Integrated Water Resources Management

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I. INTRODUCTION

Water is always portrayed in the common literature and general wisdom as a precious and priceless substance without which life would not have existed on Earth. Yet it is the same material many frown upon paying for and willingly or unwillingly squander, pollute, and show little regard for its prominent role in maintaining life. The largest share of our water consumption goes unnoticed in food production, industrial processing, and simply as a waste carrier and diluter. The benefits from water resources are not equally distributed among different sectors of society or among successive generations, if current resources are not protected for future use. The fast pace of water resources development over the past few decades has taken its toll on the environment in terms of increased pollution, wetlands destruction, fish stocks depletion, and endangerment of marine life in estuaries.

These complex issues surrounding water use are further amplified by water scarcity in the semi-arid and arid regions of the Arab region. Under these conditions water becomes the most critical factor for socio-economic development. With dramatic rise in demand, water development may have adverse impacts on environmental conditions. Water scarcity has been the norm of life in the Arab region over millennia. The region is the birthplace of the oldest civilizations, which have adapted to these harsh physical conditions by developing efficient irrigation systems that reduce evapotranspiration and maintain a viable and equitable distribution of water resources. The Qanat underground system, the Saqia, and traditional water allocation schemes feature some of the innovations that have lasted to our day (Jagannathan et al., 2009). However, the tremendous growth in population at the onset of the twentieth century has outstripped expansion in water supply brought about by investments in water infrastructure. These conditions have quickly dragged many Arab countries into water poverty that would, if not dealt with timely, impede growth, accentuate poverty, and further increase instability in the region.

Following major drought-induced crises in several developing countries in Africa and Asia that have led to malnutrition and famine, the world community has in response made a critical assessment of the discourse on water resources development and convened in two important summits to introduce the main principles of integrated water resources management (IWRM). Known first as the Dublin water principles in reference to the International Conference on Water and the Environment in Dublin in 1992, they were later refined and incorporated into the agenda adopted by the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, 1992 (Agarwal et al., 2000). With their emphasis on the trio of economic efficiency, social equity, and environmental sustainability the Dublin-Rio water principles still continue to define the central theme of contemporary water resources management. This chapter introduces the paradigm of integrated water resources management and its underlying Dublin-Rio principles and presents a well-established framework for its implementation with emphasis on water resources issues in the Arab region.

II. EVOLVEMENT OF THE IWRM PARADIGM

Management of water resources has made great strides fueled by better understanding of the physical processes driving the water cycle, improvement in data collection and analysis, and advances in the construction industry that enabled developing extensive and complex infrastructure. North America and Europe have witnessed development of mega water infrastructure projects up to the 1960s that supported large irrigation schemes and urban growth fueled by both greater access to water and better flood protection. However, a shift in the cultural attitude towards natural preservation, increased concern for human and land rights for indigenous communities who inhabit affected areas, and a rise in the number of environmental disasters and incidents ignited a powerful environmental movement in the 1970s and 1980s that confronted government developmental policies. These developments have forced many western governments to alter their water resources development policies from those focusing almost exclusively on economic growth to those that strive to achieve social equity and sustainability. The concept of sustainability embodies achieving an optimal socio-economic development of natural resources while maintaining their viability

for use by future generations and preserving their environmental services and natural ecological balance. As a result of these dramatic policy shifts, construction of large dams has ceased completely and several dams were even decommissioned to help re-establish fish populations, such as salmon in the Pacific Northwest of United States. The US Environmental Protection Agency (EPA) holds a veto power over water resources projects, which it has exercised several times to freeze plans for major water projects. More stringent regulatory rules have been established in North America and Europe to stem pollution of surface and groundwater resources.

As indicated earlier, major devastating drought-related disasters have instigated global efforts to develop the Dublin-Rio water principles, which articulate a holistic approach for integrated water resources management as follows (Solanes and Gonzalez-Villarreal, 1999):

- **1st Principle:** Fresh water is a finite and vulnerable resource, essential to sustain life, development, and the environment;
- **2nd Principle:** Water development and management should be based on a participatory approach, involving users, planners, and policy-makers at all levels;
- **3rd Principle:** Women play a central part in the provision, management, and safeguarding of water; and
- **4th Principle:** Water has an economic value in all its competing uses, and should be recognized as an economic good.

The first principle emphasizes the key role of fresh water in maintaining all forms of life and its necessity for socio-economic development. Despite their abundance in certain parts of the world, fresh water resources have limited physical quantity and can be adversely affected by human activities that not only make them unfit for human consumption, but also disturb ecological balance. This principle implicitly calls upon people to take action to protect and preserve these vital resources.

The second principle recognizes the importance of involving all stakeholders in the process of managing water resources. Failing to do so by

dissuading public engagement in decision-making, restraining accountability, and marginalizing the poor would lead to lopsided water allocation and services.

The third principle brings into the spotlight the plight of many women, particularly young girls, in poor underdeveloped countries, who are kept occupied with strenuous water fetching activities that could involve walking several kilometers everyday. Young girls may lose their educational and developmental opportunities as a result. Improving water services and delivery frees up women to take up education and more productive activities.

The fourth principle underscores the economic value of water which tends to be overlooked in setting water management policies in some countries leading to overexploitation and loss of productivity. Pricing water can be a contentious issue in some countries due to cultural and religious considerations. However, setting proper pricing policies can convey to consumers the real value of water and motivate users to treat it as such, driving them to increase their productivity and rationalize their use.

Despite being universally endorsed, the principles provide only a general sketch of IWRM without offering clear definition of how it could be implemented. There is a general agreement that water resources management should strike a balance among economic efficiency, social equity, and environmental sustainability. The World Bank has adopted this approach in a water resources management policy paper published in 1993 and reconfirmed its commitment to IWRM in a recent strategy setting publication (World Bank, 2004). Citing analysis by the Organization for Economic Cooperation and Development (OECD) of the water sector in advanced countries, the World Bank has acknowledged however that putting IWRM into practice is strewn with a multitude of difficulties even in highly developed countries. Chief among these obstacles are inadequate incorporation of environmental issues into other sectoral policies, non-comprehensive water quality standards, inadequate water pricing structures that capture the full economic and environmental value of water, lack of progress in improving water efficiency, lax water demand management, and persistence of subsidies in the agricultural sector (World Bank, 2004).

As a staunch advocate of IWRM, the Global Water Partnership (GWP) has led efforts to translate IWRM concepts into a practical conceptual framework that could be adapted in different country settings. The following sections will draw upon these efforts, as published in Agarwal et al. (2000), to discuss the range of challenges, features, and implementation methodologies of IWRM.

III. ISSUES TO BE ADDRESSED BY IWRM

Managing water resources is a delicate balancing act between meeting demand while maintaining the viability of the resource for future use without jeopardizing the integrity of the environment. Meeting basic human demands constitutes the first objective in utilizing water resources. Although several advanced societies have achieved near completion in meeting these demands, several developing countries are still lagging in securing access to clean water for drinking and sanitation. There are also great disparities among different socio-economic sectors with the well-to-do getting access to low priced, clean water whereas the poor having to contend with over-priced, unreliable, and potentially contaminated water supplies.

In semi-arid and arid regions, water is the critical factor in maintaining a viable agricultural sector which not only produces food but also employs a large segment of the population. Extended droughts can lead to crop failures and loss of livestock which could result in population relocation, epidemics, conflict, malnutrition, and even famine in countries where large segments of the population are engaged in subsistence farming and pastoralisation. For example, extended droughts in the 1980s have plunged the Sub-Saharan countries into several famines that killed hundreds of thousands of people.

Beyond maintaining basic life needs and agriculture, water is a main component in most industrial sectors including production of energy, food processing, and heavy industry. In general, insufficient water supplies preclude socio-economic development and highly

constrained water conditions may lead to general decline in communities.

Variability and uneven distribution of precipitation present challenges for the provision of secure water supplies and flood protection. For example, although Lebanon has an overall positive water balance, its heavily populated coastal cities, particularly Beirut which houses half of Lebanon's population, have insufficient local water resources to meet municipal demands. The inability of the Beirut Municipality to meet the demand of its customers has led to the proliferation of illegal extraction from the local coastal aquifer to supplement demand leading to serious sea water intrusion into the aquifer (Saadeh, 2008).

As an example of the difficulties in managing flood risk in arid regions with sporadic rainfall, major cities in Saudi Arabia are vulnerable to the rare yet very extreme rainfall storms such as the one that Jeddah suffered from in late 2009. The Jeddah disaster was compounded by the lack of capacity of the water drainage network. It is reported that infrastructure designers assumed that the region has very minimum rainfall levels and neglected to account for extreme rainfall events.

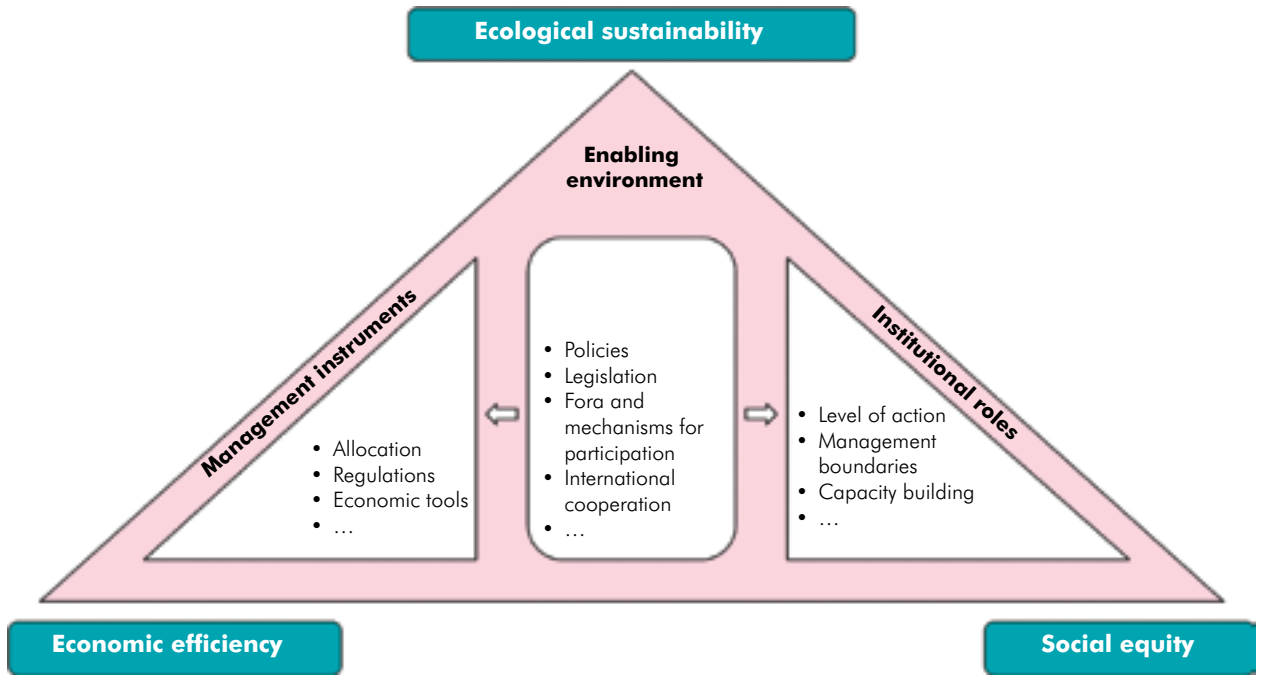
Demographic and socio-economic changes greatly influence water demand, water quality, and ecological conditions. Arab populations are getting more urban and are still expanding at one of the highest rates in the world. Urbanization has caused an increase in both total demand and demand per capita. Urban encroachment on agricultural land, wetlands, and watersheds has disturbed the ecological balance of these ecosystems and increased their exposure to industrial and municipal pollution. The near extermination of fish in the Manzala Lake in Egypt as result of the large inflow of untreated sewage from Cairo (Abbassy et al., 2003) is a stark example of the how rapid growth can conspire to destroy the health of ecosystems and disseminate the livelihoods of their inhabitants. It also underscores the disparity in power between urban and rural populations in managing water resources.

IV. IMPLEMENTATION OF IWRM

As indicated earlier, the Dublin-Rio principles are only general guidelines that leave a significant room for interpretation and implementation. The following sections are based on the widely accepted framework proposed by the GWP, depicted in Figure 1. The three key objectives of IWRM, namely, economic efficiency, social equity, and ecological sustainability are placed to surround a triangle representing implementation components in order to underscore the importance of keeping them incorporated in all implementation decisions and methods. The first objective emphasizes the necessity to optimize water usage particularly under conditions of water scarcity. To avoid placing less influential and poor groups at a disadvantage due to the lack of representation or inability to pay for services, the second objective calls for special provisions or compensation for these groups. Any implementation strategy or tool has to observe rules established by the third objective.

Elements of GWP's framework for IWRM are organized under three main elements: "the enabling environment", "the institutional roles", and "the management instruments" (Agarwal et al., 2000).

FIGURE 1 GLOBAL WATER PARTNERSHIP IWRM FRAMEWORK



Source: Agarwal et al., 2000

The first element represents a compendium of policies, legislation, and regulations available for stakeholders. The second element delineates the roles of different institutional players and stakeholders. The third element constitutes a wider range of tools for regulation, economic optimization, and monitoring.

V. THE ENABLING ENVIRONMENT OF IWRM

IWRM requires a system of policies, laws, regulations, platforms, and mechanisms to support its activities and players. It requires a culture that facilitates and encourages communication and participation of all stakeholders, particularly marginalized groups who tend to be the most affected by it yet have the least say over water resources management decisions.

a. Government role in IWRM

Considering the public nature of water, governments play a key role in its management. Governments are expected to maintain their roles in water policy setting, water supply development, flood control, and conflict arbitration. The emphasis in contemporary water governance is for governments to have a lesser role in the provision of water services, while maintaining a regulatory role. Monitored and controlled by transparent regulations, the private sector can deliver more efficient, reliable, and accountable water services. In situations where governments have to take on the role of service providers, they must take an arm's length approach that separates between regulatory and service provision bodies to maintain transparency and accountability.

Regulations have to specifically consider special provisions to mitigate or prevent the adverse impact of water development and/or water pricing policies on the poor. This is particularly important in large cities which have grown considerably in past decades as rural or displaced populations migrated to its poor neighborhoods or slum areas. As one of the largest cities in the world, Cairo exemplifies how uncontrolled growth has outpaced development of water supply infrastructure leaving many people with no access to fresh water or sanitation. To a lesser degree,

Beirut has mushroomed over the past three decades as hundreds of thousands moved into originally uninhabited and poorly served parts of the city to escape the wrath of Israeli occupation in the eastern and southern parts of the country.

Some have advocated creating water markets as an effective mechanism to achieve optimal use of water resources. Markets are expected to shift water use from low-value to high-value sectors. In practice, inadequate or disparate access to information, ill-defined water rights, risk of monopoly, exclusion of the poor, and underestimation or total neglect of social and environmental values of water create unfavorable conditions for water markets. Governments are expected to develop and implement regulations that control these adverse conditions to facilitate successful water markets.

b. Water legislation for facilitating IWRM

Legislation establishes the powers, responsibilities, and rights of different stakeholders in water resources management. In particular, it gives authority for the government to take action to implement and enforce water regulations. It also clarifies the role of different stakeholders and sets the rules for managing water resources.

Several issues need to be considered in developing a new legislation or updating an existing one. A national water resources policy supportive of IWRM should be in place to lay the ground for developing an effective legislation. The policy should address water as well as non-water sectors in setting up priorities to achieve optimal socio-economic development and environmental protection. It should encourage participation by all stakeholders particularly by setting special provisions for the least dominant groups. Legislation should clearly delineate water rights to protect basic property rights, and to facilitate dispute resolution and efficient water markets. It should also set safeguards against monopoly of water services (Agarwal et al., 2000).

c. Roles and responsibilities in water resources development and investment

There is generally no well-defined delineation between the contribution of public authorities versus the private sector in water resources development and investment. Generally, however, governments are expected to be responsible for developing and managing infrastructure that offers public goods and services such as storage and transfer facilities to manage water variability, uneven distribution, and protection from floods and extended droughts. Moreover, infrastructure projects, such as dams, have long life and cost recovery times and thus it is difficult to attract private funding to finance their construction.

In contrast, municipal water services – water service provision and wastewater collection and treatment- where individual benefits are well defined can be more efficiently developed and managed by private investors. However, privatization of public utilities does not necessarily result in improved and more cost-efficient services. Corruption, inflexible water policies, political interventions, and lack of information can derail or even result in the failure of water services. Moreover, the lack of proper legislation or mechanisms to shield the poor from unaffordable water prices may create great disparities in access to utility services.

d. Coordination among sectors and national watershed/aquifer users

Water plays an important role in different sectors including energy, housing, tourism, and commerce. Consequently, overall planning for water resources should involve different ministries to ensure an optimal allocation of water resources, coordinate public spending on water resources development, and avoid conflicting policies. For example, ministries responsible for urban development, irrigation, and environmental protection should coordinate their policies and activities to ensure an optimal socio-economic and environmental allocation of water resources. In some countries, an atmosphere of counterproductive competition among different ministries may result in an unsustainable management of water resources.

The dynamic nature of water as a fluid flowing within a watershed or an aquifer makes cooperation among different users very critical for its sustainable use. Users of water resources in a watershed or an aquifer should coordinate their activities to ensure a fair and sustainable

allocation of these resources and mitigate potential conflicts. Integrated watershed/aquifer management represents a successful model for managing watersheds or aquifers lying within single national territory. For example the Litani River Authority (LRA) in Lebanon succeeded in securing substantial international funding in 1950s to develop the hydroelectric potential of the upper part of the basin. The LRA hydroelectric system was instrumental in the socio-economic development of the country as it provided over 70% of the country's total electricity requirement up to the mid 1970s. Although the LRA faced substantial difficulties due to the lack of funding, management issues, and extended occupation and civil strife, it is now planning crucial water supply and irrigation projects.

e. *Managing water across national boundaries*

As indicated above, integrated watershed/aquifer management has merits in coordinating efforts at the national level. However as water crosses national boundaries, national sovereignty arises as a major obstacle for productive collaboration. Although international water laws exist for resolving conflicts among riparians, countries are not obliged to abide by them and may choose not to do so if potential resolutions are likely to undermine their current privileges. Zeitoun and Allan (2008) assert that power balance is a determining factor in managing transboundary waters. Though lacking a binding agreement, some initiatives such as the Nile Basin Initiative (NBI) offers a forum for riparian countries to coordinate efforts and exchange information and technical expertise. Although the NBI succeeded in maintaining peaceful conditions in the Nile Basin, it has not yet been successful in helping riparian countries agree on a final treaty.

Despite these obstacles, riparian countries should strive to reach agreements that facilitate sustainable management of shared water resources. Failing to do so would in the long run hurt the interests of all parties not only with respect to the contested-over water resources, but to their overall mutual activities such as trade, tourism, and cultural exchange. Influential independent parties such as the World Bank with its extensive international

influence over water projects financing can play an important role in resolving contentious issues among riparian countries.

VI. WATER MANAGEMENT INSTRUMENTS

Agarwal et al. (2000) provides an extensive overview of established methods and approaches that could be employed in water resources management. They comprise a wide range of instruments used in assessing water resources, regulation, economic management, conflict resolution, communication, and new technology. This section partially covers some of these methods.

a. Assessment of water resources

Assessing water resource involves getting information about their spatio-temporal distribution, quality, and social and environmental services in addition to determination of demand in different sectors, potential development options, and potential issues of conflict. The list of important information varies depending on the focus of development.

Developing an information base is an important prerequisite for reliable assessment of water resources. This task is particularly challenging in Arab countries considering the significant gaps in information that have accumulated over the years, mainly due to assigning lower priorities to data collection and analysis. Evans et al. (2004) describe the Middle East as one of the most "data-sparse" regions in the world. This deficiency has particularly complicated many water research and development efforts in the Arab region. It is imperative that Arab countries invest in monitoring and data collection of water related information.

Understanding and managing social and environmental implications of water resources development is at the core of IWRM. There is a general improvement in the Arab region with respect to consideration of these issues driven mainly by public pressure and the requirement by many international funding agencies, such as the World Bank, to carry out comprehensive environmental impact assessments (EIAs) for water projects as a prerequisite for approval.

Commonly associated with climate change, there is mounting evidence of increased frequency of extreme flooding events (e.g., Saudi Arabia and Algeria), extended droughts (e.g., Syria and North Africa), and outbreaks of violence over scarce water resources (e.g., Darfour). Given the high uncertainty and high consequences of these episodes, they are better handled through a risk management approach that ties investment in mitigation measures to benefits of reducing loss of life and material damage.

b. Regulatory methods

Depending on the method of application, Agarwal et al. (2000) categorize regulatory instruments into three types: direct controls, economic instruments, and self-regulation. Direct controls are those applied by public authorities to dictate or influence the use of water. Governments resort to executive regulations to enforce certain rules such as restrictions on groundwater extraction or discharge of wastewater. Under certain circumstance, especially when dealing with impending crises, executive regulations can be effective and efficient. For example, Jordan has frozen granting permits to the drilling of wells and put a cap on existing ones in the Amman-Zarqa basin in an attempt to stem the dramatic drop in groundwater levels and deterioration of water quality. Despite stiff resistance from powerful landlords, the government imposed heavy fines and imprisonment to enforce the regulations. Interestingly, the dramatic increase in diesel fuel prices, almost an order of magnitude higher from the mid 1990s to 2007, along with government's gradual lifting of fuel subsidies, have further suppressed water extraction (Assaf, 2009).

Establishment of water rights is another direct regulatory method that has been successfully applied in the US and Australia to allocate water for higher value uses. However, water rights are not generally received favorably or regulated properly in most Arab countries, where water is perceived as a public good. Interestingly, well established systems of water rights and trading such as the one in Morocco based on the Jrida - a publically available list of water rights defined in terms of hours of full flow - have been practiced for decades despite the more recent regulations by the government restricting sale by farmers of fresh water to urban users (World Bank, 2007).

ABU DHABI WATER RESOURCES MANAGEMENT MASTER PLAN

Mohamed A. Dawoud

1. Background

Since the 1960s water use in Abu Dhabi has exploded as a result of desert greening policies, and the expansion of agriculture into the lands surrounding traditional oases. Discovery of substantial groundwater reserves at Liwa and between it and Al Ain enabled the expansion of agriculture into formerly desert areas. Large tracts of desert and transportation routes have been afforested. Over the same time period, the population grew exponentially to its current 1.5 million people. While groundwater provided potable water supplies in the 1960s, the subsequent increase in demand for both power and water required the building of large thermal powered co-generation plants.

The rapid growth of the rural and urban economy over the last 48 years has had a profound effect on Abu Dhabi's natural resources. Traditional oases dried up and the small pockets of fresh groundwater that sustained rural and coastal communities were exhausted primarily to satisfy the voracious demand by the agricultural sector. The declining water table has caused the influx of more saline water from lower levels in the aquifer and laterally from surrounding areas. In the near-shore regions of the Gulf, very high withdrawals of seawater for desalination threatens the biodiversity of the marine environment and are contributing to raising sea temperatures – currently amongst the highest in the world.

These concerns are captured in the Plan Abu Dhabi 2030 that provides a vision of a global capital city that puts a high premium on environmental sustainability.

The Abu Dhabi Water Resources Master Plan aims to achieve three objectives:

- Preparing a strategic environmental assessment of the role of water in the Emirate;
- Identifying actions needed in the water sector to restore and protect water ecosystems; and
- Strengthening the structure of water and environmental management.

2. Reform of groundwater use

Agriculture and forestry use two-thirds of Abu Dhabi's renewable groundwater water resources. Neither sector uses the resource efficiently because of extensive support subsidies, including those supporting farm construction, land preparation, and irrigation infrastructure. Electricity and input subsidies reduce running costs while output subsidies guarantee good incomes. These policies have contributed to the rapid development of irrigation, which peaked in 2007.

Forests are exotic in Abu Dhabi's arid desert climate, yet they cover over 300,000 ha of land area and are a source of national pride. While they potentially offer important ecosystem habitats, many are in poor condition and are maintained only through irrigation by brackish groundwater provided at high cost.

There are three strategic options:

- To do nothing and allow the agricultural system to gradually fail over the next 20-40 years;
- To take positive actions to reduce water demand; or
- To meet the demand by agriculture with expensive desalinated water.

Doing nothing is not an option, as it would have important social consequences. Consistent with option 'c', agriculture consumes officially 11% of the country's desalinated water production. In practice the percentage is likely to be far higher. There are no economic or financial analyses to provide an economic justification for this approach. Rigorous analysis following the precedent set by the reform of the date industry under the leadership of HE Sheikh Hamed bin Zayed Al Nahyan could be replicated in other parts of the agricultural sector. Alternatively, the government can adopt progressive policies for agriculture and power and implement option (b). A program to reduce agricultural subsidies should be accelerated. Plans to promote drought-tolerant species should be supported. This could reduce water usage by half. Power consumed in the agricultural sector is very under-priced – farmers pay only 14% of actual electricity costs – and there are sound financial reasons to increase tariffs to recover costs. Tariffs are an effective policy instrument. Global experience shows that a 10% increase in tariffs reduces demand by 4-7%. Thus increasing power tariffs would force farmers to increase water use efficiency and adopt new cropping patterns that use less water – vegetables in preference to field crops. While many farmers may quit farming, the social consequences are better addressed by direct income support programs that are transparent and do not have such unforeseen environmental consequences.

3. Excessive household consumption of water

The latest projections by Abu Dhabi Water and Electricity Company (ADWEC) for peak power demand

indicate existing co-generation capacity will be unable to meet demand for water after 2012. New capacity will be needed unless demand can be reduced. As most desalinated water is produced by co-generation of power and water this will affect the future supply of potable water to meet demand by households, government, commerce, and industry. Consideration of gas supplies and alternative energy sources indicate that stand-alone electricity stations may offer the most flexible solution to meet future demand. And a decision to explore nuclear power generation has been taken. In this sector there are three options to ensure future water supplies:

- Demand reduction.
- Supply augmentation.
- A combination of the two.

Currently only 17% of water is lost in transmission and distribution. With state-of-the-art management this could possibly be reduced to 10% but the marginal cost becomes increasingly high for lower-losses. The technologies to reduce losses are well-known and are being introduced in the Abu Dhabi water supply sector which is among the best-managed and regulated in the Middle East. In terms of meeting demand, leakage reduction programs only delay the demand-supply gap from 2012 until about 2014. Beyond that the supply-demand gap rapidly increases. As with electricity, water tariffs have proved to be an effective instrument to lower demand and they behave in a similar way too. Thus a progressive increase in water tariffs could reduce demand by more than half.

An important finding is that the sewage collection system is very efficient, probably better than 90% at collecting indoor household wastewater. Water tariffs would primarily affect household's outdoor use of water, little of which is captured by the sewerage system. Therefore increasing tariffs will not necessarily lead to a reduction in treated wastewater which is an important water source for landscapes and amenity use.

Turning to supply, recent new water production plants have been large and very costly, typically more than US$2 billion. These lumpy investments take up to six years to come on-line considering design, contracting, and construction. In the absence of demand management there is no choice but to build new capacity. Global best practice indicates that reverse osmosis plants (RO) have significant cost and environmental advantages over the current multi-stage flash (MSF) distillation processes when not used in co-generation. With the national move towards nuclear energy it is suggested that the immediate future strategy should be to fill the demand-supply gap in relatively small increments. Brackish groundwater RO could be run at half the costs of desalinating seawater with RO. Furthermore, it has the additional advantage of generating half to three-quarters less concentrated brine and significantly lower greenhouse gas emissions when power supply is factored in. This proposal will run into fierce opposition because of the vested interests that have monopolized water generation in the Gulf region since the 1960s, and this will require much greater in-depth analysis than has been possible in this Plan. Singapore and Australia provide excellent examples of the economic and environmental advantages of RO.

4. Institutional reform will be necessary

To bring about the proposed changes of this strategic assessment, there is a need to develop the institutional structures of Abu Dhabi emirate in both water and environmental management. The most important recommendation is the creation of a Water Council in Abu Dhabi, which would be responsible for strategic planning and development across all the water sources and users. The present system operates as a series of silos with limited strategic communication between the various major water resources system management groups and user groups. The new Water Council would ensure integrated and coherent water policies in the future. It would provide independent guidance and oversight to come up with the most rational strategy economically for meeting water needs across all water consumers, and ensure that these needs are balanced within possible water and energy supply futures that meet national environmental policy objectives. In tandem with this is the very real need for an environmental regulator. The setting of acceptable standards, regulations, and practices and for exploiting natural resources and controlling waste discharge to the environment is needed to control the impacts of burgeoning developments, including water and energy supplies. Without regulatory oversight, the sustainable use of water and other natural resources will be further compromised in the future with significant deterioration in economic well-being. Additional planning and support for capacity building and for developing the Emirate's human and financial resources for monitoring and enforcement are essential.

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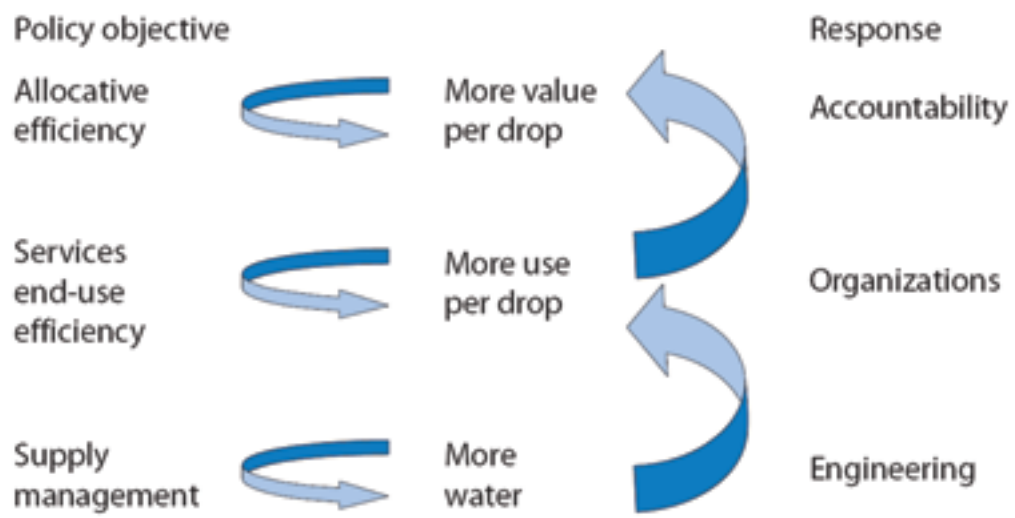
FIGURE 2 MANAGING WATER UNDER PROGRESSIVE SCARCITY



Source: World Bank, 2007

Land use can be regulated to control water use, reduce pollution, and provide social services. Governments in some countries routinely place restrictions on housing or industrial development to prevent pollution of water supplies. For example, Jordan has cordoned off selected areas to prevent pollution of groundwater resources. Egypt has directed urban growth away from its main cities into desert areas to relieve pressure on water supply systems and reduce pollution from sewage disposal.

Although direct regulatory methods are more common, economic instruments are increasingly used to influence users' consumption behavior and provide funds to support administrative costs. Chief among these instruments is setting water prices to recover the full cost of water. Subsidies can be applied to alleviate potential hardship to the poor. Direct subsidies that target poor users through reliable identification are more preferable to across-the-board subsidies since the latter do not encourage water user conservation and may provide inadequate protection to the needy segment. Alternatively or in conjunction with subsidies, a progressive water fee structure can be designed effectively to discourage wasteful use while providing protection to less advantaged groups.

Fees on wastewater discharges can both curtail demand for water and encourage reuse of wastewater. Urban users are typically charged fees for wastewater discharge based on the volume of water used, which would encourage conservation. Interestingly, in places where sewage networks are not available and cesspools are used such as in small villages in Lebanon, Jordan, and the Palestinian territories, water users conserve water to avoid paying heavy fees to private operators for wastewater discharge services. Levies on the quantity and quality of industrial wastewater discharges induce water conservation and reuse.

VII. MEETING THE CHALLENGE OF PROGRESSIVE SCARCITY

The World Bank (2007) argues that managing water resources under scarcity conditions goes through three stages of policy changes and response (
Figure 2). At first, the emphasis will be on securing water supply from resources having the least cost of development. This has been largely achieved in Arab countries which boast the highest global percentage of stored water per renewable water resource (World Bank, 2007). When the most affordable water resources have

been developed, emphasis shifts to develop and strengthen organizations responsible for serving users to optimize use of water at the user level. With mounting scarcity, there is a more urgent need to devise policies to achieve more efficient allocation of water among users. This last and most challenging task requires a transparent institutional system that ensures accountability and creates an atmosphere of trust and confidence between users and policy makers.

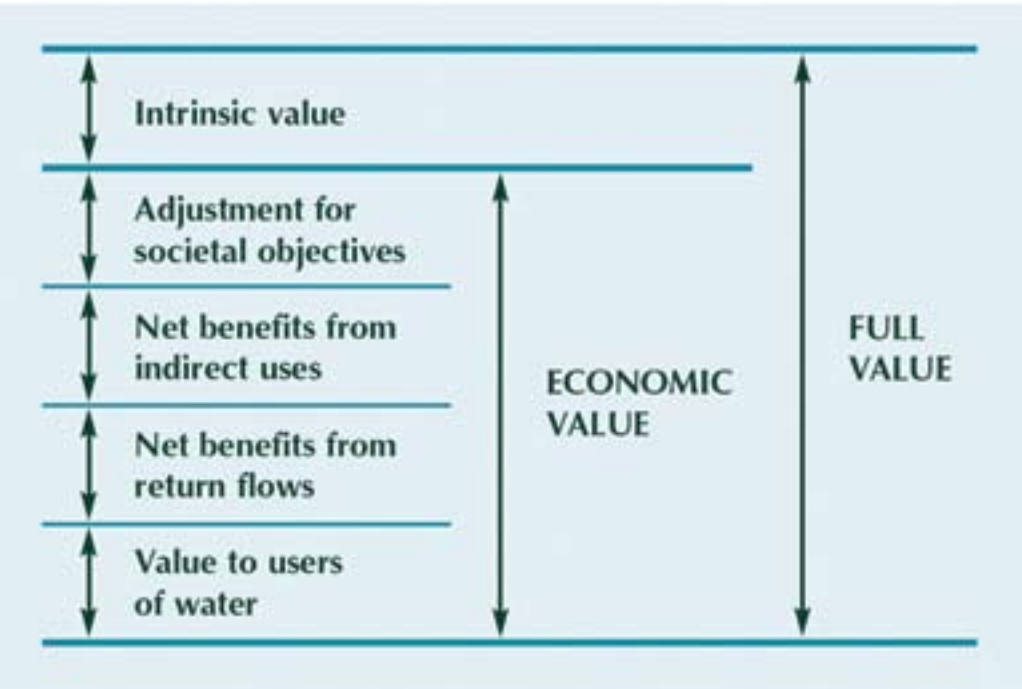
VIII. WATER AS AN ECONOMIC GOOD

The emphasis on water as an economic good reflects a practical reality that financial viability of water services necessitates full cost recovery. Offering water services below their real cost encourages wasteful usage and imposes on society water opportunity costs. Emphasizing the economic worth of water was surrounded with controversy since its application may result in neglecting water's social and environmental role particularly in potentially reducing access of less privileged groups to freshwater and in potentially destroying natural habitats.

To resolve this complex paradox, a differentiation needs to be made between "valuing" and "charging" for water (Agarwal et al., 2000). The value of water relates to its benefit to its users and its own presence. The former can be expressed in economic, i.e., material, terms and is composed of its value to its direct and indirect users, net benefits from return, unused flows, and benefits for social objectives such as helping the poor (Figure 3). Understanding the various components of water value is necessary in setting up policies and measures to optimize uses of water.

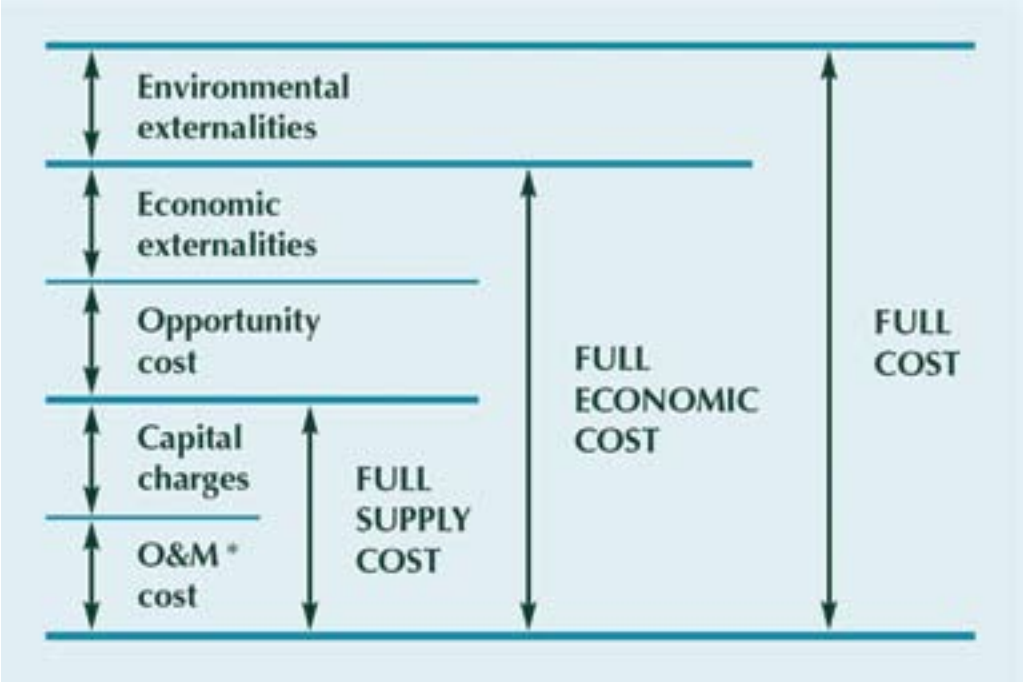
Distinct from its value, the full cost of water relates to the cost of using it. This not only includes capital outlays and the operating and maintenance costs of its extraction, treatment, transfer, distribution, and waste treatment, but also includes opportunity costs – i.e., forfeited benefits from other potential uses – as well as economic and environmental externalities (Figure 4). Economically prudent operation of water services requires that the full cost be retrieved. Failure to achieve this objective results in the failure of privately run operations, or in the case of public utilities, in transfer of payments from

FIGURE 3 THE VALUE OF WATER



Source: Agarwal et al., 2000

FIGURE 4 THE FULL COST OF WATER



Source: Agarwal et al., 2000

government reserves. This is the norm in most Arab countries where water is highly subsidized. In Gulf countries for example, desalinated water is sold at a fraction of its cost. Irrigation water in most Arab countries is highly subsidized, sticking to general policies motivated by achieving food self-sufficiency and supporting agrarian populations.

IX. CASE STUDY – THE SANA'A BASIN WATER RESOURCES MANAGEMENT PROJECT

The Sana'a Basin, home to Yemen's capital, is facing overexploitation of both its surface and groundwater resources. Absolute lack of control over drilling, indiscriminate pollution, and inefficient irrigation practices have taken their toll on the availability and quality of water resources in the Basin (World Bank, 2004). The World Bank is funding a 10-year project that would instigate a dramatic shift in the rural economy to become less water dependant. This will be achieved by integrating land and water resources management, strengthening of legal and institutional frameworks, introducing modern irrigation equipment and methods to improve agricultural efficiency and water productivity, rehabilitating water storage transfer infrastructure to reduce losses and improve efficiency, facilitating public participation in decision make, and capacity building in information management and decision-support systems (World Bank, 2004).

X. STATUS OF IWRM IN THE ARAB REGION

Wagdy and AbuZeid (2006) have reviewed several studies for the Centre for Environment and Development for the Arab Region and Europe (CEDARE) that have examined the progress of IWRM adoption by Arab countries. The studies span over the period from 2000 to 2006. The first study in 2000 indicated that towards the end of the 20th century, Arab countries had started to earnestly consider water demand options after running into serious water shortages that could not be managed through developing the few remaining untapped water resources. Water quality and environmental issues were not yet

adequately addressed. A later study by CEDARE in 2003 pointed to improvement in awareness and support of IWRM at the policy making level as well as increased involvement of stakeholders through the establishment of national water committees and boards (Tunisia and Libya), water users associations (Egypt), and the development of integrated basin management authorities (Algeria) (Wagdy and AbuZeid, 2006).

In 2006, CEDARE conducted a more elaborate survey study based on a questionnaire designed by the Danish Hydraulic Institute in cooperation with the United Nations Environment Programme (UNEP). The questionnaire addresses the status of IWRM in a country including the availability and maturity of national water policies, legislation, and regulations; institutional frameworks, capacity, and constraints; and awareness of IWRM among different stakeholders (Wagdy and AbuZeid, 2006). Responses to the survey indicated that all Arab countries have national water policies, laws, and legislations that support public participation, recognize water as a public property, and do not differentiate based on gender. Despite the incorporation of IWRM in water legislation, the study showed less faith in the effectiveness of water regulations. This was attributed mainly to the lack of awareness among users and officials as well as to weak institutional capacity, and to a lesser extent, to the complexity of regulations and weak enforcement of sanctions.

The study also looked at the main elements of institutional capacity for implementing IWRM. Weak monitoring and lax recovery of costs were deemed the most deficient. To a lesser extent, resource planning, protection, and conservation were assessed to be inadequate. On the positive side, policy formulation, data collection and management, and to a lesser extent water resources and environmental assessments and legislation drafting were considered satisfactory. Several factors were indentified that constrain the development of healthy water resources management institutions. They include inadequate equipment, overlapping in the roles and responsibilities among different institutes, ambiguous mandates, poor governance, and underfunding. The study has also pointed to deficiencies in the levels and relevance of staff training.

Without identifying countries by name, the study indicated that out of the eight countries considered in the study, three have an IWRM action plan, four are in the process of developing a plan, and a single country has no specific plans to design one.

XI. CONCLUSION AND RECOMMENDATIONS

This chapter has provided a general overview of integrated water resources management (IWRM), emphasizing economic efficiency, social equity, and environmental sustainability. It discussed the challenges in implementing IWRM particularly in dealing with water scarcity, and social and environmental issues. The chapter introduced an implementation framework for IWRM as proposed by the Global Water Partnership with emphasis on the Arab region.

Scarcity driven by natural causes, rising demand, and changing climate are the most pressing water challenges to Arab countries. The Arab region has outpaced other regions in the world in developing infrastructure in relation to renewable water resources. Faced by a rising demand outpacing affordable water supplies, Arab countries need to take strong action on strengthening institutional capacity, regulatory systems, and accountability in water resource planning. A more integrated approach involving other non-water sectors should be adopted to prioritize water allocation and to achieve efficiency, while offering protection to the poor and maintaining environmental sustainability.

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