



**Thematic Week:** Water Economics and Financing

**Thematic Axis:** Water Markets

**Title:** Managing Water Stress, Drought, and Climate Change in the 21<sup>st</sup> Century

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**Abstract:**

Chronic water shortages are a common problem around the world and promise to be growing concern in many regions during the 21st century. Drought magnifies these water problems by placing additional strain on water supply systems, and climate change adds more uncertainty about the future availability and reliability of water resources. Although progress is being made in developing and implementing risk reduction measures for hazards, such as drought, additional work is required to better understand natural hazards and how to deal with them most effectively. Addressing the inter-related issues of water stress, drought, and climate change will also require a combination of local action, national direction, and regional and global coordination. There is also a place for private investment, as well as public oversight and funding. A balance must also be struck between local autonomy and general standards for meeting basic human and environmental rights. Fostering better coordination between planning activities and initiatives at different administrative levels; the identification, evaluation, and implementation of alternative risk management strategies; and providing the funding and political will necessary to carry out these activities is critical for reducing the risks associated with water stress, drought, and climate change.

**Keywords:** water stress, drought, climate change, risk reduction

## Introduction

Chronic water shortages are a common problem around the world and promise to be growing concern in many regions during the 21st century. An estimated 1.1 billion people (16% of the world population) lack access to adequate supplies of quality water, and 2.6 billion people (39% of the world population) lack access to adequate sanitation (WWAP, 2006). These people have been left out of water development processes, placing their lives and livelihoods at risk. Water shortage problems are expected to continue since growing populations, increasing demands, water pollution, and governance problems continue to strain water supply systems in several regions of the world.

Drought magnifies these problems by placing additional strain on water supply systems. In general, drought originates from a deficiency of precipitation from “normal” over an extended period of time, resulting in a water shortage for some activity, group, or environmental sector. Recent drought events around the world in places such as Ethiopia, Australia, Iran, Spain, and the United States demonstrate the problems associated with managing water resources during these extreme events.

Climate change adds even more uncertainty about the availability and reliability of water resources. Many studies show that climates are quickly changing around the world and will continue to do so in the future, often at alarming rates. Changing temperatures are altering the timing, intensity, and form of precipitation events and ultimately, the hydrological cycles that humans and environment rely on to meet their basic needs. The uncertainty associated with these changes adds to current water problems and the difficulty of water resources planning.

Specific water-related problems take different forms in each country and region because of differences in economy, culture, governmental institutions, and environment, however, the need for adequate supplies of quality water is a global concern. Increasing pressures placed on our water resources, recurrent drought, and the uncertainties associated with climate change will ensure that water resources management will be one of the major global issues of the 21<sup>st</sup> Century. Identifying and implementing effective strategies to address these challenges is critically important for the sustainable development of our finite water resources.

## Water Stress and Scarcity

During the last century, freshwater withdrawals around the world increased seven-fold, causing water scarcity and stress in many regions<sup>1</sup>. According to the United Nations Development Programme (2006), approximately 700 million people in 43 countries are living in water stressed environments, particularly in the Middle East and Sub-Saharan Africa. Predictions are that this trend will continue and that as many as 3 billion people could be living in water stressed regions by 2025. Much of this increase is expected to occur in the developing world, in places such as India, China, and North Africa. However, there are also regions of the developed world that are also facing the overexploitation of water resources, which is causing problems with water availability and the maintenance of essential ecosystems (e.g., the southwestern United States, Australia’s Murray-Darling Basin, and local region’s throughout Europe).

Although the physical availability of water is a factor in many locales, current water supply problems are often as much about governance as the physical environment (UNDP, 2006). Management policies have often created biased development frameworks and unsustainable

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<sup>1</sup> Countries are typically classified as experiencing “water stress” when they have less than 1,700 m<sup>3</sup> of available water per inhabitant, “water scarcity” when less than 1,000 m<sup>3</sup> per inhabitant, and “absolute water scarcity” when less than 500 m<sup>3</sup> per inhabitant.

conditions by providing subsidies and incentives for the overexploitation of water resources. However, regardless of the cause, the result is that many people and activities face a shrinking supply of water resources to meet their needs. This has the potential for increasing conflicts between water users and countries that share aquifers, streams, and reservoirs. As demands increase, people are increasingly struggling to secure their water resource allocation.

### **The Occurrence of Drought**

Drought exacerbates water supply problems by making a difficult situation even worse. Drought affects a wide range of social, economic, and environmental sectors, but will more easily turn into a disaster when water supplies are overburdened and families, communities, and governments lack the capacity to effectively plan for and respond to periods of drought. For example, a combination of drought and increasing demands placed on the Colorado River in the western United States has reduced water levels in its in-stream reservoirs (i.e., Lake Mead and Lake Powell) to record lows, and forced the creation of a new interstate water compact between the riparian states that rely on the river. The rapidly growing city of Atlanta, Georgia, USA, also garnered national attention for coming dangerously close to running out of water during especially severe drought in 2007.

Similar issues have arisen around the globe where increasing water demands and/or drought are straining water systems and placing livelihoods at risk. For example, news headlines in early 2008 revealed droughts in several countries around the world, such as Ethiopia, Australia, Iran, and Spain. Seasonal rains either failed completely or were extremely poor in many parts of Ethiopia, hurting crop production, the availability of pastures, and the raising of livestock, which placed an estimated 4.6 million people at risk (UN News Centre, 2008). Australia's worst drought in a century was creating ecological and economic crises in the Murray-Darling river system, which supports most of the nation's farms (McGuirk, 2008). Extreme weather and drought conditions were predicted to cause hydropower shortages and a major decline in Iran's grain supply, causing the country to import several types of grains (United Press International, 2008). Additionally, Spain's worst drought in 70 years reduced reservoir levels, affecting hydropower production and forcing water restrictions (CNN, 2008).

In general, drought is a complex phenomenon that has affected more people during the last century than any other natural disaster (Below, 2007). Although the number of deaths associated with drought has decreased in recent years, drought continues to affect the livelihoods of many people around the world. In fact, during the last 30 years, drought has killed an estimated 560,000 people and affected another 1.6 billion people (CRED, 2008). The recurring effects of drought disasters demonstrate our current inability to effectively deal with climatic variability. Climate change adds even more uncertainty to water management and has the potential to magnify drought and water stress.

### **Climate Change Scenarios**

In 2007, the International Panel on Climate Change released its Fourth Assessment on Climate Change (IPCC, 2007). The inclusion of many new studies in the report resulted in the use of stronger cautionary language and substantiation that humans are affecting our global climate. The report concluded that the release of greenhouse gases (e.g., carbon dioxide, methane, nitrous oxides, etc.) is altering the earth's heat budget and causing climatic changes. These changes include significant alterations of the water cycle and other water-related parameters.

For example, the report states that global temperature has already increased 0.74C from 1906-2005 affecting the regional timing, amount, and distribution of precipitation, as well as mountain glaciers and snow cover that many regions depend on to maintain river flows throughout the year. In general, precipitation has decreased during the last century in the Sahel, the Mediterranean, southern Africa, and parts of southern Asia and, globally, the area affected by drought has likely increased during the last three decades. Mountain glaciers and snow cover have also declined around the world, causing increased run-off and early spring peak discharge in many areas. The increased early season run-off may supplement short-term water supplies downstream, but changes the river dynamics and calls into question the long-term viability of glacier- and snow-fed basins.

In terms of future projections, these trends are expected to continue. Temperatures are expected to increase, causing some areas to become wetter and others drier. In general, annual river runoff is expected to decrease in some dry regions in the mid-latitudes and tropics, and many semi-arid regions will suffer a decrease in water resources (e.g., Mediterranean basin, western United States, southern Africa, and northeast Brazil). Reduced rainfall, increased evaporation rates, saltwater intrusion into water systems along coastal areas, and reduced mountain glaciers and snow cover will all affect the availability of quality water supplies.

The result of these climatic changes could include the increased exposure of hundreds of millions of people to water stress and heat waves, an increase in endemic morbidity and mortality because of water-related diseases, and greater risk of malnutrition and famine. Additional impacts are also expected to include agricultural yield reductions and changes in vegetation and animal species survival and distribution, increased wildfire occurrence, reduced tourism and recreation opportunities, and significant hydropower losses. In general, climate change will likely cause additional uncertainty for people trying to maintain their livelihoods, and for water planners and institutions responsible for providing depending amounts of quality water supplies to meet the needs of citizens, industries, and the environment.

### **The Role of Water Policy and Institutions in Dealing with Drought Risk**

According to Milly et al. (2008), “systems for management of water throughout the developed world have designed and operated under the assumption of stationarity. Stationarity – the idea that natural systems fluctuate within an unchanging envelope of variability – is a foundational concept that permeates training and practice in water-resource engineering.” The authors assert that recent evidence points to the fact that hydrologic systems are exiting the envelope of contemporary natural variability. Therefore, basing decisions on past statistics and management strategies may no longer be appropriate. They assert that the concept of stationarity is dead, and water planners must seek new ways of incorporating uncertainty and risk management into their planning. The selection of the most appropriate mixture of risk management measures for a particular activity are being identified through a variety of water, drought, and climate change planning activities at a wide range of administrative levels.

In term of drought, drought planning has received increased attention in recent years by natural hazard and water planners around the world, although much more work is needed. Drought planning revolves around efforts to better understand the nature of drought and its effects on society and the environment, and using that knowledge to implement appropriate and effective measures to minimize the likelihood of experiencing harm from future drought. Drought planning provides an opportunity for decision makers to identify sectors that are vulnerable to drought and investigate management options before a crisis occurs. With this information, decision makers can identify and implement the most appropriate and cost-effective strategies available in a strategic and systematic manner. This will help foster a more informed decision-making process and the

development of efficient drought management programs, which are often outlined in a drought plan. The development of a drought plan requires at least three components: (1) monitoring and early warning; (2) risk assessment; and (3) risk management options.

### *Drought Monitoring and Early Warning*

During the last decade, drought monitoring has made great strides with monitoring and early warning systems being established in several countries and regions. For example, in Africa, regional centers such as the IGAD Climate Prediction and Applications Centre (ICPAC) and the Drought Monitoring Centre (DMC) in Harare, supported by the World Meteorological Organization and Economic Commissions and the Sahara and Sahelian Observatory, provide current data, develop climate outlooks, and issue warnings to national meteorological and hydrological services (UN/ISDR, 2007).

Similar systems have also been, or are in the process of being, developed in several other regions and countries around the world (e.g., Australia, Canada, Central Asia, China, Mexico, South Africa, southeastern Europe, and the United States). For example, in southeastern Europe, Slovenia has been selected by the eleven-country region to host the Drought Management Centre for Southeastern Europe (DMCSEE) with support from the UNCCD Secretariat in cooperation with the World Meteorological Organization (<http://www.dmcsee.org>). One of the primary goals of the DMCSEE is to establish a regional drought monitoring and early warning system. Drawing on the experience of the DMCSEE, the UNCCD Secretariat and the Organization for Security and Co-operation in Europe (OSCE) are also supporting the creation of a “Drought Management Centre in Central Asia in the context of the UNCCD (DMCCA)” in cooperation with the WMO.

The development of a drought monitoring and early warning system is critical for assessing drought conditions, communicating threats, and triggering actions in a systematic and efficient manner as drought conditions intensify. Although progress is being made, much more work is required to develop effective systems across the globe and to provide information at a scale that is meaningful for drought planning at the local level by water managers and other decision makers. Specifically, additional work is needed to: 1) enhance monitoring networks with additional stations and more accurate record keeping, 2) foster data sharing between organizations, 3) create more reliable and sector-specific forecasts, 4) develop more robust monitoring systems that include a wide variety of physical and social impact indicators, and 5) develop user-friendly early warning delivery systems (WMO, 2006).

### *Drought Risk Assessment*

A drought monitoring system will help to identify the risk of experiencing the physical onset of drought (i.e., frequency, severity, and spatial extent). However, vulnerability must also be assessed to fully understand the likelihood of being affected by drought conditions. Many people perceive drought to be largely a natural or physical event. In reality, drought, like other natural hazards, has both a natural and social component. The risk associated with drought for any region is a product of both the region's exposure to the event and the vulnerability of society. That is, the threat of harm from drought is based on a combination of the frequency, duration, and severity of drought events experienced and the susceptibility of people or activities to the negative effects associated with drought. Some regions, people, and activities are more likely to be at risk for a variety of reasons.

Exposure to drought varies regionally and there is little, if anything, we can do to reduce the recurrence, frequency, or incidence of precipitation shortfalls. However, measures can be taken to reduce our vulnerability to drought events. A risk assessment will help policy and decision makers understand the likelihood of experiencing a water shortage, as well as *who* and *what* are vulnerable to drought and *why*, in order to identify appropriate and effective drought risk management options.

As with drought monitoring, progress has also been made in developing risk assessment methodologies and undertaking risk assessments. For example, the National Drought Mitigation Center, USA, has developed the “How to Reduce Drought Risk” guide, which has been utilized by planners in many communities, provinces, and nations to assess drought risk (<http://www.drought.unl.edu/planhandbook/risk.pdf>). In addition, UN-Habitat has created the Comprehensive Disaster Risk Assessment Portal (<http://www.disasterassessment.org/>). The portal provides a forum for members of the disaster management community to exchange tools and case studies related to disaster risk assessment.

In general, more research has been undertaken to understand the physical risk of experiencing drought (e.g., frequency, severity, intensity, exposure) than the underlying social vulnerabilities. Nonetheless, there are some projects that have examined drought vulnerability for a particular region. For example, the United Nations Economic and Social Commission for Western Asia undertook recent research to better understand the vulnerability of the region to drought (ESCWA 2005). Seeing a need for more research and information on water development and drought, the ESCWA secretariat initiated a series of development reports focused on water resources in the region from 2004 to 2005. The study focused on examining the various components of socio-economic drought and identifying indicators and mapping socio-economic drought vulnerability in the ESCWA region. Similarly, in response to the 2000-2001 drought in Central Asia and the Caucasus, the Canadian International Development Agency (under the Canada Climate Change Development Fund) supported research and analysis by the World Bank to better understand the impacts of drought and needs and capabilities in its management and mitigation (see <http://go.worldbank.org/8J56VSUEZ0>). The effort resulted in two reports that outlined drought occurrence, impacts, vulnerabilities, climate change scenarios, and potential drought management strategies in several countries within the Near East region, including: Azerbaijan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan (World Bank, 2005 and 2006).

Despite these gains, the UN/ISDR (2007) outlines several recommendations to enhance risk assessment methodology and applications. They stress that risk assessment methodologies, standards, and mapping applications should continue to be tested and modified to meet the needs of stakeholders, such as water managers. They should also be required as part of national and local planning efforts to help ensure they're carried out as administrations and initiatives change over time.

#### **Box 1. Typology of Drought Risk Management Measures**

**Drought preparedness** is defined as established policies and specified plans and activities taken before drought to prepare people and enhance institutional and coping capacities, to forecast or warn of approaching dangers, and to ensure coordinated and effective response in a drought situation (contingency planning)

**Drought mitigation** refers to any structural/physical measures (e.g., appropriate crops, sand dams, engineering projects) or non-structural measures (e.g., policies, awareness, knowledge development, public commitment, and operating practices) undertaken to limit the adverse impacts of future drought

**Drought response** efforts include the provision of assistance or intervention during or immediately after a drought disaster to meet the life preservation and basic subsistence needs of those people affected. It can be of an immediate, short-term, or protracted duration

**Drought recovery** measures are decisions and actions taken after a drought with a view to restoring or improving the pre-drought living conditions of the stricken community, while encouraging and facilitating necessary adjustments to reduce drought risk

Source: Modified from UN/ISDR Terminology of Disaster Risk Reduction (<http://www.unisdr.org/>)

Researchers and planning entities should also encourage the development of common methodologies and indicators (e.g., appropriate hazard and vulnerability metrics for water management) for defining and assessing risk to encourage the adoption of standardized international practices. In addition, researchers and practitioners should develop, update periodically, and disseminate risk maps, scenarios, and related information, with a special emphasis on those populations and activities most at risk. Institutions must also cooperate locally and internationally, as appropriate, to monitor and assess regional and transboundary hazards and vulnerabilities and exchange relevant information.

### *Drought Risk Management Options*

Better understanding drought risk allows for more informed decision making and the selection of more appropriate and effective management options. Although they can be described in a variety of ways, these management options typically include a range of drought preparedness, mitigation, response, and recovery strategies (see Box 1 for a list of definitions). In the past, drought management efforts have been biased towards implementing drought response measures. Although often beneficial, they fail to reduce the long-term risk of drought when implemented in isolation from other measures. The new paradigm of drought risk management focuses on increasing the implementation of drought preparedness and mitigation measures, so that the need for response and recovery measures will be minimized.

Table 1 shows a matrix of the types of drought risk reduction measures and the relevant stakeholders that may be responsible for implementing the actions. Planners should consider how to develop a balanced distribution of drought risk reduction measures and responsibilities across the range of themes and actors. This would include determining which actions are to be taken before drought to build long-term resilience to drought, during drought situations to respond to immediate needs (e.g., during advisory, alert, and emergency stages), and during the drought recovery process. The selection

of the appropriate combination of drought risk reduction measures must be evaluated in the context of numerous constraints: time, financial and personnel resources, geography, feasibility, the level and nature of development and vulnerability, legality, public acceptance, and liability. In general, choices must be realistic, as well as socially and environmentally appropriate. The activities must also take place on a scale that is meaningful to those who must act, whether at the national, regional, or local level.

Table 1. Matrix of drought risk reduction measures and responsible stakeholders (modified from Davies, 2000)

Stages	Actors					
	Micro		Meso		Macro	
	Individuals and Households	Community Institutions	District or Provincial Government	NGOs	National Government	International Donors
Preparedness						
Mitigation						
Response						
Recovery						

Table 2 provides a classification of some of the drought risk management options that could be utilized in the water management sector. For example, as previously discussed, drought monitoring, early warning systems, contingency planning, and communication can help an organization, community, or region better prepare for drought. Many of the other available mitigation and response options include augmenting water supplies, reducing water demand, and improving water governance or minimizing the effects of drought on society and the environment. As for augmenting water supplies, many of the most feasible rivers deemed suitable for large water projects have already been dammed, and critics argue that large rivers damage the environment, are expensive, and often fail to benefit local populations (Cooper, 2003). Other augmentation strategies, such as desalinization and moving water over large distances are capital-, labor-, and energy-intensive. Although water resources continue to be tapped and redistributed in many locations and new storage options (e.g., rainwater harvesting and ground water banking) are being implemented, the “slack” in our water systems is tightening. Therefore, efforts are increasingly focusing on addressing water demand and governance through improving water use efficiency and investigating alternative management and governance strategies, such as establishing water markets, banks, and sharing agreements, and developing flexible water management options that can account for future uncertainty.

Although a variety of potential risk management strategies can be identified, most have not been analyzed thoroughly in practice to evaluate their effectiveness in reducing drought risk. Do drought preparedness and mitigation activities reduce the effects of drought? If so, which actions, under what conditions, and to what extent? Are water markets best for a certain location? Are drought response measures a better strategy than drought preparedness and mitigation in some circumstances? There are many such questions that could be asked. Therefore, additional research is needed to identify and evaluate potential risk reduction actions, especially in a real-world setting. To do this, adequate technical and financial resources should be made available to carry out pilot studies and planning processes. In addition, risk reduction case studies need to be identified and shared via collaborative networks of stakeholders within the water, drought, and climate change planning fields. With increased understanding, best management practices can be identified and implemented through appropriate policies, agreements, and institutional governance.

**A Need to Integrate Drought, Water Stress, and Climate Change Risk Reduction Efforts**

A wide variety of people and entities, from individual agricultural producers to regional groups of countries, are increasingly identifying appropriate drought risk reduction measures through the development of drought plans and drought planning networks. The UN/ISDR (2007) discusses many of the drought planning and networking activities occurring around the world, including local level, community, tribal, national, and international drought planning initiatives. At the

international level, these drought-related activities include the development of a proposed global drought preparedness network. This network would consist of an interconnected system of regional drought networks linked together, via the internet, to facilitate the exchange of drought-related information

Table 2. Some Potential Drought Risk Reduction Measures in Water Management (Rossi et al., 2007 modified)

<b>Drought Preparedness</b>	
Monitoring and Early Warning	Develop a drought monitoring and forecast system
	Develop an early warning system to communicate threats and trigger response actions
Planning	Create or update a long-term water management and conservation plan
	Create or update a hazard/drought contingency plan
	Foster effective communication channels between stakeholders
	Conduct post-drought audits to identify lessons learned
Education	Foster youth and adult educational opportunities on water and drought risk management
	Foster a culture of proactive disaster management among decision makers
<b>Drought Mitigation</b>	
Water demand reduction	Public information campaign for long-term water saving
	Permanent water restrictions for some uses (lawn watering, landscaping, etc)
	Economic incentives for water savings
	Reducing agricultural water use (e.g., more efficient technologies, management techniques, and alternative or non-irrigated crops)
	Dual distribution network for urban use
	More water-efficient industrial production systems and water recycling
	Water recycling in industry and businesses
Water supply increase	Control of seepage, evaporation losses, and other unaccounted-for-water
	Inter-basin and within-basin water transfers
	Conveyance networks for bi-directional exchanges
	Reuse of treated water
	Construction of new reservoirs or increase of storage volume of existing reservoirs
	Construction of small catchment ponds
	Desalination of brackish or saline water
	Develop equitable water rights or priorities
	Develop conjunctive use systems
	Foster exchanges among water users (water banking)
	Long-term changes in reservoir release rules under drought conditions
	Institutional and legal changes
	Operational coordination between water systems
<b>Drought Response</b>	
Water demand reduction	Public information campaign for water management and saving
	Water restriction in some urban water uses (i.e., car washing, gardening, ect.)
	Restriction of irrigation of annual crops
	Pricing
	Mandatory rationing
Water supply increase	Improvement of existing water systems efficiency (leak detection programs, operations)
	Use of additional sources of low quality or high exploitation cost water
	Additional use of aquifers or use of ground water reserves
	Increased diversion by relaxing ecological or recreational use constraints
Water governance and public relief (i.e., impact minimization)	Temporary re-allocation of water resources
	Water hauling and distribution
	Public aids to compensate income loss
	Efforts to protect fisheries and riparian areas
	Maintain navigation/recreational infrastructure (e.g., dredging, boat ramp extension)
<b>Drought Recovery</b>	
Water governance, public relief, and assistance	Public information campaign to stress cautionary drought recovery
	Conservative water use to restore hydrological systems
	Re-allocation of water resources as conditions improve
	Recovery assistance for businesses and industries
	Public aids to compensate income loss

	Re-introduction of fisheries and maintenance of riparian areas
	Shift back into preparedness and mitigation planning for the next drought

and experiences around the world. The network would provide a forum for nations and regions to share experiences and lessons learned to foster their capacity to reduce drought risk.

There are also a host of planning and risk reduction efforts around the world that are related to drought, water stress, and climate change. At the local level, for example, most public and private water utilities have a water development plan that outlines a strategy for meeting customer's water needs in the near future. Communities are also increasingly developing hazard mitigation and response plans to increase their long-term resilience and to prepare a strategy for dealing with specific hazards, such as drought. Some cities are also expanding the scope of their planning exercises to include the issue of climate change. For example, eight of the United States' largest water agencies (i.e., Denver Water, Metropolitan Water District of Southern California, New York City Department of Environmental Protection, Portland Water Bureau, San Diego Water Authority, San Francisco Public Utilities Commission, Seattle Public Utilities, and Southern Nevada Water Authority) have formed the Water Utility Climate Alliance. The goal of the Alliance is to work together to improve research on the effect of climate change on water utilities and develop strategies for adapting to climate change and future water shortages (Denver Water, 2008).

State, provinces, and national governments are also following the trend with an increased focus on water, drought, and climate change planning. At times, these efforts are synchronized but, in many cases, they are conducted in parallel or in succession. Some of the planning efforts are initiated by regional or national initiatives and others have been fostered by international programs and activities. For example, the United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1992 and entered into force in 1994. The Convention states that each signatory party take precautionary measures to anticipate, prevent, or minimize the causes of climate change and mitigate its adverse effects (<http://unfccc.int>). Similarly, the United Nations Convention to Combat Desertification (UNCCD) was adopted in 1994 and its implementation began in 1996. The UNCCD and its signatory countries are obligated to carry out activities to combat desertification and mitigate the effects of drought (<http://www.unccd.int/>). These efforts have resulted in the creation of national action plans and programs to address water stress, drought, and climate change, and the establishment of regional networks to share information on strategies and successes.

Furthermore, in 2000, the Millennium Development Goals were established by the United Nations and the international water community to set goals for human development over the next several decades (<http://www.un.org/millenniumgoals>). One of the goals is to halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation. More recently, the landmark Hyogo Framework for Action 2005-2015 was adopted by United Nations Member States in 2005. The Framework outlines priorities to enhance the resilience of nations and communities to natural hazards, including drought and climate change (UN/ISDR, 2007). Such efforts continue to bring attention to the need for additional work in the water arena and provide a unifying theme around which collaborative efforts can be structured.

Although there are numerous organizations, networks, and international agreements and frameworks, the efforts are often fragmented, under-funded, and lack the means and the political will to carry out many of the proposed recommendations. There are also controversies over which entities are appropriate to manage local water resources. Governments traditionally have had responsibility for providing water but that task has increasingly been turned over to private companies (Cooper, 2003). Privatization is often argued as an efficient method for providing water that requires less public investment. However there are competing concerns over private

companies' willingness to serve those in remote areas that are less economical and the poor who are unable to afford the cost of water. In these arguments, strong governmental oversight is necessary to ensure equal access to water, which is viewed as a basic human right.

Additional cross-disciplinary dialogue and collaboration between natural hazard, drought, water, and climate change professionals are necessary to identify appropriate risk reduction measures and coordinate and streamline the development and implementation of risk reduction strategies and initiatives. Dialogue also needs to take place in regards to the appropriate roles to be carried out by relevant stakeholders and at different administrative levels (e.g., individual, private company, non-governmental organization, community, province, national, international). These types of discussions and collaborations have the potential to develop more unified and holistic strategies for addressing the related issues of water stress, drought, and climate change.

### **Conclusions**

During the 20<sup>th</sup> Century, water use increased more than seven-fold, and the world water situation may reach alarming dimensions in future decades if water availability forecast projections are realized. The increasing water stress and recent droughts, along with unfavorable climate change scenarios, have brought greater awareness of the need to more effectively plan for future water shortages around the world. In the end, tackling the inter-related issues of water stress, drought, and climate change will require a combination of local action, national direction, and regional and global coordination. There is also a place for private investment, as well as public oversight and funding. A balance must also be struck between local autonomy and general standards for meeting basic human rights.

International frameworks and programs, such as the UNCCD and UNFCCC initiatives, the Millennium Development Goals, and the Hyogo Framework for Action, provide important coordinating mechanisms and advocate the importance of risk reduction through more proactive planning and water resources management. However, specific mitigation and preparedness actions will be implemented at the national and local level. Fostering better coordination between water, drought, and climate change planning processes and initiatives at different administrative levels; the identification, evaluation, and implementation of alternative risk management strategies; and providing the funding and political will necessary to carry out these activities is critical for reducing the risks and conflicts associated with water stress, drought, and climate change.

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