Sustainability of Water Resources in Afghanistan

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Water is a precious natural resource because it plays a significant role in maintaining human health; fulfilling the human food requirements and boosting industrial development and above all, keeping the natural heritages and beauties. An ever-increasing world population imposes quantitative pressure on water resources from one side (for provision of safe drinking water, agricultural and industrial needs). While from the other side, the quality of this natural resource is becoming deteriorated by the uncontrolled amounts of residential wastes generated by humans, discharges from agricultural fields and effluents of industrial plants. Ignorance of these realities not only confines the present human environment but also puts the future creatures to undesirable consequences. Therefore, it is crucial to deal with the issues challenging sustainable water resource management and globally embark on sound and constructive strategies to overcome these catastrophes. Among these strategies, raising public awareness on efficient water usage, natural resources preservation and a shift to renewable water sources needs to be prioritized.

On the local scale, the water resources in Afghanistan have encountered significant and irreversible negative consequences because of the past two and half decades of armed conflict. There are numerous confrontations to be dealt with here, sustainable management of water resources as the most important one. The raising of qualified human resources can strengthen this. It is also the moral responsibility of countries not to benefit from the present inabilities of their neighbors and build their infrastructure by utilizing others resources including water rights.

Key words: Afghanistan, sustainability, water resources management, domestic water management, irrigation water management, industrial water management, ecological water management

1. Background

The three topics of this year’s seminar, “sustainability”, “management” and “water resources” are the most challenging issues of the current century; amongst, the water resources. Water is a precious natural resource that is vital for human dignity, essential for health, well being and a crucial substance for development. It is imperative for maintenance of agricultural productivity and alleviation of poverty and hunger. World industrial development is indebted to this precious resource and the present decorated earth landscape is a fine art product of water.

The trends of world development are closely tied to water. The needs of the present world population and the magnificent agricultural and industrial demands for water demonstrate that water is one of the most crucial commodities. According to Richter et al. (2003), during the 20th century the global human population has increased fourfold, but the withdrawal of water from natural freshwater resources is eightfold. Because of the critical role of water in human life, TSD (2005) predicted if there is a world war in the twenty first century, it would be over water. Kofi Anan noted this threat and advised that “the water resources need not be a source of conflict, instead they can be a means for cooperation”. Acknowledging the importance of water for human life, the United Nations during its 60 years, specified 2 separate international water decades, namely Water and Sanitation (1981–
One commitment of the present water decade is to achieve one of the Millennium Development Goals, i.e. reduce the proportion of people without access to safe drinking water in half and stop unsustainable exploitation of water resources by 2015 (http://www.un.org/waterforlifedecade/). In 2002 the World Summit in Johannesburg added another goal to reduce in half the proportion of people that do not have access to basic sanitation by 2015. However, several challenges are ahead for attainment of this goal, for example, a lack of awareness on the importance of safe drinking water and safe sanitation.

To overcome problems of water scarcity, several countries have strengthened their freshwater with treated wastewater and desalinated water. Bakir (2001) reported that in some of these countries, desalinated and recycled wastewater have reached 20 to 50% of the total water withdrawn from natural resources. He has proposed a shift from the present supply-driven approach to a demand-driven approach as one strategy for increasing water efficiency.

2. Water Resources in Afghanistan

As a landlocked country, Afghanistan is faced with a scarcity of water resources. This scarcity is mainly due to unequal spatial and timely distribution of precipitation. However, as the Ministry of Irrigation, Water Resources and Environment (MIWRE, 2004) has reported, the per capita available surface water in Afghanistan (2480 m³/year) is higher than Iran (1430 m³/capita/year). In Afghanistan 80% of the winter precipitation falls at elevations higher than 2000 m above sea level (asl) in the form of snow. This amount is estimated to be approximately 150 billion m³. The remaining 20% of the annual precipitation (30 billion m³) falls in places lower than 2000 m asl (MIWRE, 2004). From the annual surface water, an estimated 84 billion m³ (47% of the total precipitation) is discharged out of the country.

A study on the hydrogeologic conditions in Afghanistan (Radojicic, 1977) shows that the complex geomorphologic, geologic and tectonic structures of Afghanistan predominate heterogeneous hydrogeologic conditions throughout the country. The geomorphologic features vary from a desert plateau in the southwest (Southern Plain) to the Pamir in the northeastern parts of the country. Geologically, all formations are represented from the achean to the quaternary in Afghanistan. Therefore, almost all kinds of rocks including igneous, metamorphic and sedimentary, as well as all tectonic forms from plate-forms to the most complex foldings and dislocations exist in Afghanistan (Radojicic, 1977).

As shown in Fig. 1, hydro-geologically, Afghanistan is divided into three major groundwater basins. These are namely: Great Southern Basin in the south; Central Highland Region (Hindu Kush Mountain range in central parts) and Northern Plain (Amu Dary Basin). Rodajicic (1977) has studied these regions and provided the following information.

The Great Southern Plain is composed of Eolian sand in its east, Pleistocene-Neogene clay, siltstone, sandstone and tuff in its central and Eolian sand and Pleistocene-Neogene clay, siltstone and sandstone locally conglomerate in its western parts. Because of minimum precipitation and absence of surface water, the aquifers are believed to be low productive and the groundwater brackish to saline.

Highland Region constitutes of the central Hindu Kush mountain ranges starting from Pamir in the northeastern parts to the west; Koh-e-Baba mountain ranges. This region is a hydro-geological complex structure. Various geologic formations, generally very low productive discontinuous aquifers exist in this region.

Northern Plain is located in a narrow belt along the Amu River. In part of this plain fluvial and delta deposits are saturated with fresh groundwater upstream. This aquifer is composed of gravel and sand, downstream mainly of sand. The largest part of the Amu Darya Plain is, however, built up of Eolian sand and Loess (resorted) that either cover or are interstratified with the basin deposited in the central, and proluvial deposits in the marginal piedmont area of the basin. This complex overlies a Neogene series of clay, siltstone, marl and sandstone that primarily also contains gypsum and salt. Drilling in this plain have demonstrated both shallow and deep aquifers with brackish or saline water.

Groundwater forms essential sources of domestic
water supplies and meet agricultural demands. An accurate estimation of discharge and recharge of groundwater sources in Afghanistan is currently unavailable. Water availability for irrigation purposes is dependent on seasonal variation of stream flow. While, the snowmelt and heavy rainfalls result in a significant amount of stream flow in the spring season, a small amount of flow is observed in the late summer where the crop water requirements are high at this time. Nevertheless, by assuming an infiltration rate of 10% for the winter precipitation, the total groundwater recharge in a normal year can be estimated to be approximately 15 billion m³ (MIWRE, 2004).

Land suitable for farming or horticulture in Afghanistan is limited, approximately 10% of the country. More than half of all irrigated arable land lies in the north (the northern foothills and plains of the main Hindu Kush ranges), while most of the remaining irrigated land lies in the Helmand river basin. Wheat cultivation is practiced even on rain-fed agricultural lands of very steep slopes and in the high mountains.

In Afghanistan the water-dependent land cover can be divided into irrigated land, intermittently cultivated land, rain-fed land, rangeland and forest. From a total land area of 382,135 km², 4.08% is covered with irrigated land, 4.31% intermittently cultivated, 11.82% with rain-fed land, 76.36% with rangeland and 3.42% with forest (calculated from data released by MIWRE, 2004). The remaining 212,865 km² of the land areas are mountains and deserts. The percentage of land cover for each watershed in Afghanistan is shown in Fig. 2.

Groundwater quality in Afghanistan depends on the geology of the area. Fresh and saline water exist throughout the country. Saline water is found mainly in the northern region, while bacteriologically contaminated water exists in most urban areas. This is due to the absence of sewage systems in the country, even in Kabul City. This problem is critical especially in congested areas; where discharges of different types of wastes ultimately reach the water bodies. If decisive action is not taken, groundwater pollution in the country will induce a great disaster for the inhabitants of Afghanistan in the future.

Drought and mismanagement of groundwater have caused the water table to drop almost all over the country, including Kabul City. However, Japan International Cooperation Agency (JICA) studying groundwater resources in Kabul as a program of the Ministry of Mines and Industries (MMI) identifies this as vague because of an incomplete feasibility study and lack of a monitoring system (MMI, 2005).

The damages incurred in the production wells of the provinces during the war, have retarded the development of water resources. Moreover, the above-mentioned report has found the agencies cur-
rently involved in groundwater extraction affairs have either technical or operational problems. However, due to the lack of technical knowledge, lack of adequate management and a low level of coordination between theses agencies groundwater development has taken place in an unprofessional manner. The uncontrollable extraction of groundwater in rural areas of the country by the Ministry of Rural Rehabilitation and national and international NGOs are some examples. In addition, apart from engineering-oriented projects, the local communities are exploiting groundwater through use of private well drilling firms that are cheap and available almost everywhere, but have no sound groundwater knowledge. Therefore, groundwater remains as an unresolved issue in the context of the rebuilding of Afghanistan.

In order to launch an integrated water management program in Afghanistan, MIWRE has initiated the River Basin Management (RBM) approach in the country. Under this program, the country is divided into five major river basins; the Amu Darya, Northern, Harirod-Murghab, Helmand and Kabul River Basins. The River Basins in Afghanistan are shown in Fig. 3.

The Amu Darya Basin covers approximately 15.68% of the total land area, but holds about 57% of the water flow (48120 × 10^6 m³); whereas, Helmand with 45.35% of area holds only 11% of the water flow (9300 × 10^6 m³). Kabul River Basin in the east of the country and covers an area of approximately 13.3% and holds about 26% of the water flow (21650 × 10^6 m³). Northern Basin holds 12.26% of the area and drains about 2% of the discharge (1880 × 10^6 m³) and Harirod-Murghab Basin has a coverage area of 13.41% and holds 4% of the discharge (3060 × 10^6 m³). This information is summarized in Table 1.


Sustainable water resources management is the approach for meeting the present water demands without challenging the future needs. It is reported that 5000 km³ of freshwater was used worldwide in 2000. Of this global consumption, about 70% was agricultural consumption, while 20% was industrial and 10% for domestic uses (Bhasker and Nalco, 2004). Therefore, agriculture is the main consumer of water from natural water bodies. However, the percentages of water usage vary between developing and developed countries. Attaining a sustainable water resources management strongly depends on coordination between the major water users; namely, domestic, agricultural, industrial and ecological. This coordination among water
users is shown in Fig. 4.

3.1. Sustainability of Domestic Water Supplies

Water and sanitation along with hygiene education are complements of human health. According to the World Health Report (WHO, 2002), 88% of all diseases in the developing world are related to usage of unsafe drinking water and inadequate sanitation. Unfortunately, more than one billion people are presently without safe drinking water and half of the world population without safe sanitation facilities. Because of this, about 2.2 million people die from diarrhea (water-borne disease) every year; 90% of them children less than 5 years
of age.

In another scenario 300 million people, a large majority are children, suffer from malaria (vector-borne disease) each year. Vectors responsible for transmission of this disease pass part of their lives in stagnant water bodies. Environmental management significantly reduces the spread of this disease. Similarly, trachoma (a water-washed disease) is the leading cause of preventable blindness. An estimated 6 million people suffer from loss of sight and there are about 146 million acute cases worldwide. Improving sanitation and teaching children to wash their faces with clean water can prevent this disease.

As can be realized, all these incidents of human losses and suffering are preventable and economically feasible. The health risks associated with water- and sanitation-related diseases incur economic burden on humans and make them unable to participate in economic activities. Therefore, the absence of safe drinking water and safe sanitation facilities are major contributors of poverty on the earth.

According to MIWRE (2004), the annual volume of water consumed for drinking purposes in Afghanistan is no more than 0.346 billion m$^3$. This amount is less than 1.5% of the total water consumption in the country. It is imperative to note that currently Afghanistan is one of the countries with the lowest safe drinking water coverage. As an average in urban and rural settlements, this coverage was estimated to be only 24.6% in 1999.

3.1.1. Approaches (strategies) toward Sustainable Domestic Water Supply Management

Generally sustainable domestic water supply systems can be attained by a number of interventions. These include adopting policies for water conservation, using non-conventional water sources, water reclamation and recycling, adopting the appropriate water treatment technologies and control of water wastage. These interventions are shown in Chart 1.

3.1.2. Sustainable Water Supply Management Indicators

A sustainable water supply system is generally capable of fulfilling the purpose of its establishment. There are certain indicators by which one can examine the sustainability of domestic water supply systems. Among other indicators, the followings (summarized in Chart 2) can be taken into consideration:

a. National water supply coverage: In Afghanistan, the present domestic water supply coverage is approximately 30%.

b. The mortality and morbidity rates of water-borne diseases: The mortality rate of children under five (mostly due to diarrheal disease) is 257 per 1000 and the infant mortality rate is 189 per 1000 live birth (WHO, 2004).

c. The ratio of water withdrawal compared to the annual recharge at the sources

d. Changes in the level of contaminants in water sources

e. Ratio of recycled water usage compared to the amount of water extracted from the water sources.

3.2. Sustainable Agricultural Water Management

Today more than 250 million ha are irrigated worldwide. This is nearly five times more than at the beginning of the 20th century. TSD (2005) has estimated that in 2030, approximately 14% more water will be withdrawn from the natural water sources than today.

Inappropriate water and agricultural policies and soil or inefficient irrigation management have affected water resources, damaged soils, deteriorated the water quality and have retarded agricultural production. In addition, an increase in crop production is associated with the use of nitrogen, phosphorus and pesticides. All these substances are added as impurities to natural water bodies in the end. If this condition continues, agriculture will be a major cause of environmental degradation over the next 50 years (http: //www.umweltbundes
Based on an FAO (2003) report, Shobair and Alim (2004) also found that presently agriculture is the major water consumer in Afghanistan. In this context, out of approximately 21.91 bcm agricultural water consumption, 19.07 bcm (87.04%) is met by surface sources and 2.89 bcm (12.96%) by groundwater. The total annual groundwater extraction is estimated to be approximately 3 bcm with 2.654 bcm of this used for agriculture. Fig. 5 shows a breakdown of agricultural water that is furnished from groundwater sources.

**3.2.1. Approaches (Strategies) toward Sustainable Irrigation Water Management**

Sustainable irrigation water management can be achieved by the following strategies (shown in Chart 3):
- Sustainable extraction of water from water sources
- Improve water use efficiency
- Introduction of efficient and appropriate methods

**Chart 1.** Sustainable Domestic Water Supply Strategies.
for irrigation such as drip irrigation
- Minimize downstream environmental damages
- Use non-conventional water sources, e.g. water recycling
- Utilize appropriate water treatment technologies, e.g. water desalination
- Put emphasize on rain-fed agriculture with possibilities of limited supplementary irrigation

- Capacity building of farmers for efficient water use

3.2.2. Sustainable Irrigation Water Management Indicators

Cai, et al. (2001) introduced the following indicators for measuring the sustainability of irrigation water management:

a. System reliability (probability of the system success against risks), reversibility (the probability of system recovery from failure) and vulnerability (the severity or magnitude of a system failure).

b. Environmental system integrity (minimizing the interference of irrigation systems with the associated environmental systems).

c. Equity in water sharing (no one should be disadvantaged).

d. Economic acceptability (food self sufficiency achieving net profit over the long term).

In addition, the following measurable indicators (shown in Chart 4) can be used to analyze the sustainability of irrigation water systems:

a. Water use efficiency improvement: In Afghanistan this rate is as low as 25%
b. Release of pollutants with irrigation water discharge

c. Amount of sediments at the downstream discharge from the agricultural lands

d. Ratio of water utilization from non-conventional and conventional sources

e. Percentage of farmer’s awareness for efficient irrigation methods and timing for irrigation

f. Type of irrigation method.

### 3.3. Sustainable Industrial Water Supply Management

Industry extracts fresh natural resources and returns products and wastes back to the environment. Besides diffuse toxic wastes, industry discharges an ever increasing amount of gaseous, liquid and solid pollutants into the air, water and soil, respectively. In the rapidly growing population of the third world, increasing industrial activities imply considerable pressure on the energy and natural resources and results in source depletion, introduces industrial waste into the environment and causes accidents.

According to Bhasker and Nalco (2004), the industrial water demands for industrialized countries (like USA, Germany, France and Canada) are significantly higher than the agricultural demands. However, as was seen, agricultural water is dominant for the developing nations. For example, in India and China, respectively, 93 and 87% of freshwater is used for agriculture, whereas industry currently uses 4% and 7%, respectively.

With regard to industrial water consumption in Afghanistan, at present the country is in a post war era and no major industrial plant is in operation. Therefore, industry cannot be counted as a major water consumer. However, it is estimated that 0.5% of the total fresh water of the country is used for the minor industrial activities.

In summary, the major water consumers in Afghanistan are agriculture, domestic and industry at 98.0%, 1.5% and 0.5%, respectively. The percentages of water consumption for agriculture, domestic and industry in the world, India, China and Afghanistan are shown in Fig. 6.

### 3.3.1. Strategies for Sustainable Industrial Water Management

A sustainable industrial water management can be achieved by observing the following strategies:

- Efficient water usage
- Control of water wastage
- Recycling of treated wastewater
Desalination of sea/saline water

These strategies are shown in Chart 5.

3.3.2. Sustainable Industrial Water Management Indicators

Sustainable industrial water management can be examined through the following indicators (summarized in Chart 6):

a. Ratio of discharge of treated industrial wastewater released into the environment compared to the total amount of water extracted from the water sources

b. Ratio of water extracted from non-conventional water sources compared to the amount extracted from conventional sources

c. Temporal changes in biochemical oxygen demand (BOD), pH and temperature of natural water bodies where the industrial effluents are discharged

d. Annual drop of the water table in production wells in the area where the industrial plants are located

e. Percentage of water loss in the industrial plant

f. Living conditions of fishes and other living species in open water bodies where the industrial effluents are discharged.

3.4. Sustainable Ecosystem Water Supply Management

The importance of water for ecosystem in many countries has only been recognized recently. The
goal of ecological sustainable water management is to protect first, the ecological integrity of the fresh water ecosystem, and second, to meet the inter-generational human needs for fresh water ecosystems.

Ecological integrity is protected when the compositional and structural diversity and natural functioning of the ecosystem is maintained (Richter, et al., 2003). To retain ecological integrity of freshwater systems, certain critical aspects of flow need to be maintained. These aspects include the base flow, regularly recurring higher flows, floods and droughts.

3.4.1. Strategies for Sustainable Ecosystem Water Management

To achieve a sustainable ecosystem water supply, among others, the following approaches (shown in Chart 7) can be followed:

1. Ecological heritage conservation
2. Maintaining ecosystem flow requirements
3. Control the introduction of pollutants into the ecosystem
4. Control other causes of environmental degradation, e.g. soil erosion

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**Chart 6.** Sustainable Industrial Water Supply Indicators.

**Chart 7.** Sustainable Ecosystem Water Supply Strategies.
3.4.2. Sustainable Ecosystem Water Management Indicators

Unfortunately the negative impacts of unsustainable ecosystem water management can only be measured over a long span of time. These long-term negative impacts can only be calibrated by performing an environmental audit. However, the following points can be typical indicators in a relatively short period of time:

1. Degree of ecological integrity in the area
2. Changes in the inter-generational human water requirements
3. Degree of survival of water-dependent species
4. Changes in environmental quality of the area
5. Vulnerability of main environmental elements, e.g., soil, air, water, etc.

These indicators are shown in Chart 8.

4. Challenges ahead of Sustainable Water Resources in Afghanistan

4.1. Weak Water Resources Institutional Infrastructure

The two and half decades of armed conflict started by Russian invasion have imposed numerous negative environmental impacts in Afghanistan. The weak institutional infrastructure as one of the negative impacts has introduced the following consequences on natural water resources:

1. Intrusion of pollutants into water bodies, etc.
2. Flood generation or intensification because of deforestation and prolonged drought
3. Changes of river morphology in the upper stream sites
4. Uncontrolled deep well boring without studies on groundwater recharge mechanism
5. Water resources contamination across the country due to poor solid waste management
6. Usage of Afghanistan water resources by neighboring countries.

Because of the collapse of institutional infrastructure in the country and lack of water resource control, 47% of the surface water of Afghanistan (84000 million m³) flow to the neighboring countries to fulfill their numerous needs MIWRE (2004). According to the above reference, Afghanistan uses only 2 km³ (63.42 m³/sec) from Amu Dary of an annual discharge of 9 km³ (285.39 m³/sec) that it is entitled to use. Only part of the water from the HariRod and Murghab rivers remain within the country, the remaining is used for irrigation or dried up in Turkmenistan. Similarly, the Helmand River originating from the western side of the Paghman Mountains covers about 43% of the territory of the country finally draining into Iran. In addition, the Kabul River with 26% of the mean annual flow crosses the Afghanistan boundary and after irrigating vast agricultural lands in Pakistan, finally is discharged into the Indian Ocean.

4.2. Low awareness on the importance of water resources by the communities

- Low level public awareness regarding the environment in general and the significance of water resources in particular. This is a major barrier for sound utilization of domestic and irrigation water resources.
- Lack of knowledge about the safe usage of pesticides and fertilizers (chemical and animal fertilizers) by farmers.

4.3. Existence of Traditional Irrigation Methods

- Inappropriate methods of irrigation practices, such as ponding and furrow irrigation
- Disregarding crop water requirements in irrigation practices
4.4. Shortage of Human Resources in the Field of Water Resource Conservation and Protection
The long lasting war in Afghanistan has enforced a human resource shortage in the country. This shortage is apparent in all areas from academic institutions to offices and fields.
- Lack of human resources for conducting environmental impact assessments
- Lack of an environmental auditing system in the country

4.5. Impact of long lasting war on Water Resources
- Desertification / flood generation in the country
- Unlawful ownership of water rights by influential personalities
- Degradation of natural resources for which the following impacts can be mentioned:
  - Massive destruction / cutting of trees and intentional burnings of forests,
  - Degradation of rangelands for fuel collection
  - Changing of pastureland to rain-fed cultivation (MIWE, 2004).

5. Conclusions
Sustainability of water sources can be evidenced by:
- Water conservation, water recycling and efficient water usage practices
- Rehabilitation / upgrading of water utilization systems
- Mitigation of environmental problems such as drought and flood disasters
- Recharge of groundwater, natural and artificial
- Keeping balance between groundwater recharge and discharge
- Respecting the water rights of downstream users, including the ecological requirements
- Protection of environmental resources, prevention / reduction of pollution
- Raising public awareness of the importance of water resources and proper usage of water in their daily activities.

6. Recommendations
- Raise awareness of efficient water usage and encourage habitual changes in water users by launching “water education” programs through various communication channels is highly efficient
- For water conservation and enhancement of groundwater recharge, construction of water management infrastructures such as check dams and rain harvesting structures are necessary
- Capture water by making storage reservoirs where the topography is appropriate with consideration for downstream water needs.
- Promote water use from non-conventional water sources, such as rain harvesting, recycling of wastewater and effective use of water for irrigation should be encouraged.
- Make the existing systems more efficient by reforming water management and policies and investing in improved technology and infrastructure
- Limit the usage of groundwater by industrial plants to conserve it for domestic purposes and hence impose limitations on groundwater extraction through laws and regulations and awareness among water users
- Enforce the national by-laws and regulations in connection with watershed protection

Acknowledgments
The author would like to express thanks to Eng. S.S. Shobair, the water expert of FAO, Afghanistan for reviewing the manuscript and giving valuable comments. I would also like to thank Mr. Robert McKinney, the QIP program manager of IOM, Afghanistan, for granting me permission to attend TASAE 2005.

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