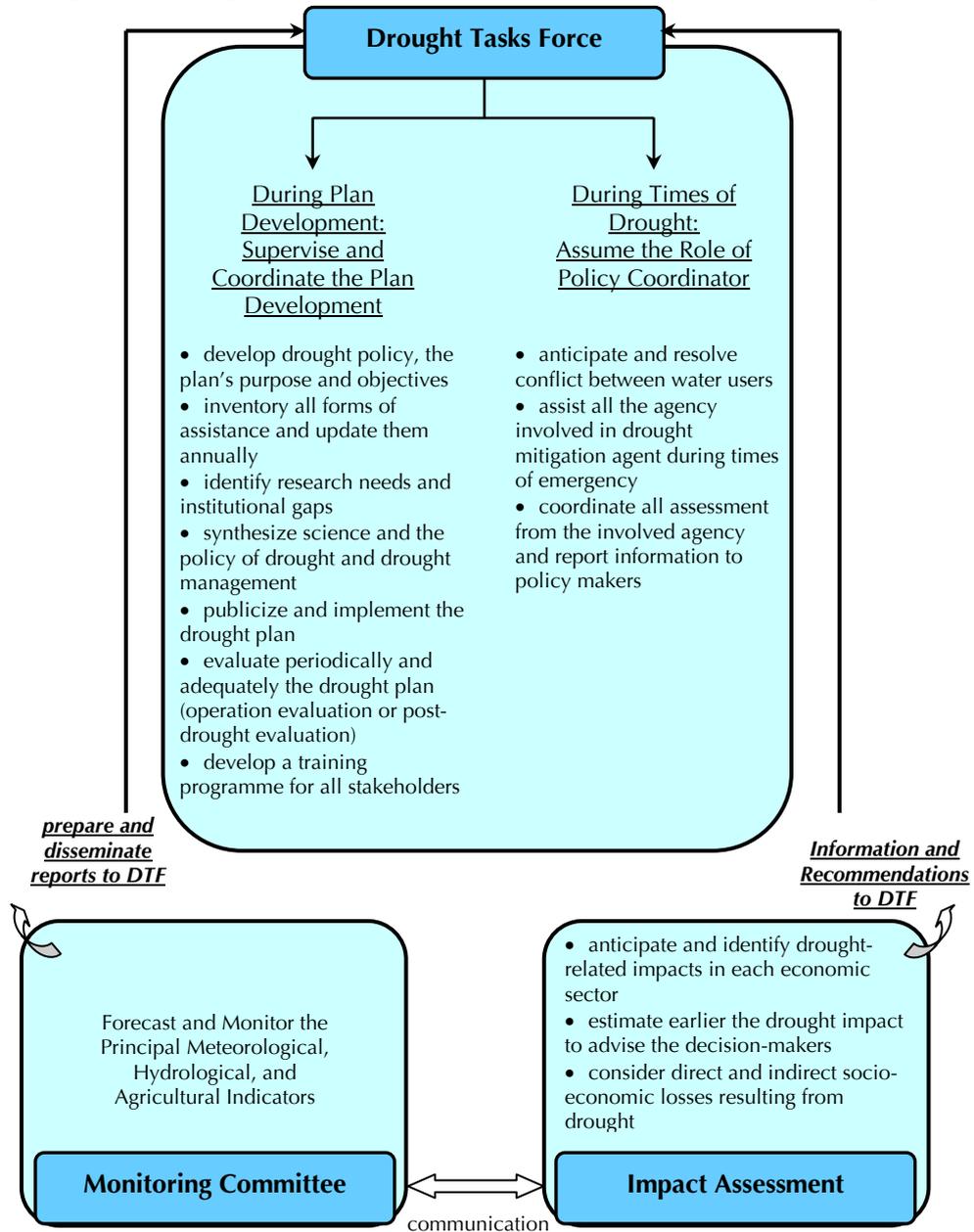


Fig.2 – Drought planning and response framework

In this regard, we would like to highlight the followings:

- the pattern of country – level drought planning is quite complex and cannot be explained adequately on the basis of drought climatology alone. Governmental decisions to develop a drought

plan have to be based on specific climatologically, political, economical, environmental and demographic factors.

- The basic goal of a country drought plan is to improve the effectiveness of central and local government response efforts by enhancing monitoring and early warning, impact assessment, and preparedness, response, recovery and mitigation programmes. These plans are also directed at improving coordination within scientific institutions, universities, NGOs, private sector and stockholder's organizations.
- This implies the development of institutional capacity for national drought policy and planning that includes the creation of a drought task force or commission composed of government agencies with principal responsibility for drought preparedness, monitoring and assessment, mitigation, and response. This task force could also include key stakeholder/citizen groups, NGOs, and donors.

The objectives of a national drought policy should be broadly stated and

- establish a clear set of principles or operating guidelines to govern drought management;
- be consistent and equitable for all regions, population groups, and economic/social sectors;
- be consistent with the goals of sustainable development;
- reflect regional differences in drought characteristics, vulnerability, and impacts;
- promote principles of risk management by encouraging development of
  - reliable forecasts
  - comprehensive early warning systems
  - preparedness plans at all government levels
  - mitigation policies and programs that reduce drought impacts
  - a coordinated emergency response program that ensures timely and targeted relief during drought emergencies.

- Country drought plans can take many forms. Some concentrate largely on impacts in one principal sector (e.g. agriculture, municipal water supply), while others attempts to address a full range of impacts within the country. Therefore, it is to be suggested an increased concern about the potential impact of extended water shortages and an attempt to address those concerning through planning.

Therefore, drought plan objectives have to be more specific, but it could vary between countries reflecting the unique physical, environmental, socioeconomic, and political characteristics of the country. A national drought preparedness plan should include the following:

1. Collection and analysis of drought-related information in a timely and systematic manner.
2. Criteria for declaring drought emergencies and triggering various mitigation and response activities.
3. An organizational structure and a delivery system that assures information flow between and within levels of government.
4. Definition of the duties and responsibilities of all agencies with respect to drought.
5. Maintenance of a current inventory of mitigation and response programs used in assessing and responding to drought conditions.
6. Identification of drought-prone areas and vulnerable economic sectors, individuals, or environments.
7. Identification of mitigation actions that can be taken to address vulnerabilities and reduce drought impacts.
8. A mechanism to ensure timely and accurate assessment of drought's impacts on agriculture, industry, municipalities, wildlife, tourism and recreation, health, and other areas.
9. Provision of accurate, timely information to media in print and electronic form (e.g., via TV, radio, and the World Wide Web) to keep the public informed of current conditions and response actions.

10. A strategy to remove obstacles to the equitable allocation of water during shortages and requirements or incentives to encourage water conservation.

11. A set of procedures to continually evaluate and exercise the plan and provisions to periodically revise the plan so it will stay responsive to the needs of the country.

- It should be clear that country drought plan should be viewed as a practical step by step process for identifying actions that can be taken to reduce potential drought related impacts before a drought occurs. Such steps could be arranged as follows:

- The primary step: the crucial one, begins with making sure that the right people are brought together and supplied with adequate data to make informed and equitable decisions during the process.

- The second step is identifying high priority drought related impacts that are relevant to the user's location activity.

- The third step is to understand the underlying environmental, economic and social causes of impacts in order to reduce the potential for the identified impacts to occur in the future.

- The fourth step, the final one, is to utilize all of the previous information to identify feasible, cost effective and equitable actions that can be taken to address the identified causes.

<b>10 Steps for Drought Planning</b>	
1.	Appoint a Drought Task Force
2.	State the Purpose and Objectives of the Drought Plan
3.	Seek Stakeholder Participation and Resolve Conflict
4.	Inventory Resources and Identify Groups at Risk
5.	Develop Organizational Structure and Prepare Drought Plan
6.	Integrate Science and Policy, Close Institutional Gaps
7.	Publicize the Proposed Plan, Solicit Reaction
8.	Implement the Plan
9.	Develop Education Programs
10.	Post-Drought Evaluation

Beside those four main steps, several steps should be included in the drought planning such as the inventory data quantity and quality,

closing the institutional gap, human resources development through tailored training and educational programmes.

Following such systematic manner (step by step), true vulnerabilities can be addressed that will subsequently reduce drought related impacts. However, there are two main requirements upon which the success of such planning is based: adequate monitoring for water resources for drought mitigation and the institutional adjustment and legal framework for elaborating and implementing such plans.

## Water Resources Management Planning and Drought Mitigation: The Traditional Approach

The traditional approach of government response to drought has been characterized as being of the reactive-type, or emergency response, or crisis management, or unplanned response. Referring to water supply planning, Werick (1993) and Whipple (1994) refer to this type of response as tactical measures to address water deficiency problems once drought has already started and it is too late to build new water facilities. These are opposed to strategic measures which are planned actions, such as supply increase infrastructure or modifications of laws and institutions. These terms characterize the same approach which consists of the following steps:

1. Monitoring the available water resources (reservoirs, rivers, precipitation)
2. Deciding drought onset (based essentially on a threshold of available water resources and precipitation during the growing season)
3. Preparing a relief programme and identifying funds (rapid preparation of activities on ad hoc basis. The sources of funds are generally external relief aid, loans and regular budgets channeled to relief while stopping normative development programmes.)
4. Implementing the programme (often by a super Department such as that of Interior or Civil Protection).
5. Forgetting about the whole thing upon return to normal

Often the institutional setups and the legal frameworks related to water resources management in the country constitute hindrances to the implementation of the response. The shortfalls of unplanned reactive response to drought have been described thoroughly by several

authors. The overall conclusion is that the approach is too expensive, not well effective and results in unsustainable environment and social impacts.

This necessitates moving from the reactive response approach to a more proactive approach in drought management. The proactive approach consists of measures that are planned in advance, as a strategy to prepare for drought and to mitigate its effects. This will require a very well prepared drought planning including the planning process with its specific successive steps.

## Planning of Water Resources Management for Drought: Proactive Approach

The primary concern of drought is water shortage, most of the planned activities aim at reducing the effect of such shortage, through measures that are taken before, during and after drought. The activities per se comprise a wide range of measures to reduce societal vulnerability that are not necessary linked to water resources. In addition to planning, effective water resources management in drought prone areas hinges on the institutional and legal set-up established for addressing the interrelated issues of water conservation and planning for drought (see below). Because of the close relationship between water resources and drought, drought management is an essential element of national water resources policy and strategies.

From the water resources perspective, a proactive approach to drought is equivalent to strategic planning of water resources management for drought preparation and mitigation. Such planning consists of two categories of measures, both planned in advance (Chancelliere *et al.*, 1998, Rossi, 2000):

- long-term actions, oriented to reduce the vulnerability of water supply systems to drought, i.e. to improve the reliability of each system to meet future demands under drought conditions by a set of appropriate structural and institutional measures.
- short-term actions, which try to face an incoming particular drought event within the existing framework of infrastructures and management policies.

The overriding objective of the long-term actions is adjustment to drought conditions, even under normal situations, as a proactive and preparatory measure. This includes for instance the increase of water

storage capacity, the adoption of water saving technology, the recharge of groundwater, etc.

Depending on the severity of drought, long-term actions may or not eliminate completely the risks associated with it. They are supplemented by short-term measures which correspond to the actions taken during what is called a drought contingency plan. The plan is implemented during drought but the shift to it is usually gradual reflecting the progressive onset of drought. An effective water resources plan is one that has an optimal combination of both long and short term measures.

The measures that can be included in each of the above two categories for alleviating drought impacts can also be grouped into three main types or sub-categories (Yevjevich *et al.*; 1978): i) water-supply oriented measures; ii) water-demand oriented measures; iii) drought impact minimization measures (Fig. 3).

The measures related to supply management aim at increasing the available water supplies, whereas those pertaining to demand management aim at improving the efficient use of the available resources. These two categories of measures aim to reduce the risk of water shortage due to a drought event, while the third category is oriented to minimize the environmental, economic and social impacts of drought (Rossi, 2000). In practice, the measures are actually interrelated and, at times, even overlapping; but such interrelationships are necessary in order for the plan to achieve its goals.

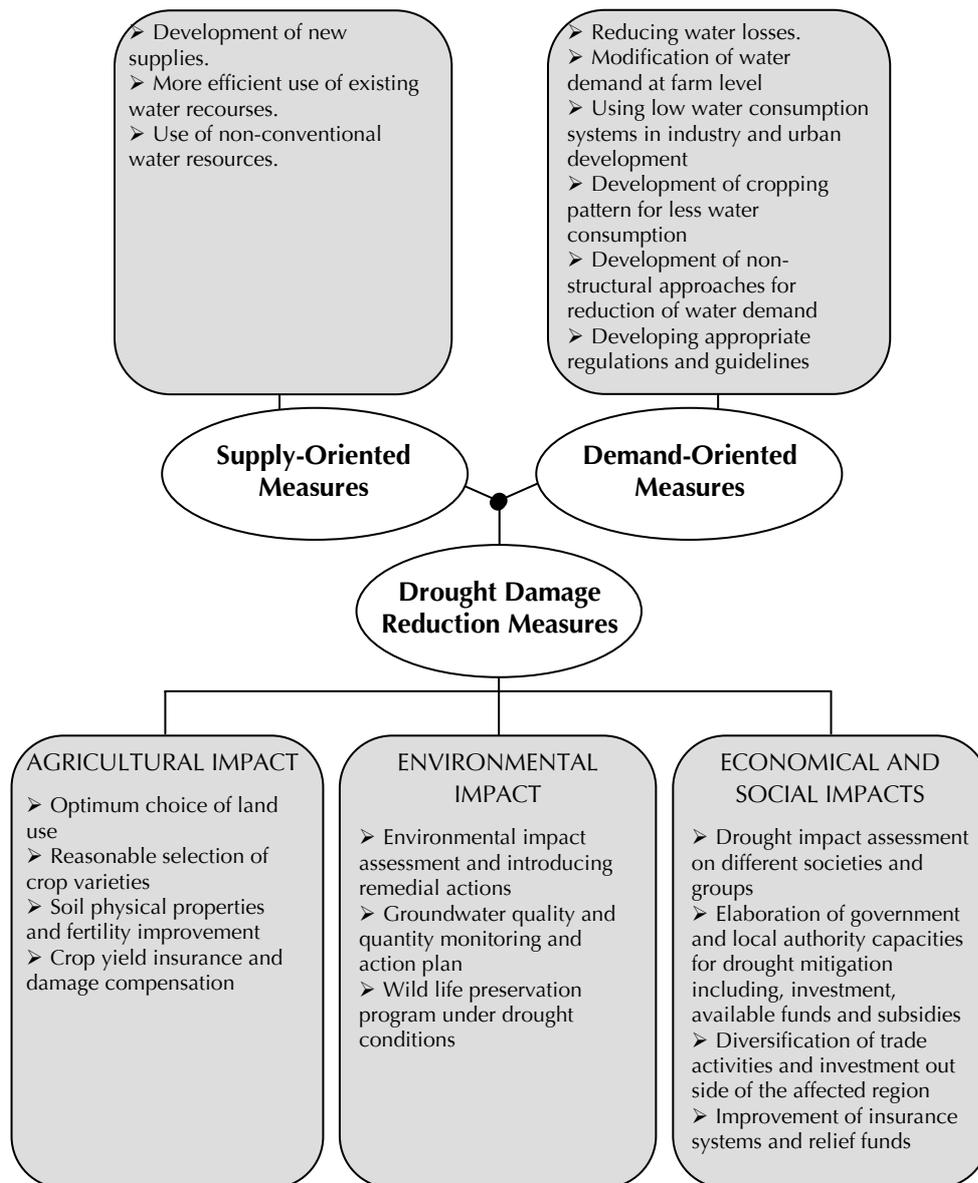


Fig. 3. Measures for alleviating drought impacts

## Drought Policy and Preparedness

Drought-prone nations should develop national drought policies and preparedness plane that place emphasis on risk management rather than the following traditional approach of crisis management. Many governments in the region now understand the fallacy of crisis management and are striving to learn how to employ proper risk management techniques to reduced societal variability to drought and therefore lessen the impacts with future drought events.

Recently, drought policy and preparedness plans have received increasing attention from governments, international and regional organizations, and NGOs. Simply stated, a national drought policy should establish a clear set of principles or operating guidelines to govern the management of drought and its impacts. The policy should be consistent and equitable for all regions, population groups, and economic sectors and consistent with the goals of sustainable development. The overriding principle of drought policy should be an emphasis on risk management through the application of preparedness and mitigation measures. Preparedness refers to pre-disaster activities designed to increase the level of readiness or improve operational and institutional capabilities for responding to a drought episode. Mitigation actions, programs, or policies are implemented during and in advance of drought to reduce the degree of risk to human life, property, and productive capacity. Emergency response will always be a part of drought management because it is unlikely that government and others can anticipate, avoid, or reduce all potential impacts through mitigation programs. A future drought event may also exceed the "drought of record" and the capacity of a region to respond. However, emergency response should be used sparingly and only if it is consistent with longer-term drought policy goals and objectives.

A national drought policy should be directed toward reducing risk by developing better awareness and understanding of the drought hazard and the underlying causes of societal vulnerability. The principles of risk management can be promoted by building greater institutional capacity within countries through encouraging the improvement and application of seasonal and shorter-term forecasts, developing integrated monitoring and drought EWS and associated information delivery systems, developing preparedness plans at various levels of government, adopting mitigation actions and programs, and creating a safety net of emergency response programs that ensure timely and targeted relief.

### Drought preparedness: major shortcomings

Vulnerability of drought is complex and yet essential to understand in order to design successful strategies for drought preparedness and mitigation (DPM).

In an expert meeting on drought early warning systems in the Mediterranean jointly prepared by World Meteorological Organization (WMO) and US National Drought Mitigation Center, held in 2000 in Lisbon, it was considered that effective information delivery and early warning systems are the foundation for effective drought policies and

plans. Given the importance of early warning for the operationalisation of national drought preparedness, strengthening the early warning systems should be considered as an integral component of strengthening the countries's drought management capacities. It has also been noted that in most south-eastern countries meteorological departments are not well prepared to function effectively in drought early warning systems for the agricultural sector because of shortcomings in analytical tools, poorly conceived or prepared informational products, and deficient data sharing practices; systems are in place, but need strengthening, networking and coordination at the central as well as the provincial levels. The main shortcomings to the current approaches to drought management in the Mediterranean are concerning the following areas (Wilhite, 2000, 2001).

**Data Networks.** In many countries, the density of meteorological and hydrological stations is insufficient to provide adequate coverage for drought monitoring. A wide range of data is necessary to adequately monitor climate and water supply status (i.e., precipitation, temperature, streamflow, ground water and reservoir levels, soil moisture, snowpack). These data are often not available at the density required for accurate assessments. Data quality (i.e., missing data) and length of record also represent critical deficiencies in data networks for many locations. Existing data networks need to be maintained and expanded in coverage and data reporting needs to be automated wherever possible to ensure timely receipt of data.

**Drought Preparedness: Major Shortcomings**

- inadequate data networks and lack of data on all major climate and water supply parameters;
- inadequate data sharing between government agencies and other institutions involved beside the high acquisition costs for these data by end users;
- early warning systems products-data and information are often not user friendly;
- unreliable seasonal forecasts and the lack of specificity of information;
- absence of integrated drought / climate monitoring approach based on multiple indicators;
- drought monitoring tools-indices for detecting the early onset and end of drought are not adequate;
- lack of impact assessment methodology;
- lack of an effective evaluation of real impacts of the actions and measures taken to alleviate the drought effects;
- the non-continuity and the abundance of the activities of the national drought task force the time the drought cycle is over;
- retardation of the delivery system in providing the data and information related to drought in a timely manner.

**Data Sharing.** Meteorological and hydrological data often are not widely shared between agencies of government. This restricts early assessment of drought and other climate conditions and retards its use in drought preparedness, mitigation, and response. In some countries, the high cost of data acquisition from meteorological services restricts the flow of information for timely assessments and for use in research.

Memoranda of Understanding (MOUs) between government agencies would facilitate data sharing and use and could bring tremendous societal benefits.

**Early Warning System Products.** Data and information products produced by early warning systems often are not user friendly. Many products are too complicated and do not provide the type of information needed by users for making decisions. Users are seldom trained on how to apply this information in the decision-making process or consulted before product development. Many products are not evaluated for their utility in decision making. User needs should be assessed and products evaluated through permanent feedback mechanisms.

**Drought Forecasts.** Long-term drought forecasts (a season or more in advance) are not reliable in most instances. Drought forecasts often do not provide the specificity of information needed by farmers and others (e.g., the beginning and end of the rainy season, distribution of rainfall within the growing season) to be useful for operational decisions. Greater investments in research to improve the reliability of seasonal forecasts would provide significant economic benefits to society if these forecasts were expressed in user-friendly terms and users were trained in how these forecasts can be applied to reduce climate risks.

**Drought Monitoring Tools.** Tools for detecting the early onset (and end) of drought are inadequate. The Standardized Precipitation Index (SPI) was noted as an important new tool that is receiving widespread acceptance in many countries. The SPI needs to be tested and applied in more drought-prone areas, and the results should be shared. Triggers for specific mitigation and response actions are often unreliable because of the inadequacy of detection tools and inadequate linkages between indices and impacts. Integrated assessment products are preferred, but few attempts have been made to integrate meteorological and hydrological information into a single product for purposes of detecting and tracking drought conditions and development. The Drought Monitor product recently developed in the United States could serve as a model. More research is needed on climate indices such as the SPI as an early warning tool and the relationship between SPI values and impacts in specific sectors to form the basis for triggers for mitigation and response actions. Also, drought should be monitored on weekly rather than monthly time intervals in order to more accurately evaluate changes in severity and spatial characteristics. Satellite-derived remote sensing data (AVHRR) offers considerable advantages and should be an integral part of drought early warning systems.

**Integrated Drought/Climate Monitoring.** It is critical that an integrated approach to climate monitoring be employed to obtain a comprehensive assessment of the status of climate and water supply. Too often, drought severity is expressed only in terms of precipitation departures from normal, neglecting information about soil moisture, reservoir and ground water levels, streamflow, snow pack, and vegetation health. Seasonal climate forecasts may also provide valuable information regarding whether conditions are likely to improve or deteriorate in the coming months. Use of multiple climate indices and parameters provides monitoring specialists with an assortment of tools, each with its own strengths and weaknesses. Understanding these strengths and weaknesses will provide a scientific basis for accepting or rejecting indicators. By comparing multiple drought indicators, the relationships between these indices/tools will be better understood. The experiences in the United States with the integrated drought assessment tool, the Drought Monitor, during 1999–2000 is potentially a good model to follow in future assessment efforts for some countries. This product integrates six different indicators/parameters, including vegetation health, in its assessment of drought severity in the United States.

**Impact Assessment Methodology.** One of the missing links in early warning systems is the connection between climate/drought indices and impacts. The lack of effective impact assessment methodologies has hindered the activation of mitigation and response programs and reliable assessments of drought-related impacts. Impact assessment methodologies need to be improved in order to help document the magnitude of drought impacts and the benefits of mitigation over response. Significant investment in interdisciplinary research on impact assessment methodologies could result in considerable progress in addressing this problem. Social scientists should be an integral part of the research team necessary to address this issue.

**Delivery systems.** Data and information on emerging drought conditions, seasonal forecasts, and other products often are not delivered to users in a timely manner. This characteristic significantly limits the usefulness of these products for most users. It is critical that delivery systems are improved and that they be location appropriate. For example, the Internet provides the timeliest and cost-effective method of information delivery in many settings but is inappropriate in most developing countries. Electronic and print media, as well as local extension networks, need to be used more fully as part of a comprehensive delivery system to diverse user groups.

**Global Early Warning System.** Because of the many definitions and characteristics of drought, no historical drought database exists. Similarly, no global drought assessment product illustrating current and emerging drought conditions is available to governments, international organizations, donors, and NGOs. A global drought assessment product that relies on one or two key variables (e.g., precipitation, vegetation health) would be a valuable tool to provide early warning of areas of potential concern.

## Drought Mitigation

Compared to other water-related disasters, drought is generally slow but the associated human and socio-economic losses are significant. To mitigate droughts, a range of short-term measures are available including relief programmes, crop insurance schemes, changes in land use practices, conjunctive water use of both surface and underground water, as well as the use of non-conventional water resources as additional water source for irrigation. Long-term measures include changing crops, building storage reservoirs, initiating effective water harvesting programmes and decreasing risk rates for communities.

### Drought mitigation: major constraints

Lack of know-how;  
Poor organizational capacity;  
Fragmented drought management policies;  
Shortage of capital resources;  
Inappropriate distribution arrangements and responsibilities.

However, the success and/or failure in implementing such measures are fundamentally a matter of the institutional capacity in finding the reasonable solutions to overcome the major constraints impeding an effective drought water management. Here, emphasis will be given to the needed measures to mitigate drought in the agricultural sector.

## Measures to mitigate drought in agriculture

Such measures could be outlined in:

- Estimating water requirements and agricultural drought risk

For irrigation purposes, rain distribution is at least as important as its total amount.

Ideally, rains should match crop needs throughout the year to avoid stresses depending on water excess or insufficiency. Short of that, efficient modern agriculture should act to correct both extremes through drainage and irrigation. A sound, economically effective

planning, however, must be based on the knowledge of the inherent risk as well as an accurate estimation of crop reaction to climatic vagaries and resulting stress. Combining the evaluation of risk and related losses in yield and/or soil fertility, one may obtain a platform for the estimation of the "threshold cost" (namely of maximum acceptable cost) of protective structures and practices, according to the desired safety degree (Haan and Bunn, 1971).

Agricultural drought, which occurs whenever available water in the soil is insufficient to satisfy plant needs, is defined according to S (severity), M (magnitude) and duration (D); being magnitude the average water deficit, and severity the cumulative deficit, we can define  $S = M \times D$ . However, it must be noted that it is not only the drought itself to imperil crop production, but also the more or less sensitive phenophase of the crop during the drought period, as clearly stated by Hiler and Clark (1971). Thus, in order to correctly estimate the "threshold cost", it is necessary that a reliable estimation of the risk of a relatively severe drought spell during a more or less sensitive crop phenophase be available, along with a sufficiently reliable provision of concomitant reference evapotranspiration: only such a set of information can enable the operators to work out a valid trade-off between expected crop losses and the costs of protective structures such as those for water procurement and distribution.

- Reducing crop water requirements

Many adaptive strategies can be adopted, including the selection of less water-demanding varieties and the change –as far as possible– of planting dates. The adoption of new varieties with a shorter life cycle can help to better adapt crops to harsh environmental conditions by permitting them to escape the periods of more probable or severe drought events.

Some considerable potential support in reducing plant water requirements or tolerance to water stress is expected from biotechnology, although "firm evidence on tillage and water effects must await further research and development of new transgenic varieties" (Henry, 2000).

A reduction in water consumption can be obtained by improving the efficiency of water conveyance systems as well as the application efficiency of irrigation systems, since combined water losses in such segments can exceed the value of fifty per cent (Hamdy and Lacirignola, 1999; Hamdy, 2001). An accurate irrigation management can help to considerably reduce water consumption per unit of yield

by enhancing water crop productivity: for this reason the “demand management” is of paramount importance (Hamdy, 2001).

- **Water Harvesting**

Water harvesting is a practice midway between water requirement reduction and water availability increase. The term "water harvesting" was coined by Geddes (1963) to indicate "the collection and storage of any farm waters, either runoff or creek flow, for irrigation use". Structures for water harvesting range from big artificial reservoirs damming creeks to store flowing water, down to microbasins with the capacity of 100 litres or less (Oweis, 2001).

Water harvesting structures are of special interest to face the forecast climate changes: in fact, they are useful to combat both the impact of more intense precipitation and that of longer drought periods.

In Mediterranean climate, micro-basins (otherwise called "diked furrows" or "tied ridges"), are particularly suitable for application in tree crops (olive, grapevines, fruit and stone crops) since they can be implemented soon after harvesting, before the rain season at fall and can be cancelled, if required, at springtime. Furthermore, such “microbasins” technique not only permits to capture all the incoming precipitations and enrich the soil and the aquifer with water, but has also the parallel advantage of eliminating or drastically reducing runoff and soil erosion. One further technique for water harvesting is the injection of artificial seepage into suitable aquifers of excess surface water to be recovered when needed. This solution can be attractive under specific conditions but in all cases it requires additional energy costs for lifting when re-used. Interventions on a smaller scale include land shaping to obtain farmed strips where water flows and is “harvested” from collecting areas.

- **Non-conventional water resources**

The ever more acute scarcity of freshwater availability has encouraged investigation on new forms of water supply. Seawater desalination has been the object of intense research, which has succeeded in considerably reducing treatment costs, resulting in an appreciable diffusion of such a technique and enriched know-how; however, seawater desalination is still too expensive in economic and energetic terms to be proposed as a large-scale solution for agriculture. Actually, its cost in excess of USD 0.50 /m<sup>3</sup> confines its use to high value crops. Towing icebergs or using large tankers to procure freshwater are solutions that have been proposed and experienced on a limited scale,

but have enjoyed no wide acceptance. Basically, only two non-conventional water resources can be proposed at present, namely, brackish waters and urban wastewaters, both of them entailing some degree of risk and in need of further research.

- Brackish Water

Using brackish waters is risky for the crop, and in a more or less long term, also for soil fertility, unless provisions are made for adequate salt leaching; also the aquifer can be damaged if an appreciable amount of salts pollutes it. The problem is that the existing guidelines, which were worked out in a period of unlimited freshwater resources, are very conservative and therefore in need of being profoundly revised. They do not take into account the complex relationships in the soil-plant-atmosphere continuum nor place sufficient emphasis to the type of management, which has a considerable impact on plant response. In addition, ranking plant response to salinity according to a generic "yield reduction" has been criticized as a non-scientific approach and the adoption of more soundly based approaches has been suggested (Behboudian *et al.*, 1979; Everard *et al.*, 1994; Steduto *et al.*, 2000).

When operating with saline waters, irrigation scheduling must take into account leaching requirements and the different response of plants to a given water quality. In particular, it is debated if it is useful to reduce the interval, since, contrary to what maintained among others by Goldberg and Gornat (1971) and Bernstein and Francois (1973), Hamdy (1996) concludes that "the bulk of evidence does not support shortening irrigation intervals when saline water is used". Of course, also the irrigation method and management can affect plant response, not only with saline water scorching plant leaves when sprinkled, but also with the different plant response to day or night sprinkling, and depending on water and salt distribution in the soil.

The use of brackish waters obliges to adopt appropriate practices for leaching the salts that accumulate in the soil. Leaching management raises problems regarding leaching fraction amounts and intervals. Early equations proposed to determine leaching requirements (USDA, 1954; Ayers, 1976) were based on rather nebulous principles. Hamdy (1996) suggests simply leaching residual salts, when needed, increasing by 20-30 % water volumes required for full irrigation after carefully controlling soil salinity build-up.

The management of multi-source water can basically be reduced to blending or alternating freshwater with saline water: the second option is generally recommended, with the water selection to be done

according to plant phenophases and expected precipitations (Hamdy, 1999).

- Urban Wastewater

Urban wastewaters are a very promising non-conventional resource, deserving full consideration for at least three good reasons:

- ❖ their use permits to free freshwater resources to satisfy more pressing uses (domestic, industrial);
- ❖ they are presently a costly burden for their treatment;
- ❖ they are rich in organic matter and fertilizers (which can be a blessing to the crops but pollute the environment if released without control).

On the other side, the uncontrolled use of urban wastewaters implies risks to the health of irrigators and consumers and is potentially harmful to the soils, the aquifers and the water bodies due to the heavy metals, the parasites and the pathogens they could carry. As a consequence, an a priori evaluation of the level of treatment needed for a safe use, and the total maximum daily load (TMDL), namely the permissible amount of pollutants for any particular environment, are necessary. The ever-shrinking freshwater availability encourages the reuse of wastewaters for irrigation: for instance, Tunisia is planning to irrigate 30.000 hectares with them, while Egypt has a programme to treat nearly 3 billion m<sup>3</sup> by the year 2010 (Hamdy, 2002).

However, a major problem with the reuse of wastewaters for irrigation is the determination of the treatment level in order to make them safe; worldwide, the trend has been to follow the stringent guidelines set initially by the Environmental Protection Agency (EPA) in California, making them ever more stringent, in the assumption that "more stringent means more advanced". The trouble is that these guidelines were elaborated in an age of abundant freshwater resources and that the underlying philosophy is "better safe than sorry". Having realized that the full acceptance of such guidelines leads to absurdly limiting consequences, the World Bank and the World Health Organization proposed some more lenient standards, which received only a limited acceptance by the responsible authorities.

This is actually a major problem, seriously impacting the diffusion and the safe reuse of wastewaters; it will be necessary to collect and elaborate the results of the ongoing research to obtain those data which are required to revise and update the existing standards and,

parallel to this, it is necessary that the responsible authorities abandon their exceedingly conservative approach trading the principle that “more stringent is more advanced” in favour of “more advanced is as lenient as possible”. Indeed, the sad consequence of the present unreasonably stringent standards is that quite often farmers simply ignore them, irrigating with untreated wastewaters.

In perspective, it would be advantageous to the farmers and the society at large if simple, natural, inexpensive treatment procedures such as bio-depuration of wastewaters and vegetative filter strips for the protection of water bodies become widely accepted, due to their ability to combine low-cost solutions and reasonably efficient level. Also the infiltration of wastewaters through soils after a primary treatment (Soil Aquifer Treatment, SAT), under appropriate conditions (e.g. no karstic conditions, no shallow water table) is a simple and inexpensive solution that deserves full consideration; researches are in course to fully explore the potentiality of this solution under various soils and daily load conditions.

### Drought mitigation: priorities to be addressed

To mitigate the extreme event, the drought, beside the technical measures, effective adaptation measures are needed by strengthening the resilience of societies and natural ecosystems. However, this will require an accurate prediction of climate change and scenarios building and greater cooperation and dialogue between water managers and the climate community.

As a matter of fact, funding of work related to climate change has been underway since 1990s. The United Nations framework convention on climate change (UNFCCC) established a special fund to aid the developing countries in preparing and implementing national programmes of action for adapting the climate change. However, the fund has given priority to mitigation strategies for reducing greenhouse gas emission. Activities to adopt water management strategies under climate change have received little attention and often do not meet the funding criteria.

Inadequate institutions in the majority of the Mediterranean countries are one of the major constraints to manage effectively water-under drought conditions. Few countries have established consistent coordinated programmes that involve governments, institutions, the private sector and the communities for drought mitigation.

In the region, a range of actions relating to the challenge of managing water to combat drought is urgently needed. These actions should

cover several themes focusing on specific objectives and directions. Beside these actions, several priorities need to be addressed at local, national and regional levels, some of them being:

- Integrating drought prevention, preparedness and mitigation into socio-economic development;
- Establishing comprehensive policies and strategies, an appropriate legal framework, and relevant institutions to ensure effective drought mitigation;
- Improving the capacity building in water management. Education and training addressed to all levels are the fundamental key elements;
- Promoting regional cooperation sharing knowledge and information and working on shared challenges between the Northern and Southern countries of the Mediterranean;
- Abundant information is available locally, nationally, regionally and globally. The question is how to make the best use of it and to ensure that it gets to those who need it most at the time and in the form they need it.
- Creating networks and partnerships aids drought preparedness by providing platforms for exchanging data, know how, experiences and sharing lessons and best practices;
- Enhancing advanced research introducing recent technological innovations (satellite monitoring, geographical information systems, computer and communication technologies).

A crucial priority is to increase the direct involvement and participation of local communities and NGO's in planning, decision-making and implementations of water management strategies; community-based approaches are effective for several reasons:

- Communities define their problems more accurately than outsiders and thereby identify appropriate measures to overcome them.
- Communities draw local skills and experts living with the disasters.
- Communities deploy low-cost appropriate technologies effectively, and the technologies are likely to be sustainable because they are owned by the community and build local capacity.

Finally, the Mediterranean countries, and the developing ones in particular, are facing big challenges. Climate change mitigation and water-related disasters, the drought cannot be faced without providing the needed technical and financial support. This is the important role for international organizations. The United Nations agencies, bilateral and multilateral aid agencies, industrialized countries and other international organizations can provide important support to national disasters management by developing research and study programmes, introducing the new advanced technologies in this field as well as sharing professional knowledge and practice.

Strengthened coordination and solidarity is needed not only among those affected by hazards but also among donor agencies and other organizations concerned to ensure effective and efficient use of the limited resources. Sound sustainable financing mechanisms need to be developed for risk management and climate change adaptation, drawing on national, bilateral, multilateral and private investments. The costs of prevention and mitigation are usually far less than those for disaster relief and recovery.

## Concluding Remarks

- In the Mediterranean, evaluation of past experience on water resources management for drought conditions shows that most countries adopt a reactive approach following droughts which has several shortcomings regarding effectiveness and sustainability of natural resources. The adverse impacts of drought are likely to increase in view of the decreasing per capita water resources and the increase in drought occurrence. Reducing long-term vulnerability to drought remains possible but requires a fundamental shift in approach to deal with water resources management.
- The significant diversity existing within each country of the region, each country has to develop national drought policies and preparedness plans that address the unique features of drought and to conduct risk assessment to identify and address the most vulnerable people and sectors at the national and sub-national level. A comprehensive drought early warning system must be a foundation of national drought policy and preparedness plan. Therefore, governments of the Mediterranean countries are called upon to:
  - develop national drought planning and action programmes for combating drought, with particular

emphasis on policies, required infrastructures, co-ordination, community participation, political commitment, raising public awareness and provision of finance.

- give due support to co-ordination mechanisms at country level, that would accommodate cooperative programmes, joint activities and institutional setups leading to harmonization of national drought preparedness plan among neighboring countries.
- A drought preparedness and mitigation plan should be integrative, proactive and incorporate the following elements:
  - drought monitoring and early warning system;
  - drought risk and impact assessment; and
  - institutional arrangements including mitigation and response actions and programmes.

All the above elements must be underpinned by research:

- ❖ Priority should be given to improving existing observations networks and establishment new meteorological, agricultural and hydrological networks, as well as predictive tools and models;
- ❖ Relevant regional and international organizations, NGOs and other stakeholders in the region join their efforts to provide assistance and funding related to drought preparedness activities and drought mitigation;
- ❖ Developing triggers that link indicators of drought severity to impacts during the onset and termination of drought conditions; and
- ❖ Appropriate interpretation of information and clearly expressing the assessment to decision makers in a timely manner;
- ❖ Awareness on the necessity to move to a more proactive approach in drought management is growing, but the capacity to do so is still remaining low. Most countries are in need for technical assistance to establish programmes aimed at developing and implementing strategic water resources management plan that would make term less vulnerable to future drought.

The bottleneck for our success and/or failure is a matter of the institutional capacity in setting the appropriate plans, policies and strategies to overcome the major constraints impeding an effective drought water management.

## Future Challenges

Drought is an insidious natural hazard that is a normal part of the climate of virtually origins. It should not be viewed as merely a physical phenomenon. Rather drought is the result of interplay between natural events and the demand placed on water supply by human use systems.

There are many challenges before us if we are to improve our management of droughts. First, drought must be accepted as a natural hazard within the natural hazard community of scientists and policy-makers. Because of its slow-onset characteristics and lack of structural impacts, it is often disregarded. This lack of recognition of the importance of drought by the natural hazards community has been an impediment to obtaining adequate research support and, in many instances, an obstacle to building awareness among policy-makers at the local, national, region, and international level. This lack of awareness in turn has resulted in underappreciation of drought and its far-reaching impacts. It has also perpetuated the process of dealing with drought is a crisis management mode when the knowledge and technology necessary to improve preparedness and mitigation impacts is readily available.

A second challenge is to build awareness of drought as a normal part of climate. It is often considered to be a rare and random event – thus the lack of emphasis on preparedness and mitigation. Improved understanding of the different types of drought and the need for multiple definitions and climatic/water supply indicators that are appropriate to various sectors, applications, and regions is critically part of this awareness-building process.

A third challenge is to erase misunderstandings about drought and society's capacity to mitigate its effects. Many people consider drought to be purely a physical phenomenon. We may ask, "if drought is a natural event, what control do we have over its occurrence and the impacts that result"? Drought originates from a deficiency of precipitation over an extended period of time. The frequency or probability of occurrence of these deficiencies varies spatially and represents a location's exposure to the occurrence of drought. Some

regions have greater exposure than others, and we do not have the capacity to alter that exposure.

As with other natural hazards, drought has both a physical and social component. It is the social factors, in combination with our exposure, that determines risk to society. Some of the social factors that determine our vulnerability are level of development, population growth and its changing distribution, demographic characteristics, demands on water and other natural resources, government policies (sustainable versus unsustainable resource management), technological changes, social behaviour, and trends in environmental awareness and concerns. It is obvious that well-conceived policies, preparedness plans, and mitigation programmes can greatly reduce societal vulnerability and, therefore, the risks associated with drought.

A fourth challenge is to convince policy and other decision makers that investments in mitigation are more cost effective than post-impact assistance or relief programs. Evidence from around the world, although sketchy, illustrates that there is an escalating trend of losses associated with drought in both developing and developed countries. Also, the complexity of impacts is increasing. It seems clear that investments in preparedness and mitigation will pay large dividends in reducing the impacts of drought. A growing number of countries are realizing the potential advantages of drought planning. Governments are formulating policies and plans that address many of the deficiencies noted from previous response efforts that were largely. Most of the progress made in drought preparedness and mitigation has been accomplished in the past decade or so. Although the road ahead will be difficult and the learning curve steep, the potential rewards are numerous. The crisis management approach of responding to drought has existed for many decades and is ingrained in our culture and reflected in our institutions. Movement from crisis to risk management will certainly require a paradigm shift. The victims of drought have become accustomed to government assistance programmes. In many instances, these misguided and misdirected government programmes and policies have promoted the unsustainable use of natural resources. Many governments have now come to realize that drought response in the form of emergency assistance programmes only reinforces poor or unsustainable actions and increases self-reliance.

Policies that encourage self-reliance and the sustainable use of natural resources will be more effective in the long term and will reduce the need for government and donor intervention. A critical first step is to identify and quantify the sectors and peoples at risk from drought. Once this step is completed, policies, plans, and mitigation

programmes can be formulated to address these vulnerabilities in a systematic manner.

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