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## **Water Resources Planning and Management for Drought Mitigation**

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by

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## I. Introduction

In general terms, drought can be viewed as a natural shortfall of precipitation and water resources to levels that do not meet the uses established for normal conditions. Drought is therefore an abnormal shortage of water or moisture and the problems of drought management are actually problems of water management. The effects of drought however spell beyond water resources to affect society and its living conditions and environment, making a holistic and interdisciplinary approach necessary for addressing these effects.

This paper looks at water resources management from the perspective of being a tool for both preparation to and mitigation of drought. The focus is on water use in agriculture in the Near East region and elsewhere. It analyzes briefly past experiences and their success as well as shortfalls to achieve proper drought preparedness and mitigation, then makes proposals of measures to address existing constraints, through changes in policy, regulations, institutions and practices.

Countries of the Near East region and elsewhere that have invested in water resources development during the past decades are generally better off in absorbing drought effects than those that adopted different policies. The harnessing of water resources, intended initially for boosting agricultural production and providing drinking and industrial water supplies in addition to power generation, through the construction of water storage and transport infrastructure, buffered water shortages that resulted from drought episodes. The mobilization of river flow during wet periods regulated the availability of water resources and their partitioning over dry periods, allowing for the satisfaction of drinking water supplies, the maintenance of trees and at times even substantial crop production through supplementary or deficit-irrigation. While being non negligible, these achievements remain generally below the potential of adequate management of water resources for drought preparedness and mitigation.

The inadequacy of conventional water management approaches to prepare for drought conditions stems from the fact that these approaches were established during and for periods of water abundance. The policy was to encourage water usage for higher crop production, so the measures taken were all oriented towards this policy, including the institutional setup, the norms and regulations, the technology and the practices. Now that water resources have become scarce and drought periods more frequent, the conventional water resources management approaches are no longer valid; they need to be reviewed and adapted to water-scarcity and drought conditions.

From the perspective of managing drought per se, some countries have learned how to plan for managing their water resources during drought. Funds are mobilized and the event creates a lot of awareness and motivation for addressing the problem, through measures such as water reallocation and rationing, incentives for saving water, digging of wells and so on. However the momentum created by these episodes dies out completely once the crisis is over and water resources are back to their normal level. This is also an issue that needs to be addressed; the memory about drought should be kept alive and considered in all decisions and activities undertaken during the following normal years.

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Evaluation of past experience shows that the traditional approach to water management has several shortcomings for preparing to drought and becomes ineffective during water shortage periods. Reducing long term vulnerability to drought will require a fundamental shift in government approaches to deal with water resources management, through adequate planning and the creation of an enabling policy and institutional environment.

## **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.

### **Strategic Planning of Water Resources for Drought Conditions**

Nowadays, there is more and more awareness and sensitizing among decision-makers about the necessity to move to a more proactive approach in drought management. A proactive approach consists of measures that are planned in advance, as a strategy to prepare for drought and to mitigate its effects. The planning process takes place before the onset of drought whereas its implementation is partitioned over a long period of time, from way before drought starts until some time after it has passed. The planning process should never end in drought prone countries, but be continuous through evaluation of the plan and its amendments to adapt it to the dynamic changes. The most arduous part however is to get started.

As 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 et 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<sup>1</sup>. 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.

Besides the approach which can be reactive or proactive (short-term and long-term) and the category of measures that can be taken in the strategic planning process (supply-related, demand-related, impact minimization) a third dimension consists of the end-users of water resources or the sectors concerned by the actions (drinking, agricultural, industry, other). The planning process should indicate clearly the classification of the planned measures, distinguishing between the sectors, at each level of the other two dimensions. Thus, a specific drought mitigation measure can be classified according to a three-dimensional (Rossi, 2000) matrix. A sample of measures (FAO, 2001; Dziegielewski, 2001) classified in such a matrix, as adapted from Rossi (2000), is given in Table 1.

Table 1: Sample classification of drought mitigation measures related to water resources

| Category | Long-term  | Concerned sectors <sup>(*)</sup> | Short-term                            | Concerned Sectors |
|----------|--|----------------------------------|---------------------------------------|-------------------|
|          | - Increase water collection and storage opportunities (reservoirs) | U,A,I,R                          | - Mixing fresh and low quality waters | U,A,I,R           |
| Supply   | - Desalination of brackish   | U                                | - Exploiting high-cost waters         | U,A,I             |

<sup>1</sup> Dziegielewski (2001) classifies these measures as: 1) water supply planning, 2) drought contingency planning, and 3) drought management. In the literature on natural hazards, these are known, respectively, as : 1) mitigation, 2) preparedness, and 3) response. This classification is not correct however, as long-term measures are not limited to water supply but include water demand as well. In fact, water demand management as a long-term measure is the main area of focus in countries where the possibilities for increasing supply are limited.

|                     |  |  |  |   |
|---------------------|--|--|--|---|
| management          | <ul style="list-style-type: none"> <li>and saline water</li> <li>- Treatment and reuse of wastewater</li> <li>- Water transfers</li> <li>- Artificial precipitation</li> <li>- Locate potential new resources (standby supplies)</li> <li>- Aqueducts and canals</li> <li>- Groundwater recharge</li> <li>- Monitoring and forecasting</li> <li>- Adjust legal and institutional framework</li> </ul>  | <ul style="list-style-type: none"> <li>A,I</li> <li>U,A,I,R</li> <li>U,A,I,R</li> <li>U,A,I</li> <li>U,A,I</li> <li>U,A,I</li> <li>U,A,I,R</li> <li>U,A,I,R</li> </ul>             | <ul style="list-style-type: none"> <li>- Over-drafting aquifers</li> <li>- Diverting water from given uses</li> <li>- Decreasing transport and distribution losses</li> <li>- Adjust legal and institutional framework</li> <li>- etc.</li> </ul>  | <ul style="list-style-type: none"> <li>U,A,I</li> <li>U,A,I</li> <li>U,A,I</li> <li>U,A,I,R</li> </ul>  |
| Demand management   | <ul style="list-style-type: none"> <li>- Adopting supplementary and deficit-irrigation</li> <li>- Water saving irrigation techniques (drip, sprinkler, ...)</li> <li>- Incentives to invest in water saving technology</li> <li>- Water recycling</li> <li>- Dual distribution networks for drinking water supply</li> <li>- Inventory private wells and negotiate their public use</li> <li>- Assess vulnerability and advise water users</li> <li>- Elaborate alert procedures</li> <li>- Carry-over storage</li> <li>- Conjunctive use</li> <li>- Adjust legal and institutional framework</li> <li>- Etc.</li> </ul> | <ul style="list-style-type: none"> <li>A</li> <li>A</li> <li>U,A,I</li> <li>U</li> <li>U,I</li> <li>U,A,I</li> <li>U,A,I,R</li> <li>U,A,I</li> <li>A,I</li> <li>U,A,I,R</li> </ul> | <ul style="list-style-type: none"> <li>- Restricting agricultural uses (rationing, subjecting certain crops to stress, ...)</li> <li>- Restricting municipal uses (lawn irrigation, ...)</li> <li>- Review operations of reservoirs</li> <li>- Water metering and pricing</li> <li>- Water rationing</li> <li>- Education and awareness creation</li> <li>- Provide permits to exploit additional resources</li> <li>- Provide drilling equipment</li> <li>- Adjust legal and institutional framework</li> <li>- Negotiate transfer between sectors</li> <li>- Etc.</li> </ul> | <ul style="list-style-type: none"> <li>A</li> <li>I</li> <li>U,A,I</li> <li>U,A,I</li> <li>U,A,I</li> <li>U,A,I</li> <li>U</li> <li>U</li> <li>U,I,A,R</li> <li>U,A</li> </ul>  |
| Impact Minimization | <ul style="list-style-type: none"> <li>- Development of early warning system</li> <li>- Reallocation of water resources on the basis of water quality requirements</li> <li>- Use of drought resistant plants</li> <li>- Development of a drought contingency plan</li> <li>- Mitigation of economic and social impacts through voluntary insurance, pricing and economic incentives</li> <li>- Education activities for improving preparedness to drought</li> <li>- Elaborate set-aside regulations</li> </ul>   | <ul style="list-style-type: none"> <li>U,A,I</li> <li>U,A,I</li> <li>A</li> <li>U,A,I,R</li> <li>U,A,I</li> <li>U,A,I</li> <li>U,A,I,R</li> </ul>                                  | <ul style="list-style-type: none"> <li>- Temporary reallocation of water resources (on the basis of assigned use priority)</li> <li>- Restrict uses</li> <li>- Emergency supplies</li> <li>- Public aid to compensate loss of revenue</li> <li>- Tax relief (reduction or delay of payment deadline)</li> <li>- Rehabilitation programs</li> <li>- Resolving conflicts</li> <li>- Postpone payment of credits</li> <li>- Implement set-aside regulations</li> </ul>  | <ul style="list-style-type: none"> <li>U,A,I</li> <li>U,A,I</li> <li>U</li> <li>U,A,I</li> <li>U,A,I</li> <li>U,A,I</li> <li>U,I,A,R</li> <li>U,I,A</li> <li>U,I,A,R</li> </ul> |

(\*): U: Urban; A: Agriculture; I: Industry; R: Recreation

## **Requirements for Strategic Planning of Water Resources for Drought Mitigation**

If planning water resources management for mitigating drought seems simple, its implementation is very difficult for several reasons. Long-term planning in general is not a common practice in most developing countries where matters are managed on a daily basis, tackling problems as they arise. Planning becomes even more difficult when it concerns unforeseen events such as drought. The understanding of drought and how to cope with it is also difficult by nature, as it is not easy to predict drought episodes and their severity in time and space. Moreover, most countries lack sufficient capacity (know-how and infrastructure) and mechanisms for monitoring drought and managing their water resources. In this respect, most countries of the Near East region are in the need of technical assistance for establishing programmes for the management of the existing water supply systems and the adoption of water conservation technologies.

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. The large set of possible measures for planning water use makes it difficult to choose the most effective ones. It is important however that the right combination of measures be identified and applied for successful planning and achievement of the objectives. The process is improved through comparison between different options, optimization modeling and dynamic evaluation of past plans.

The comparative advantages of strategic planning over reactive measures are often not well understood by decision-makers and technicians. Countries with relatively good experience in drought management have actually learned to elaborate relatively good reactive mitigation plans in a record time and to identify funds for their implementation. The latter has also become more rapid in view of the frequent droughts that have hit these countries and the learning-by-doing process. However, real proactive planning as inferred to above is actually not well understood and rarely implemented. In the United States and until 1990, state governments devoted minimal resources to statewide drought planning. The situation has changed since then and as of 1997, 27 states had some form of drought contingency plan (Wilhite, 2000.)

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. In addition to good understanding of strategic planning and the willingness to adopt it, there are two main requirements upon which the success of such planning is based. These are: adequate monitoring of water resources for drought mitigation and the institutional adjustment and legal framework for elaborating and implementing such plans.

### **Water Resources Monitoring for Drought Mitigation**

In the Near East Region and other parts of the world as well, a drought is declared officially in a country when delays in precipitation and water shortage have caused damages to crops and grazing lands. The delays could be early in the growing season or during different stages of crop growth. The on-set of drought however is gradual on one hand, and drought usually hits different regions of a country, with varying levels of intensity and at different moments, on the other. Official declaration of drought is actually a recognition that the catastrophe has already taken its toll and that the Government is elaborating a reactive programme to relief the affected population, the livestock, and rarely wildlife. The customary way of doing is stopping most if not all regular development activities and shifting the funds to the provision of food, drinking water and fodder, often directly, but also through food for work programmes intended essentially for creating labor opportunities.

As the on-set of drought is gradual, so should be the actions taken to face it. But this can be achieved only if drought is regularly monitored through indicators or indices that are established as part of the planning process. The monitoring system allows decision-makers to follow the development of

drought before it becomes evident, to make the right decision regarding its onset and the type of mitigation measures to be launched. This is accomplished by linking the monitoring system to decision-making, through pre-established linkages between different levels of the indices (triggers) with drought mitigation measures discussed above. As indicated by Dziegielewski (2001), the essence of a contingency plan is a determination of which drought response actions will be implemented under what conditions of water shortage. Drought indicators or indices integrate several variables on precipitation and water resources into comprehensible indices upon which decisions are made. Most indices give indications of how far precipitation has deviated from historical records. The conditions for the application of each index are known and should be respected. Several indices have been developed and tested in the United States, Australia, India and Europe. An analysis of the applicability of the most used index, the Palmer index, in the Mediterranean region is given by Rossi et al. (1996) and a review of eight drought indices by Michael J. Haynes, from the National Drought Monitoring Centre (USA), is available in the Center website under:

<http://www.drought.unl.edu/whatis/indices.htm>

A drought monitoring system is based essentially on the monitoring of water in its different forms (precipitation, river flow, groundwater, etc.) and linking it to the drought mitigation plan, through a decision support system and various mechanisms. With the exception of some American States, Australia and probably India, no country has a permanent drought monitoring system, but several countries have gained ample experience in the field of water resources monitoring during droughts.

Monitoring provides also the required information needed for evaluating the performance of the water resources management plan in alleviating the effects of drought. Such evaluation is normally performed at the term of every drought to assess the achievements of the drought plan and to learn from the experience by recommending the corrections necessary for future plans.

### **Legal Aspects of Water Resources and Drought Mitigation**

Explicit legal frameworks for managing water resources are either lacking or fragmented in most Near East countries. The decisions regarding water resources development and allocation are often centralized and driven by political and social motives rather than by economic and use efficiency criteria. The decisions are top-down with no involvement of the stakeholders and beneficiaries. Water allocation and use plans are made for “average-year” situations, with little or no consideration of extremes such as drought years. Allocation is also effected on the basis of administrative entities rather than on natural boundaries such as river basins. The principle of increased capacity and responsibility of farmers to cope with drought is making its way in some countries.

Under normal climatic conditions, water is allocated on the basis of established water rights. In the Near East region, water rights are very diversified. Surface waters from springs and permanent streams are used according to inherited traditional rights that have been acquired over time. Flush floods and non permanent flows are used by riparian farmers, often starting from upstream to downstream. Surface and at times ground waters that have been newly mobilized by governments, through the construction of dams and tube wells, are also allocated according to rules set up by governmental agencies. These rules are based on criteria such as the crops grown or simply quotas per unit area, etc.

The right to groundwater is of three categories. The first category consist of privately owned wells and is by far the largest in the region. In this category, farmers dig their own wells, with or without subsidy from governments, and have free access to as much water as they want or they can afford to pump. The number of wells under this category continues to grow, except where aquifers have been partially depleted or subjected to the intrusion of brackish or saline water. The second category consists of public or private wells from which farmers are allocated water quotas they cannot go beyond. The third category includes farmers who are given permits to access water only when their allocation does not affect the right of the already existing wells. Enforcement of the law governing this category is low in the region.

The established water rights often become a source of problem during drought periods. When governments embarked in irrigated agriculture and water resources development, water was relatively abundant so the targets, and hence the established rules and practices, were to encourage water use. Important incentives were provided by governments to make farmers adopt the use of water, particularly in areas that were newly put under irrigation. At times dissuasive and persuasive measures were applied to enhance water use, such as the minimum water quotas that farmers had to pay for even if not used. There was no incentive for using less water. During drought periods, it is completely the opposite that is sought as officials find themselves calling for the use of less water and hence implementing the opposite of the established practices and rules.

Drought mitigation measures are intended, among other purposes, to overcome the drawbacks and limitations of water allocation rights and practices. In drought prone areas, the guiding policy as well as the entire set of development practices and accompanying measures should target limited usage of water and higher productivity per unit of water used, even during normal years. The approach to water resources management and the existing laws and water rights should be reviewed and gradually modified to cater for implementation of the policy. More specifically, the rights should prioritize water allocation under varying levels of its availability. Water markets open avenues for allocating water on the basis of its economic value while enhancing higher productivity and conservation measures. Quota systems and incremental water tariffs can be adopted to protect poor farmers from being affected by water pricing.

An example of water rights that are unsuitable for shortage conditions is the right to get unlimited amounts of groundwater, free of charge and with no prior authorization. Although such a right may not be expressed as so, it is implicitly recognized and actually practiced in many countries of the Near East region. Even when water quotas or fees are inferred to by the law, they are often not enforced. Regulations specific to drought mitigation should be established as part of the planning process as required. In addition to modifying the legal framework of water management to adapt it to water shortage conditions, set-aside regulations and emergency legislation that might be needed for implementing drought mitigation plans should be prepared within the framework of preparation of such plans. Firmness in setting up regulations for the interests of all and for the effective application of water management for drought plans cannot be emphasized enough, as influential individuals and special-interest groups may impede the process.

### **The Institutional Issue of Water Resources Planning for Drought Management**

Except in small countries of the Near East region, water resources development and management are under the authority of several institutions and agencies, essentially governmental but at times also private. The number of people involved in water resources sector is often high, which indicates the importance given to the sector on one hand and the potential for addressing the problems associated with it on the other. However what is intended to be a solution becomes actually a problem. The agencies lack cooperation and coordination mechanisms, with unclear mandates and unspecified responsibilities, and it is not unusual that they work in opposite directions. Some countries have high level institutions constituting a framework for co-ordination and supervision of water resources planning and management. At times, leadership and arbitration of a higher level, such as National Councils, are also set-up as several sectors are involved (public works, water supply and sanitation, agriculture, industry, etc.) While such councils are important in providing overall strategy and supervision, they are usually less active, lacking the necessary mechanisms and power for being effective.

A limiting factor for the effective development and implementation of strategic planning of water resources for drought is the existing institutional framework. Coordinated policies and guiding principles need to be established by each country, to ensure good governance of water resources for national interests. During the planning process, the concerned government departments and institutions need to be identified and their tasks and roles in planning and implementing the planned

measures well indicated. As pointed out by Wilhite (1991), Grigg and Vlachos (1993), and Fontane and Frevert (1995), a correct definition of the roles of the different levels of government in planning and co-ordination is a primary need in drought management process. Such level (local, regional, national or international) can be seen as the fourth dimension of the classification of the measures (Ross, 2000) discussed above.

Decentralization of water resources management is essential for rapid drought monitoring and response implementation. But decentralization becomes chaos when there is no coherence between the various levels (local, district, national) and no coordination between sectors. Basin agencies and basin councils where all stakeholders are represented have proven to be more effective than the traditional centralized institutions, when they are set-up in an appropriate manner. Councils enhance interagency planning, harmony in the goals and principles and coordination of activities.

Strategic planning of water management for drought mitigation is developed in close concert with the key stakeholders such as associations of water users, government agencies, local communities and other interest groups. The plans are formulated and coordinated first at the national level, then at that of river basins or hydrological regions, then local level. The top-down planning process is justified by the fact that under scarcity, the response by a region affects the other regions of the country, the response by a community affects the other communities within the same region, and the response by an individual affects the other individuals within his/her community. The actions undertaken at every level have to respond to the needs of the lower levels, in developing and implementing their emergency and contingency plans. The plans are based on actual field data and information and normally highlight the different drought mitigation measures to be implemented, by each level of the hierarchy, at each stage of water supply shortage. The institutions in charge of developing and implementing these plans have the double role of ensuring their feasibility and administering their effective implementation. The roles of all institutions involved should be explicitly indicated.

## **Conclusions**

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 the Near East region 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 the approaches to deal with water resources management.

From the water resources perspective, a proactive approach to drought is equivalent to strategic planning of water resources management for drought preparation and mitigation. Most of the planned activities aim at reducing the effect of water shortage, through measures that are taken before, during and after drought. It comprises long-term and short terms actions addressing water supply and water demand management as well as response to drought, and encompassing all the concerned sectors of water use. This an approach is the major water resources challenge in drought prone countries and constitutes the unique alternative to the conventional one which was developed for and adapted to periods of plenty of water.

The planning process is not easy. In addition to a large array of possible technical measures, facilities and operational rules, it requires a review of the regulations and institutions related to water resources to adapt the legal and institutional framework to the conditions of water shortage. Moreover, it necessitates a sound system for monitoring water resources and its close linkage to the planned measures. The overall objective of the process is to improve the reliability of the available water resources to meet the demands. The combination of planned measures is not fortuitous, but their selection is based on optimization and modeling. The plan also gives explicit indications of the roles of the different institutions involved and the timely implementation of various measures.

Awareness on the necessity to move to a more proactive approach in drought management is growing, but the capacity to do so remains low. Most countries are in the need for technical assistance to establish programmes aimed at developing and implementing strategic water resources management plans that would make them less vulnerable to future droughts.

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