Water Reforms versus Climate Changes In Developing Countries

M H. KARIM [1]
Science & Education Director of Iran in India,
Associate Professor, University of Economic Science, Tehran - Iran.

M. ESMAEILI [2]
PhD Scholar, University of Pune – India.

ABOLHASAN HASHEMI [3]
Faculty Member, University of S&B, Zahedan - Iran.

Abstract
Water reform policy in developing countries, where economy is mostly agricultural based, is the main precondition for sustainable agricultural economic development. Since water is an important input in all economic sectors, particularly agriculture, climate changes and water scarcity will be two important aspects that should be looked into and worked on in this millennium. Providing sufficient water for use, especially in agriculture sector, is one of the major problems facing the developing countries such as Iran. Water-reforms are important, while the multi-oriented issue of sustainability is of interest as well. The pros and cons of water-reform policy are discussed in this project.

Keywords: Water reforms policy, climate changes, and sustainable development process.

1. Email: Karimsistani482@gmail.com
2. Email: Esmaeili06@yahoo.com
3. Email: Hashemi@eco.usb.ac.ir

1. Introduction

In the new millennium tensions have risen in various parts of the world over the division and distribution supply of sweet water resources. Such strains appear in many forms between water-use in urban and rural areas in the world, especially among developing countries of Asia. The International Water Management Institute (IWMI) reported that more than 70 per cent of world agricultural irrigated area is located in Asia (IWMI, 2010). Therefore, water-reform is one of the most important issues in these countries, which also plays a key role in the social behavior and economic development of these nations.

It is widely recognized that many countries, including Iran, will face severe water shortage by 2025. With an annual average precipitation of 251 millimeters(1998-2009 average), the volume of average water resources in Iran stand at 398 mm3 of which only 100 mm3 can be used. The annual world water consumption has been estimated at about 78 mm3 of which about 4.5 mm3 are used for drinking and industrial purposes, whereas the rest is used for irrigation.

The primary objective of this paper is to address the climate changes and economic analysis of water use in Asian developing Countries with special reference to Iran's agricultural sector. While secondary objectives are to analyze fresh water resources and water use pattern, determination of major global irrigated and cultivated area, considering relation of irrigated arable and total harvested area, studying Water demand and supply condition in Iran, addressing challenges and strategies, and in the end applicable recommendations are provided for improving water management and sustainability of agricultural sector.

To address the above objectives, the following sections are organized in this paper. Section two presents water resources and water use in the world. Iran's water resources and water use are also discussed in this section. Section three explains the relationship between irrigated arable areas and the total grain production in the world. An economic analysis of water supply and demand in Iran's agricultural sector is discussed in section four. Section five proposes water reform strategies derived from the analysis of water market in the agricultural sector of Iran. Section six concludes remarkable points.

2. Climate changes and Water Resources

2.1 Climate Changes

Global climate change and atmospheric pollution could have an impact on freshwater resources and their availability and, through sea-level rise, threaten low-lying coastal areas and small island ecosystems. Freshwater is an essential component of the Earth's hydrosphere and an indispensable part of all terrestrial ecosystems. The freshwater environment is characterized by the hydrological cycle, including floods and droughts, which, in some regions, have become more extreme and dramatic. Therefore, surface water and groundwater are the major components of water resources, which mainly come from precipitation. Table 1 shows total renewable freshwater supply for selected countries in each continent. According to above mentioned table, Brazil was the first country, which received the most freshwater supply (8,233 cubic kilometer) among others in the world (FAO, 2009). Russia (4,507 cubic kilometer) in Europe was in the second place followed by the United States (3,069 cubic kilometer) in North America, China (2,897 cubic kilometer) in Asia, Congo Democratic Republic (1,283 cubic kilometer) in Africa, and Papua New Guinea in Oceania (801 cubic kilometer). Iran approximately received 137.5 cubic kilometer of freshwater in 2009.

The annual rainfall in each continent of the world varies from one country to another (Table 1). According to the Intergovernmental Panel on Climate Change (IPCC) database in 2009, Brazil had the highest annual average precipitation with 15,235 cubic kilometer. Russia received an average precipitation of 7,855 cubic kilometer within the same period, while U.S. was in the third place with an average of 7,087 cubic kilometer of precipitation. During the same period, China was the first in Asia that received an annual average of 6,018 cubic kilometer followed by Indonesia with 5,147 cubic kilometer of precipitation. The average annual rainfall in Iran was approximately 376 cubic kilometer.

2.2 Water Resources

The allocation of freshwater supply to various users (domestic, industry, and agriculture) varies from one country to another depending up on climate changes intensity. Table 2 shows how total renewable water resources are distributed among various users. It implies that of 137.5 cubic kilometer of Iran’s freshwater, 92.2% was used in the agricultural sector, 6.6% was allocated to domestic and the remaining 1.2% was used by various industrial firms. These figures in China varied from one sector to the other. For instance, 64.6% of the total 2,897 mm3 of China's freshwater supply was used by the agricultural sector, whereas 12.2% and 23.2%, respectively, were allocated to domestic and industry sectors. To compare these figures with European countries in the same year we chose Norway where only 10.5% of the total 382 cubic kilometer of freshwater supply had been used in agricultural sector, 22.8% allocated to domestic and 66.7% to industrial users. Water consumption quantity by various sectors depends upon the industrialization & development of the region, agricultural dependence on rain & irrigation, and ability of water utilization and irrigation efficiency.

As mentioned earlier total renewable water resources are allocated to a series of economic activities of which water consumption varies from one activity to another in each country. Table 2 implies that three major water users are agricultural sector, domestic, and industrial firms. Water demands are derived from several competing economic activities in each of the three above categories. For instance, the significant volume of freshwater supply in agricultural sector is used to irrigate different types of crops. Plants in their growing season need different amounts of water, which varies due to some uncontrollable factors like land topography, soil type, climate, ground cover, crop pattern, and land use. Other competitive activities in demand for water in agriculture are livestock production and aquaculture. Finally, the major water users in domestic and industrial sectors respectively, are residential and recreational hydroelectric. This study focuses mainly on the agricultural sector of selected Asian developing countries.

3. Irrigated Arable Area and Grain Production

3.1 Global Top Ten Irrigated Area

Table 3 presents total arable and irrigated areas of selected developing countries in 2009. Table 3 shows that China with 64 million hectares of irrigated land is about 21 % of the total world irrigated arable areas followed by India and U.S. with 62 and 23 million hectares of irrigated lands, respectively. Iran is in the fifth place with 8.9 million hectares that is about 3 % of the world-irrigated arable areas. From Table 3, one may conclude that these countries should be categorized among the top world regions with respect to agricultural production, on the grounds that irrigated croplands hypothetically, on average, produce higher yield than of the non-irrigated areas. In this context, cereals are of interest because these products contain 99 % of the world staple for human consumption. However, in reality, this does not occur. Except India, USA and China, an opposite direction to the above statement is observed in the world

3.2 Global Top Ten Cultivated Area

Table 4 shows total harvested cereals area in the world. China and India are the two major cereals producers because these countries contain more than 29 % of the world's total harvested grain area. Other main grain producers, such as U.S., Russia, Brazil, Canada and Australia, rely on the percentage of precipitation and its distribution during the period of crop year.

Irrigated agriculture has driven much of the increase in global food production over recent decades. While only 20% of the world's farmland is irrigated, it produces 40% of our food supply. The highest yields obtained from irrigation are more than double the highest yields from rain fed agriculture; even low-input irrigation is more productive than high-input rain fed farming. Although climate change and population growth will affect global irrigated area and sustainable agriculture decade by decade in long run (figure-1). To increase irrigation's contribution to sustainable agriculture in developing countries, what is needed is improved efficiency in water use that may be called water reforms.

4. Developing countries Water Market

4.1 Asian Selected Developing Countries

Table 5 & 6 have depicted Irrigated and harvested areas in top ten Asian developing countries. Table 5 indicates that Iran has 4th largest irrigated agriculture in Asian countries after India, China and Pakistan. On the other hand Table 6 implies that Iran is although among top ten Asian developing countries for harvested area, but it has fallen to 8th position before Vietnam and Myanmar. A comparison between Tables 3 and 4 also indicates that although Iran falls in the top five global major irrigated areas, its cereal harvested area and volume of production is not placed among the first top ten countries.

Several questions can be raised on why Iran is not be able to increase its grain production more than what it has done till date? What kinds of obstacles do preclude Iran from being a major grain producer in the world with such considerable water resources? Is Iran able to alleviate these limitations simultaneously considering sustainability in agricultural development? If yes, what strategies should this country include in its policy agenda? One reason for failure in grain mass-production can be imputed to the issue of water management. Water management in Iran does not conform to the conventional international standard levels nor does it relatively correspond to the latest technology in agricultural production. No matter how much freshwater Mother Nature provides to this country, it is depleted easily due to lack of proper water reforms strategies.

4.2 Iran Water Resource and Agriculture

In terms of agricultural production, Iran is known as a four-season country where one may find any kind of grain, oilseed, fruit and vegetable throughout the year.

As such, it is no surprise that both tropical and cool-season crops are grown and produced in Iran. Just to name a few, one could mention citrus dates, pistachio sugarcane, and rice, as well as apples, cherries , walnuts, and apricots. However, the most extensive cultivated area is devoted to wheat and barley, which are the main sources of staple food and protein for the average Iranian. Wheat alone covers about one third and fruits cover nearly one fifth of the total irrigated land of Iran.

Both systems of irrigated and rain fed farming are practiced in different parts of the country while the area devoted to each system varies considerably depending on the climate changes. Rain fed agriculture and dry farming are most successful in western and northwester of Iran, as well as the sloping lands in the Caspian coast. In other parts of the country, dry farming is also practiced in hilly areas, but the yields obtained are limited.

As to the water resources, by far the largest source is the annual precipitation. The latest estimate of the average annual precipitation is 398 Km3. Out of this volume, nearly 300 Km3 directly evaporates from soil surface or is evaporated from forest canopies, rain fed crops, etc. The annual surface streams with internal origin are about 105 Km3, including 13 km3 of surface water which enters the country from the neighboring states. Presently, the annual volume of water used in different sectors is as follows: agricultural sector 81 km3, urban and industrial sectors 6 km3.

Based on the fourth Socio-Economic Development Act (2000-2005), Iran aims to reconsider its water and aquifer management. Various methods of water-reform have been studied. Constructing more dams, harnessing surface water, and changing the traditional systems of irrigation from surface irrigation to sprinkler and micro-irrigated system of irrigation are some examples of these methods.

4.3 Water Use Methods in developing countries

The economic analysis of water market in most developing countries can be viewed from different scenarios. The first scenario views water market from a natural phenomenon perspective. Since rainfall is the major resource of both surface and ground water, the analysis of supply and demand of water in agricultural sector will entirely depend on the amount of rain and snow (supply side) and the amount of water used (demand side) in each year. For example, if the precipitation rate in a particular year is much larger than the withdrawals of water for various users, then resource allocation is not an issue any more. In this scenario, no market failure exists, and the marginal cost of water used in the process of production is zero implying a zero price for water. This occurs because there is no market for water and farmers can use water as much as they need mostly through inefficient irrigation system (i.e., surface irrigation).

The second scenario views water market from a more focused economic perspective. This postulation, which brings similar situation as to the first scenario, can occur in the event of market failure. Market failure in agricultural sector can be imputed to a couple of reasons. First, there is not appropriate policy implemented to enact a pricing system for various water users. Second, the current pricing system of water in Iran's agricultural sector is not based on water scarcity and availability throughout the seasonal growth of plants. It means that the price of water is not equal to its shadow price at each time. The reasons why market failure exists in water market depends on water reforms policies.

To model both scenarios in which demand side is more important than of the supply side, consider Figure 2 which shows the relationship between water scarcity and availability throughout the seasonal growth. When the amount of flow does not meet the need for water, water shortage occurs at each period of time. Farmers are willing to pay more for water they use. In this case, price is continually increased above zero till the quantity demanded will exactly equal to the quantity of water that is supplied. At the equilibrium point, water price is equal to farmers' willingness to pay. Figure 2 shows market demand for water in Iran's agricultural sector. The horizontal axis represents the annual amount of water demanded while the vertical axis shows the price of water. Suppose w0 is the total amount of water per litre demanded from all water resources. If the cost of extraction water is zero, or if the price of water doers not reflects its shadow price, then all the demand is satisfied (D1). At the time of water shortage, demand will be more than supply that puts pressure on prices, which ultimately leads to a rise in price P1. In this case, price is entirely determined by the opportunity cost of the water at the first best use. As demand shifts outward, say D3, opportunity cost of water use is increased which leads to a rise in price of water to P3.

What makes the optimum allocation of water for various users is its scarcity. In general, the allocation of water resources is described when the value of the applications in which water is used is greater than the opportunity costs of water. To do this, property rights for different water resources should be considered in Iran's water markets. Currently, the water pricing system in Iran's agricultural sector is not functioning well because property rights for water resources are not defined properly. In fact, political lobbies and regulatory forces prevent price of water to be increased above its opportunity costs. With this situation, farmers do not pay the real price of water they use in their production process. In the following section, the pros and cons of water constraint in Iran's agricultural sector are discussed, while climate changes are the main challenges in this subject.

5. Water-Reforms in Developing Countries

5.1 Challenges

- A Thirsty World

The achievements in cultivated area, irrigated area and cereals production, described in previous section could have been reached better than what it is observed, had water resources been used properly. Although there are other factors, such as low rate of machinery-use, small land size, inappropriate method of crop management, decreasing returns to size, lack of manure management and diseconomies of scale that affect insufficient increase in grain production. Mismanagement in water-use was one of the main reasons why total grain production has not increased properly till date. In this case, following points are worth mentioning.

Farmers usually irrigate their crops by the conventional water resources (springs, canal and deep-and-semi deep wells). Methods of irrigation are other sources of water depletion. In Iran, the conventional method of irrigation is the gravity system. More than 70 % of water-in-use is sunk into the ground with this inefficient method of irrigation because streams are constructed in soil and therefore cannot preclude water depletion. Soil streams changing into cement streams, which can be assumed as a sign of improving in water management needs considerable amount of investment. Inefficient methods of irrigation are also seen in areas that are located under the dams. It is rarely seen that all streams located in the downstream of dams are mass-reinforced constructed, which means water is also misused. The annual bulletin of world irrigation and water statistics (FAO, 2002) reported that Iran has 116 dams whose heights are at least 15 meters. Although such construction in water resources places Iran among first 7 countries in Asia, it is not enough, while water resource studies predicted that Iran will be among thirsty world countries in 2025(Table-8). If Iran wants to be major grain producer in the future more water collection facilities, such as cement dams, must be constructed.

- World Largest countries

Due to the specific characteristics of water it is hard to find an organized market structure for water use in Iran. These characteristics can be divided into two main categories: physical and economical. Brown and McGuire (1967) listed the physical characteristics of water. The most economic characteristic of water in Iran is that its agricultural use is almost free of charge, which means farmers do not pay the actual price of water use. Thus, when a product does not have a price then any efforts to put an economic viewpoint is meaningless. In spite of having considerable accomplishments in Iran's population growth rate, still the need for raising self sufficiency rate in providing food is felt more since population growth research by UNO has anticipated that Iran will fall in top ten most populated countries in 2050(Table-9).

- Risk of Hunger

Risk of hunger will increase if scarce resources are not allocated economically and efficiently. Warmer temperatures will also increase water demand for crop growth. In areas where increased water demand is not offset by additional rainfall or irrigation water supplies, climate change may further intensify the competition between growing urban, industrial, recreational, environmental, and agricultural users of water.

Fischer and others (1994) predict that the number of undernourished people will fall from 23 percent of the developing world population in 1980 to 9 percent in 2060 (table-10), although population growth is sufficient to increase the absolute numbers from 501 million to 641 million.

In Asia, problems could arise because of dependency on irrigation. Climate change may increase aridity and evaporation rates in areas already at risk from salinization, so more irrigated land could be degraded. Conversely, global warming-induced increases in precipitation could increase soil erosion, leading to lower crop yields and faster salitation of irrigation dams and canals. However, the poor state of knowledge on the impacts of soil erosion on crop yields makes these problems difficult to assess. Above mentioned table shows that yet 18% of African and 11% of west Asian people are under risk of hunger in 2060. Iran also as a West Asian country may suffer more from hunger risk compare to some other developing countries.

5.2 Strategies

Fortunately, tremendous results have been obtained from research and development in agriculture sector. In addition, in lieu of water management several dams have been constructed in the past decades, which provide water at the time when it is needed. However, there are several points that can be addressed to improve water resource management in the future. These points are assumed as various scenarios that should be implemented in Iran's agricultural sector. Each scenario can be done in a time fashion; given the fact that all must be considered as complementary policies to each other. All these scenarios can be fitted in the government's agenda for water-reform policy.

- Water should be viewed as an economic product and not given gift.

This way of looking to the issue requires recognition of market structure in water use. The pros and cons of demand and supply and their elasticities derived in various market structures should be studied before making any decision in regards of price determination. As mentioned earlier, water is used in three major activities: domestic, industry, and agriculture. There is no doubt that elasticity of demand varies from one activity to another. Even in each activity, users have different preferences, which distinguish one individual form another.

Water-pricing system has not been established properly in Iran's agricultural sector, and as a result cannot reflect the real value of water as a scarce resource in various agricultural uses. What is proposed in this study is to establish a pricing system that takes into account the opportunity costs of water in different use. This is the only way that Iranian farmers can pay the real price of the scare resource that they use. However, policy-decision makers should not increase the price of water use to its opportunity cost alone and other policy decisions must be made. One possible policy that Iranian agricultural authorities must follow is to stop determining ceiling-price for agricultural products. In other words, they should allow the mechanism of market to set the price. For instance in the case of wheat, from one side the government purchases farmers' wheat at the predetermined support price. Form the other side; it subsidizes consumers (usually urban consumers) to pay less for the final product. The difference between the purchasing price of wheat and the selling price will be covered by the government. Farmers are worse-off from implementing price support policy (Schmitz et al., 2002). This occurs because grain growers have to purchase their agricultural inputs (seeds, fertilizers, chemicals, labor, machinery operations accrual expenses, etc.) at the market price and sell the product at the price that is usually lower than of the market price. In practice, Iranian wheat growers cannot find another buyer for their wheat since 95 percent of milling factories are government-owned. Even if the ceiling price were high it would not be good enough because the term-of-trade between agricultural products and non-agricultural products are in favor of the latter group. One outcome of implementing the price support policy is to discriminate between Iranian grain growers themselves. Those farmers who are close to the cities or counties have the same access to the cheaper bread similar to the urban citizens. Instead, those who live far from cities, prepare bread from their own product, which is more expensive compared to the former group.

-Improvement of Rules & Regulation/ Limpid Property Rights

The second approach refers to a lack of rules and regulations in both sides of water supply-and-demand. Haghiri and Phillips (2003) addressed the non-existence of transparent regulations in Iran's agricultural sector. There have been several conflicts between large-size agricultural state enterprises and small-and-moderate land size farmers. At present, most rules and regulations, though inefficient and to some extent hidden, are in favor of the former group.

Property rights is one of the main issues in agricultural sector and more than 50% of judiciary & courts files & cases in rural area are related to property rights disputes. "I know of nine-year-old farm lads in jail for murder over water disputes".

-Modernization, Participation and Investment

Where irrigation has a comparative advantage, irrigation institutions need to adopt a service orientation and improve their economic and environmental performance. Sharing the benefits of a common natural resource base may prove hard to negotiate. But the economic benefits can be significant if flexible transfers in land and water are permitted within a well-constructed regulatory framework. So, encouragement & incentives of individuals and user groups are required to invest in water resource and optimization.

The construction, development, and maintenance of structural physical investment, such as dams, in each country must be done by the state enterprise. The sunk costs of such constructions are so high that no individual or group of farmers can afford such investment. Moreover, the social benefits of implementing such projects are so high that it covers both actual and social costs. Iran needs to perform innovative technologies, including the improvement of indigenous technologies to utilize limited water resources in an optimum way and simultaneously to safeguard those resources against pollution. It also needs to consider rationalizing water utilization schemes for the development of surface and underground water supply sources and other potential sources to support concurrent water conservation and wastage minimization measures along with improvement in water management and changing of cropping pattern. As a conclusion the public welfare will be maximized and everyone will be better off. Finally, whether or not the state will be able to retrieve the sunk costs by charging various users is another issue. The answer to this question depends upon how well the government responds to the precedent issues.

6. Conclusions:

- Due to climate changes in many Developing regions, water is a limiting factor in agricultural production. The optimum use of such a scarce resource is always in question. Water-reform strategies must be planned in each country to preclude water shortage.
- While only 20% of the world's farmland is irrigated, it produces 40% of global food supply, so– water reform is burning issue in this century while land reform was a required issue in the last century.
- As world population grows agriculture must respond to demand for food, mitigate poverty and compete for scarce water with other users, to meet those multiple demands, agriculture policies will need to unlock the potential of water management practices and promote equitable access to water and conserve the resource base.
- New Millennium will throw up new challenges while water important will be more than that of oil & petroleum. Warning bell of climate changes water scarcity will spread for more populated & irrigated countries.
- During last 50 years, significant productivity gains in agriculture have protected the world from devastating food shortages. Water management in both rain fed and irrigated agriculture, was instrumental in achieving those gains.
- Sustainability of agricultural development in developing countries depends on water resource reforms and pursuing agricultural policies, such as optimizing water allocation in different methods of water usage, increasing water capacity through implementing scientific method of water reserve, improving the methods of water management,

optimizing the exploitation of water resources by increasing the efficiency of water transfer.

- Increasing agricultural productivity is considered by applying those policies that are more resource preservations-oriented. One way to allocate optimum use of water is to determine the price of water to be equal to its opportunity cost at the best alternative.
- It proposes a strategy to "Re-forms & Re-invent" water management in the agriculture sector, based on modernization of irrigation infrastructure and institutions, the full participation of water users in the distribution of costs and benefits, and the revival of flagging investment in key areas of the agricultural production chain.

References:

Boggess, W., Lacewell, R. and D. Zilberman (1993), “Economics of Water Use in Agriculture,” in G. A. Carlson, D. Zilberman and J. A. Miranowski (eds.), *Agricultural and Environmental Resource Economics,* New York: Oxford University Press, pp.319-391.

Brown, G. and C. B. McGuire (1967), “A Socially Optimal Pricing Policy for a Public Water Agency,” Water Resources Research, Vol.3, pp.33-43.

FAO (2002), “AQUASTAT,” Retrieved from the World Wide Web at: http://www.fao.org/ag/agl/aglw/aquastat/dbase/index.stm

Haghiri, M. and P. W. B. Phillips (2003), “The Impact of Globalization on Agricultural Biotechnology in Iran: A Model for Regional-Intellectual Property Rights,” *Journal of Perspectives on Global Development and Technology (*forthcoming).

Haghiri, M. (2002), “The Economic Impact of using Biotechnology in Agricultural Developing Economies,” *Malaysian Journal of Agricultural Economics* (forthcoming).

International Water Management Institute (2002), Annual Report, various issues.

Iran Ministry of Agricultural Jahad (2001), Annual Report, Various issues, Tehran

Karim Koshteh MH(1995), “Greening The Desert” Agro-economic Impact of IG Canal of Rajasthan, Renaissance Publication, N. Delhi, India.

Karim Koshteh, MH and Urutyan, V (2003) “Globalization process and sustainable agricultural development “, 1st International Conference on Sustainable Planning & Development, WIT-UK, Skiathos Island- Greece.

Schmitz, A., Furtan, H. and K. Baylis (2002), “Agricultural Policy, Agribusiness, and Rent-Seeking Behavior,” Toronto: University of Toronto Press.

APPENDIX

Table 1. Total Renewable Freshwater Supply and Average Precipitation by Country (cubic kilometer/year)

Continent	Water Resource	Precipitation (km^3/year)
Africa:		
Nigeria	286	1,050
Madagascar	337	888
Congo	832	563
Congo Democratic Rep.	1,283	3,618
Asia:		
Iran	**137.5**	**398**
Myanmar	1,168	1,415
India	**1,911**	**3,560**
Indonesia	2,019	5,146
China	2,840	6,192
Europe:		
Romania	212	152
Croatia	106	63
Norway	382	458
Russia	4,508	7,865
North and Central America:		
Nicaragua	197	311
Mexico	457	1,472
United States of America	3,069	7,087
Canada	2,902	5,352
South America:		
Argentina	814	1,643
Colombia	2,132	2,982
Venezuela	1,233	1,710
Brazil	8,233	15,174
Oceania:		
New Zealand	327	464
Australia	492	4,134
Papua New Guinea	801	1,454

Source: Food and Agriculture Organization of the United Nations (2009).

Table 2. Water Use in Selected Country (Percent)

Continent	Agriculture	Domestic	Industry
Africa:			
Nigeria	68.8	21.1	10.1
Madagascar	95.7	2.8	1.5
Congo	8.7	69.6	21.7
Congo Democratic Rep.	30.6	52.7	16.7
Asia:			
Iran	92.2	6.6	1.2
Myanmar	98.2	1.2	0.6
India	90.4	7.4	2.2
Indonesia	91.3	8	0.7
China	64.6	12.2	23.2
Europe:			
Romania	20.2	18.4	61.4
Crotia	N/A	N/A	N/A
Norway	10.5	22.8	66.7
Russia	19.9	20.2	59.8
North and Central America:			
Nicaragua	83.1	14.6	2.3
Mexico	77.1	17.4	5.5
United States of America	40.2	13.7	46.1
Canada	11.8	19.5	68.7
South America:			
Argentina	73.7	16.8	9.5
Colombia	45.9	50.4	3.7
Venezuela	47.5	45.5	7
Brazil	61.8	20.3	18
Oceania:			
New Zealand	42.2	48.3	9.5
Australia	75.3	14.7	10
Papua New Guinea	1.4	56.3	42.3

Source: Food and Agriculture Organization of the United Nations (2007).

Table 3: Global Top Ten Countries for Irrigated Areas (2008)

Country	Irrigated Areas (1000 Ha)	World Share (%)	Arable Areas (1000 Ha)	World Share (%)
China	64,141	20.94	108,642	7.86
India	62,286	20.33	158,145	11.45
USA	23,000	7.51	170,500	12.35
Pakistan	19,870	6.48	20,347	1.47
Iran	8,993	2.93	17,037	1.23
Indonesia	6,722	2.19	22,000	1.59
Mexico	6,300	2.05	24,800	1.79
Thailand	6,415	2.09	15,200	1.10
Turkey	5,215	1.70	21,555	1.56
Russia	4,346	1.41	121,649	8.81
World	**306,247**	**100**	**1,380,515**	**100**

Source: FAO

Table 4: Total Harvested Cereal Areas in Selected Countries

Country	**Cereal Areas**		**Production**	
	(000 Ha)	% of world total	(000 MT)	% of world total
India	100,696	14.21	246,774	9.91
China	88,593	12.5	483,680	19.43
USA	58,001	8.18	419,810	16.86
Russia	41,716	5.88	95,079	3.81
Nigeria	18,899	2.66	30,209	1.21
Brazil	20,220	2.85	71,288	2.86
Australia	19,806	2.79	39,942	1.60
Canada	14,863	2.09	49,059	1.97
Indonesia	16,312	2.3	82,029	3.29
Turkey	11,956	1.68	33,570	1.34
World	708,495	100	2,489,302	100

Source:FAO, 2009

Table 5: Irrigated, Cultivated and Total Area of Selected Asian Developing Countries

Country	1992			2002			2008		
	Irrig. 1000 Ha	Cultiv. (1000 Ha)	Total (1000 Ha)	Irrig. 1000 Ha	Cultiv. (1000 Ha)	Total (1000 Ha)	Irrig. 1000 Ha	Cultiv. (1000 Ha)	Total (1000 Ha)
China	49,152	123,764	959,805	54,402	124,136	959,805	64,141	123,480	932,749
Bangladesh.	3,229	8,018	14,400	4,187	8,139	14,400	5050	8,005	13,017
India	48,500	162,370	328,726	54,800	161,800	328,726	62286	161,490	297,319
Indonesia	4,500	18,100	190,457	4,815	20,500	190,457	6722	19,954	181,157
Iran	7,000	16,969	164,820	7,500	14,324	164,820	8993	14,758	162,855
Myanmar	998	9,534	67,658	1,982	9,900	67,658	2250	9,786	65,352
Pakistan	16,850	20,600	79,610	18,090	21,302	79,610	19870	22,015	77,088
Thailand	4,433	17,238	51,312	4,998	14,700	51,312	6415	15,649	51,089
Turkey	4,000	24,514	77,482	4,500	24,138	77,482	5215	24,019	77,482
Viet Nam	2,900	5,506	33,169	3,000	5,750	33,169	4600	5,240	31,007
Others	15,947	43,998	760,644	16,541	44,088	760,644	16,987	41,611	754,547
Total ADg.	157,509	450,611	2,728,083	174,815	448,777	2,728,083	189,873	436,114	2,709,045
World	251,454	1,379,844	13,425,432	271,689	1,364,238	13,425,432	306247	1,300,347	13,003,469
% of ADg.	62.6	32.6	20.3	64.3	32.9	20.3	62	33.5	20

Source: FAOSTAT, FAO, UNO

Table 6: Cereals Total Harvested Area, Production and Yield of Selected Asian Developing Countries

Country	1992			2002			2009		
	Area Harv. 1000 ha	Prod. 1000 MTs	Yield (hg/ha)	Area Harv. 1000 ha	Prod. 1000 MTs	Yield (hg/ha)	Area Harv. 1000 ha	Prod. 1000 MTs	Yield (hg/ha)
China	92,596	404,269	43,659	82,083	401,808	48,952	88,593	483,680	54,374
Bangladesh	10,861	28,654	26,383	11,728	40,668	34,675	11,613	46,812	40,309
India	99,499	201,468	20,248	95,050	222,840	23,445	99,880	246,774	24,707
Indonesia	14,733	56,235	38,171	14,792	57,931	39,165	17,044	82,029	48,127
Iran	9,787	15,811	16,154	8,360	15,123	18,090	9,095	20,836	22,909
Myanmar	5,577	15,342	27,508	6,882	22,140	32,171	8,912	31,950	35,850
Pakistan	11,758	22,123	18,815	11,846	26,445	22,325	13,689	38,374	28,032
Thailand	10,587	23,864	22,542	11,225	31,161	27,759	12,283	36,280	29,536
Turkey	13,731	29,157	21,234	13,906	30,540	21,962	11,956	26,558	22,562
Viet Nam	6,953	22,338	32,126	8,319	33,569	40,352	8,529	33,570	39,359
Others	28,972	60,333	28,834	26,190	62,733	32,542	26,9431	65,987	24,589
Total ADg.	305,054	879,594	28,834	290,381	944,958	32,542	294,843	761,634	24,589
World	709,113	1,973,289	27,828	663,540	2,031,749	30,620	708,459	1,692,521	23,887
% of ADg.	**43**	**45**	**104**	**44**	**47**	**106**	**41**	**44.9**	**103**

Source: FAOSTAT, FAO, UNO

Table 7: Iran Total Cultivated Area Along With Cereals & Fruits Harvested Area, Production and Yield

Crop & year	Total Cultiv .	Rainfed	Irrig.	Cereals			Fruits		
				Area (1000 Ha)	Production (1000 MTs)	Yield (Hg/Ha)	Area (1000 Ha)	Production (1000 MTs)	Yield (Hg/Ha)
1980	12,981	8,033	4,948	8,044	8,583	10,669	538	4,290	72,531
1985	14,900	8,100	6,800	8,769	10,728	12,233	676	5,358	79,197
1990	15,190	8,190	7,000	9,468	13,684	14,453	846	7,163	84,641
1992	16,969	9,969	7,000	9,787	15,811	16,154	917	8,384	91,413
1993	17,332	10,068	7,264	9,938	16,287	16,388	941	8,892	94,481
1994	17,337	10,073	7,264	9,187	16,691	18,167	1,001	9,704	96,859
1995	17,388	10,124	7,264	9,010	17,032	18,903	1,004	9,665	96,193
1996	17,097	9,700	7,397	8,712	16,083	18,459	1,031	10,085	97,763
1997	16,502	9,173	7,329	8,508	15,823	18,598	1,087	10,818	99,547
1998	16,837	9,275	7,562	8,788	18,979	21,596	1,089	10,953	100,545
1999	16,300	8,738	7,562	6,927	14,186	20,478	1,100	11,622	105,623
2000	14,324	6,824	7,500	7,022	12,874	18,333	1,123	11,512	102,522
2001	14,359	6,859	7,500	7,738	14,945	19,312	1,113	11,769	105,682
2002	14,324	6,762	7,562	8,360	15,123	18,090	1,114	11,769	105,682
2009	16,969	9,969	7,000	9,095	20,836	22,909	1,378	13,184	118,648

Source: Ministry of Agriculture Jahad, Iran

Table 8: A Thirsty World (m^3/person)

Country	1990	2025
Egypt	1,070	620
Ethiopia	2,360	980
Somalia	1,510	610
Libya	160	60
Iran	2,080	960
Saudi Arabia	160	50
Haiti	1,690	960
Peru	1,790	980

Source: Gleik, 1996

Table 9: World Largest Countries

	2010			2050	
1	**China**	1,341		**India**	1,533
2	**India**	1,224		**China**	1,517
3	**USA**	310		**Pakistan**	357
4	**Indonesia**	239		**USA**	348
5	**Brazil**	194		**Nigeria**	339
6	**Pakistan**	173		**Indonesia**	318
7	**Nigeria**	155		**Brazil**	243
8	**Bangladesh**	148		**Bangladesh**	218
9	**Russia**	142		**Ethiopia**	213
10	**Japan**	126		**Iran**	170

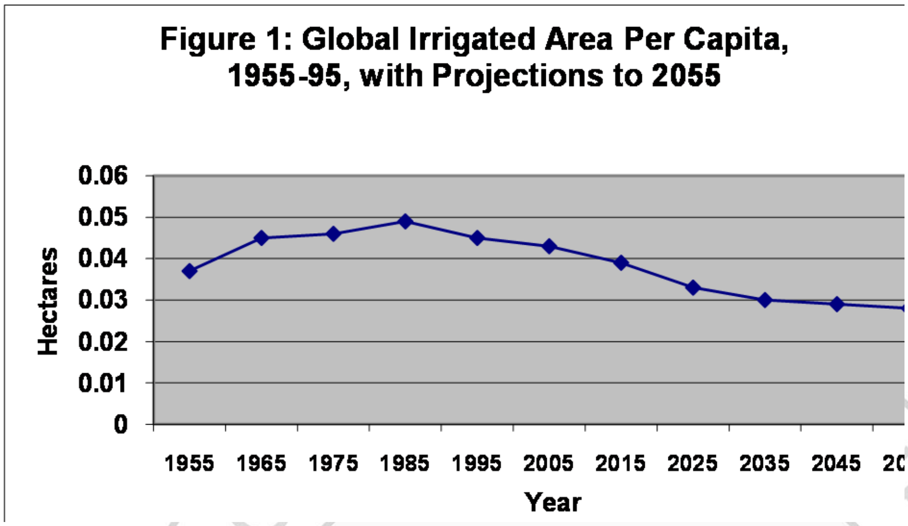
Source: UNO, 2010

Table 10: Projected number of people at risk of hunger (Million)

Region	1980	2000	2020	2040	2060
Developing	501(23)	596 (17)	717 (14)	696 (11)	641 (9)
Africa	120 (26)	185 (22)	292 (21)	367 (19)	415 (18)
Latin America	36 (10)	40 (8)	39 (6)	33 (4)	24 (3)
S and Se Asia	321(25)	330 (17)	330 (13)	232 (8)	130 (4)
West Asia	27 (18)	41 (16)	55 (14)	64 (12)	72 (11)

Source: Economic Research Service from Fischer and others (1994)

* Numbers in parentheses show percentages of population.



Source: FAO, 1998.

Figure 2, Water Demand and its Scarcity