

STUDY AND ANALYSIS OF DROUGHT ENVIRONMENTAL IMPACTS WITH EMPHASIS ON ROLE OF WATER MANAGEMENT TO MITIGATE CONSEQUENCES OF DROUGHT IN IRAN

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ABSTRACT

Iran has faced adverse natural disaster such as drought and flood because of locating drought latitudes, besides along recent years these impacts have impressed environmental condition.

Available statistics show that rate of precipitation in Iran has declined about 43 percent in comparison with 31 years annual average periods.

Drought negative impacts on environment will emerge increasingly if current situation continues without effective management. Hence it is necessary to plan for achieving optimal use of water resources, using water with high efficiency in agriculture section, water reuse, and changing water use patterns. In this study, at first it has been tried to analyze hydrological and meteorological data and also water management strategies. In next stage common types of drought impacts on environment and socio-economic aspects has been identified. Finally in order to diminish drought impacts, according to water resources limitation and increasing trend of water consumption, appropriate measures addressing short-term and long-term solutions and national strategies water resources management have been proposed.

Key words: Water Limitation, Drought, Water Management, Optimal Use

1- INTRODUCTION

Water crisis is one of the most important issues in international levels. Islamic Republic of Iran locates in an arid and semi-arid area, with low annual precipitations and inappropriate and unequal rainfall has intensified the existing conditions. Although climate change is seen in most of the world, decrease of rainfalls and drought occurrence in Iran, especially in the recent years (due to specific regional conditions), has been followed by more environmental impacts.

Iran has experienced one the driest years during the last several decades. According to the recent statistical studies, the amount of rainfalls in our country with average of the same period during 31 years was up to 43%, which indicates about 25% decrease between years 1999 and 2000. [6]

Water shortage crisis and drought are threatening the Earth and this is intensified by increase of green house gases (mainly CO₂ from deforestation, irregular use of fossil fuels) and consequent global warming, Elnino phenomenon and also drought conditions. If the concentrations of green house gases increase two times of concentration before industrialization, the global temperature will increase between 1.5-4.5 °C. Enforcement of water cycle is caused by increasing the temperature leading to occurrence of drought periods and huge floods.[8] Occurrence of drought in Iran is mainly affected by global factors but decrease of rainfalls and drought emerge are due to specific geographical characteristics (arid and semi-arid climate) which has intensified the current condition and also the environmental impacts.

2- ENVIRONMENTAL IMPACTS OF DROUGHT

Although the environmental impacts of drought in each region varies differently, the most important environmental impacts of Drought in our country are on:

Water Resources, Land and Land Use, Climate and Climate Change, Ecology and Biology, Agriculture and Socio- Economical Impacts.

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2-1- Impacts on Water Resources

Nowadays water shortage crisis has become one of the most serious problems in the world. At present about 1.3 billion people suffer from inadequate and unhealthy drinking water and 2 billions of inadequate sanitary facilities. [6]

According to U.N. Report in 2001, the drought conditions in Iran were so intensive and extensive that has been affected the limited existing water resources [8]. It is predicted that in the future and specially during summer this condition will be intensified and also according to the latest statistics, the rate of existing abstraction from aquifers in 117 important plains (center and eastern regions) is more than permitted exploitation (over exploitation) [4]. At present maximum potentials of aquifers are being used in 20 provinces. Over exploitation is the main reason for reduction of water table, saline waters intrusion [3]. During the drought conditions, water pollution will be intensified due to discharge of pollutants (such as different types of wastewater /effluents) to surface water, because when the volume of surface waters decreases, self-purification will also be decreased, leading to degradation of water quality. In most of water reservoirs of the country the water storage was in minimum (during 2000-2001) due to increase of temperature and decrease of rainfalls.

2-2- Impacts on Land and Land Use

Deserts and desertification are seen in about 70% of dry lands. It is obvious that drought increases desertification phenomenon. In order to prevent desertification, the development of deserts should be prevented in the regions that this phenomenon has not occurred yet. Generally flora that are important factor for soil conservation and soil erosion prevention are damaged in the drought conditions. Deserts and pastures with an area of 90 millions hectares that are main resources for fodder supply have been destroyed during the recent drought in Iran. Irrigated and rain fed lands in Iran are 8 and 6.5 millions hectares respectively and during the recent years 200000 hectares of rain fed and 2 millions hectares of irrigated lands, ten thousands hectares of tea gardens and more than ten thousands of hectares banana gardens in Sistan and Baloochestan province and Jiroft gardens have been damaged.

Soil subsidence is also one of the most important outcomes of overexploitation from the groundwater aquifers, which can be seen in Sirjan plain near to Kerman. [6]

2-3- Impacts of Climate and Climate Change

Due to global warming throughout the world, which is mainly caused by increasing the concentration of green house gases, it is predicted that in the future the temperature of Earth will be increased, leading to increase of water evaporation. [8]

The most predominate climate in our country is arid and semi-arid. According to FAO Report in 2000; continuation of drought and lack of rainfalls are the main reasons for drought in 18 of 25 provinces of the country. About half of the total population (more than 30 millions) is affected from these conditions [2]. **(Figure 1)**

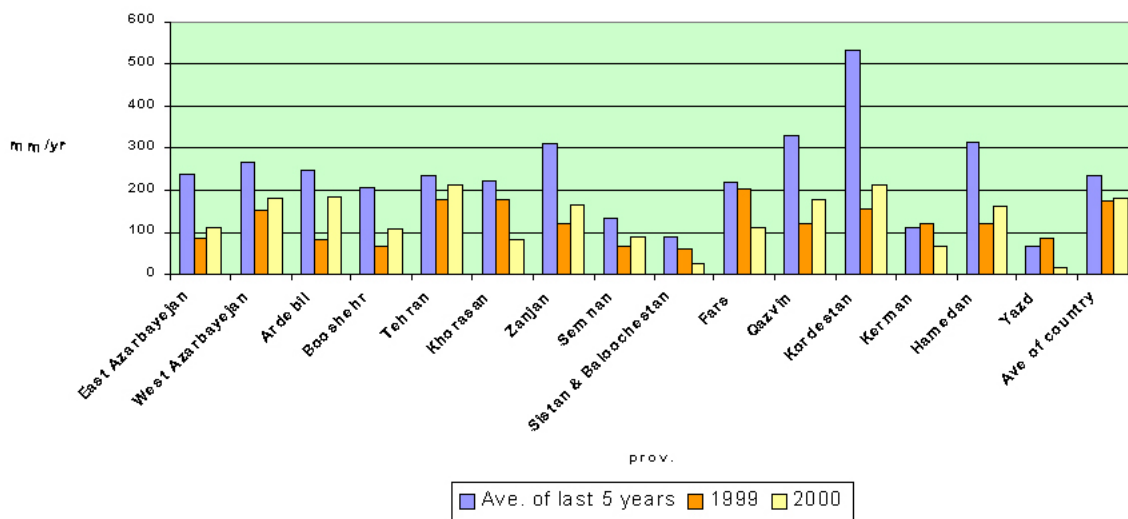


Figure (1) Distribution of rainfalls between different provinces

2-4-Impacts on Ecology and Biology

The most Important Impacts on Ecology and Biology are on: Fauna, Flora, Habitats, Wetlands and also Water Quality.

Aquatic life is affected by discharging different types of wastewater into receiving waters and as a result unusual color and odor of water resources are caused, leading to imbalance of animal life and migration of different species, including rodents and other animals.

Drying lakes and wetlands such as Bakhtegan, Arjan and Kaftar Lakes in Fars province, Hamoon Wetland, water regression in Oroumieh Lake, drying the Zayanderoud River after Flaverjan city and Qarbalbiz Spring in Mahriz region (which is the most beautiful summer residence in Yazd province), saline water intrusion in the Bahmanshir River and changing the freshwater resources to brackish or brine waters are the most important impacts on ecology. Ecological imbalances are due to reduction or drying of wetlands. The number of migratory birds, migrating from north of Asia to spend winter in Hamoon Wetland has been reduced from 200 thousands to 90 thousands in the year 2000.

The number of wildlife has been decreased from 16500 (in 1990) to 2000 of different species in Golestan National Park in 2000. The number of wildlife in Bakhtegan region has been decreased from 14000 in 1997 to 56 of different species in 2000. Because of drought conditions in Bakhtegan, Arjan and Kaftar lakes, a great number of aquatic, crustacean and aquatic birds have been damaged. The rate of damages especially to Flamingo colonies and diseases outbreak were so intensive that it could be considered as an important environmental disaster. A kind of Iranian crocodile, which is unique in the world, has been migrated from Sistan and Baloochestan region as a result of drought conditions.

The other negative impacts of drought are also fire accidents and decrease of fauna. [6]

2-5- Impacts on Agriculture

At present, about 800 millions people of the world suffering from malnutrition. It is predicted that production of foods will be doubled during three or four future decades.

Where dry land, exists no irrigated agriculture dominates, and crop yield are likely to decrease with even small changes in temperature, especially in Africa, Latin America and Asia.

It is estimated that the overall agriculture productivity of Iran will be decreased between 10-20 percent during the next 50 years [8]. **(Figure 2)**

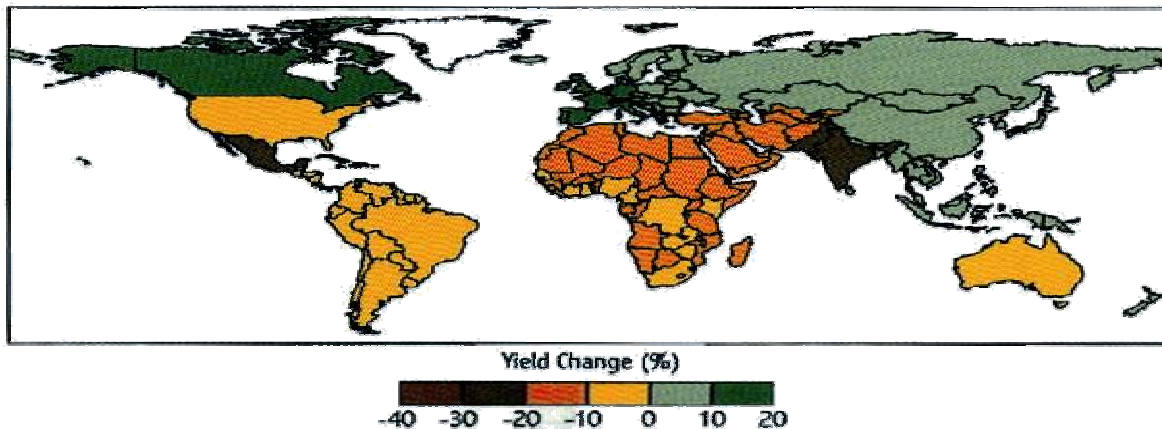


Figure (2) Prediction of world yield change

2-6- Socio- Economical Impacts

According to the investigations, between 1990 and 1998 about 94% of important natural disasters of the world, which was 568, and also more than 97% of death due to these disasters have been occurred in developing countries. The most important economical impacts are on agriculture, industry, tourism and recreation, energy, transportation and on national and local economy. The most important social impacts are on stress and health, nutrition, recreation,

social security, cultural aspects and aesthetical aspects. Human health is sensitive to changes in climate because of changes in food security, water supply and quality and the distribution of ecological systems. Indirect effects could include increases in infectious diseases such as salmonellas; cholera and other food and water related infections and also increases the transmission of vector-borne infectious diseases (such as malaria, dengue, yellow fever, and encephalitis).

Based on United Nations Representatives' Visits in 2001, occurrence of many diseases have been reported due to water and consuming water from water tankers. Drought not only reduces crop yields, but also affects employment conditions in rural areas in our country. According to the recent United Nations Report, the amount of damaging costs has been increased from 120 million dollars in the year of 2000 to more than billions in 2001.

Drought has affected agriculture sector, which contributes about 26 percent of Gross National Product (GNP) and also national economy and according to UN Reports in 2001, regarding impacts on agriculture in Iran, 2.8 million tons of wheat crops, 280000 tons of barley-corns have been damaged and this was also seen in fodder crops, leading to increase of agriculture crops import to the country, for example Iran should have imported up to 300000 tons barley in the last year.

Based on the present statistics only in the year of 2000 about 5.8 million tons of crops have been damaged, affecting animal husbandries and more than 15 millions livestock were perished due to lack of water. The damages to agriculture specially to fodder crops were considerable and to summer crops as well. [7]

3- DROUGHT MANAGEMENT

We usually tend to focus on drought when it is upon us. We have to take an approach that seeks to minimize the effects of drought when it inevitably occurs.

There are two main management approaches for drought management; Risk Management and Crisis Management.

Risk management is prediction of crisis conditions and planning for undertaking actions beforehand. At present, what is being undertaken in our country is crisis management, but believe our high vulnerability against drought, we should shift toward risk management approach rather than crisis management.

3-1- Steps in Drought Risk Management

The Western Drought Coordination Council has constructed a guide to assist organizations to reduce short and long-term risks. According to this guide, there are six steps for drought risk management as follow. (Figure 3) [1]

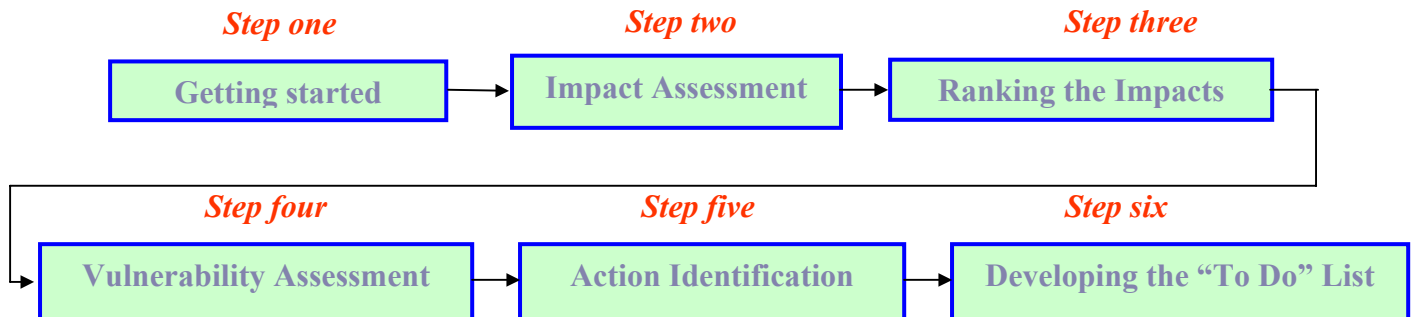


Figure (3) Steps in Drought Risk Management

In drought management making the transition from crisis to risk management is difficult. **Getting Started** (step one) is essential to bring together the right group of people and supply them with adequate data to make fair, efficient and informed decisions pertaining to drought risk. **Drought Impact Assessment** (step two) begins by identifying direct consequences of drought such as reduced crop yields, livestock losses, and reservoir depletion. For **Ranking the Impacts** (step three) a checklist should be completed as follows: (Figure 4)

Figure (4)
Checklist for Ranking the Drought Impacts

H= Historical Drought
 C= Current Drought
 P= Potential Drought

H	C	P	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<u>Economical Impacts</u> Loss from crop production Loss from dairy and livestock production Loss from fishery production Disruption of water supplies
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<u>Environmental Impacts</u> Damage to animal species Damage to plant species Increased ground water depletion Loss of biodiversity Loss of wetland
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<u>Social Impacts</u> Mental and physical stress Loss of human life Loss of aesthetic values Reduced quality of life Increased conflicts (water user, political)
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

To perform the assessment-using checklist, check the box in front of each category. That has been affected by drought in the study area. The checklist selection is based on either common or extreme drought or a combination of the two. If drought planning is based on the “drought of record” a historical review would need to be completed and appropriate sing should be marked under the “Historical” column. Next, with the current knowledge about the local area, if another “drought of record” occurs, speculate as to what the local impacts may be and record them on the checklist under the “current” column. Finally if we predict what the impacts of the same drought would be for the area in five or ten years, it should be recorded in “potential”.

Once the checklist has been completed, all of the categories that were checked should be made into a new list, with the unchecked categories omitted. This new list contains the drought impacts that are relevant to your location or activity.

From the new list, the “current” impacts should then be ranked according to the most important impacts. In choosing the highest priority impacts, it may be helpful to ask some of the following questions:

- ✓ Which impacts are important to the affected individual’s or group’s way of life?
- ✓ If impacts are not distributed evenly, should hard-hit groups receive greater attention?
- ✓ Is there a trend of particular impacts becoming more of a problem than others?

It may be also useful to develop some kind of a matrix, as shown in **Table 1** below, to help organize the information use in your decision-making.

Table (1) Drought impact decision matrix

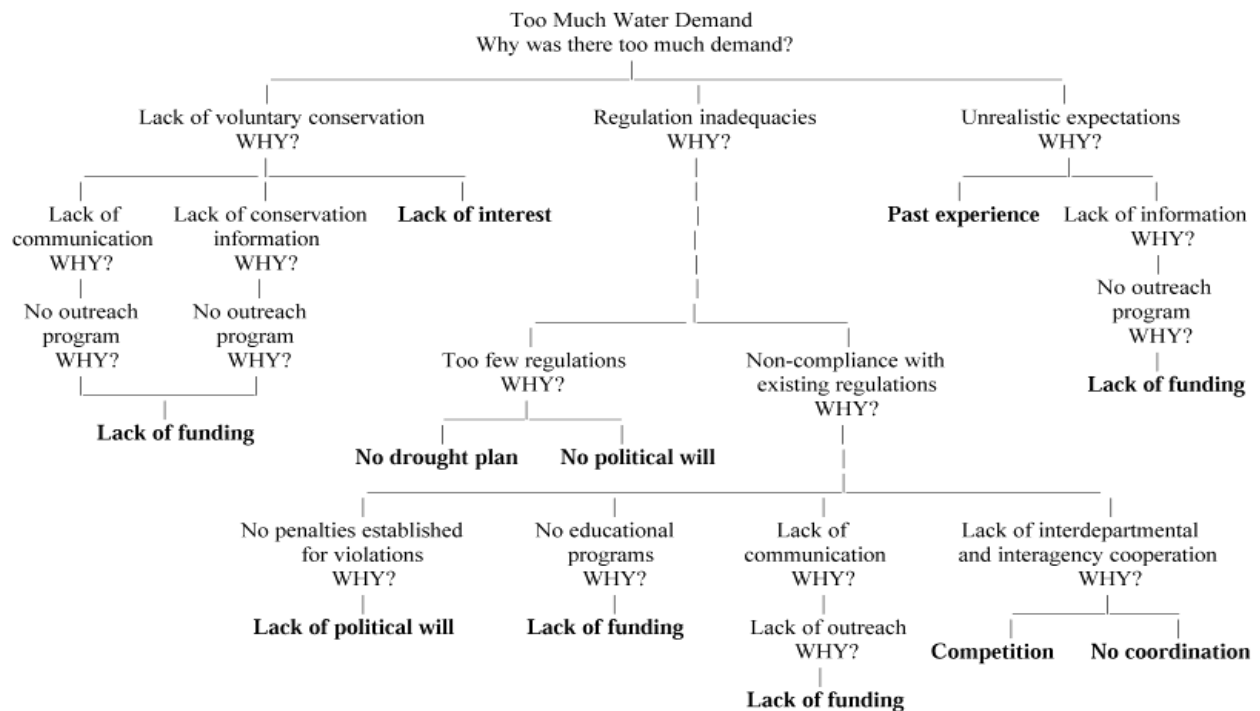
<i>Impact</i>	<i>Cost</i>	<i>Equally Distributed?</i>	<i>Growing?</i>	<i>Public Priority?</i>	<i>Equitable Recovery?</i>	<i>Impact Rank</i>

The result of this step is the development of a list of the highest priority impacts that are relevant to your particular region or activity and supported by scientific researchers, policy makers, and the public. These impacts can then be investigated further. In **Vulnerability Assessment** (step four), which provides a framework for identifying the social, economic and causes of drought impacts (**table 2**).

Table (2) Water shortage Vulnerability Continuum (by Deborah Braver, 11/97)

	Higher Vulnerability	Lower Vulnerability
Meteorological Drought	Wide Precipitation Variation	Stable Precipitation Pattern
	Lack of Data/Single Source Data	Good Long-Term Data / Multiple Sources of Data
	Passive Drought “Acceptance”	Advance Warning
	Longer Duration	Shorter Duration
	Higher Severity Shortage	Lower Severity Shortage
	Sudden Change in Supply	Gradual Changes in Supply
Supply/Demand Balance or “Institutional Drought”	Single Water Source or Low Supply Reliability	Multiple Water Sources or High Supply Reliability
	Low Priority Water Rights or Low Contractual Rights	Senior Water Rights or High Contractual Rights
	Water Supply at Risk from Contamination	Protected Water Supply
	Imported Water Supply(ies)	Local Supply(ies) and Locally Controlled
	Subject to Other Natural Disasters	Low Likelihood of Other Natural Disasters
Preparedness	Wait Until Shortage is “Declared” (or beyond...)	Early Shortage Response
	Lack of Political Will	Leadership
	Ignoring Situation/Abdicating Responsibility	Preparedness/Actions to Protect Community / Economy / Environment
	Non-interconnected Water Supply Systems OR Non-Collaborative 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	Pre-determined and Equitable Allocation Methods
	Little Public Awareness	High Community Involvement (from all social and economic sectors)

For each of the identified impacts that are relevant to our application (**Figure 4**), begin asking why have (might) these impacts occurred (occur). It is important to realize that a combination of factors might produce a given impact (i.e., environmental, economic, and social factors). It might be beneficial to diagram these causal relationships in some form of a tree diagram (**Figure 5**). This figure demonstrates a potential urban scenario and illustrates the complexity of understanding drought impacts.



(Depending on your situation, it may even be possible to break these causes down further)

Figure (5) Tree diagram for understanding drought impacts

Once drought impact priorities have been set and the corresponding underlying causes of vulnerability have been exposed, It is time to **Identify actions** (step five) that are appropriate for reducing drought risk. In accordance with the overall goal of drought mitigation rather than drought response, we stress that mitigative actions should be identified before potential response actions.

The following sequence of questions may be helpful in identifying potential actions:

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

With above mentioned questions we can provide some list of many actions that could be proposed for drought risk reduction planning in categories such as Assessment, Legislation and Public Policy, Water Conservation / Demand Reduction, Increasing Water Supply/ Economic Development, Public Education and participation, Health and Nutrition, media Participation, Conflict Assistance, and Emergency Response. All of the listed items are not necessarily recommendation. In the last step **Developing the “To Do” list** (step six) will be discussed not all items are appropriate in all cases. Many of the ideas are more in the short-term emergency response, or crisis management, rather than long-term mitigation, or risk management. Then after identifying the impacts, causes and relevant potential actions, in this step we choose the actions that are taken in the risk reduction planning. This selection should be based on such concerns as feasibility, effectiveness, cost and equity.

To choose the appropriate actions for developing the “To Do” List, it might be helpful to ask some of the following questions:

1. What are the cost/benefit ratios?
2. Which actions does the general public assume feasible and appropriate?
3. Which actions are sensitive to the local environment (i.e., sustainable practices)?
4. Are your actions addressing the right combination of causes to adequately reduce the relevant impact?
5. Are your actions addressing short-term and long-term solutions?
6. Which actions would fairly represent the needs of affected individuals and groups?

It is suggested that **Developing the “To Do” List** be fragmented into actions that are to be done now, versus those that are to be performed during or after a drought. In addition, it may be helpful to clarify the areas of

vulnerability that you have identified as falling under the acceptable risk categories. Upon completion of step six, the risk analysis is finished.

4- DISCUSSION AND CONCLUSION

The harmful and adverse impacts of drought in developing countries will be minimized by implementation of Risk Management. Nowadays, in developed countries, drought is not considered as a threatening phenomenon to human beings and it is just an economical problem. This is because of having the planning of Risk management to control drought.

As mentioned before in this paper, Iran is located in arid and semi-arid region and is faced with shortage of water. If the program of drought risk management will be developed and applied in Iran, it would be possible to prevent intensive impacts of drought.

Nowadays, National plan and approaches against drought are being investigated and some guidelines to reduce drought impacts are being studied too, in our country. These plans are based on Risk management method, which is given in this paper. The importance of this study is because of that we applied crisis management in drought conditions at present and this leads to inappropriate, and inadequate activities. However, in last decades the planning of drought risk management has been prepared in developed countries. These programmers not only have decreased vulnerability of so cities during drought conditions but also have caused to increase the coordination between different governmental levels and effectiveness of productivity of substantial, financial,, potentials. So, implementation of risk management has been recommended to those countries, which have the potential of drought intensive and extensive impacts of drought. Nowadays, National planning and approaches of drought are being investigated and some guidelines to reduce drought impacts are being studied too, in our country. These plans are based on risk management method, which is mentioned in this paper.

5- RECOMMENDATIONS

In this paper following measures are recommended regarding drought condition; Promoting public awareness, Soil erosion prevention in drought conditions, Natural resources management for mitigating water shortage impacts

4-1- Promoting public awareness:

- Promoting community knowledge and public awareness on national environmental problems
- Planning and development of environmental studies
- Collection of environmental data specially ecological changes
- Encouraging people for optimized water use via mass media
- Development of educational programs to promote public awareness

4-2-Soil erosion prevention in drought conditions:

- Formulation of laws and regulations for land use (nationally and locally)
- Replacement of modern technologies instead of current traditional methods
- Development of forestry plans and restoration of forests and pastures
- Optimization of water and soil resources to prevent agriculture land salinity

4-3- Natural resources management:

- Effective use of available water resources
- Water quality management in drought conditions
- Formulation of specific standards for effluent discharges
- Improved water use management and determination of appropriate consumption patterns
- Community participation in water management and water quality conservation

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