I. NATURAL RESOURCE DEGRADATION IN THE MIDDLE EAST AND NORTH AFRICA

The Middle East and North Africa (MENA) extends from the Atlas Mountains in northwest Africa to the Zagros Mountains in Iran (Figure 1). The region's coastlines border the Atlantic Ocean, the Mediterranean Sea, the Red Sea, and the Indian Ocean and Persian Gulf. The number of countries in the region range from 17 to 21, depending on the political and economic criteria used to define it, and regional statistics vary accordingly.

While the Initiative's five participating countries together accounted for just 11 percent of the Middle East and North Africa region's land area and 33 percent of its population, the issues to be addressed in the Dryland Initiative were characteristic of the region as a whole. High and accelerating population growth and expanding urbanization placed increasing pressure on the scant water resources and fragile soils of the region's drylands, which account for virtually its entire land area. Resource degradation led directly to reduced agricultural productivity and rural incomes across national borders. In a context of severe water scarcity, agriculture accounted for more water use than any other sector in all five countries. The RIDM project sites are shown in Figure 2.

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Figure 1: MENA countries and their drylands.

Source: United Nations Environment Programme. World Atlas of Desertification. Second Edition. London. 1997.

A. Geography, Demography and Economy

The region covers an area of 11.1 million square kilometers, with a population of 311.6 million by the World Bank's estimation in 2005 – including Djibouti and excluding Bahrain, Israel, Kuwait, Qatar, and the United Arab Emirates. The broader definition used by the United Nations placed the region's population at 380 million in 2000. It has the smallest population of any developing region. Yet its population increased 3.7 times over the second half of the twentieth century, the highest rate of population growth of any region in the world during that period of time. The annual population growth rate as of 2004 was 1.7 percent. The five countries that participated in the Initiative have a population density of 81 persons per square kilometer, nearly three times higher than the regional average. Among them, PNA-governed territories had the highest density with 627 persons per square kilometer, and Jordan had the lowest with 63. The PNA also has the highest rate of population growth among Initiative participants at 3.36 percent per year, while Tunisia had the lowest population

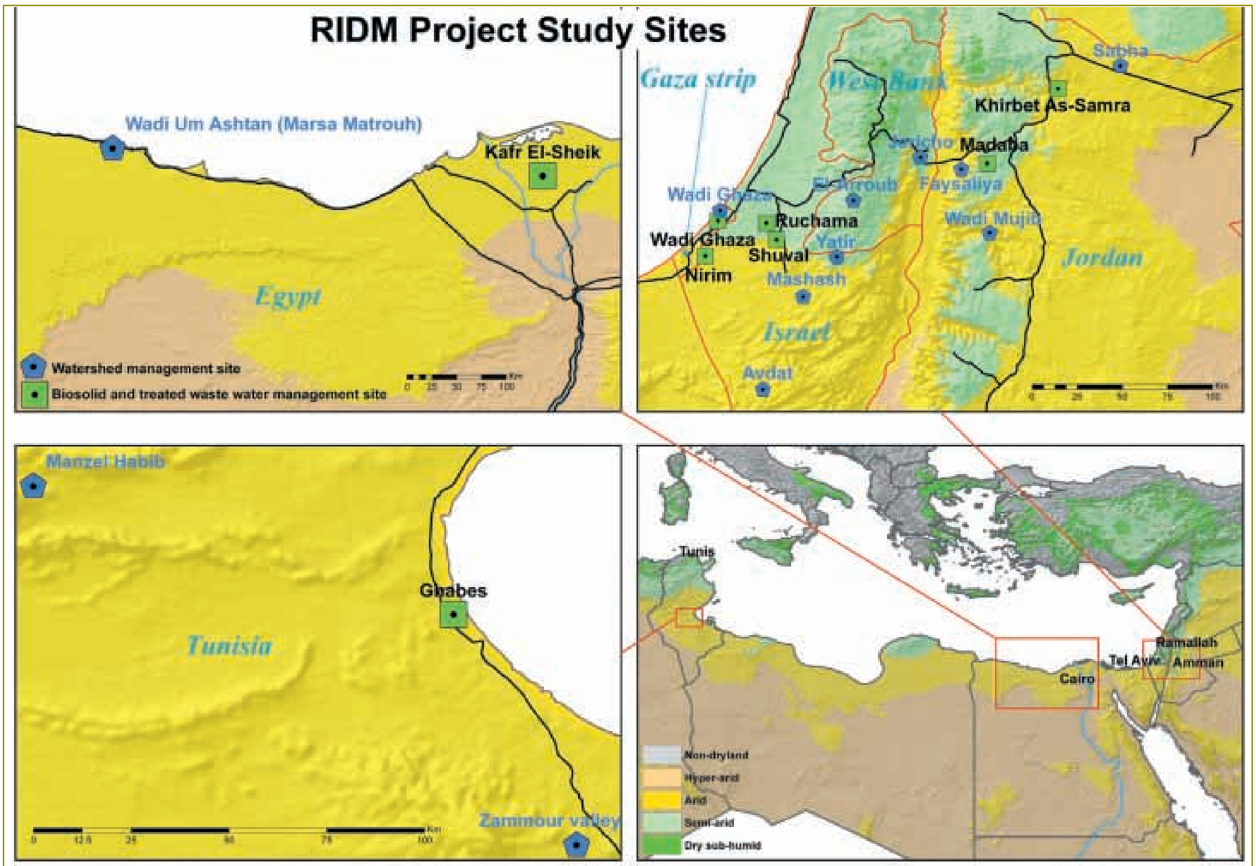

Figure 2: The RIDM countries by dryland zone

growth rate at 0.99 percent per year. The population growth rate among all five countries averages 2 per cent per year as compared to the global average of 1.14 percent, a rate of growth that suggests the great relevance of population issues to the five parties. The implications of high population growth for the natural resource bases of these countries will become clear as this report goes on to describe the climatic and agro-ecological conditions that prevail in Egypt, Israel, Jordan, the Palestinian Territories, and Tunisia.

While MENA accounts for just 5 percent of the world's population, it holds two thirds of the world's known oil reserves and provides more than 50 percent of global crude oil exports. It also accounts for 22 percent of the world's natural gas exports and 40 percent of natural phosphate exports. Its low population combined with this abundance of non-renewable resources goes far in explaining the region's relatively high per capita gross national income, which, at an estimated US$2,240 per person, is second only to Latin America and the Caribbean among developing regions.

The abundance of non-renewable resources stands in stark contrast to the region's scarcity of renewable resources, leaving it deeply dependent on international trade. Some 85 percent of its land area is covered by arid and hyper-arid drylands (Figure 3), and with few large rivers to form fertile plains. Relatively fertile semiarid and dry sub-humid areas account for the remaining 15 percent, enabling MENA to provide 11 percent of global exports of citrus fruits and 8 percent of cotton exports while importing a considerable share of global foodstuffs and manufactured luxury products. Given 5.6 percent economic growth in recent years, among the highest in the developing world, MENA's consumer market is projected to expand substantially in coming years. Its large share of global trade and its geographic disposition linking Africa, Asia, and Europe give the region great economic and geopolitical importance.

The region is socially and economically diverse, and the 5.6 percent aggregate growth rates recorded in 2003 and 2004 conceal enormous disparities. The

Figure 3: Drylands in Northwest Egypt.

highest per capita gross national incomes are heavily concentrated among the region's 10 oil exporters, for example Kuwait at US$16,340. All others, except for Israel, range from $490 (Yemen) to $1,990 (Tunisia). Nor have recent economic booms been broadly experienced within countries, and growth rates projected for MENA countries are not sufficient to address high unemployment. The particularly low overall productivity of drylands carries little or no capacity to support expanding populations, and diminishing agricultural production per capita is a direct cause of much of the region's poverty.

About 40 percent of the region's population lives in rural areas, where poverty rates are often high and acute. In 2001, some 70 million people—23 percent of the region's population—lived on an income of under US$2 a day. Seven million of these people lived on an income of under $1 a day. Rural poverty in MENA is concentrated in rainfed dryland areas, where pastoral livelihoods integrate livestock, principally sheep, with cultivated cereal fodders in seasonal migrations. These migrations may respond to rainfall variability or consist of regular seasonal transhumance. Highland agriculture, producing both rainfed and irrigated cereals and cash crops, commonly entails a vertical seasonal migration of flocks. Small scale agriculture associated with oases and boreholes likewise plays a role in livestock migrations and local trading, and provides additional sources of mainly subsistence-related production. Among Initiative participants pastoral land use patterns and livelihoods underwent significant change over the second half of the twentieth century. Transhumant livestock gave way to more intensive sedentary husbandry with a diversification of income generating livelihood sources, representing a large scale abandonment of nomadic lifestyles. This often placed increased pressure on the natural resource base in the immediate vicinity of the newly sedentary communities.

The expansive traditional rainfed agriculture of seasonal cereals and fruit trees is rapidly giving way to crops like wheat and barley, which receive supplemental irrigation. Summer cash crops like melons, sugar beets, vegetables, and cut flowers depend entirely on irrigation. Large scale irrigation is expanding, enabling intensive production of high value cash and export crops, including fruits, vegetables, cereals, and sugar. In 2001, agricultural land covered 34 percent of the region. 38 percent of this agricultural area was irrigated, the rest was rainfed. Irrigation accounts for some 87 percent of water use in MENA.

B. Land and Water Resources

Drylands are defined as continental areas of low rainfall and high evapotranspiration, with evaporation more than 1.5 times greater than precipitation. When little is precipitated and much of it evaporates, soil moisture is low and becomes the limiting resource of biological productivity. This combination also does not enable perennial rivers to form within drylands. Drylands cover some 41 percent of the earth's land surface, but nearly all of the Middle East and North Africa. They are categorized according to the degree of aridity, from hyper-arid and arid desert drylands, to semi-arid and dry sub-humid non-desert drylands, all four of which are represented in MENA.

Drylands are characterized by high between-year variability and frequent droughts (Figure 4). Water supply from rivers originating outside the region is moreover acutely vulnerable, and is subject to the use and management of river flows upstream. Storage of water to prevent evaporation requires extensive investments in infrastructure and technology. Increased rates of evapotranspiration are projected throughout the MENA region as a result of global warming.

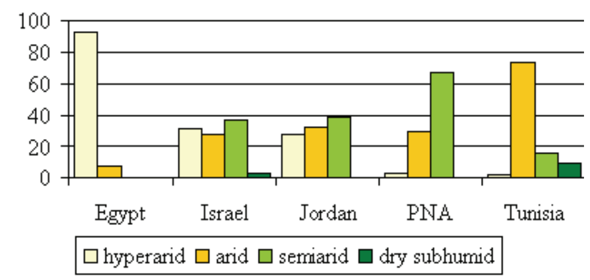

Figure 5: The distribution of aridity in each of the RIDM countries, expressed in the percentage of land belonging to each dryland category.

Among the five countries that participated in the Dryland Initiative, hyper-arid conditions cover the largest area, followed by arid and then semi-arid areas (Figure 6). The relatively fertile dry sub-humid classification applies to just 1 percent of their combined area. Hyper-arid drylands are used as rangelands and support only small populations of pastoralists. Egypt was the most arid country to participate. With 93 percent of its area classified as hyper-arid, the country's biological productivity relies heavily on the Nile River and its delta. 32 percent of Israel's territory and 29 percent of Jordan's are likewise hyper-arid, and there too agricultural cultivation was made possible only by virtue of "subsidized" non-rain water sources, such as the fossil aquifers in the Arava Valley (Figure 5).

Arid and semi-arid drylands predominate within the territories governed by the Palestinian National Authority and in Tunisia – which was the only Initiative partner with sub-humid drylands, covering about 7 percent of the country's area. Israel and Jordan are both roughly equally divided between arid and semi-arid drylands. Mixed pastoral-farming systems prevail in the arid drylands that account for 73 percent of Tunisia's territory, 33 percent of Jordan's, and 7 percent of Egypt's. Farming prevails in the arid drylands of Israel, which account for 28 percent of the country's territory, and in the Palestinian Territories, where arid drylands cover 30 percent of the area governed and semi-arid lands cover 67 percent. Farming also prevails in the semi-arid areas covering 37 percent of Israel, 39 percent of Jordan, and 16 percent of Tunisia. Figure 7 presents the relative size of the dryland categories and the overall land size by country in the five countries that participated in the Initiative.

The process of land degradation and productivity loss in dryland areas is commonly referred to as "desertification." While the rate of desertification region-wide is difficult to quantify, annual soil losses

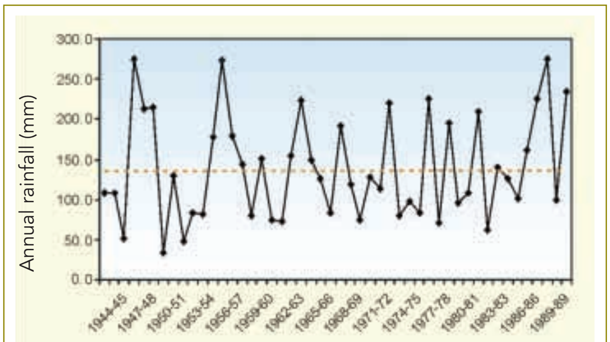

Figure 4: Rainfall Variability
Source: Oweis et al., 2001. Data for Matrouh, Northern Egypt.

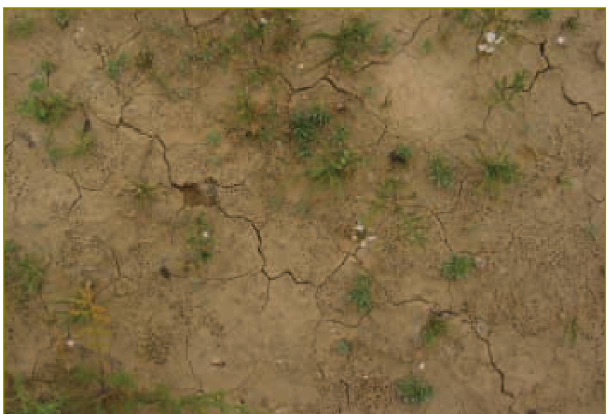

Figure 6: Germination of annual plants – response to first rain in the arid dryland of Israel (loess soil).

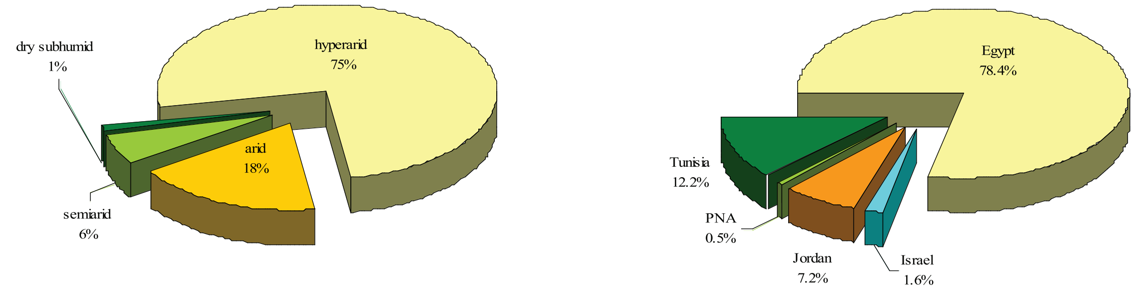

Figure 7: Drylands Initiative land area by aridity classification (left) and by country (right)

of between 5 and 50 tons per hectare, together with related forms of resource base degradation, suggest that some 35 percent of cultivated area in MENA have been affected by degradation over the last 40 to 50 years. Soil erosion is evident in all five countries that participated in the Initiative with widespread overgrazing and unsustainable fuelwood collection in Jordan, the Palestinian Territories, and Tunisia, and soil and water salinization from over-pumping in Egypt, Israel, the PNA, and Tunisia.

Given the preeminence of drylands in MENA, and the region's rapidly growing population, countries here experience the most severe water shortages on earth. The region is home to between 5 and 6 percent of the world's population, but holds only 1 to 1.4 percent of the world's accessible and renewable fresh water. Regional population growth was associated with a reduction in per capita water resources from 3,300 cubic meters per person in 1975 to 1,500 cubic meters in 2001, and is projected to decline further to around 1,000 cubic meters by 2025. Water shortages drive rates of groundwater extraction that actually double average rates of replenishment in a number of MENA countries, often leading to groundwater salinization.

Water availability per capita varies widely among the five countries that took part in the Dryland Initiative. The Gaza strip, which has the highest annual population growth rate (3.77 percent) within the five parties, also has the lowest volume of water per capita at 52 cubic meters per person. Tunisia, which has the lowest population growth rate among the five parties (0.99 percent), has 482 cubic meters of water per person – more than nine times the volume seen in Gaza (Figure 8).

Initiative partners also differ in how available water resources are allocated across sectors. The sectoral allocation of water relates naturally to geography and the role of the respective sectors within the national economy, but the relative size of a country's rural and urban sectors is also highly significant. 56 percent of Egypt's population lives in rural areas and 86 percent of the water used in the country is devoted to agriculture. While a similar proportion of the Palestinian population is rural, a variety of constraints limits the proportion of the available water that is applied to agriculture to just 64 percent (Figure 9).

Water resource utilization also differs by source. Israel, Jordan, and of course Egypt benefit from

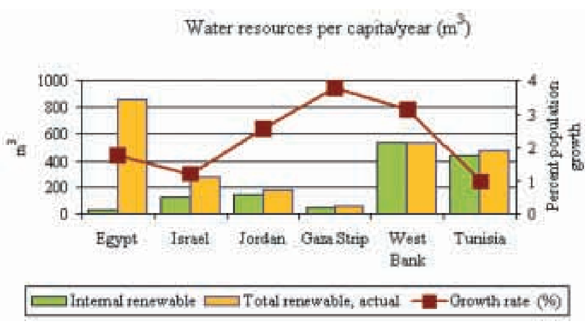

Figure 8: Water resources per person and population growth rate.

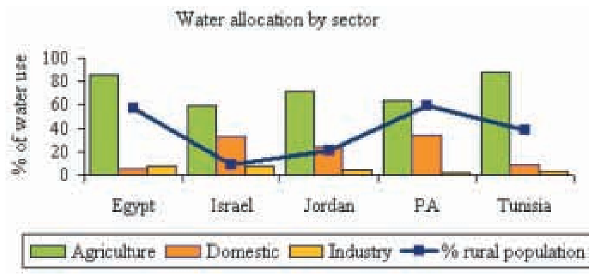

Figure 9: Percentage of water used for agriculture, and domestic and industry purposes, related to the percentage of rural population within each country.

access to water resources that originate externally, flows from the Jordan and Nile rivers. Some 98 percent of Egypt's water supply is provided by the Nile. The scarcity of water in a context of high population growth has driven a succession of historic transitions in all five countries. Pastoral livelihoods give way to farming livelihoods and rainfed agriculture gives way to irrigated agriculture. These processes represent a continuous trend toward intensification in agricultural production and to sedentary livelihoods, leading to more and more sophisticated water resource development.

Water resource development includes the management of trans-boundary rivers, the utilization of groundwater sources, the treatment and reuse of wastewater, and the desalination of brackish and sea water. All these sources have been developed among the Dryland Initiative partners. The management of river flows dates from beyond antiquity to the very dawn of history in the Nile river valley and its sister civilizations along the Tigris and Euphrates, and on a smaller scale along the Jordan River. Elsewhere, increasing dependence on groundwater resources would lead to the development of that resource by Tunisia and the PNA, including non-renewable groundwater resources in Israel and Jordan. The West Bank currently has no access to Jordan River flows and groundwater therefore constitutes 91 percent of its water supply. Increasing reuse of wastewater is now practiced in all five countries in the Initiative, generally for agricultural purposes.

Finally, desalination of seawater is underway in Israel and Jordan, which is generally used for domestic purposes (Figure 10).

In spite of the accelerated development of water resources by the Initiative partners and throughout the MENA region more broadly, rapid population growth in a natural context of low biological and agricultural dryland productivity is likely to lead to further resource depletion. Overgrazing, soil erosion, and depletion of fresh water sources are all expressions of desertification, and all are likely to intensify in the face of growing human population. Water resources decline in quality as well as quantity through salinization and chemical and biological pollution, trends which may be aggravated by wastewater reuse and even by desalination. Groundwater pollution from industrial and domestic waste and fertilizer and pesticide applications is widespread in Israel, the PNA, and Tunisia. Coastal and marine pollution endangers fisheries and tourism in Egypt, Israel, and the PNA. Traditional livelihoods and the knowledge systems that sustained them lose practical relevance in the face of rural unemployment and urbanization, and traditional social structures that once sustained whole cultures are breaking down.

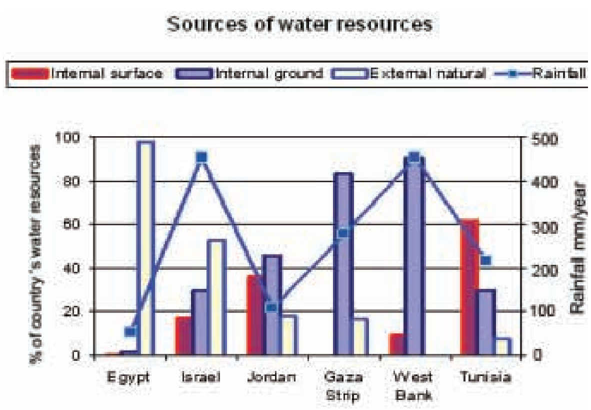

Figure 10: The divergent dependence of RIDM countries on the three natural water resources – surface runoff, groundwater and trans-boundary, external resources, mainly rivers (columns) and rainfall per country (line).

Inappropriate policies, weak governance, and limited institutional capacity among regulatory agencies also contribute to the degradation of MENA's renewable resource base. Water tariffs obscure the resource's scarcity, and together with a range of agricultural subsidies, seriously distort producer incentives – particularly incentives to use sustainable practices and technologies. Weakening of land tenure has a similar effect on incentives to use resources sustainably, and can be linked to both resource degradation and poverty.

Combinations of social, demographic, and economic dynamics have encouraged rapid urbanization, an average annual urban growth rate of 2.7 percent among the region's 25 largest cities – a rate projected to continue until 2010. Urban expansion generally takes place in fertile areas, displacing livestock and farming into less productive lands. Increasing income levels in the cities increases the demand for meat, driving unsustainable intensification of stocking rates on rangelands already approaching or exceeding their capacity to regenerate. Competition for water between urban consumers and agricultural producers becomes increasingly acute. Millennium Ecosystem Assessment projections foretell an ongoing intensification of freshwater scarcity in which the greatest stresses will be experienced in dryland areas, where if left unmitigated, will further exacerbate desertification.[1] The pressures impose critical limitations on the availability of water for either consumption or irrigation, impinging on both rural and urban development particularly in a region in which water scarcity is so endemic (Figure 11). Yet the agricultural sector is the most vulnerable, relying directly on water as the critical production input.

Urban demand—particularly in contexts of prevailing rural poverty—likewise increases pressure to intensify cultivation of crops and fuelwood in areas with inherently low productivity. Intensified cropping entails deep ploughing and irrigation using brackish waters, leading to soil erosion and salinization of croplands. Intensified fuelwood collection and

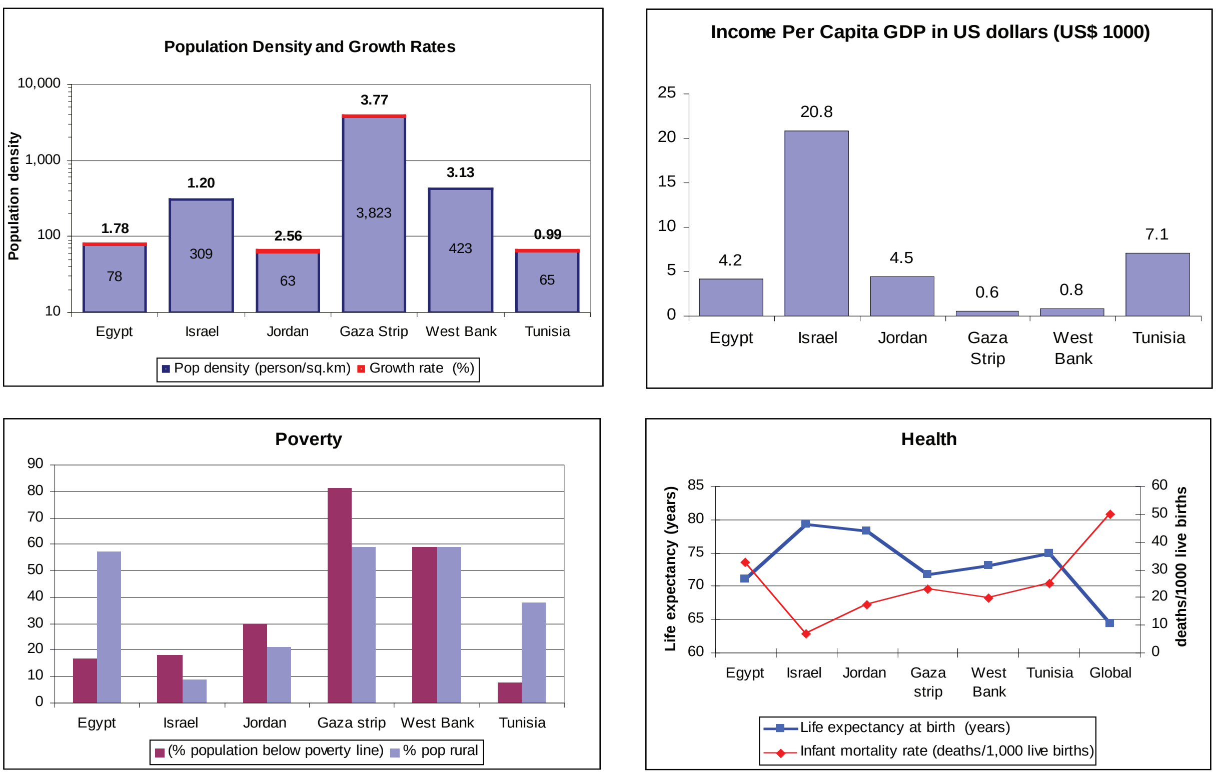

Figure 11: Development Indicators

1. *Millennium Ecosystem Assessment 2005. Ecosystems and Human Well-being: Desertification Synthesis.* World Resource Institute, Washington, DC.

grazing leads to substantial loss of vegetative cover. Forests are rare in drylands generally, and cover just 1.5 percent of MENA's land area, leaving the region with the lowest per capita forest area in the world. Rising demand for wood-based products for construction and infrastructure, as well as for non-timber forest products, brings increasing pressure to bear on the region's overall vegetation.

Recent years have however seen growing international awareness of the role forests and woodlands play in conserving soil fertility, supporting biological diversity, and in carbon sequestration. Their significance to local cultures and as a source of public goods and services is likewise increasingly recognized. Thus, while forests in MENA remain under great pressure, substantial afforestation efforts have been underway in the region, and led to a one tenth of one percent increase in total forest area between 1990 and 2000. Governmental and non-governmental organizations were actively engaged in interventions and policies addressing social and economic conditions that impinged on the environment during the life of the Initiative, and enjoyed substantial support from bilateral and multilateral sources outside the region. Much of this work focused on agriculture and rural development, and is likely to continue given Initiative participants' and supporters' attention to Intergovernmental Panel on Climate Change projections of increasing aridity throughout MENA.

Strategic planning for natural resource management among the five Initiative countries is manifest in integrative national programs that explicitly address degradation issues while establishing compliance with international commitments to sustainable development. In Jordan, national programs tend to focus on the rehabilitation of rangelands. In Tunisia, 580,000 hectares of rangelands were rehabilitated, and 320,000 hectares underwent afforestation under the National Strategy for the Development of the Forestry Sector for 2002-2011, which also includes sand dune rehabilitation. In Israel, 11 percent of the country's land area has undergone afforestation through the Israeli National Plan of Forest and Afforestation implemented by the Jewish National Fund which administers a number of other soil conservation activities as well.

Government agencies are assigned to administer water resource management in all five Initiative countries, though their coordination with land management agencies is often quite weak. The intrinsically close relationship between water and land resource issues in dryland areas makes cooperation between these agencies especially important. An opportunity for improving this cooperation was provided by the UNCCD, which encourages party countries to undertake national action programs (NAPs) to combat desertification. Two Dryland Initiative participants responded to the appeal by issuing such national action programs; Egypt and Tunisia. The Tunisian NAP was introduced in 2000 and implemented by the Ministry of Environment and Land Management. The Plan applied participatory approaches, using trees to fix dunes in restoring rangelands. The Egyptian NAP introduced in 2005 by the Ministry of Agriculture and Land Reclamation, emphasized irrigated agriculture, rangeland rehabilitation, pollution control, and population issues.

The impacts of human activity are by no means new to the Middle East and North Africa or to the areas the Dryland Initiative focused on. Demographic and social pressures, including the effects of political upheaval have a long history throughout MENA. Drylands in the coastal deserts of Egypt and Tunisia almost certainly experienced degradation following the collapse of the Roman Empire. The fall of Rome's successor, the Byzantine Empire, saw desert farming cultures in the highlands of Jordan and the Negev revert to nomadic pastoral land use. The ancient run-off cereal farming and orchard systems based on terraces and cisterns provided the principal sources of livelihoods in rocky-loessial watersheds. Bedouins continue to practice a variation of this agriculture in each Arab country that participated in the Initiative, with smaller scale production of fodders and orchard fruits for local consumption in place of the earlier cultivation of cereal crops for export to old world urban centers. Nomadic pastoral livelihoods persist in a number of areas including grazing lands in Jordan and northwest coastal Egypt. Yet with dramatically increased and still growing populations in the drylands of the Mediterranean Basin, land and water resources are now becoming acutely scarce, often exceeding their carrying capacity.

The linkages between the rural and urban sectors in MENA through rural-urban migration, urban expansion, and competition over scarce water resources require extensive reform of national and regional institutions and policies, as well as advanced technologies, to support the transition to better water conservation and higher efficiency in water use.

Among the challenges facing effective water policy in the region, two are particularly prominent. The first is widespread resistance to local water pricing policies in the most water-scarce countries. The second is a culturally-based aversion to the reuse of treated wastewater and biosolids that is prevalent throughout much of the region (Figure 12). Secure land tenure can similarly reduce pressure on water resources by improving the incentives of farmers and pastoralists to adopt more sustainable forms of cultivation and grazing and more efficient irrigation practices. Increasing farmers' and pastoralists' access to markets is another key factor that can contribute to raising income levels. In order to reach the product quality levels required by many of these markets, farmers need to adopt appropriate knowledge and

Figure 12: Primary / secondary wastewater treatment in Jordan.

technologies, acting within an improved framework of research and development, education, and certified quality assurance systems. In a region where agriculture by far uses the largest share of fresh water resources while some of the scarce water resources are left unused (non-harvested rain water draining to the Mediterranean; unused treated wastewater), adaptations of the agricultural and water policy are urgently required in order to increase available water resources at sustainable levels and to encourage more sustainable land use and increased water-use efficiency.

Poverty and vulnerability to an erratic climate restrain local decisions about how to use resources, compelling land users to focus more strictly on responding to more immediate, short term concerns. The benefits of longer term strategic investments in tree planting and soil conservation take relatively long to become apparent. And without secure tenure, land users have every reason to suspect that they would incur the full costs of any such investments while whatever benefits that eventually result will be enjoyed by others. Even assuming that tenure is reasonably secure, the financial resources required to construct and maintain water storage infrastructure is usually well beyond the means of local communities. Poverty also often rules out the purchase of external energy sources for cooking and for heating during the winter, leaving communities directly dependent on fuelwood collected from the local area. As pressure on those areas increases, the livelihoods that depend most directly on the productivity of those resources are undermined. The degradation of local resources, particularly in a context of rapid population growth, and the deepening of poverty become mutually reinforcing.

C. Controlling Land Degradation

The mechanisms that drive land and natural resource degradation in MENA are relatively well understood, and are essentially the same as those found in other regions. Methods to prevent, arrest, and reverse land degradation are generally available and comprise the subject matter of an existing knowledge base that Dryland Initiative research, experiments, and demonstrations would ultimately add to. Measures for controlling dryland degradation through improved management of water resources can best be described in terms of three concepts: (i) bringing about a net increase to water supply by adding to the water balance; (ii) increasing the efficiency with which water is used, achieving "more crop per drop" through improved technologies including genetic materials; and (iii) reusing existing water, wastewater in particular.

Increasing Water Availability

Water scarcity is the cardinal constraint limiting the biological productivity of dry areas. There are a number of technical approaches to mitigate this constraint as it impinges on the productivity of human activities that rely directly on this larger biological productivity – agriculture and livestock husbandry. The most effective such technical approach is *water transport*, widely practiced within three of the countries that participated in the Dryland Initiative. The Ghor Canal in Jordan and the National Water Carrier in Israel transport water from the semi-arid Sea of Galilee basin to arid drylands in both countries. Canals likewise transport Nile river water to desert areas of Egypt. The treatment of wastewater to be reused in irrigation also entails water transport (mainly from urban to rural areas), but represents a separate approach to water supply given that the treatment processes employed, rather than the transport of water to or from treatment facilities, are the primary focus of investment. Another option is to artificially increase rainfall by *cloud-seeding*, a practice which has been experimented with in Israel and Jordan. All three approaches—water transport, water treatment (and transport), and cloud seeding—are large scale operations that require substantial mobilization of resources nationally and sometimes regionally.

Yet given the region's agro-ecological environment, focusing on local solutions of far smaller scale is generally more appropriate. For even assuming that sufficiently massive financial resources somehow become available to increase the general availability of freshwater resources, and sufficiently detailed regional and international agreements were put in place to govern the activities – large proportions of the rural population in MENA will always rely on inherently limited locally available water resources. Nor could some hypothetical large-scale effort to raise general availability conceivably mitigate the need to reduce losses (through evaporation and runoff) and to increase the efficiency with which water is used locally. Yet in another respect, such local level solutions are not small in scale at all, but warrant substantial coordination across quite large geographic areas in which different uses of available water may come into competition, or be integrated. The most useful concept to apply to these larger water resource bases is the *watershed* – and the *watershed management* provides the most effective overarching framework for coordinating the various water uses in this larger milieu.

Water harvesting techniques (Figure 13) encompass landscape manipulation to redistribute incident

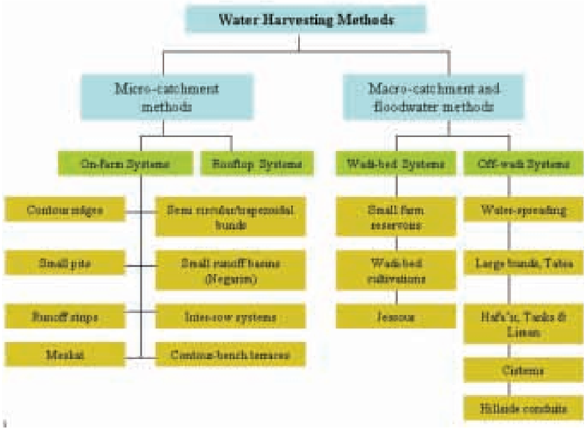

Figure 13: Classification of water-harvesting systems

(From *Indigenous Water Harvesting in West Asia and North Africa*, ICARDA, 2004).

Figure 14: Small runoff basin water-harvesting at ICARDA station, at Tel Hadya, in Aleppo, Syria.

(From Indigenous *Water Harvesting in West Asia and North Africa*, ICARDA, 2004).

rainfall. Rather than being thinly spread over the ground surface with low infiltration and high evaporation–surface rainwater runoff is channeled into *sinks* where penetration deep into the ground prevents its evaporation (Figure 15). The effectiveness with which runoff is captured from the larger contributing area can be augmented by mechanical or chemical *compaction*, by the use of plastic or other impermeable cover, and by protecting the surface against livestock trampling and vehicles. The water storage capacity of the sink can be increased by *ripping* its soil surface to increase infiltration. The area around the sink is planted with trees, field crops, and forages as well as simply being allowed to support indigenous vegetation. Improved vegetative cover protects surface soil from raindrop impact, preventing the development of impermeable soil crust that is characteristic of degraded drylands. The vegetative cover also provides shade, protecting the captured surface water from immediate evaporation.

The means for concentrating the runoff and directing it to the sink are diverse and depend on watershed properties – slopes and soil cover. Rocky surfaces generate runoff quite well, and where they are located in the upper parts of a slope, runoff can be directed with channels and dykes to the lower reaches of the slope, where mini-catchments of different shapes and sizes can be dug and into which the runoff can be directed. On soil-covered surfaces on generally more gently-graded slopes, contour earthen ridges can be hand- or machine-made, forming ditches on their up-slope sides. The inter-ridge areas function as contributing areas, and the ditches function as sinks. Vegetation planted at the upslope flank of the ridge helps stabilize and conserve the ditch, and can be also used as crop or forage. On a steep slope building horizontal terraces supported by stonework is preferable. On the terrace surface mini-catchments, especially for trees, can be constructed (Figure 14). Terraces are also effective in wadi tips and wide channels. The ridges and terraces not only increase soil storage but also prevent destructive runoff to develop and thus conserve soil or even rehabilitate

Figure 15: Harvested rainwater in depressions in Marsa Matrouh, Northern Egypt.

(From Water Harvesting. Indigenous Knowledge for the Future of the Drier Environments. Oweis et al., 2001.)

degraded soils. Finally, depending on local needs and conditions, runoff can also be directed to surface and subsurface reservoir or for recharging springs, in conjunction or instead of being used for promoting soil moisture storage.

Runoff is also harvested during the rainy season for storage in enclosed, sub-surface water reservoirs such as wells and cisterns, and is channeled in subsurface flows to reservoirs from which it is released as springs. The sub-surface reservoirs of harvested water are used mainly in the dry season as drinking water and for irrigating croplands, and they are critical for sustaining livelihoods during years of low rainfall. Locally harvested water is the only source of water for many of the communities and farmers in MENA and within the five countries that participated in the Initiative. Even among those rural settlements that are connected to a government-provided water grid, locally harvested water often plays an important role in production, even if a proportionately less central role in direct human consumption.

Improving Water Use Efficiency

Watershed management packages such as those which would be introduced during the Dryland Initiative must integrate two related elements: techniques for increasing the amount of runoff harvested, and techniques for increasing the efficiency with which the runoff harvested is used on farms and pastures. The two elements are mutually complementary, since the more efficient farming and rangeland management techniques and practices themselves increased water harvesting and storage. The plants used in these activities both improve runoff capture and benefit from its capture. There is moreover a direct relation between runoff harvesting and soil conservation in which improved biological productivity nourishes and stabilizes soils. *Crop production and rangeland management* techniques introduced may be used to prevent land degradation, and to rehabilitate lands that were already degraded.

Watershed management programs that pursue positive social impacts, and poverty reduction in particular, generally select project sites in relatively poor rural areas. In the Middle East and North Africa the livelihoods of a substantial part of local populations in these areas are based on agro-sylvi-pastoral production systems. The pastoral element of these systems is generally very important, and rangelands in the region are only able to serve as pasture during the brief rainy season. During the rest of the year livestock is fed on stored feeds—stubble, hays, and grains—which are produced during the rainy season. The prevailing climatic variations sometimes enable this farming to generate surpluses as well as to support vegetables and other field crops for subsistence and shorter term income generation.

Tree cultivation is another production system that is both enabled by the increased soil water storage achieved by runoff harvesting, and instrumental in soil conservation. Trees are not an annual crop cultivated only during the short rainy season, but rather must survive throughout the year, the dry season included. They cannot therefore be cultivated in drylands where soil moisture depends entirely on the incidence of rain. But where run-off water infiltrates deep into the soil horizon and is there safely stored—as is the case in the sinks of run-off harvesting systems—trees' deep root systems enable them to flourish even in the most arid drylands. Once established, trees are very effective in soil conservation and hence are recommended for rehabilitating degraded drylands. There they are used in the production of fruits (dates, almonds, figs, pistachio, and olives), gums (acacia), forages, fodders, and fuelwood.

Genetic resources and biological diversity. Loss of biological diversity or "biodiversity" is a fundamental concern in drylands that are subject to degradation, particularly when some proportion of indigenous plants and animals are unique to a particular locality. Biodiversity surveys and inventories and the use of genetic resource facilities like gene banks, botanic gardens, and nurseries are therefore essential elements of dryland resource conservation, and perhaps more urgently than in any other ecosystem. In addition to the conservation of local genetic resources, biodiversity specialists can identify exotic, non-endogenous species for introduction based on their adaptive suitability for local conditions and potential for rangeland restoration, crop improvement, and farm diversification. Experiments with the introduction of exotic species must incorporate concerns over species competition and insurance against alien invasive species. More recently, eco-tourism components have been incorporated, providing another channel of economic returns to biodiversity conservation.

Reusing Existing Water: Wastewater, Drainage Water and Biosolids

Wastewater is water that has been used and then disposed of from domestic sources, either urban or rural, as well as from industrial sources. Wastewater treatment is the process of removing pollutants from water that has been used. Treatment of waste is rooted in the early evolution of human settlements and cities, and was institutionalized by the Roman and Greek empires. As of the 19th Century, when pathogenicity was discovered, wastewater treatment focused on minimizing health risks, primarily infectious diseases. More recently, the treatment was broadened to include chronic health risks and environmental concerns. The resource consists of the water itself and the materials it contains - either pollutants to be disposed of, or solids that may serve a useful purpose. The levels of wastewater treatment and technologies used vary widely, but can be generally classified as primary, secondary, and tertiary.

Wastewater, drainage water, and biosolids are resources of particular importance in dryland areas (Figure 16). They increase the general availability of water beyond what is possible through the primary harvesting of freshwater sources, and they can be instrumental in recycling nutrients to build soil fertility. Domestic sewage is a case in point. Its sanitary removal necessarily requires investment in waste disposal facilities. This investment can be modified to serve not only the purpose of discarding materials, but of turning them into a useful resource – and in a region in which that very resource is manifestly scarce.

There are large volumes of "marginal water" within the five Initiative partner countries. Areas of Egypt, Israel, and Jordan contain large subterranean sources of fossil water as well as very slowly renewed brackish groundwater. These are used heavily for agriculture in Israel, and somewhat less so in Jordan. While fossil water is not wastewater, its use in agriculture bears a significant risk of soil salinization. Drainage is another source of marginal water, consisting of excess irrigation water that is polluted with fertilizer and pesticides and typically relatively high in salinity after it has flowed over and leached into irrigated fields. Reuse of drainage water therefore also carries significant risk of soil salinization.

Figure 16: Wastewater (treated): a water resource of increasing importance in dryland areas.

The recycling of treated wastewater and its sludge byproduct addresses both the problem of water shortage and of waste management. These two problems are particularly serious in the Initiative countries, given their population growth, and their proximity to the Mediterranean Sea. Four of the five parties to the Dryland Initiative border the Mediterranean, and all four dump wastewater and sludge into the Sea. This impacts their own marine environment and resources, and violates the Barcelona Convention for the Protection of the Mediterranean Sea against Pollution, to which Egypt, Israel, and Tunisia are signatories.

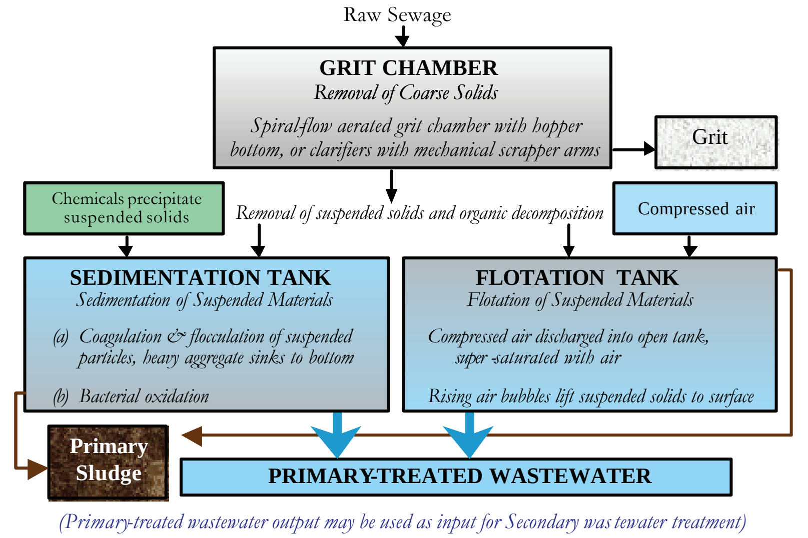

Figure 17: Primary Wastewater Treatment

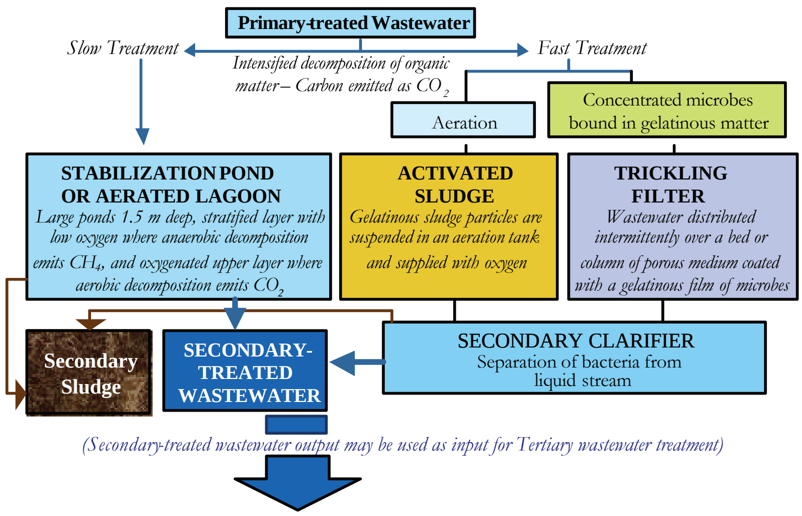

Figure 18: Secondary Wastewater Treatment

Primary treatment (Figure 17) involves removing the largest solids from wastewater and then letting the water settle in tanks so that the smaller solids and particles sink to the bottom. In this way a large proportion of the suspended solids is removed from the water. The solids can then be buried or burned, and the fluid can be released to the environment. *Secondary* wastewater treatment (Figure 18) reduces the amount of organic matter in the water by accelerating natural microbial consumption. This is achieved through aeration or by adding microbes. Bacteria that occur naturally in all moist organic wastes digest (decompose) organic molecules. During the decomposition process the bacteria absorb oxygen with which the organic molecules are oxidized. The carbon in organic matter is oxidized to carbon dioxide, which is released as gas to the atmosphere. The nitrogen and phosphorous components of the organic matter become dissolved nitrates and phosphate minerals. Since this decomposition is driven by oxygen dissolved in the water, the organic content in wastewater is measured by its *biological oxygen demand* (BOD). BOD is routinely monitored to judge the efficiency of the secondary treatment of wastewater. *Tertiary* treatment (Figure 19) removes most chemical compounds from the wastewater. These compounds are mainly nitrogenous and phosphorous. If they remain in high concentration in the released treated wastewater, they encourage growth of photosynthetic micro-organisms in aquatic and moist media. Primary treatment of wastewater typically removes between 25 and 60 percent of suspended solids, and between 60 and 80 percent of minerals and dissolved organic matter. Secondary treatment generally removes between 15 and 40 percent of dissolved organic material and minerals. Tertiary treatment leaves one percent or less of suspended and dissolved organic material, and very low mineral content.

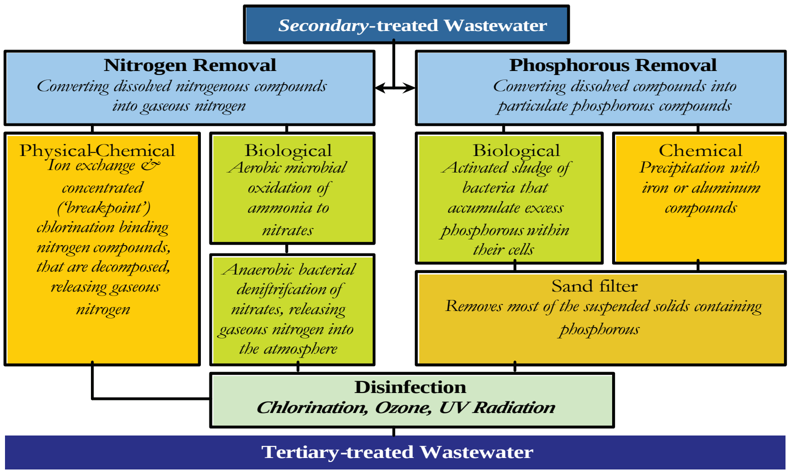

Figure 19: Tertiary Wastewater Treatment

Biosolids are waste of biological origin, and generate serious health and environmental problems. The process of wastewater treatment generates great volumes of bio-solids in the form of sludge. Whereas the water treatment process is mostly engaged with organic matter, sludge accumulates inorganic matter from industrial effluents and other chemicals carried into sewers by storm water runoff from roads and other paved surfaces. These include chemicals toxic to micro-organisms, plants, animals, or people. Sewage sludge also contains pathogenic bacteria, viruses, and protozoa along with other parasitic helminthes, which are also dangerous to humans and other organisms. On the other hand sewage sludge contains nitrogenous minerals (in different concentrations depending on the wastewater treatment level) and phosphorus minerals (usually at concentrations of 50 percent, irrespective of treatment), which are useful for plant growth, as well as organic matter that can increase the water-holding capacity of soils. The availability of the phosphorus content in the year of application is about 50 percent and is independent of any prior sludge treatment.

Sludge can be disposed of or used to improve soils in raw state. Two sludge treatment methods are composting and digestion. *Composting* is a controlled microbial decomposition, encouraged by mechanical mixing, aeration, ventilation, and controlled moisturizing, either in ventilated chambers or in the open air. The high temperature generated by the microbial activity pasteurizes the mixture, which gradually turns into a product quite similar to humus – the fraction of organic matter in the soil resulting from decomposition and mineralization of organic matter. *Digestion* too is a form of microbial decomposition, but is carried out in more anaerobic conditions, often inside of closed tanks known as "digesters." During the process the sludge is first made soluble by enzymes, and then it is fermented by bacteria that reduce it to simple organic acids. These are then microbially converted into methane and carbon dioxide. Digestion reduces organic matter by 45 to 60 percent. In both the composting and the digestion method, the treated sludge is eventually air-dried, by placing it on sand beds in the open or in a greenhouse. The treated, dried sludge can be used as a soil conditioner and crop fertilizer.

II. THE MIDDLE EAST PEACE PROCESS: THE ROOTS AND CONTEXT OF THE DRYLAND INITIATIVE

After decades of Arab-Israeli conflict, the years between 1996 and 2006 saw a variety of undertakings to resolve discord through active cooperation. For some 10 years between 1996 and 2006, the Regional Initiative for Dryland Management (RIDM) (for simplicity will be referred to in this report as the "Dryland Initiative") worked to build bridges of confidence and cooperation between Arab and Israeli technical experts, providing a venue for the creation and exchange of knowledge regarding a subject of common interest; the sustainable management of dryland resources. While the Initiative marked the beginning of technical dialogue and cooperation between Israel and four Arab countries: Egypt, Jordan, the Palestinian Authority, and Tunisia, it was perhaps the least publicized.

A. The Middle East Peace Process and the Conception of the Initiative

In 1978, after three decades of armed conflict between Israel and her Arab neighbors, including four wars, the Camp David Accords paved the way for the first peace agreement between Israel and an Arab country, the Egypt–Israel Peace Treaty the following year. The Accords provided the framework for comprehensive peace negotiations, including negotiations surrounding possible autonomy for Palestinians living in the West Bank and Gaza Strip. More broadly the success of Prime Minister Menachem Begin and Presidents Anwar Sadat and Jimmy Carter in negotiating the Accords established the possibility of normal relations between Israel and Arab countries. The preamble to the Accords expressed the hope that "the vast human and natural resources of the region can be turned to the pursuits of peace so that this area can become a model for coexistence and cooperation." [2]

In the two decades following the Camp David Accords the Arab–Israeli conflict changed substantially, essentially becoming a narrower Israeli–Palestinian conflict. Before the two parties returned to the negotiating table, two major Israeli–Palestinian confrontations would take place during the 1980s: the 1982 war in Lebanon and the first *intifada* beginning in 1987. The environment for negotiation improved following the Gulf War in 1991, with talks between the Arab states, Israel, the Soviet Union, and the United States leading to the Madrid Conference that same year. During the Conference two parallel negotiating tracks would emerge, one bilateral and one multilateral. Bilateral talks would target separate peace treaties between Israel, Jordan, Lebanon, the Palestinians, and Syria. The negotiations with Palestinians targeted interim Palestinian self government in five years, to be followed by negotiations on the permanent status of the West Bank and Gaza Strip. Multilateral negotiations would be carried out by working groups launched in 1992 and devoted to five region-wide issues: arms control, economic development, refugees, water, and the environment. It was the Multilateral Working Group on the Environment (WGE) that would go on to launch the Regional Initiative for Dryland Management.

The Role of the WGE was to identify key environmental problems common to the region and requiring joint action on the part of participating countries. Such joint action was seen as an opportunity to contribute to the peace process through normalized relations and active cooperation – a conception of

2. US Department of State. *Camp David Accords: The Framework for Peace in the Middle East,* September 17, 1978.

'peace' considerably more ambitious than simply an avoidance of war. Several areas of prospective cooperation suggested themselves to the Working Group: oil spills in the upper Gulf of Aqaba, environmentally sound uses of pesticides, and – in line with the then ongoing negotiations that would lead to the creation of the United Nations Convention to Combat Desertification (UNCCD) – dryland degradation. The Working Group was chaired by the government of Japan, and during its third meeting held in Tokyo in May 1993, began developing a proposal identifying desertification as a cross-boundary problem requiring regional cooperation. The proposal was presented and discussed at the Working Group's fourth meeting held in Cairo in November 1993, where Egyptian, Jordanian, Palestinian, and Tunisian delegations agreed to treat degradation-sensitive land management as a theme for technical cooperation with Israel. A series of meetings between technical experts from the five countries ensued between December 1993 and May 1994, and it was during these meetings that a program for the Regional Initiative was developed.

The development of the Initiative's program following the fourth meeting of the Working Group took place in the wake of the Oslo Accords of September 1993, in which Israeli and Palestinian negotiators committed themselves to the Declaration of Principles (DOP) (Figure 20). By this agreement, Israel recognized the Palestine Liberation Organization (PLO) as the representative of the Palestinian people in subsequent peace negotiations, and the PLO recognized the right of Israel to exist in peace and security. The agreement provided for a transitional five year period of Palestinian self-government in the West Bank and Gaza Strip, and for establishing a Palestinian National Authority (PNA) with an elected Palestinian Legislative Council. The completion of the Initiative program document by a joint team of the prospective Initiative's Regional Experts in May

Figure 20: Arafat and Rabin shake hands after signing the Palestinian-Israeli Peace Accord, September 13, 1993. (from left – Yitzhak Rabin, Bill Clinton, Yasser Arafat).

1994 coincided with the transfer of Gaza and Jericho from Israeli to Palestinian self-rule, in compliance with the DOP-inspired Interim Agreement which set forth the future relations between Israel and the PNA.

Additional positive developments in the peace process took place during the period between the completion of the Initiative's program and its adoption by the Working Group in October 1994, effectively stimulating international financial support for the project. A number of significant developments took place while members of the Working Group—the regional parties, the International Center for Agricultural Research in the Dry Areas (ICARDA), and the World Bank—negotiated modes of operation and funding for the Initiative. The first public meeting between King Hussein and Prime Minister Rabin took place in Washington in July 1994 and led to the Israel–Jordan peace treaty which was signed the following October. The treaty included annexes on cooperation in environmental protection, water, and agriculture. In September 1994 the Israeli-Palestinian Interim Agreement on the West Bank and the Gaza Strip was signed in Washington, setting the stage for broadening Palestinian self-government to proceed until May 1999, when a permanent status agreement was to be negotiated. This timetable was intended to provide for a period of gradual reduction in the friction between Israelis and Palestinians, while promoting channels for cooperation and peaceful coexistence. When the sixth meeting of the Working Group convened in Bahrain in October 1994 to adopt the Initiative program—the "Bahrain document"—it became clear that the Initiative was to be implemented during this period set by the Interim Agreement. Preparations for the implementation of the Initiative following the adoption of the Bahrain document benefited from the gradual implementation of the Israeli-Palestinian Interim Agreement.

B. Implementation of the Peace Agreements and the Birth of the Initiative

As preparations to launch the Initiative progressed, the peace process deteriorated ominously and the favorable political climate that had prevailed in 1995 gave way to renewed conflict. Israelis and Palestinians exchanged mutual accusations of breached agreements. These developments seriously undermined the multilateral track of negotiations, which stalled as the Arab League endorsed formal suspension of Arab participation in the Working Group on the Environment in 1997.

The Dryland Initiative itself was formally launched in August 1996, two months after the election of Israeli Prime Minister Binyamin Netanyahu and seven months after the election of Palestinian National Authority President Yasser Arafat. As these political developments unfolded the five countries participating in the Initiative, ICARDA, and the World Bank worked to define the components of the Initiative. Seed money for project preparation was provided by Japan and the World Bank. A *Facilitation Unit* was established and based at the ICARDA office in Cairo. The Unit was headed by an International Facilitator appointed by ICARDA. In two seminal meetings of the five Regional Experts held in Cairo and Amman, elements of the program were consolidated.

The first sign of the effects of the worsening political atmosphere on the Initiative, however, had became evident in the inability to convene the scheduled first technical thematic meeting of the Initiative in Israel. A series of four such technical meetings had been intended to finalize the plans for the Regional Support Programs the respective parties would be responsible for coordinating. The first such meeting was to be held in Israel to finalize the *Economic Forestry and Orchards* program that Israel had been assigned to coordinate. The meeting was cancelled when it became clear that none of the Arab experts could attend. The three other programs, to be coordinated by Egypt, Jordan, and Tunisia, were finalized in three regional workshops held in those countries in May and June 1996. Though Israeli teams actively participated in these regional workshops, the program for the *Economic Forestry* theme was prepared by Israel alone. While all four programs were subsequently approved by the Initiative's Steering Committee in Paris in July 1996, the unavoidable deviation from mutual Arab and Israeli cooperation just prior to the Initiative's kickoff in August 1996 would set the tone of interaction for years to follow.

C. The Ups and Downs of the Peace Process during the Life of the Initiative

Political upheavals severely affected the cooperation planned for the Initiative, and yet neither these upheavals nor funding problems prevented the Initiative from becoming operational in August 1996. The disagreements that would disrupt the peace process during the first four years (Phase I) of the Initiative escalated repeatedly into armed conflict and generated repercussions throughout the Arab world that would seriously impinge upon the

Initiative. In March 1997 the Arab League passed a resolution to ban Arab participation in all multilateral negotiations, and three years later announced a boycott of all international scientific conferences held in Israel. These resolutions prevented Arab partners from visiting Israel – however essential such visits were to the Initiative's own program. Between outbreaks of acute conflict, the first years of the Initiative saw several rounds of negotiations resulting in promising agreements like the 1997 Israel-PLO Protocol Concerning Redeployment in Hebron, the 1998 Israel-PLO Wye River Memorandum, and the September 1999 Sharm el-Sheikh Agreement.

The changing political environment would oblige a more cautious and pragmatic program for cooperation under Phase II, relative to the ambitious design of Phase I which had been conceived in the optimistic period following the Madrid talks and Oslo Accords. The Phase II program was purposefully less bold both with respect to its technical and its political aspirations, such as to assure greater resilience to the vicissitudes of the peace process. The transition between the two phases enjoyed a relatively peaceful and promising lull in the region's violence. Planning for Phase II took place as negotiations were reopened to determine the permanent status of the West Bank and Gaza Strip in September 2000 after a three year hiatus, and as Israel unilaterally withdrew its forces from southern Lebanon. A regional meeting held in October 1999 was the first to be held in Israel and saw nearly full attendance of the participating countries. The meeting was followed by a traveling workshop in which all Phase I sites were jointly visited by members of all five national teams. A final planning workshop in Sharm El Sheikh in February 2000 led directly to the launching of the second phase of the Initiative now shortened to "The Regional Initiative for Dryland Management" (RIDM), in June 2000. The following month saw negotiations on permanent status culminate in the July 2000 Camp David Summit between President Arafat, Prime Minister Barak, and President Clinton. Two months later however the process was derailed as the second *intifada* broke out in September, just as the first Initiative workshop to be hosted by the Palestinian team was being held in Hebron. The workshop in Hebron was attended by all teams, including the Israelis. Phase II would cover a period characterized by widespread violence in the West Bank and Gaza and a series of futile talks including the Taba negotiations in 2001. Hebron would be the only Initiative workshop to be carried out within the five countries during the life of Phase II. The final year of Phase II would see the now defunct Oslo Accords implicitly replaced with the *Roadmap* for resolving the Israeli–Palestinian conflict through a two state solution. The *Roadmap* was proposed by the EU, Russia, UN, and US in April 2003 and accepted by both sides the following month.

An extension of Phase II was recommended by an external review which assessed the Phase II experience. The recommendation was endorsed by the Initiative's Steering Committee in 2003. This "extension of Phase II" became generally referred to as the "Extension Phase" of the Initiative, given its revisions to the Phase II program – these too based on recommendations of the external review. The Extension Phase would be more demanding in its technical aspirations than either of the two preceding phases. It was also more realistic regarding cooperation, increasing the number and diversity of direct interactive activities, while allowing meetings to be held outside the region if need be to ensure the participation of all five partners. The Extension phase was launched in June 2003, coinciding with the Middle East Summit in Aqaba that was hosted by Jordanian King Abdullah II and attended by Israeli Prime Minister Ariel Sharon, Palestinian President Mahmoud Abbas, and U.S. President George Bush. The Summit took place during the *hudna* or cease-fire announced by the Fatah, Hamas, and Islamic Jihad, and once again raised hopes that cooperation within the Initiative might be reinvigorated during this, the final stage of its 10 year life. Once again however such hopes were disappointed as the *hudna* was shattered in September 2003.

In February 2005, Egyptian President Hosni Mubarak hosted a summit meeting in Sharm el-Sheikh, attended by President Abbas, King Abdullah, and Prime Minister Sharon in which measures for ending violence and implementing the *Roadmap* were elaborated. In May 2005 former World Bank President James Wolfensohn was appointed coordinator of the EU-Russia-UN-US "Quartet" for the *Disengagement Plan* by which all Israeli settlements and military personnel were evacuated from the Gaza Strip and sections of the West Bank, thus ending 38 years of occupation.

Political turmoil and periodic, often protracted conflict, impinged on the regional cooperation under the Dryland Initiative. This regional cooperation, however, was maintained at a minimum level throughout the entire 10-year lifetime of the Initiative and the ups and downs of the Middle East peace process. Regular external reviews provided the occasion and analytical substance to adjust the structure and work program of the Initiative to reflect the changing environment in which the Initiative was being implemented.