

University of Nebraska - Lincoln

**DigitalCommons@University of Nebraska - Lincoln**

---

Drought Mitigation Center Faculty Publications

Drought -- National Drought Mitigation Center

---

2005

## Drought Preparedness Planning: Building Institutional Capacity

Donald A. Wilhite

Michael Hayes

Cody L. Knutson

Follow this and additional works at: <https://digitalcommons.unl.edu/droughtfacpub>



Part of the [Climate Commons](#), [Environmental Indicators and Impact Assessment Commons](#), [Environmental Monitoring Commons](#), [Hydrology Commons](#), [Other Earth Sciences Commons](#), and the [Water Resource Management Commons](#)

---

This Article is brought to you for free and open access by the Drought -- National Drought Mitigation Center at DigitalCommons@University of Nebraska - Lincoln. It has been accepted for inclusion in Drought Mitigation Center Faculty Publications by an authorized administrator of DigitalCommons@University of Nebraska - Lincoln.

Wilhite D A, Hayes M J, Knutson C L (2005) Drought Preparedness Planning: Building Institutional Capacity. In Wilhite D A (ed.) Drought and Water Crises: Science, Technology, and Management Issues. pp. 93–135. CRC Press. Boca Raton, FL

# 5

---

## Drought Preparedness Planning: Building Institutional Capacity

DONALD A. WILHITE, MICHAEL J. HAYES,  
AND CODY L. KNUTSON

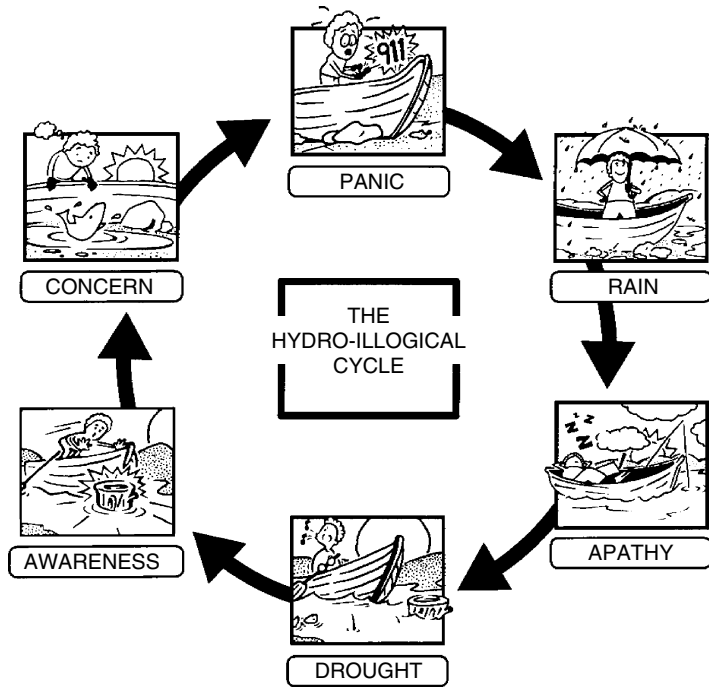
### CONTENTS

I.	Introduction .....	94
II.	Planning for Drought: The Process.....	96
III.	Step 1: Appoint a Drought Task Force .....	98
IV.	Step 2: State the Purpose and Objectives of the Drought Plan .....	99
V.	Step 3: Seek Stakeholder Participation and Resolve Conflict .....	101
VI.	Step 4: Inventory Resources and Identify Groups at Risk.....	102
VII.	Step 5: Establish and Write Drought Plan .....	103
	A. Monitoring, Early Warning, and Prediction Committee.....	104
	B. Risk Assessment Committee .....	108
	1. Task 1: Assemble the Team .....	109

2.	Task 2: Drought Impact Assessment .....	110
3.	Task 3: Ranking Impacts .....	111
4.	Task 4: Vulnerability Assessment .....	116
5.	Task 5: Action Identification.....	118
6.	Task 6: Developing the “To Do” List .....	121
7.	Completion of Risk Analysis.....	122
C.	Mitigation and Response Committee.....	122
D.	Writing the Plan.....	129
VIII.	Step 6: Identify Research Needs and Fill Institutional Gaps .....	129
IX.	Step 7: Integrate Science and Policy .....	130
X.	Step 8: Publicize the Drought Plan—Build Public Awareness and Consensus.....	130
XI.	Step 9: Develop Education Programs .....	131
XII.	Step 10: Evaluate and Revise Drought Plan .....	132
A.	Ongoing Evaluation.....	132
B.	Post-Drought Evaluation .....	132
XIII.	Summary and Conclusion.....	133
	References .....	134

## I. INTRODUCTION

Past attempts to manage drought and its impacts through a reactive, crisis management approach have been ineffective, poorly coordinated, and untimely, as illustrated by the hydro-illogical cycle in Figure 1. The crisis management approach has been followed in both developed and developing countries. Because of the ineffectiveness of this approach, greater interest has evolved in recent years in the adoption of a more proactive risk-based management approach in some countries (see Chapter 6). Other countries are striving to obtain a higher level of preparedness through development of national action programs that are part of the United Nations Convention to Combat Desertification (UNCCD) or as part of separate national initiatives. In part, these actions directly result from the occurrence of recent severe drought episodes that have persisted for several consecutive years or frequent episodes that have occurred in succession with short respites for recovery between events. Global warming, with its threat of an



**Figure 1** Hydro-illogical cycle. (Source: National Drought Mitigation Center, University of Nebraska, Lincoln, Nebraska, USA.)

increased frequency of drought events in the future, has also caused greater anxiety about the absence of preparation for drought, which is a normal part of climate. Other factors that have contributed to this trend toward improved drought preparedness and policy development are spiraling costs or impacts associated with drought, complexity of impacts on sectors well beyond agriculture, increasing social and environmental effects, and rising water conflicts between users.

Progress on drought preparedness and policy development has been slow for a number of reasons. It certainly relates to the slow-onset characteristics of drought and the lack of a universal definition. These characteristics (defined in more detail in Chapter 1) make early warning, impact assessment, and response difficult for scientists, natural resource managers, and policy makers. The lack of a universal

definition often leads to confusion and inaction on the part of decision makers because scientists may disagree on the existence of drought conditions and severity. Severity is also difficult to characterize because it is best evaluated on the basis of multiple indicators and indices rather than a single variable. The impacts of drought are also largely nonstructural and spatially extensive, making it difficult to assess the effects of drought and respond in a timely and effective manner. Drought and its impacts are not as visual as other natural hazards, making it difficult for the media to communicate the significance of the event and its impacts to the public. Public sentiment to respond is often lacking in comparison to other natural hazards that result in loss of life and property.

Another constraint to drought preparedness has been the dearth of methodologies available to planners to guide them through the planning process. Drought differs in its characteristics between climate regimes, and impacts are locally defined by unique economic, social, and environmental characteristics. A methodology developed by Wilhite (1991) and revised to incorporate greater emphasis on risk management (Wilhite et al., 2000) has provided a set of guidelines or a checklist of the key elements of a drought plan and a process through which they can be adapted to any level of government (i.e., local, state or provincial, or national) or geographical setting as part of a natural disaster or sustainable development plan, an integrated water resources plan, or a stand-alone drought mitigation plan. We describe this process here, with the goal of providing a template that government or organizations can follow to reduce societal vulnerability to drought.

## II. PLANNING FOR DROUGHT: THE PROCESS

Drought is a natural hazard that differs from other hazards in that it has a slow onset, evolves over months or even years, affects a large spatial region, and causes little structural damage. Its onset and end are often difficult to determine, as is its severity. Like other hazards, the impacts of drought span economic, environmental, and social sectors and can be reduced through mitigation and preparedness. Because

droughts are a normal part of climate variability for virtually all regions, it is important to develop drought preparedness plans to deal with these extended periods of water shortage in a timely, systematic manner as they evolve. To be effective, these plans must evaluate a region's exposure and vulnerability to the hazard and incorporate these elements in a way that evolves with societal changes.

The 10-step drought planning process developed by Wilhite (1991) was based largely on interactions with many states in the United States, incorporating their experiences and lessons learned. This planning process has gone through several iterations in recent years in order to tailor it to specific countries or subsets of countries (Wilhite et al., 2000). It has also been the basis for discussions at a series of regional training workshops and seminars on drought management and preparedness held throughout the world over the past decade. With the increased interest in drought mitigation planning in recent years, this planning process has evolved to incorporate more emphasis on risk assessment and mitigation tools.

The 10-step drought planning process is illustrated in Figure 2. In brief, Steps 1–4 focus on making sure the right people are brought together, have a clear understanding of the process, know what the drought plan must accomplish, and are supplied with adequate data to make fair and equitable decisions when formulating and writing the actual drought plan. Step 5 describes the process of developing an organizational structure for completion of the tasks necessary to prepare the plan. The plan should be viewed as a process, rather than a discrete event that produces a static document. A risk assessment is undertaken in conjunction with this step in order to construct a vulnerability profile for key economic sectors, population groups, regions, and communities. Steps 6 and 7 detail the need for ongoing research and coordination between scientists and policy makers. Steps 8 and 9 stress the importance of promoting and testing the plan before drought occurs. Finally, Step 10 emphasizes revising the plan to keep it current and evaluating its effectiveness in the post-drought period. Although the steps are sequential, many of these tasks are addressed simultaneously under the leadership of a drought task force and its complement of committees

Step 1	Appoint a drought task force
Step 2	State the purpose and objectives of the drought preparedness plan
Step 3	Seek stakeholder participation and resolve conflict
Step 4	Inventory resources and identify groups at risk
Step 5	Prepare/write the drought preparedness plan
Step 6	Identify research needs and fill institutional gaps
Step 7	Integrate science and policy
Step 8	Publicize the drought preparedness plan and build public awareness
Step 9	Develop education programs
Step 10	Evaluate and revise drought preparedness plan

**Figure 2** Ten-step planning process. (*Source:* National Drought Mitigation Center, University of Nebraska, Lincoln, Nebraska, USA.)

and working groups. These steps, and the tasks included in each, provide a “checklist” that should be considered and may be completed as part of the planning process.

### III. STEP 1: APPOINT A DROUGHT TASK FORCE

A key political leader initiates the drought planning process through appointment of a drought task force. Depending on the level of government developing the plan, this could be the president or prime minister, a provincial or state governor, or a mayor. The task force has two purposes. First, it supervises and coordinates development of the plan. Second, after the plan is developed and during times of drought when the plan is activated, the task force coordinates actions, implements

mitigation and response programs, and makes policy recommendations to the appropriate political leader.

The task force should reflect the multidisciplinary nature of drought and its impacts, and it should include appropriate representatives of government agencies (provincial, federal) and universities where appropriate expertise is available. If applicable, the governor's office should have a representative on the task force. Environmental and public interest groups and others from the private sector can be included (see Step 3), as appropriate. These groups would be involved to a considerable extent in the activities of the working groups associated with the Risk Assessment Committee discussed in Step 5. The actual makeup of this task force would vary considerably, depending on the principal economic and other sectors affected, the political infrastructure, and other factors. The task force should include a public information official that is familiar with local media's needs and preferences and a public participation practitioner who can help establish a process that includes and accommodates both well-funded and disadvantaged stakeholder or interest groups.

#### **IV. STEP 2: STATE THE PURPOSE AND OBJECTIVES OF THE DROUGHT PLAN**

As its first official action, the drought task force should state the general purpose for the drought plan. Government officials should consider many questions as they define the purpose of the plan, such as the

- Purpose and role of government in drought mitigation and response efforts
- Scope of the plan
- Most drought-prone areas of the state or nation
- Historical impacts of drought
- Historical response to drought
- Most vulnerable economic and social sectors
- Role of the plan in resolving conflict between water users and other vulnerable groups during periods of shortage



- Current trends (e.g., land and water use, population growth) that may increase or decrease vulnerability and conflicts in the future
- Resources (human and economic) the government is willing to commit to the planning process
- Legal and social implications of the plan
- Principal environmental concerns caused by drought

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

The task force should then identify the specific objectives that support the purpose of the plan. Drought plan objectives will vary within and between countries and should reflect the unique physical, environmental, socioeconomic, and political characteristics of the region in question. For a provincial, state, or regional plan, objectives that should be considered include the following:

- Collect and analyze drought-related information in a timely and systematic manner.
- Establish criteria for declaring drought emergencies and triggering various mitigation and response activities.
- Provide an organizational structure and delivery system that ensures information flow between and within levels of government.
- Define the duties and responsibilities of all agencies with respect to drought.
- Maintain a current inventory of government programs used in assessing and responding to drought emergencies.

- Identify drought-prone areas of the state or region and vulnerable economic sectors, individuals, or environments.
- Identify mitigation actions that can be taken to address vulnerabilities and reduce drought impacts.
- Provide a mechanism to ensure timely and accurate assessment of drought's impacts on agriculture, industry, municipalities, wildlife, tourism and recreation, health, and other areas.
- Keep the public informed of current conditions and response actions by providing accurate, timely information to media in print and electronic form (e.g., via TV, radio, and the World Wide Web).
- Establish and pursue a strategy to remove obstacles to the equitable allocation of water during shortages and establish requirements or provide incentives to encourage water conservation.
- Establish a set of procedures to continually evaluate and exercise the plan and periodically revise the plan so it will stay responsive to the needs of the area.

## **V. STEP 3: SEEK STAKEHOLDER PARTICIPATION AND RESOLVE CONFLICT**

Social, economic, and environmental values often clash as competition for scarce water resources intensifies. Therefore, it is essential for task force members to identify all citizen groups (stakeholders) that have a stake in drought planning and understand their interests. These groups must be involved early and continuously for fair representation and effective drought management and planning. Discussing concerns early in the process gives participants a chance to develop an understanding of one another's various viewpoints and generate collaborative solutions. Although the level of involvement of these groups will vary notably from location to location, the power of public interest groups in policy making is considerable. In fact, these groups are likely to impede progress in the development of plans if they are not included in the process. The task force should also protect the interests of stakeholders who

may lack the financial resources to serve as their own advocates. One way to facilitate public participation is to establish a citizen's advisory council as a permanent feature of the drought plan, to help the task force keep information flowing and resolve conflicts between stakeholders.

State or provincial governments need to consider if district or regional advisory councils should be established. These councils could bring neighbors together to discuss their water use issues and problems and seek collaborative solutions. At the provincial level, a representative of each district council should be included in the membership of the provincial citizens' advisory council to represent the interests and values of their constituencies. The provincial citizens' advisory council can then make recommendations and express concerns to the task force as well as respond to requests for situation reports and updates.

## VI. STEP 4: INVENTORY RESOURCES AND IDENTIFY GROUPS AT RISK

An inventory of natural, biological, and human resources, including the identification of constraints that may impede the planning process, may need to be initiated by the task force. In many cases, various provincial and federal agencies already possess considerable information about natural and biological resources. It is important to determine the vulnerability of these resources to periods of water shortage that result from drought. The most obvious *natural resource* of importance is water: its location, accessibility, and quality. *Biological resources* refer to the quantity and quality of grasslands or rangelands, forests, wildlife, and so forth. *Human resources* include the labor needed to develop water resources, lay pipeline, haul water and livestock feed, process citizen complaints, provide technical assistance, and direct citizens to available services.

It is also imperative to identify constraints to the planning process and to the activation of the various elements of the plan as drought conditions develop. These constraints may be physical, financial, legal, or political. The costs associated

with plan development must be weighed against the losses that will likely result if no plan is in place. The purpose of a drought plan is to reduce risk and, therefore, economic, social, and environmental impacts. Legal constraints can include water rights, existing public trust laws, requirements for public water suppliers, liability issues, and so forth.

In drought planning, making the transition from crisis to risk management is difficult because, historically, little has been done to understand and address the risks associated with drought. To solve this problem, areas of high risk should be identified, as should actions that can be taken to reduce those risks before a drought occurs. Risk is defined by both the exposure of a location to the drought hazard and the vulnerability of that location to periods of drought-induced water shortages (Blaikie et al., 1994). Drought is a natural event; it is important to define the exposure (i.e., frequency of drought of various intensities and durations) of various parts of the state or region to the drought hazard. Some areas are likely to be more at risk than others. Vulnerability, on the other hand, is affected by social factors such as population growth and migration trends, urbanization, changes in land use, government policies, water use trends, diversity of economic base, cultural composition, and so forth. The drought task force should address these issues early in the planning process so they can provide more direction to the committees and working groups that will be developed under Step 5 of the planning process.

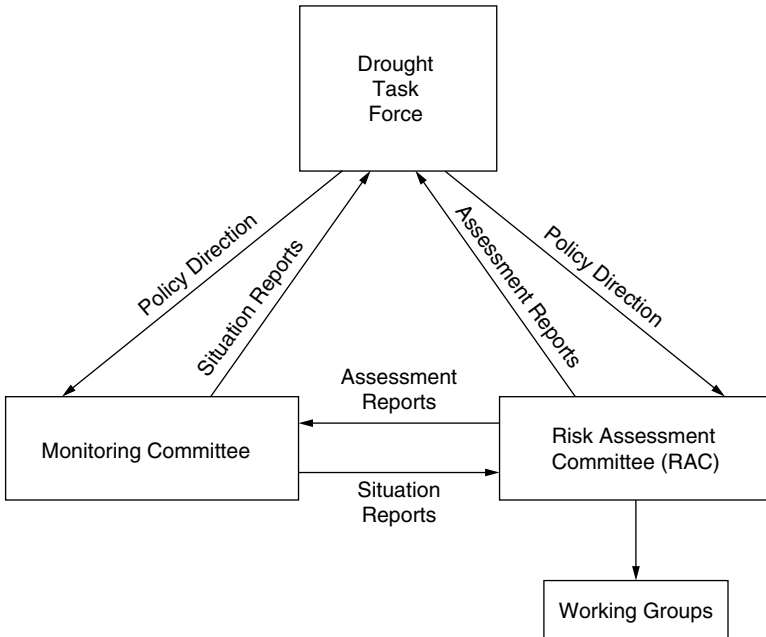
## **VII. STEP 5: ESTABLISH AND WRITE DROUGHT PLAN**

This step describes the process of establishing relevant committees to develop and write the drought plan. The drought plan should have three primary components: (1) monitoring, early warning, and prediction; (2) risk and impact assessment; and (3) mitigation and response. We recommended that a committee be established to focus on the first two of these needs; the drought task force can in most instances carry out the mitigation and response function.

The suggested organizational structure for the plan is illustrated in Figure 3. The committees will have their own tasks and goals, but well-established communication and information flow between committees and the task force is necessary to ensure effective planning.

**A. Monitoring, Early Warning, and Prediction Committee**

A reliable assessment of water availability and its outlook for the near and long term is valuable information in both dry and wet periods. During drought, the value of this information increases markedly. The monitoring committee should include representatives from agencies with responsibilities for monitoring climate and water supply. Data and information on each of the applicable indicators (e.g., precipitation, temperature, evapotranspiration, seasonal climate forecasts, soil



**Figure 3** Drought task force organizational structure. (Source: National Drought Mitigation Center, University of Nebraska, Lincoln, Nebraska, USA.)

moisture, streamflow, groundwater levels, reservoir and lake levels, and snowpack) ought to be considered in the committee's evaluation of the water situation and outlook. The agencies responsible for collecting, analyzing, and disseminating data and information will vary considerably from country to country and province to province.

The monitoring committee should meet regularly, especially in advance of the peak demand season. Following each meeting, reports should be prepared and disseminated to the drought task force, relevant government agencies, and the media. The chairperson of the monitoring committee should be a permanent member of the drought task force. If conditions warrant, the task force should brief the governor or appropriate government official about the contents of the report, including any recommendations for specific actions. The public must receive a balanced interpretation of changing conditions. The monitoring committee should work closely with public information specialists to keep the public well-informed.

The primary objectives of the monitoring committee are to

1. Adopt a workable definition of drought that could be used to phase in and phase out levels of local state or provincial, and federal actions in response to drought. The group may need to adopt more than one definition of drought in identifying impacts in various economic, social, and environmental sectors because no single definition of drought applies in all cases. Several indices are available (Hayes, 1998), including the Standardized Precipitation Index (McKee et al., 1993, 1995), which is gaining widespread acceptance (Guttman, 1998; Hayes et al., 1999; also see <http://drought.unl.edu/whatis/Indices.pdf>).

The trend is to rely on multiple drought indices to trigger mitigation and response actions, which are calibrated to various intensities of drought. The current thought is that no single index of drought is adequate to measure the complex interrelationships between the various components of the hydrological cycle and impacts.

It is helpful to establish a sequence of descriptive terms for water supply alert levels, such as “advisory,” “alert,” “emergency,” and “rationing” (as opposed to more generic terms such as “phase 1” and “phase 2,” or sensational terms such as “disaster”). Review the terminology used by other entities (i.e., local utilities, provinces, river basin authorities) and choose terms that are consistent so as not to confuse the public with different terms in areas where there may be authorities with overlapping regional responsibilities. These alert levels should be defined in discussions with both the risk assessment committee and the task force.

In considering emergency measures such as rationing, remember that the impacts of drought may vary significantly from one area to the next, depending on the sources and uses of water and the degree of planning previously implemented. For example, some cities may have recently expanded their water supply capacity while other adjacent communities may have an inadequate water supply capacity during periods of drought. Imposing general emergency measures on people or communities without regard for their existing vulnerability may result in political repercussions and loss of credibility.

A related consideration is that some municipal water systems may be out of date or in poor operating condition, so that even moderate drought strains a community’s ability to supply customers with water. Identifying inadequate (i.e., vulnerable) water supply systems and upgrading those systems should be part of a long-term drought mitigation program.

2. Establish drought management areas; that is, subdivide the province or region into more conveniently sized districts by political boundaries, shared hydrological characteristics, climatological characteristics, or other means such as drought probability or risk. These subdivisions may be useful in drought management because they may allow drought stages and mitigation and response options to be regionalized.

3. Develop a drought monitoring system. The quality of meteorological and hydrological networks is highly variable from country to country and region to region within countries. Responsibility for collecting, analyzing, and disseminating data is divided between many government authorities. The monitoring committee's challenge is to coordinate and integrate the analysis so decision makers and the public receive early warning of emerging drought conditions. Considerable experience has developed in recent years with automated weather data networks that provide rapid access to climate data. These networks can be invaluable in monitoring emerging and ongoing drought conditions. Investigate the experiences of regions with comprehensive automated meteorological and hydrological networks and apply their lessons learned, where appropriate.
4. Inventory data quantity and quality from current observation networks. Many networks monitor key elements of the hydrologic system. Most of these networks are operated by federal or provincial agencies, but other networks also exist and may provide critical information for a portion of a province or region. Meteorological data are important but represent only one part of a comprehensive monitoring system. These other physical indicators (soil moisture, streamflow, reservoir and groundwater levels) must be monitored to reflect impacts of drought on agriculture, households, industry, energy production, transportation, recreation and tourism, and other water users.
5. Determine the data needs of primary users. Developing new or modifying existing data collection systems is most effective when the people who will be using the data are consulted early and often. Soliciting input on expected new products or obtaining feedback on existing products is critical to ensuring that products meet the needs of primary users and, therefore, will be used in decision making. Training on how



to use or apply products in routine decision making is also essential.

6. Develop or modify current data and information delivery systems. People need to be warned of drought as soon as it is detected, but often they are not. Information needs to reach people in time for them to use it in making decisions. In establishing information channels, the monitoring committee needs to consider when people need what kinds of information. These decision points can determine whether the information provided is used or ignored.

## **B. Risk Assessment Committee**

Risk is the product of exposure to the drought hazard (i.e., probability of occurrence) and societal vulnerability, represented by a combination of economic, environmental, and social factors. Therefore, to reduce vulnerability to drought, one must identify the most significant impacts and assess their underlying causes. Drought impacts cut across many sectors and across normal divisions of government authority. These impacts have been classified by Wilhite and Vanyarkho (2000) and are available on the website of the National Drought Mitigation Center (NDMC) (<http://drought.unl.edu>).

The membership of the risk assessment committee should represent economic sectors, social groups, and ecosystems most at risk from drought. The committee's chairperson should be a member of the drought task force. Experience has demonstrated that the most effective approach to follow in determining vulnerability to and impacts of drought is to create a series of working groups under the aegis of the risk assessment committee. The responsibility of the committee and working groups is to assess sectors, population groups, communities, and ecosystems most at risk and identify appropriate and reasonable mitigation measures to address these risks. Working groups would be composed of technical specialists representing those areas referred to above. The chair of each working group, as a member of the risk assessment committee, would report directly to the committee. Following

this model, the responsibility of the risk assessment committee is to direct the activities of each of the working groups and make recommendations to the drought task force on mitigation actions.

The number of working groups will vary considerably between countries or provinces, reflecting the principal impact sectors. The more complex the economy and society, the larger the number of working groups is necessary to reflect these sectors. Working groups may focus on some combination of the following sectors: agriculture, recreation and tourism, industry, commerce, drinking water supplies, energy, environment, wildfire protection, and health.

In drought management, making the transition from crisis to risk management is difficult because little has been done to understand and address the risks associated with drought. A methodology has been developed by the NDMC to help guide drought planners through the risk assessment process. This methodology focuses on identifying and ranking the priority of relevant drought impacts; examining the underlying environmental, economic, and social causes of these impacts; and then choosing actions that will address these underlying causes. What makes this methodology different and more helpful than previous methodologies is that it addresses the causes behind drought impacts. Previously, responses to drought have been reactions to impacts. Understanding why specific impacts occur provides the opportunity to lessen impacts in the future by addressing these vulnerabilities through the identification and adoption of specific mitigation actions. This methodology is described below, divided into six specific tasks. Once the risk assessment committee identifies the working groups, each of these groups would follow this methodology.

### 1. Task 1: Assemble the Team

It is essential to bring together the right people and supply them with adequate data to make fair, efficient, and informed decisions pertaining to drought risk. Members of this group should be technically trained in the specific topical areas

covered by the working groups. When dealing with the issues of appropriateness, urgency, equity, and cultural awareness in drought risk analysis, include public input and consideration. Public participation could be warranted at every step, but time and money may limit involvement to key stages in the risk analysis and planning process (public review vs. public participation). The amount of public involvement is at the discretion of the drought task force and other members of the planning team. The advantage of publicly discussing questions and options is that the procedures used in making any decision will be better understood, and it will also demonstrate a commitment to participatory management. At a minimum, decisions and reasoning should be openly documented to build public trust and understanding.

The choice of specific actions to deal with the underlying causes of the drought impacts will depend on the economic resources available and related social values. Typical concerns are associated with cost and technical feasibility, effectiveness, equity, and cultural perspectives. This process has the potential to lead to the identification of effective and appropriate drought risk reduction activities that will reduce long-term drought impacts, rather than ad hoc responses or untested mitigation actions that may not effectively reduce the impact of future droughts.

## 2. Task 2: Drought Impact Assessment

Impact assessment examines the consequences of a given event or change. For example, drought is typically associated with a number of outcomes. Drought impact assessments begin by identifying direct consequences of the drought, such as reduced crop yields, livestock losses, and reservoir depletion. These direct outcomes can then be traced to secondary consequences (often social effects), such as the forced sale of household assets or land, dislocation, or physical and emotional stress. This initial assessment identifies drought impacts but does not identify the underlying reasons for these impacts.

Drought impacts can be classified as economic, environmental, or social, although many impacts may span more than one sector. Table 1 provides a detailed checklist of impacts that could affect a region or location. Recent drought impacts, especially if they are associated with severe to extreme drought, should be weighted more heavily than the impacts of historical drought, in most cases. Recent events more accurately reflect current vulnerabilities, the purpose of this exercise. Attention should also be given to specific impacts that are expected to emerge in the future.

To perform an assessment using the checklist in Table 1, check the box in front of each category that has been affected by drought in your study area. Classify the types of impacts according to the severity of drought, noting that in the future, droughts of lesser magnitude may produce more serious impacts if vulnerability is increasing. Hopefully, interventions taken now will reduce these vulnerabilities in the future. Define the “drought of record” for each region. Droughts differ from one another according to intensity, duration, and spatial extent. Thus, there may be several droughts of record, depending on the criteria emphasized (i.e., most severe drought of a season or year vs. most severe multi-year drought). These analyses would yield a range of impacts related to the severity of drought. In addition, highlighting past, current, and potential impacts may reveal trends that will also be useful for planning purposes. These impacts highlight sectors, populations, or activities that are vulnerable to drought and, when evaluated with the probability of drought occurrence, identify varying levels of drought risk.

### 3. Task 3: Ranking Impacts

After each working group has completed the checklist in Table 1, the unchecked impacts should be omitted. This new list will contain the relevant drought impacts for your location or activity. From this list, prioritize impacts according to what work group members consider to be the most important. To be effective and equitable, the ranking should consider concerns such as cost, areal extent, trends over time, public

**TABLE 1** Checklist of Historical, Current, and Potential Drought Impacts

To perform an assessment using this checklist, check the box in front of each category that has been affected by drought in your study area. Your selections can be based on common or extreme droughts, or a combination of the two. For example, if your drought planning was going to be based on the “drought of record,” you would need to complete a historical review to identify the drought of record for your area and assess the impacts of that drought. You would then record the impacts on this checklist by marking the appropriate boxes under the “historical” column. Next, with the knowledge you have about your local area, if another drought of record were to occur tomorrow, consider what the local impacts may be and record them on the checklist under the “current” column. Finally, consider possible impacts of the same drought for your area in 5 or 10 years and record these in the “potential” column.

If enough time, money, and personnel are available, it may be beneficial to conduct impact studies based on common droughts, extreme droughts, and the drought of record for your region. These analyses would yield a range of impacts related to the severity of the drought, which is necessary for conducting Step 3 of the guide and could be useful for planning purposes.

H = historical drought  
C = current drought  
P = potential drought

<b>H</b>	<b>C</b>	<b>P</b>	<b>Economic Impacts</b>
			Loss from crop production
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Annual and perennial crop losses
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Damage to crop quality
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Reduced productivity of cropland (wind erosion, etc.)
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Insect infestation
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Plant disease
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Wildlife damage to crops
			Loss from dairy and livestock production
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Reduced productivity of rangeland
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Forced reduction of foundation stock
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Closure/limitation of public lands to grazing
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	High cost/unavailability of water for livestock
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	High cost/unavailability of feed for livestock
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	High livestock mortality rates
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Disruption of reproduction cycles (breeding delays or unfilled pregnancies)

**TABLE 1** Checklist of Historical, Current, and Potential Drought Impacts (continued)

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Decreased stock weights
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Increased predation
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Range fires
			Loss from timber production
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Wildland fires
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Tree disease
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Impaired productivity of forest land
			Loss from fishery production
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Damage to fish habitat
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Loss of young fish due to decreased flows
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Income loss for farmers and others directly affected
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Loss of farmers through bankruptcy
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Unemployment from drought-related production declines
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Loss to recreational and tourism industry
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Loss to manufacturers and sellers of recreational equipment
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Increased energy demand and reduced supply because of drought-related power curtailments
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Costs to energy industry and consumers associated with substituting more expensive fuels (oil) for hydroelectric power
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Loss to industries directly dependent on agricultural production (e.g., machinery and fertilizer manufacturers, food processors, etc.)
			Decline in food production/disrupted food supply
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Increase in food prices
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Increased importation of food (higher costs)
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Disruption of water supplies
			Revenue to water supply firms
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Revenue shortfalls
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Windfall profits
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Strain on financial institutions (foreclosures, greater credit risks, capital shortfalls, etc.)
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Revenue losses to federal, state, and local governments (from reduced tax base)
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Loss from impaired navigability of streams, rivers, and canals
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Cost of water transport or transfer

**TABLE 1** Checklist of Historical, Current, and Potential Drought Impacts (continued)

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Cost of new or supplemental water resource development
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Cost of increased groundwater depletion (mining), land subsidence
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Reduction of economic development
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Decreased land prices
			Damage to animal species
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Reduction and degradation of fish and wildlife habitat
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Lack of feed and drinking water
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Disease
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Increased vulnerability to predation (from species concentration near water)
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Migration and concentration (loss of wildlife in some areas and too many in others)
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Increased stress to endangered species

<b>H</b>	<b>C</b>	<b>P</b>	<b>Environmental Impacts</b>
----------	----------	----------	------------------------------

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Damage to plant species
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Increased number and severity of fires
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Loss of wetlands
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Estuarine impacts (e.g., changes in salinity levels)
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Increased groundwater depletion, land subsidence
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Loss of biodiversity
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Wind and water erosion of soils
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Reservoir and lake levels
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Reduced flow from springs
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Water quality effects (e.g., salt concentration, increased water temperature, pH, dissolved oxygen, turbidity)
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Air quality effects (e.g., dust, pollutants)
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Visual and landscape quality (e.g., dust, vegetative cover, etc.)

<b>H</b>	<b>C</b>	<b>P</b>	<b>Social Impacts</b>
----------	----------	----------	-----------------------

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Mental and physical stress (e.g., anxiety, depression, loss of security, domestic violence)
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Health-related low-flow problems (e.g., cross-connection contamination, diminished sewage flows, increased pollutant concentrations, reduced firefighting capability, etc.)

**TABLE 1** Checklist of Historical, Current, and Potential Drought Impacts (continued)

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Reductions in nutrition (e.g., high-cost-food limitations, stress-related dietary deficiencies)
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Loss of human life (e.g., from heat stress, suicides)
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Public safety from forest and range fires
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Increased respiratory ailments
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Increased disease caused by wildlife concentrations
			Increased conflicts
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Water user conflicts
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Political conflicts
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Management conflicts
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Other social conflicts (e.g., scientific, media based)
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Disruption of cultural belief systems (e.g., religious and scientific views of natural hazards)
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Reevaluation of social values (e.g., priorities, needs, rights)
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Reduction or modification of recreational activities
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Public dissatisfaction with government regarding drought response
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Inequity in the distribution of drought relief
			Inequity in drought impacts based on:
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Socioeconomic group
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Ethnicity
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Age
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Gender
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Seniority
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Loss of cultural sites
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Loss of aesthetic values
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Recognition of institutional restraints on water use
			Reduced quality of life, changes in lifestyle
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	In rural areas
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	In specific urban areas
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Increased poverty in general
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Increased data/information needs, coordination of dissemination activities
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Population migrations (e.g., rural to urban areas, migrants into the United States)



opinion, fairness, and the ability of the affected area to recover. Be aware that social and environmental impacts are often difficult, if not impossible, to quantify. Each work group should complete a preliminary ranking of impacts. The drought task force and other work groups can participate in a plenary discussion of these rankings following the initial ranking iterations. We recommend constructing a matrix (see an example in Table 2) to help prioritize impacts. From this list of prioritized impacts, each working group should decide which impacts should be addressed and which can be deferred.

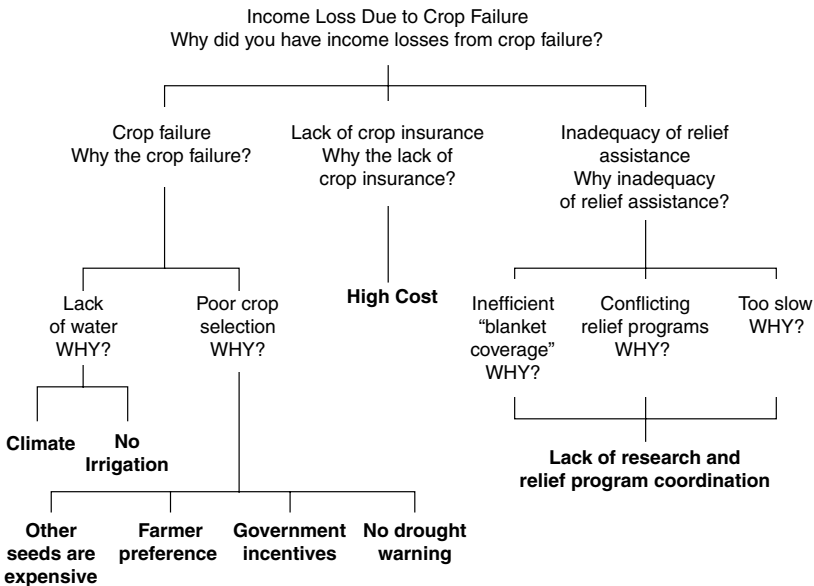
#### 4. Task 4: Vulnerability Assessment

Vulnerability assessment provides a framework for identifying the social, economic, and environmental causes of drought impacts. It bridges the gap between impact assessment and policy formulation by directing policy attention to underlying causes of vulnerability rather than the result, the negative impacts, which follow triggering events such as drought (Ribot et al., 1996). For example, the direct impact of precipitation deficiencies may be a reduction of crop yields. The underlying cause of this vulnerability, however, may be that the farmers did not use drought-resistant seeds, because they did not believe in their usefulness, the costs were too high, or there was some commitment to cultural beliefs. Another example could be farm foreclosure. The underlying causes of this vulnerability might include small

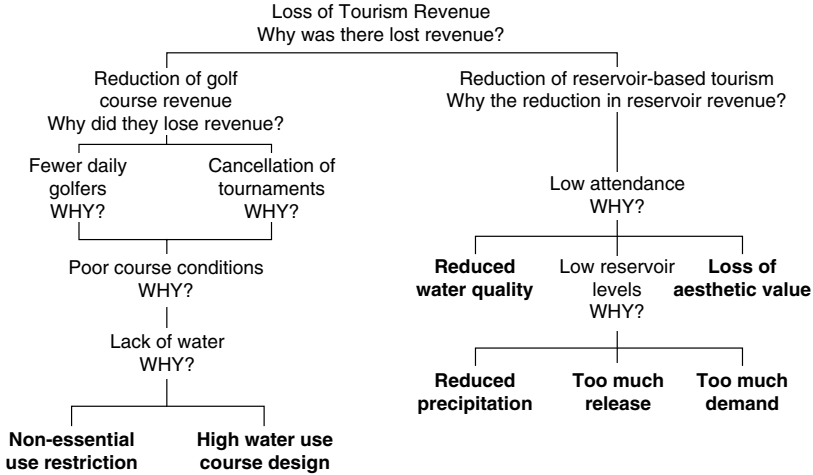
**TABLE 2** Drought Impact Decision Matrix

Impact	Cost	Equally Distributed?	Growing?	Public Priority?	Equitable Recovery?	Impact Rank

farm size because of historical land appropriation policies, lack of credit for diversification options, farming on marginal lands, limited knowledge of possible farming options, a lack of local industry for off-farm supplemental income, or government policies. Therefore, for each of the identified impacts from Table 1, begin asking why these impacts have occurred or might occur. It is important to realize that a combination of factors might produce a given impact. It might be beneficial to display these causal relationships in some form of a tree diagram (see examples in Figures 4 and 5). Figure 4 demonstrates a typical agricultural example and Figure 5 a potential urban scenario. Depending on the level of analysis, this process can quickly become somewhat complicated, which is why working groups must be composed of



**Figure 4** An example of a simplified agricultural impact tree diagram. (Notice the boldface items represent the basal causes of the listed impact. Although these items may be broken down further, this example illustrates the vulnerability assessment process.) (Source: National Drought Mitigation Center, University of Nebraska, Lincoln, Nebraska, USA.)



**Figure 5** An example of a simplified urban impact tree diagram. (Notice the boldface items represent the basal causes of the listed impact [in this case, the loss of tourism revenue]. Although these items may be broken down further, this example illustrates the vulnerability assessment process.) (Source: National Drought Mitigation Center, University of Nebraska, Lincoln, Nebraska, USA.)

the appropriate mix of people. Table 3 lists many factors that typically make an area vulnerable to drought; these should be considered when forming tree diagrams.

The tree diagrams illustrate the complexity of understanding drought impacts. The two examples provided are not meant to be comprehensive or represent an actual location. Basically, their main purpose is to demonstrate that impacts must be examined from several perspectives to expose their true underlying causes. For this assessment, the lowest causes on the tree diagrams, the items in boldface, will be referred to as basal causes. These basal causes are the items that have the potential to be acted on to reduce the associated impact. Of course, some of these impact causes should not or cannot be acted on for a wide variety of reasons (discussed in Step 5).

5. Task 5: Action Identification

Mitigation is defined as actions taken in advance of or in the early stages of drought that reduce the impacts of the event.

**TABLE 3** Vulnerability Consideration

	Water Shortage Vulnerability Continuum	
	Higher Vulnerability	Lower Vulnerability
Meteorological drought	Wide precipitation variation Lack of data/single-source data	Stable precipitation pattern Good long-term data/multiple sources of data
Supply-and-demand balance or “institutional drought”	Passive drought “acceptance” Longer duration Higher severity shortage Sudden change in supply Single water source or low supply reliability Low-priority water rights or low contractual rights	Advance warning Shorter duration Lower severity shortage Gradual changes in supply Multiple water sources or high supply reliability Senior water rights or high contractual rights
Water use patterns	Water supply at risk from contamination Imported water supplies Subject to other natural disasters High-growth area/high additional demand High percent water use improvements requires earlier demand management response Landscape/ag irrigation usual practices or landscape/ag dependence on precipitation	Protected water supply Local supplies and locally controlled Low likelihood of other natural disasters Stable or decreasing water demand Low percent water use/efficiency improves “slack” in system = requires more demand management response “Climate-appropriate” plants or nonirrigated agriculture/grazing
Preparedness	Wait until shortage is “declared” (or beyond ...)	Early shortage response

**TABLE 3** Vulnerability Consideration (continued)

Water Shortage Vulnerability Continuum	
Higher Vulnerability	Lower Vulnerability
Lack of political will	Leadership
Ignoring situation/abdication responsibility	Preparedness/actions to protect community/economy/environment
Noninterconnected water supply systems or noncollaborative approach with neighbors	Coordination with others (i.e., neighboring water, disaster response and fire agencies, mutual aid agreements, etc.)
Revenue/rate instability	Rate stabilization fund
"Knee jerk" rationing	Predetermined and equitable allocation methods
Little public awareness	High community involvement (from all social and economic sectors)

Source: D. Braver, personal communication, 1997.

Once the group has set drought impact priorities and exposed the corresponding underlying causes of vulnerability, it can identify actions appropriate for reducing drought risk. The matrix lists the impact as well as the described basal causes of the impact. From this point, the working group should investigate what actions could be taken to address each of these basal causes. The following sequence of questions may be helpful in identifying potential actions:

- Can the basal cause be mitigated (can it be modified before a drought)? If yes, then how?
- Can the basal cause be responded to (can it be modified during or after a drought)? If so, then how?
- Is there some basal cause, or aspect of the basal cause, that cannot be modified and must be accepted as a drought-related risk for this activity or area?

A list of potential actions to mitigate drought is available at <http://drought.unl.edu/plan/handbook/risk.pdf>. As will be discussed in the next section (Task 6), not all ideas are appropriate in all cases. Many of the ideas are more in the realm of short-term emergency response, or crisis management, rather than long-term mitigation, or risk management. Emergency response is an important component of drought planning, but it should be only one part of a more comprehensive mitigation strategy.

## 6. Task 6: Developing the “To Do” List

After the group identifies the impacts, causes, and relevant potential actions, the next step is to determine the sequence of actions to take as part of the risk reduction planning exercise. This selection should be based on such concerns as feasibility, effectiveness, cost, and equity. Additionally, it will be important to review the impact tree diagrams when considering which groups of actions need to be considered together. For example, if you wanted to reduce crop losses by promoting the use of a different type of seed, it probably would not be effective to educate farmers on the benefits of the new variety

if it is too expensive or there are government incentives for planting other crops.

In choosing the appropriate actions, you may want to ask some of the following questions:

- What are the cost/benefit ratios for the actions identified?
- Which actions do the general public consider feasible and appropriate?
- Which actions are sensitive to the local environment (i.e., sustainable practices)?
- Do the actions address the right combination of causes to adequately reduce the relevant impact?
- Do the actions address short- and long-term solutions?
- Which actions would fairly represent the needs of affected individuals and groups?

This process has the potential to lead to the identification of effective and appropriate drought risk reduction activities that may reduce future drought impacts.

## 7. Completion of Risk Analysis

Following Task 6, the risk analysis is finished. Remember, this is a planning process, so it will be necessary to periodically reevaluate drought risk and the various mitigation actions identified. Step 10 in the planning process is associated with evaluating, testing, and revising the drought plan. After a severe drought episode would be an appropriate time to revisit mitigation actions in association with an analysis of lessons learned.

### C. Mitigation and Response Committee

Mitigation and response actions may be the responsibility of the drought task force or be assigned to a separate committee. It is recommended that the task force, working in cooperation with the monitoring and risk assessment committees, has the knowledge and experience to understand drought mitigation techniques, risk analysis (economic, environmental, and social aspects), and drought-related decision-making processes at

all levels of government. The task force, as originally defined, is composed of senior policy makers from various government agencies and, possibly, key stakeholder groups. Therefore, it is in an excellent position to recommend or implement mitigation actions, request assistance through various federal programs, or make policy recommendations to a legislative body or political leader.

Mitigation and response actions should be determined for each of the principal impact sectors identified by the risk assessment committee. Wilhite (1997) assessed drought mitigation technologies implemented by U.S. states in response to drought conditions during the late 1980s and early 1990s. The transferability of these technologies to specific settings or locations needs to be evaluated further. These drought technologies are available on the NDMC's website (<http://drought.unl.edu/mitigate/mitigate.htm>).

The State of Georgia recently developed a drought management plan and identified a broad range of pre-drought mitigation strategies that could be used to lessen the state's vulnerability to future drought events. These strategies are divided by sector into municipal and industrial, agriculture, and water quality. Selected examples of these actions are provided in Table 4. These examples illustrate the types of actions identified by states that have recently completed the drought mitigation planning process.

Tribal governments in the United States, many of which are located in extremely drought-prone areas, are also pursuing development of drought mitigation plans. For example, the Hopi Nation followed the 10-step guidelines and the NDMC's risk assessment methodology (Knutson et al., 1998) in its plan development process. The plan is pending approval through the U.S. Bureau of Reclamation, which provided funding for its development. The vulnerability analysis revealed four sectors of concern: range and livestock, agriculture, village water supplies, and environmental health. A unique feature of the Hopi drought plan is the inclusion of current and proposed monitoring systems to evaluate climatic conditions, soil, vegetation, and water resources for farming, ranching, and domestic purposes. The drought plan describes establishing a



**TABLE 4** Summary of Selected Pre-Drought Strategies Included in the Georgia Drought Management Plan

<b>MUNICIPAL AND INDUSTRIAL</b> <i>State Actions</i>	<b>AGRICULTURE</b> <i>Farmer Irrigation Education</i>	<b>WATER QUALITY, FLORA, AND FAUNA</b> <i>State Actions</i>
Formalize the Drought Response Committee as a means of expediting communications among state, local, and federal agencies and nongovernmental entities.	Recommend that farmers attend classes in best management practices (BMP) and conservation irrigation before (i) receiving a permit, (ii) using a new irrigation system, or (iii) irrigating for a coming announced drought season. Provide continuing education opportunities for farmers.	Encourage all responsible agencies to promote voluntary water conservation through a wide range of activities.
Establish a drought communications systems between the state and local governments and water systems.	Provide continuing education opportunities for farmers.	Monitor streamflow and precipitation at selected locations on critical streams.
Provide guidance to the local governments and water supply providers on long-term water supply, conservation and drought contingency planning.	Encourage the use of BMPs, conservation irrigation, efficient use of irrigation systems, and the Cooperative Extension Service's water conservation guidelines.	Monitor water quality parameters, such as temperature and dissolved oxygen at selected critical streams.
Review the local governments and water supply providers' conservation and drought contingency plans.	Develop electronic database for communicating with water use permit holders.	Provide the streamflow and water-quality data in real time for use by drought managers and work with drought managers to optimize information delivery and use.

- Work with the golf course and turf industry to establish criteria for drought-tolerant golf courses.
- Encourage water re-use.
- Encourage development and distribution of information on water efficient irrigation techniques.
- Evaluate the impact of water withdrawals on flow patterns, and the impact of wastewater discharges on water quality during drought.
- Field/Crop Type Management**
- Investigate indicators and develop tools to analyze drought impacts for waterways such as coastal ecosystems, thermal refuges such as the Flint River, and trout streams.
- Encourage the use of more drought-resistant crops.
- Improve the agencies' capabilities and resources to monitor land-disturbing activities that might result in erosion and sedimentation violations.
- Provide water efficiency education for industry and business.
- Identify funding mechanisms and develop rescue and reintroduction protocols for threatened and endangered species during extreme events.
- Conduct voluntary water audits for businesses that use water for production of a product or service.
- Develop and execute an effort to identify pollutant load reduction opportunities by wastewater discharge permit holders.
- Encourage the use of innovative cultivation techniques to reduce crop water use.
- Conduct crop irrigation efficiency studies.
- Provide farmers with normal year, real time irrigation, irrigation scheduling, and crop evaporation/transpiration information.
- Identify vulnerable water-dependent industries, fund research to help determine impacts and improve predictive capabilities.

**TABLE 4** Summary of Selected Pre-Drought Strategies Included in the Georgia Drought Management Plan (continued)

<b>MUNICIPAL AND INDUSTRIAL</b> <i>State Actions</i>	<b>AGRICULTURE</b> <i>Farmer Irrigation Education</i>	<b>WATER QUALITY, FLORA, AND FAUNA</b> <i>State Actions</i>
Develop and implement a statewide water conservation program to encourage local and regional conservation measures.	Irrigation Equipment Management Encourage the installation of water-efficient irrigation technology.	Evaluate the impact of water withdrawals on flow regimes and the impact of wastewater discharges on water quality during drought.
Develop and implement an incentive program to encourage more efficient use of existing water supplies.	Retrofit older irrigation systems with newer and better irrigation technology. Update any system more than 10 years old.	Develop and promote implementation of sustainable lawn care programs based on selected BMPs and/or integrated pest management practices.
<b>Local/Regional Actions</b> Develop and implement a drought management and conservation plan.	Encourage farmers to take advantage of available financial incentives for retrofitting and updating older or less efficient systems.	Encourage protection and restoration of vegetated stream buffers, including incentives for property owners to maintain buffers wider than the minimum required by state law.
Assess and classify drought vulnerability of individual water systems.	Recommend irrigation system efficiency audits every 5 to 7 years.	Provide for protection of recharge areas through measures including land purchase or acquisition of easements.

Define predetermined drought responses, with outdoor watering restrictions being at least as restrictive as the state's minimum requirements.		
	<b>Government Programs</b>	
	Improve irrigation permit data to create a high degree of confidence in the information on ownership, location, system type, water source, pump capacity, and acres irrigated for all irrigation systems to determine which watersheds and aquifers will be strongly affected by agricultural water use, especially in droughts.	Encourage and explore wildland fire mitigation measures.
Establish a drought communications system from local governments and water supply systems to the public.	Improve on the agriculture irrigation water measurement and accounting statewide.	Enhance programs to assist landowners and farmers with outdoor burning.
	Improve communications and cooperation among farmers and relevant state and federal agencies regarding available assistance during drought conditions.	
	Support legislation and efforts to enhance the ability of farmers to secure adequate water supplies during drought conditions.	

*Source:* Georgia Department of Natural Resources (2003).

network of approximately 60 transects to provide a detailed analysis of range conditions. The transects will be selected to represent major climates, soils, water resources, and land uses present on the Hopi reservation and will help identify trends in vegetation health. These monitoring networks will not only help monitor and quantify the drought impacts, but also be used to assess the effectiveness of any mitigation actions that are implemented.

As was the case with the Georgia plan cited above, the Hopi drought plan developed a list of short- and long-term drought mitigation and response actions for each impact area. For example, to mitigate range and livestock losses, the plan suggests that range management plans be completed for each range unit. To facilitate rotations and proper use of rangelands, the Hopi range management plan also includes fencing and water development projects for the unit range management plans. Water availability in these units will be improved through a combination of rehabilitating surface water impoundments, additional wells at key locations, improved water distribution from the supply point to multiple stock watering troughs, and other conjunctive uses. The Hopi planners hope these mitigation actions will decrease the vulnerability of the range and livestock economic sector.

In addition to identifying mitigation actions that will reduce the tribe's drought risk, the Hopi drought plan is unique in that it identifies the responsible agencies, provides a timeline to complete the actions, and proposes a cost estimate for these actions. For example, a cost of \$12 million is estimated to upgrade the water supply systems of 12 tribal villages by improving pumping capacity, storage tank size, and pipe capacity. The tribe plans to seek funding for these actions through a variety of agencies and sources while enhancing water conservation at the same time.

Before the onset of drought, the task force should inventory all forms of assistance available from governmental and nongovernmental authorities during severe drought. The task force should evaluate these programs for their ability to address short-term emergency situations and long-term miti-

gation programs for their ability to reduce risk to drought. Assistance should be defined in a very broad way to include all forms of technical, mitigation, and relief programs available.

#### **D. Writing the Plan**

With input from each of the committees and working groups, the drought task force, with the assistance of professional writing specialists, will draft the drought plan. After completion of a working draft, we recommend holding public meetings or hearings at several locations to explain the purpose, scope, and operational characteristics of the plan. You must also discuss the specific mitigation actions and response measures recommended in the plan. A public information specialist for the drought task force can facilitate planning for the hearings and prepare news stories to announce the meetings and provide an overview of the plan.

As mentioned previously, the plan should not be considered a static document. The plan is dynamic. A copy of the plan should be available through the drought task force website and in hard copy form for distribution.

### **VIII. STEP 6: IDENTIFY RESEARCH NEEDS AND FILL INSTITUTIONAL GAPS**

As research needs and gaps in institutional responsibility become apparent during drought planning, the drought task force should compile a list of those deficiencies and make recommendations to the appropriate person or government body on how to remedy them. You must perform Step 6 concurrently with Steps 4 and 5. For example, the monitoring committee may recommend establishing an automated weather station network or initiating research on the development of a climate or water supply index to help monitor water supplies and trigger specific actions by state government.

## **IX. STEP 7: INTEGRATE SCIENCE AND POLICY**

An essential aspect of the planning process is integrating the science and policy of drought management. The policy maker's understanding of the scientific issues and technical constraints involved in addressing problems associated with drought is often limited. Likewise, scientists generally have a poor understanding of existing policy constraints for responding to the impacts of drought. In many cases, communication and understanding between the science and policy communities must be enhanced if the planning process is to be successful.

Good communication is required between the two groups in order to distinguish what is feasible from what is not achievable for a broad range of science and policy issues. Integration of science and policy during the planning process will also be useful in setting research priorities and synthesizing current understanding. The drought task force should consider various alternatives to bring these groups together and maintain a strong working relationship.

## **X. STEP 8: PUBLICIZE THE DROUGHT PLAN—BUILD PUBLIC AWARENESS AND CONSENSUS**

If you have communicated well with the public throughout the process of establishing a drought plan, there may already be better-than-normal awareness of drought and drought planning by the time you actually write the plan. Themes to emphasize in writing news stories during and after the drought planning process could include:

- How the drought plan is expected to relieve drought impacts in both the short and long term. Stories can focus on the human dimensions of drought, such as how it affects a farm family; on its environmental consequences, such as reduced wildlife habitat; and on its economic effects, such as the costs to a particular industry or to the state or region's overall economy.

- What changes people might be asked to make in response to different degrees of drought, such as restricted lawn watering and car washing or not irrigating certain crops at certain times.

In subsequent years, you may want to do “drought plan refresher” news releases at the beginning of the most drought-sensitive season, letting people know whether there is pressure on water supplies or reason to believe shortfalls will occur later in the season, and reminding them of the plan’s existence, history, and any associated success stories. It may be useful to refresh people’s memories about circumstances that would lead to water use restrictions.

During drought, the task force should work with public information professionals to keep the public well informed of the status of water supplies, whether conditions are approaching “trigger points” that will lead to requests for voluntary or mandatory use restrictions, and how victims of drought can access assistance. Post all pertinent information on the drought task force’s website so that the public can get information directly from the task force without having to rely on mass media.

## **XI. STEP 9: DEVELOP EDUCATION PROGRAMS**

A broad-based education program to raise awareness of short- and long-term water supply issues will help ensure that people know how to respond to drought when it occurs and that drought planning does not lose ground during non-drought years. Try to tailor information to the needs of specific groups (e.g., elementary and secondary education, small business, industry, homeowners, utilities). The drought task force or participating agencies should consider developing presentations and educational materials for events such as a water awareness week, community observations of Earth Day, relevant trade shows, specialized workshops, and other gatherings that focus on natural resource stewardship or management.



## **XII. STEP 10: EVALUATE AND REVISE DROUGHT PLAN**

The final step in the planning process is to create a detailed set of procedures to ensure adequate plan evaluation. Periodic testing, evaluation, and updating of the drought plan are essential to keep the plan responsive to local, state, provincial, or national needs. To maximize the effectiveness of the system, you must include two modes of evaluation: ongoing and post-drought.

### **A. Ongoing Evaluation**

An ongoing or operational evaluation keeps track of how societal changes such as new technology, new research, new laws, and changes in political leadership may affect drought risk and the operational aspects of the drought plan. Drought risk may be evaluated quite frequently whereas the overall drought plan may be evaluated less often. We recommend an evaluation under simulated drought conditions (i.e., drought exercise) before the drought plan is implemented and periodically thereafter. Remember that drought planning is a process, not a discrete event.

### **B. Post-Drought Evaluation**

A post-drought evaluation or audit documents and analyzes the assessment and response actions of government, nongovernmental organizations, and others and provides a mechanism to implement recommendations for improving the system. Without post-drought evaluations, it is difficult to learn from past successes and mistakes, as institutional memory fades.

Post-drought evaluations should include an analysis of the climatic and environmental aspects of the drought; its economic and social consequences; the extent to which pre-drought planning was useful in mitigating impacts, in facilitating relief or assistance to stricken areas, and in post-recovery; and any other weaknesses or problems caused by or not

covered by the plan. Attention must also be directed to situations in which drought-coping mechanisms worked and where societies exhibited resilience; evaluations should not focus only on those situations in which coping mechanisms failed. Evaluations of previous responses to severe drought are also a good planning aid.

To ensure an unbiased appraisal, governments may wish to place the responsibility for evaluating drought and societal response to it in the hands of nongovernmental organizations such as universities or specialized research institutes.

### **XIII. SUMMARY AND CONCLUSION**

For the most part, previous responses to drought in all parts of the world have been reactive, representing the crisis management approach. This approach has been ineffective (i.e., assistance poorly targeted to specific impacts or population groups), poorly coordinated, and untimely; more important, it has done little to reduce the risks associated with drought. In fact, the economic, social, and environmental impacts of drought have increased significantly in recent decades. A similar trend exists for all natural hazards.

This chapter presents a planning process that has been used at all levels of government to guide the development of a drought mitigation plan. The goal of this planning process is to significantly change the way we prepare for and respond to drought by placing greater emphasis on risk management and the adoption of appropriate mitigation actions. The 10 steps included in this process are generic so that governments can choose the steps and components that are most applicable to their situation. The risk assessment methodology is designed to guide governments through the process of evaluating and prioritizing impacts and identifying mitigation actions and tools that can be used to reduce these impacts for future drought episodes. Drought planning must be viewed as an ongoing process, continuously evaluating our changing vulnerabilities and how governments and stakeholders can work in partnership to lessen risk.

## REFERENCES

- Blaikie, P, T Cannon, I Davis, B Wisner. *At Risk: Natural Hazards, People's Vulnerability, and Disasters*. London: Routledge Publishers, 1994.
- Georgia Department of Natural Resources. Georgia Drought Management Plan. Atlanta, GA, 2003. Available online at [http://www.state.ga.us/dnr/enviro/gaenviron\\_files/drought\\_files/drought\\_mgmtplan\\_2003.pdf](http://www.state.ga.us/dnr/enviro/gaenviron_files/drought_files/drought_mgmtplan_2003.pdf).
- Guttman, NB. Comparing the Palmer Drought Index and the Standardized Precipitation Index. *Journal of the American Water Resources Association* 34(1):113–121, 1998.
- Hayes, M. *Drought Indices*. Lincoln, NE: National Drought Mitigation Center, University of Nebraska–Lincoln, 1998. Available online at <http://drought.unl.edu/whatis/indices.htm>.
- Hayes, M, M Svoboda, D Wilhite, O Vanyarkho. Monitoring the 1996 drought using the SPI. *Bulletin of the American Meteorological Society* 80:429–438, 1999.
- Knutson, C, M Hayes, KT Phillips. How to Reduce Drought Risk. Prepared by the Preparedness and Mitigation Working Group of the Western Drought Coordination Council. Lincoln, NE, 1998. Available online at <http://drought.unl.edu/plan/handbook/risk.pdf>.
- McKee, TB, NJ Doesken, J Kleist. The relationship of drought frequency and duration to time scales. Proceedings of the Eighth Conference on Applied Climatology, Anaheim, CA, January 17–23, American Meteorological Society, Boston, MA, pp. 179–184, 1993.
- McKee, TB, NJ Doesken, J Kleist. Drought monitoring with multiple time scales. Proceedings of the Ninth Conference on Applied Climatology, Dallas, TX, January 15–20, American Meteorological Society, Boston, MA, pp. 233–236, 1995.
- Ribot, JC, A Najam, G Watson. Climate variation, vulnerability and sustainable development in the semi-arid tropics. In: JC Ribot, AR Magalhães, SS Panagides, eds. *Climate Variability, Climate Change and Social Vulnerability in the Semi-Arid Tropics* (pp. 13–51). New York: Cambridge University Press, 1996.

- Wilhite, DA. Drought planning: A process for state government. *Water Resources Bulletin* 27(1):29–38, 1991.
- Wilhite, DA. State actions to mitigate drought: Lessons learned. *Journal of the American Water Resources Association* 33(5):961–968, 1997.
- Wilhite, DA, O Vanyarkho. Drought: Pervasive impacts of a creeping phenomenon. In: DA Wilhite, ed. *Drought: A Global Assessment* (Volume I, pp. 245–255). London: Routledge Publishers, 2000.
- Wilhite, DA, MJ Hayes, C Knutson, KH Smith. Planning for drought: Moving from crisis to risk management. *Journal of the American Water Resources Association* 36:697–710, 2000.

