STATE OF THE WATER REPORT
in the Arab Region

CEDARE
سيداري

المجلس العربي للمياه
Arab Water Council

December 2004

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Foreword

In no other region of the world has water availability played such a dominating role in determining human activities, settlement, socio-economic interactions and growth, as it did in the Arab region. Limited water resources in this region is an overwhelming condition, making 90% of the region classified as arid and hyper-arid. Per capita consumption rates are the lowest in the world, but municipal and industrial water requirements are expected to double and triple over the next years. Projections for the coming decades indicate that the whole region will suffer from water scarcity, and a water barrier may prevent any further socio-economic development.

The existence of reliable information, and dependable assessment of water resources is a prerequisite for proper water management, successful development plans and correctly guided decision making processes. With the aim of providing a base for flourishing water resources planning, and furnishing a vision for the water resources development, this report on the State of the Water was prepared.

This report presents the country level water resources assessment for the Arab region, together with the methodology applied. The assessment is the first to take into account the concepts of green water and blue water with green water being the amount of rain water that is utilized directly by forests, rainfed agriculture, and green cover pasture land. This report recognizes the fact that in areas where green water exists, urban development are transform green water into blue water through increased runoff. It also sheds the light on the water needs and water utilization in each Arab country.

The assessment is deemed imperative to enhance the knowledge on the state of the water in the Arab region and to help recognize the critical need for a dynamic programme to assess and deal with declining supply versus the growing demand through developing integrated water resources management plans.

I would like to encourage the reader of this report to appreciate the forms of water that we have unintentionally been ignoring, and the potential that could be realized from water resources. The attempts being made in this report at assessing the water supply and sanitation services coverage provides a starting point for monitoring our progress towards achieving the water related Millennium Development Goals.

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Preface

Scarce freshwater resources are the top priority of concern in the Arab Region, which in general is characterized by harsh climatic conditions, in particular low average rainfall as compared with the overall yearly average all over the world, higher summer temperatures and high evaporation and transpiration rates, all of which tend to produce repeated drought and increased desertification.

Groundwater resources play a major role in satisfying the growing water demand in the Region. In general, easily accessible groundwater resources in the Region are over-exploited which risks the sustainability of this resource. Several Arab countries use non-conventional water sources to meet water demands. These include desalination and reuse of treated municipal wastewater. However, the extent of use is still limited.

Major water quality problems in the Arab countries include: high salinity of non-perennial rivers, high Total Suspended Solids in rivers during the peak flows, and pollution in localized groundwater sites.

This publication presents a description of the state of the water in the 22 Arab countries, together with relevant maps with particular emphasis on the water balance in each country. A new approach of water assessment is introduced in this study to take into account the water used for rain fed agriculture, pasture, and forests.

It is hoped that the information provided here will be useful for those who are working in the field of Water Resources Management in the region.

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EXECUTIVE SUMMARY

Amongst all the renewable natural resources of the world, ***Fresh Water*** is the mere and sole resource upon which the existence of life depends. Be it in the form of stream flow, groundwater, soil moisture, or atmospheric water vapour, fresh water presents potential livelihood to the different forms of life. Water resources, although globally abundant, are distributed in pronounced uneven patterns throughout the globe. Global renewable surface and groundwater resources amount for an average annual share of 7500 m^3/capita for year 2000, had these resources been evenly distributed throughout the land. The greatest water availability is estimated at 170 - 180 thousand m^3 per capita for 1995 is in the regions of Canada with Alaska and in Oceania. At the same time, in the north of Africa and on the Arabian Peninsula, it is as much as 200 - 300 m^3 per capita per year of renewable resources.

In no other region of the world has water availability played such a dominating role in determining human activities, settlement, socio-economic interactions and growth, as it did in the Arab Region. The Nile River hosts one of the greatest early civilizations on Earth, and similarly does the Euphrates and Tigris rivers. The ancient Yemen civilization is closely tied to water resources availability, and its declination is historically related to the destruction of the ancient Maareb Dam. The history of Holly Makka starts at the incidence of revelation of Zamzam well for Prophet Ismail, peace be upon him.

More than 85% of the Arab Region is classified as arid and hyper-arid, receiving an average annual rainfall of less than 250 mm. Since the onset of the third millennium, almost the whole region is suffering from water scarcity, and a water barrier is liable to prevent any further socio-economic development. Competition for the limited supplies may result in potential and serious conflicts. In 2002 at the World Summit on Sustainable Development held in Johannesburg, the international community called for all countries to develop integrated water resource management and water efficiency plans by 2005. These future development plans for the Arab Region have to be balanced between proper water supply management and demand-oriented water management within a sustainable development prospective. Moreover, such plans shall address inter-sectoral integration, institutional and legislative reforms, financial sustainability, and holistic water management. Regional cooperation is a must to confront serious challenges to development of the region. In all conditions, the success potential for these plans greatly depends on the existence and reliability of the information, data, and statistics pertaining to the water resources status at the region.

A systematic methodology for water resources assessment is proposed and followed throughout this report. Regional and national coverage for precipitation, land use, soil holding capacities, and solar radiation are compiled and processed. Data pertaining to rainfall, stream flows, groundwater recharge, shared rivers and aquifers, sectoral demands, water supply / sanitation coverage, and non conventional water resources are compiled from different sources and compared. The water balance for each nation is calculated while considering all different water utilization. The results are presented in tables for the region and each individual country, in addition to GIS coverage layers for the different parameters for each country. Data sources include FAO, WRI, DCW, UNESCO, CEDARE, and several country reports. Most of the data are, currently, relevant to year 2000.

It is crucial to note that the **availability** of fresh water resources is jointly governed by hydro-climatologically features as well as population densities and geographic distributions. Other important parameters in defining the national status of water resources include water quality, accessibility, and reliability of water supply. An essential distinction has to be made between the ***water potential yield*** and the ***water development potential***. The former refers to the availability of water resources whether it is stream flows, groundwater reservoirs, or directly exploited atmospheric water (necessary to produce natural vegetation/forest covers). The **water potential yield** is readily defined in many sources as internal (or actual) renewable (or non-renewable), or merely available, water resources. These figures are used in calculating per capita shares, defining water stress and water scarcity limits, …etc. On the other hand, the **water development potential** takes into account the dependability of the flow, time and spatial distributions, feasibility of extraction of groundwater, and the availability of surface water post floods, navigation considerations, environmental and aquatic life minimum requirements. This figure is not yet clearly defined in most water resources assessment assignments.

The proposed assessment methodology comprises selection of representative ***parameters*** for water supply, demand, utilization, availability, variability, accessibility, and quality. Moreover, ***standardized processes*** for monitoring and processing these parameters have to be identified and unified. The parameters will be used to define a complete set of *indicators* describing the water potential yield (abundance / scarcity), water development potential (adequacy / deficiency), dependency, resource management efficiency, sustainability, history of utilization, short / long term implications of sectorial water allocation, and finally the overall vulnerability to water shortages and crises. It is hoped that such *model* would gain a collaborate consensus and act as a fair and valuable tool for design, evaluation and resolution of conflicts associated with water resources. The full application of the assessment methodology requires additional data and further processing, which are not currently available. Nevertheless, this report presents the launching of the assessment process which is of dynamic nature and has to be updated annually to include new data and up to date measurements required for satisfying the different assessment components. Currently, an information system for the Arab Region, based on the assessment results is hosted at CEDARE and is limited to the available data. A great deal of input is expected from the different nations, in the near future in order to complete this very first draft of the water resources assessment for the Arab Region.

Overall, the Arab Region renewable freshwater availability is estimated at about 338 Km^3/year. More than 55% of this amount is originating from outside the region. A considerable variation in the distribution of available freshwater resources exists throughout the region. The average amount of rain received by the Arab Region is estimated at 2148 Km^3/year, out of which 378 Km^3/year occur in the countries of West Asia. About 50 % of the rainfall occurs in Sudan. The average annual precipitation for the Arab nations varies considerably between 18 mm/year in Egypt and the Gulf countries and 827 mm/year in Lebanon and averages at 156 mm/year (FAO, 1995, 1997). More than 75% of the limited precipitation received by the region is evaporated indicating the highest aridity in the world.

Due to the scarcity of water resources in the region, non-conventional water supplies have been widely adopted in the form of desalination plants, wastewater reuse programs, and irrigation schemes utilizing mixed agricultural drainage water. Fossil groundwater has been extensively tapped in the desert areas. A total of about 30 Km^3/year of non renewable and non conventional water supplies are being produced. The demand, on the other hand is exceeds 200 Km^3/year (about 60% of the renewable resources) and is highly escalating. On the average, irrigation consumes about 88% of the total sectoral abstractions. Industrial and domestic uses account for 7% and 5%, respectively. In 1950, the average annual share per inhabitant of renewable water resources in the Arab region was exceeding 4000 m^3/cap/year. The later share decreased dramatically to 1312 m^3/cap/year in 1995, 1233 m^3/cap/year in 1998, and is projected to drop to 547 m^3/cap/year by year 2050. A clear imbalance between the available water resources and water demands is thus expected to continue in the future.

At present, groundwater resources in the Arab Region, in general and in the Arabian Peninsula in particular are under critical conditions. The current rate of groundwater extraction far exceeds the natural recharge resulting in a continuous decline in groundwater levels and quality deterioration in most of the countries due to seawater and connate waters encroachment

Transboundary pollution of shared watercourses presents a possible future threat for the Arab Region. The countries of the region are starting to realize the necessity of establishing measures to prevent, reduce, and preserve freshwater quality. The threats to contamination of deep (and shallow) groundwater aquifers, by mining industries, illegal dumping of hazardous wastes, excessive exploitation, and other man made activities, should be equally considered. The legal framework governing the management of the shared water resources in the region needs to be addressed in a consistent and comprehensive way.

With the outset of the 21st century, the Arab Region will experience several challenges resulting from:

1. The escalating water demands among the sectoral users.
2. The deterioration of water quality, salinization, and reduction of the yield of the heavily exploited aquifers.
3. The inefficient wastewater treatment, solid waste management, pollution control and abatement programs for the developing urban communities.
4. The outcropping conflicts of the shared surface and groundwater resources

The Arab countries will have to review their water strategies and define their long-term goals within the framework of integrated water resources management Several countries have already commenced national programs for enhancing irrigation efficiency, minimizing conveyance losses, participatory water management, protection and improvement of water quality. The development of the vulnerable water resources on a sustainable basis should be achieved through regional coordination and cooperation. A balanced understanding of the security problems of food and water supply must be achieved.

THE HYDROLOGICAL CYCLE

The hydrologic cycle is a simulation of the storage and movement of the mass of water on the planet between the atmosphere, hydrosphere, lithosphere and the biosphere as shown in Figure (2). The main water storage reservoirs on the earth include: oceans, lakes, rivers, soils, glaciers, groundwater aquifers, and atmosphere.

Water is continuously cycled between its various reservoirs. This exchange occurs through the processes of evaporation, evapotranspiration, condensation, precipitation, interception, runoff, infiltration, deep percolation, snow melt, sublimation, transpiration and return flow to oceans. The hydrological cycle of the earth is inherent to the earth's climate system. The recycling and exchange of water, in all of its phases, between the atmosphere and the various repositories on the earth's surface, are intimately related to the earth's energy budget (Brutsaert, 1984).

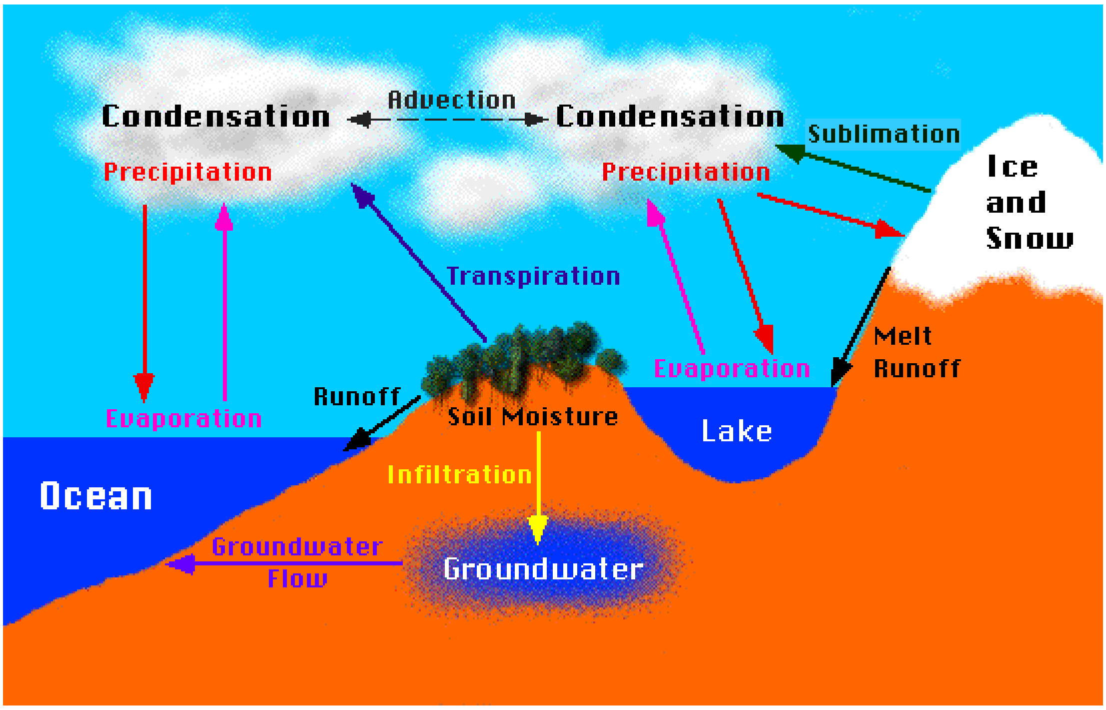


Figure (2) Schematic Illustration for the Hydrological Cycle of the Earth (downloaded from the internet)

The total amount of water on the planet sums up to about 1.4 billion Km^3 (Engleman at al. 1993), out of which approximately 97.25% is stored in the oceans as salt water and 2.05% in ice caps and glaciers as shown in **Figure(3)** (Berner and Berner, 1987). The remaining 0.7% which may provide potential sources for fresh water abstractions, is divided as follows: About 97% is present in the form of groundwater, 1.4% is stored in lakes, ponds, and man made reservoirs, 0.7% is retained as soil moisture, 0.15% as atmospheric water, 0.02% as streams and rivers capacity, and the remaining is bound in the biosphere as given in **Figures(4,5).**

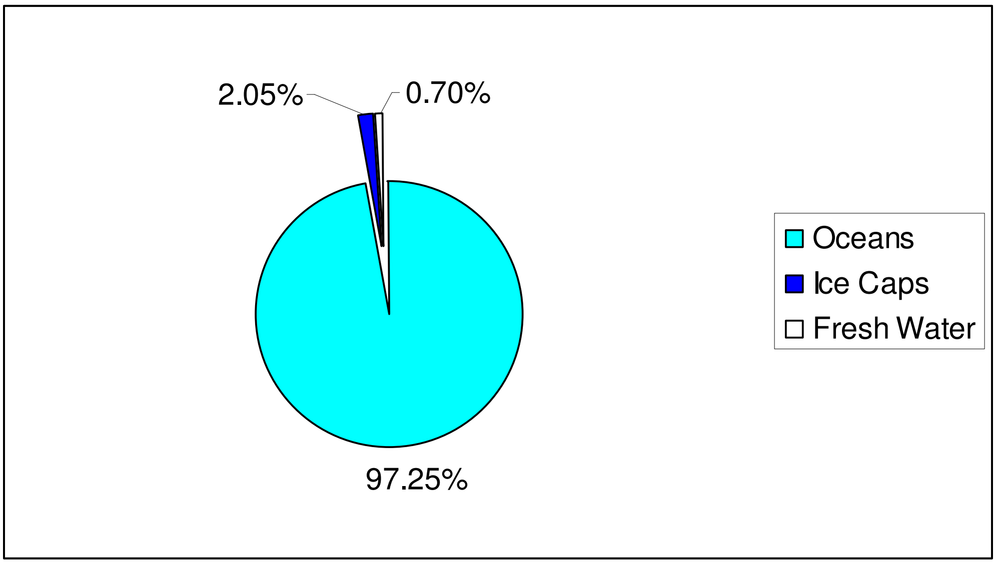


Figure (3) Global Distribution of Water on the Planet.

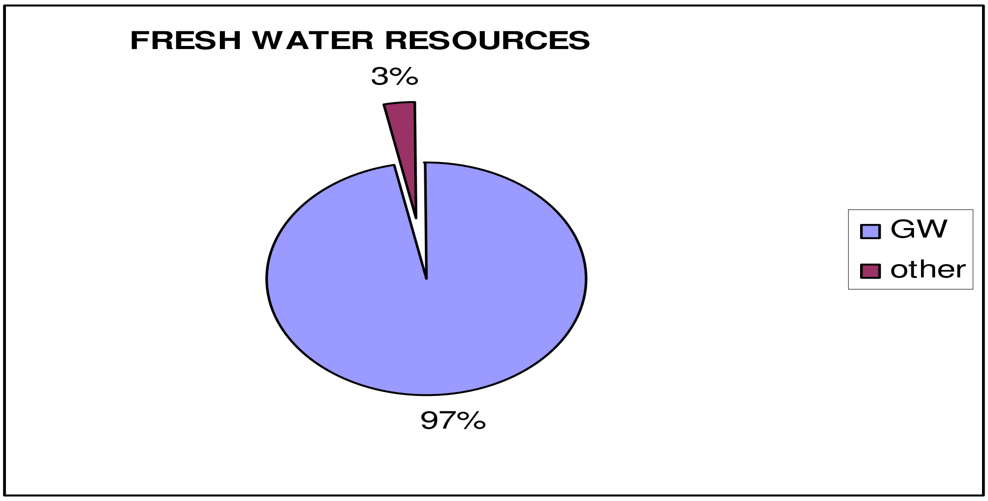


Figure (4) Global Fresh Water Distribution

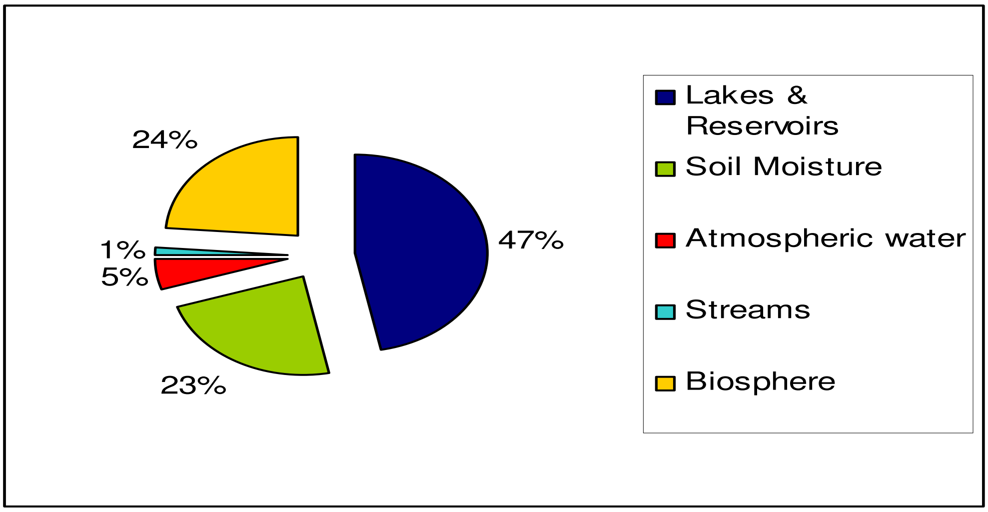


Figure (5) Different Fresh Water Repositories Excluding Groundwater.

The exchange rates between these reservoirs vary greatly (in magnitude and duration). On the average a period of one week is required for the complete renewal of atmospheric water, surface streams may require biweekly periods, soil moisture may be renewed seasonally, while groundwater and ice sheets may need hundred to thousand years. The replenishment period greatly defines the distinction between renewable and non-renewable water resources. Shiklomanov 1993 (Water in Crisis), argues that the average rate of exchange of water between the atmosphere and the earth is 577,000 Km^3/year. Precipitation over the oceans and the dry lands are estimated as 458,000 Km^3/year and 119,000 Km^3/year, respectively. Evaporation from the oceans and evapotranspiration from dry land are estimated as 505,000 Km^3/year and 72,000 Km^3/year. The figures, although being debatable, indicate some interesting facts: First, global state of water is in equilibrium and there are no extraterrestrial or juvenile fluxes (or net flux). Second, only 10% of the evaporation from oceans contribute to land precipitation. Next, about 60% of the land precipitation are returned directly to the atmosphere (evapotranspiration), while 40% of the rain is returned to the oceans (44,800 Km^3/year) as surface and groundwater runoff. A distinction should be made between beneficial evapotranspiration (used to provide for vegetation and green cover) and non-beneficial evaporation (from lakes, ponds, swamps, conveyance...etc). Finally, the globally generated surface and groundwater runoff amounts for an average annual share of 7500 m^3/capita by year 2000, had this runoff been evenly distributed through out the dry land.

Global Demand on Water Resources

In most of the available literature, the demand on water resources is divided between three major categories. These are: agriculture, domestic, and industrial uses. Perhaps more than 95 % of the earth's renewable fresh water resources are being consumed by vegetation. Natural pasture, forests, and rainfed agriculture derive their waters directly from the atmospheric water, while irrigated agriculture is dependent upon water abstractions from surface rivers, streams, groundwater, or non-conventional sources like reuse of agricultural drainage water, treated waste water, and desalinated sea water. Other major sectoral demands for water resources include domestic and industrial uses. Other demands for water resources encompass navigation requirements, hydropower, cooling water, and recreational purposes. The concept of including reservoir evaporation as a major water consumer is only introduced by Shiklamonov 1992. Dam construction around the globe has resulted in the generation of storage reservoirs with a total capacity of about 6,000 km^3 [1] and a total surface area of about $5x10^5$ km^2 (Shiklomanov, 1998). Such a vast surface area contributes largely to evaporation and, therefore, reservoirs are considered as partial consumers of available water resources.

The values of water consumption in different regions of the world are dependent on the following main factors:

- **The climatological features of the region*,*** where the abundance of atmospheric water supply in humid regions dramatically reduce the irrigation abstractions as compared to arid regions. For example, several arid countries with excessive irrigation (like Egypt) have abstractions equal or more than 1000 m^3/cap/y, while in the United Kingdom such rate is equal to 250 m^3/cap/y due to the preferred atmospheric conditions.
- **Population and demographic features**
- **Economical development status**

Apart from the directly supplied atmospheric water, estimates for the global and continental sectoral fresh water withdrawals has been performed by the State Hydrological Institute of the Former Soviet Union, and separately by the US Geological Survey (Gleick 1992). A differentiation has to be made between ***Abstractions*** and ***Consumption***. Abstraction refers to the total amount of water which is withdrawn from the freshwater resources[2] to satisfy various demands, while consumption refers to that portion of withdrawals which does not join back the water resources (like ET). A country, which progressively applies programs for reuse of agricultural drainage water, has to have its total abstractions assessed in two different manners depending on the purpose of the assessment. A national scale is suitable for the calculation of the ***global*** abstractions and consumption, while a local scale is crucial for project level assessments since for one project a specified abstraction may contribute to the abstractions of a neighbouring project through return flow. Estimates for global water consumption and abstraction are shown in Table (1).

[1] This number varies widely between various sources, for example World Registry of Dams, 1988 gives 2,900 Km^3 , Water Power and Dam Construction Handbook gives 7,800 Km^3

[2] Presumably renewable resources

Table (1) Global Water Resources: Availability, Abstractions, and Consumption.

PHASE	Total Estimate Km^3 / Year	Return to Hydrological Cycle Km^3 / Year
Global renewable surface runoff & infiltration	**40,000**	**26,500**
Economically available runoff & infiltration	**13,500**	**9,500**
Abstractions	**4,000**	**1,560**
Consumption	**2,440**	**0,000**
		37,560

The evolution of global water abstractions throughout the twentieth century along with estimates for population and population growth are envisioned from **Figures (6).**

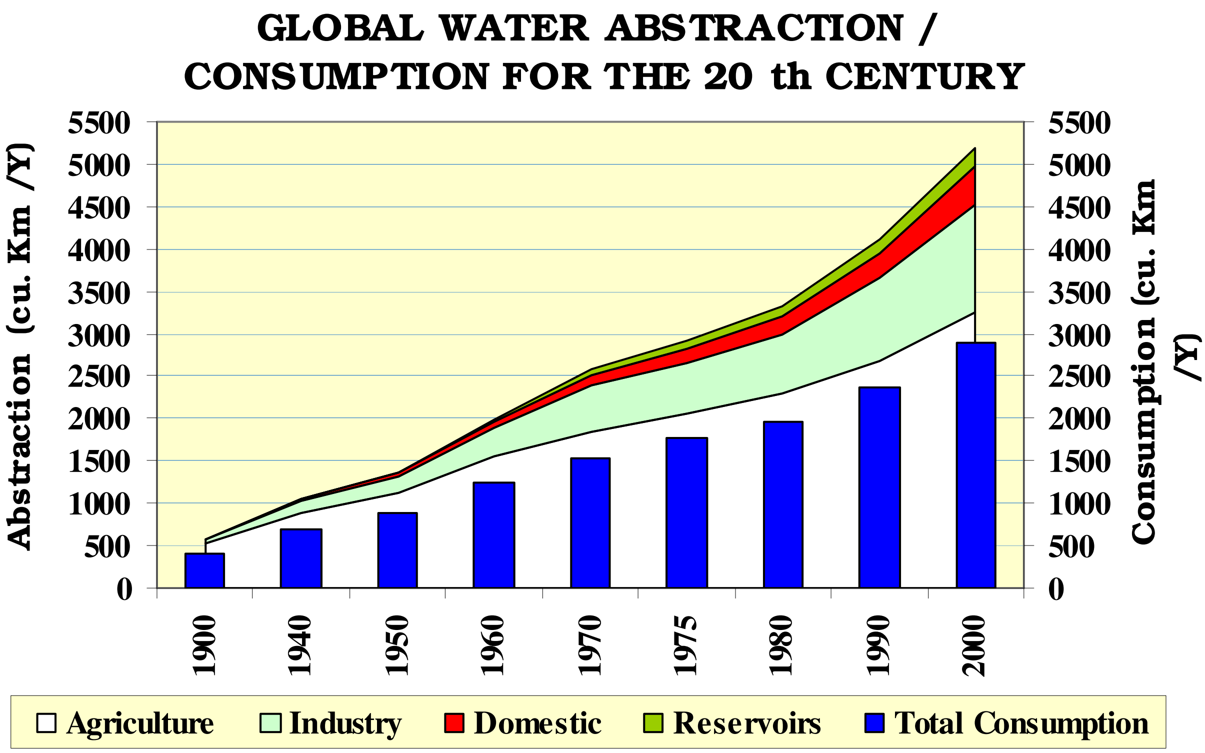


Figure (6) Global Water Abstraction and Consumption during the 20th Century

The global abstractions have been dissected into the major demand sectors, namely: irrigation, domestic, industry, and reservoirs[3]. The consumption figures have been added for comparison. It is clear from the figures that the total water abstractions have increased by more than ten folders throughout the century while the world population is expected to grow by 400% between 1950 and 2050. Two points of interest have to mentioned :

1. The figures for abstraction ***do not*** include the substantial amount of water which is directly consumed from the atmospheric water, and
2. The figures corresponding to consumption may be highly subjective since no clear methodology for estimation is presented (for example untreated industrial and wastewater effluents, which actually return back to water ways should be counted as actual consumption).

THE WATER RESOURCES ASSESSMENT MODEL

The existence of reliable information, dependable data, and unbiased statistics is a prerequisite for proper water management, successful development plans and correctly guided decision making processes. A lot of interest has been devoted to the subject by research institutes, multi-national organizations, scientists, and decision makers all around the world through out the last quartile of the twentieth century. The outcome has been a number of valuable studies, field investigations, and consultation processes. Nevertheless, a lot of discrepancies exist between such studies due to using different methodologies and/or due to lack (or extreme difficulty of accurate estimation) of data, and in some cases may not be in agreement with individual national data. Double counting of internal renewable water resources is a repeated feature, and negligence of atmospheric water consumed by natural vegetation and forests is a persisting defect. Improper estimation of potential water resources for riparian countries sharing international rivers, which originate in humid regions while terminating in arid climates is a common consequence. The relative easiness of utilization of surface water has often led to the misconception of considering surface water as THE indicative of the status of water resources in a region, while in fact, surface water is only AN indicative of such status. The soaring demand for fresh water is putting high pressure on the effective consideration of other water resources like groundwater and direct fresh water supply from atmospheric vapour. Of equal importance is exploration of non-conventional water resources potential. The need for a unified systematic approach towards the identification, compilation and processing of reliable data, consistent methodology for the water balance calculations, and consequently prediction and evaluation of the vulnerability to water problems is inevitable. The lack of a unanimous set of definitions for water resources related terminology also needs urgent attention.

Bearing in mind the aforementioned review, the current state of the water report, is based on a water resources assessment model augmented by a

[3] Included for the sake of comparison only

water resources information system for the Arab Region that was developed by CEDARE. The assessment procedure is a dynamic process which has to be updated periodical to account for new data and enhanced measurements required for satisfying the various assessment components. Currently, the compiled information for the Arab Region is only limited to the data available in the international literature. This very first draft is subject to review by all national authorities related to water resources management in order to verify and update the included estimates and to build a coherent water resources information system. The system will provide direct inputs to the Arab Region Status of the Water Report which is proposed to be issued on a biannual basis.

The model which was used addresses the practical aspects, which are of relevance to water resources management. This includes the identification of :

1. **Parameters;** representing and describing as much as possible water supply, demand, utilization, availability, variability, accessibility, and quality.
2. **Standardized processes;** for measuring, calculating, and estimating the former parameters should be unified to allow for correct comparative analysis for different nations and regions.
3. **Indicators**; The parameters will be used to define a complete set of indicators describing the water potential yield (abundance / scarcity), water development potential (adequacy / deficiency), dependency, resource management efficiency, sustainability, history of utilization, short / long term implications of sectorial water allocation, and finally the overall vulnerability to water shortages and crises.

The water balance equation for a defined region is introduced along with definitions of the various terminologies. The main components contributing to the water balance equation are :

1. Precipitation : estimated according to a standardized process to account for variability
2. Surface runoff :
    - Internally generated
    - Transboundary incoming flow
    - Transboundary out-flowing
3. Groundwater :
    - Internally generated by infiltration
    - Transboundary incoming flow
    - Transboundary out-flowing
4. Direct Atmospheric Supply (Beneficial Evapotranspiration):
    - Rain-fed agriculture
    - Natural vegetation
    - Forests

Parameters describing water utilization and supply / demand include among others :

5. Development potential of water supplies :
   - Surface water
   - Ground water
   - Atmospheric water
   - Non conventional water resources :
     - Reuse of agricultural drainage water
     - Reuse of treated waste water
     - Desalination of sea water
     - Water importation
6. Sectorial withdrawals
7. Evaporation from water bodies and ground surface

Indicators include among others :

8. Dependency ratio
9. Irrigation efficiency
10. Access to potable water supply and sanitation services

Following the scheme endorsed by CEDARE (1999) for the assessment of freshwater resources, an average annual national water balance equation can be written as:

$$\left(\textbf{\textit{Input water resources}}\right) - \left(\textbf{\textit{Outgoing water resources}}\right)$$
$$=$$
$$\left(\textbf{\textit{Beneficial Abstractions}}\right) + \left(\textbf{\textit{Evaporation}}\right) + \left(\textbf{\textit{Un utilized water resources}}\right)$$

Where

- **Input water resources** include the summation of indigenous precipitation, trans-boundary incoming surface water resources, share from boarder rivers, and in-flowing groundwater,
- **Outgoing water resources** include the summation of trans-boundary outcoming surface water resources, and out-flowing groundwater,
- **Beneficial Abstractions** include the summation of abstractions from renewable water resources for: irrigation, industry, domestic uses, and atmospheric water directly consumed by rainfed agriculture, natural pasture, and forests,
- **Evaporation** includes the amount of water evaporated annually and is a direct function of the local aridity,
- **Un-utilized water resources** include the summation of water discharged to oceans, lost from reservoirs, a part of the nation's

share of international water resources which is willingly bypassed to neighbouring riparian, …etc.

Estimates for forest coverage are quoted from the WRI, while natural pasture coverage, solar radiation, and soil holding capacities are derived from DCW. Other figures are extracted from FAO reports.

Estimates for the beneficiary abstraction for rain fed crops, pasture, and forests are derived from area under irrigation, effective rainfalls period per year, and factor account infiltration losses.

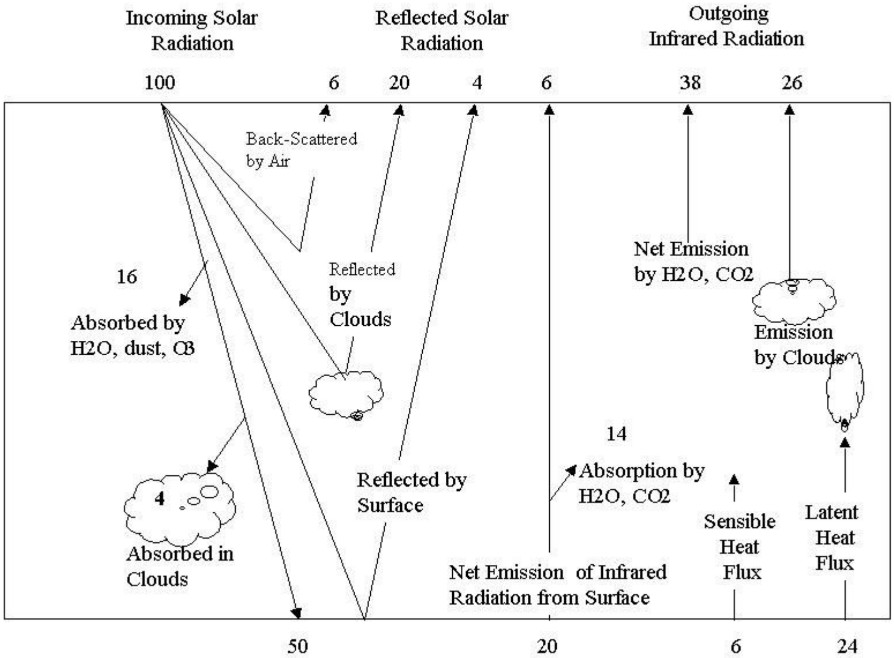


Figure (1) Radiation Fluxes between the Atmosphere and Earth's Surface

It is believed that a comprehensive understanding of the physical processes governing the various components of the assessment will be of great benefit. The main external energy source for the earth, its climate system and global hydrological cycle is the sun throughout its solar radiation. The intensity of solar radiation, received at the top of the atmosphere is reduced by three processes before reaching the earth's surface, namely: back-scattering and reflection from clouds, absorption by water vapour and clouds, and obliqueness of the earth's surface (Chow, Madement, and Mays1988).

For every 100 units of incoming *short wave* solar radiation, shown in Figure (1), 30 units are reflected by the atmosphere and the earth's surface (*short waves*), 20 units are absorbed by the atmosphere (water vapor, Ozone, and clouds), while 50 units are absorbed by the earth's surface (ocean and land). Because the planet is in approximate ***thermal balance*** (no long term net heating), the absorbed 70 units are eventually re-radiated back to space, but this time in the form of long waves corresponding to the temperature of the earth and the atmosphere. It could be seen that out of 100 incoming units only 30 units are left at the earth's surface, 23 unites of which are used to evaporate water and drive the hydrological cycle. The interaction between the solar radiation and the atmosphere, soil, and water surfaces governs the global hydrological processes. (Handbook of Hydrology, 1992).

STATE OF THE WATER IN THE ARAB REGION (A REGIONAL PERSPECTIVE)

The Arab Region extends between longitude 16.5 ° West passing through Nouakchott, Mauritania on the African coast of the Atlantic Ocean and longitude 60° East near the city of Masqat, Oman. The region also extends from the equator south crossing the southern Somali boarder to latitude 37.5 ° North at the Iraqi-Turkish border. It is bound from the west by the Atlantic Ocean, from the east by the Arabian Gulf and Iran. Central Africa, the great Lakes Plateau, the Ethiopian, Plateau, and the gulf of Eden constitute the southern boundaries while the Mediterranean Sea and Turkey constitute the northern boarders.

Twenty two countries are studied in the current report with a total area of about 14 million square kilometers, out of which, more than 86 percent are deserts, thus constituting the most arid region in the world. The region is very poor in water resources and in the vegetation cover. Some mountainous ranges are scattered throughout the region. The Atlas Mountains run along the northwestern boarders with its highest peak in Morocco (4165 meters above m.s.l.). The Lebanon Mountains reach a height of 3000 m above m.s.l. and so does the Tebetsy Mountain in Libya. The mountains in Yemen have a crest elevation of about 3300 m. The region also comprises the lowest depression in the world at the Dead Sea (Jordan).

A number of international rivers originating from outside the region exist. These include the Nile River and its tributaries (Sudan and Egypt), Senegal River (Mauritania), the Juba and Shebilli rivers (Somalia), the Tigris and Euphrates and their tributaries (Syria and Iraq). Several smaller rivers exist inside the region, which are shared by more than one country like the Majerda, the Jordan, and the Orantos rivers. A network of ephemeral wadies and non perennial streams also exists.

Freshwater is by all means the most precious and limited natural resource in the hyper-arid Arab Region. Freshwater is considered a top priority environmental concern, which capture special attention from the countries of the region, and is being addressed at all levels from local to regional. Except for Sudan, Iraq, and Mauritania, water stress and scarcity dominate much of the region with increasing severity projected for the future.

The basic information of relevance to water resources assessment activities has been compiled in **Tables (2 – 11)**, including population, area, precipitation, generated surface runoff, groundwater recharge, transboundary incoming and outgoing surface and groundwater flows. The land use is basically divided into: irrigated crop lands, rain-fed vegetation, and deserts. Rain-fed vegetation is further divided into rain-fed crop lands, natural pasture, and forests. Sectoral fresh water abstractions are also included along with non-conventional sources of freshwater like desalination of sea water, waste water reuse and reuse of agriculture drainage water.

Table [2] Population Growth and Projections Following the UN Medium Projections

	POPULATION PROJECTIONS					
	1950	1990	1995	1998	2025	2050
ALGERIA	8.753	24.900	27.900	30.175	47.322	58.991
BAHRAIN			0.564			
DJIBOUTI			0.577			
EGYPT	21.834	56.300	62.900	65.675	95.766	115.480
IRAQ	5.158	18.000	20.400	21.795	41.600	56.129
JORDAN	1.237	4.200	5.400	5.956	11.894	16.671
KUWAIT	0.152	2.100	1.550	1.809	2.904	3.406
LEBANON	1.443	2.550	3.000	3.194	4.424	5.189
LIBYA	1.029	4.540	5.400	5.980	12.885	19.109
MAURITANIA	0.825	2.000	2.270	2.453	4.443	6.077
MOROCCO	8.953	24.334	27.028	28.012	39.925	47.276
OMAN	0.456	1.751	2.163	2.504	6.538	10.930
QATAR			0.551			
SAUDI ARABIA	3.201	16.048	17.880	20.207	42.363	59.812
SOMALIA	3.072	8.677	9.250	10.653	23.669	36.408
SUDAN	9.190	24.585	28.000	28.526	46.850	59.947
SYRIA	3.495	12.340	14.660	15.335	26.303	34.463
TUNISIA	3.530	8.080	8.896	9.497	13.524	15.907
U.A.E.	0.070	1.671	1.904	2.354	3.297	3.668
YEMEN	4.316	11.361	14.501	16.891	39.589	61.129
ARAB REGION	**76.714**	**223.437**	**254.794**	**271.016**	**463.296**	**610.592**
WORLD	**2523**	**5284**	**5716**	**5929**	**8039**	**9366**

Table (3) Water Resources Estimates by WRI for the Arab Region

	Population		Total Country Area	IRWR (WRI)	Surface IN Flow (WRI)	Surface OUT Flow (WRI)
	1995	1998	Km^2	Km^3/Y	Km^3/Y	Km^3/Y
ALGERIA	27.900	30.175	2,381,740	13.87	0.40	0.70
BAHRAIN	0.564		0,695		0.00	0.00
DJIBOUTI	0.577		23,200			0.00
EGYPT	62.900	65.675	1,001,450	2.80	55.50	0.00
IRAQ	20.400	21.795	438,320	35.20	40.20	0.00
JORDAN	5.400	5.956	89,210	0.68	0.20	0.00
KUWAIT	1.550	1.809	17,820	0.02	0.00	0.00
LEBANON	3.000	3.194	10,400	4.20	0.60	0.90
LIBYA	5.400	5.980	1,759,540	0.60	0.00	0.00
MAURITANIA	2.270	2.453	1,025,520	0.40	11.00	0.00
MOROCCO	27.028	28.012	446,500	30.00	0.00	0.30
OMAN	2.163	2.504	312,500	0.99	0.00	0.00
QATAR	0.551		11,000		0.00	0.00
SAUDI ARABIA	17.880	20.207	2,149,690	2.40	0.00	0.00
SOMALIA	9.250	10.653	637,660	6.00	7.50	0.00
SUDAN	28.000	28.526	2,505,810	35.00	119.00	55.50
SYRIA	14.660	15.335	185,180	7.00	37.70	32.00
TUNISIA	8.896	9.497	163,610	3.52	0.60	0.00
U.A.E.	1.904	2.354	83,600		0.00	0.00
YEMEN	14.501	16.891	527,970	4.10	0.00	0.00
ARAB REGION	**255**	**271**	**13,771,415**	**146.78**		

Table (4) Water Resources Estimates by FAO for the Arab Region

	Internal Renewable Water Resources (FAO)				External Renewable Water Resources (FAO)				Total Renewable Water Resources (FAO)	
	Surface	GW	Overlap	Total	Surface Water (Km^3/Y)		Groundwater (Km^3/Y)			
	Km^3/Y	Km^3/Y	Km^3/Y	Km^3/Y	Natural	Actual	Natural	Actual	***Natural***	***Actual***
ALGERIA	13.200	1.700	1.000	**13.900**	0.400	0.400	0.000	0.000	14.300	**14.300**
BAHRAIN	0.004	0.000	0.000	**0.004**	0.000	0.000	0.112	0.112	0.116	**0.116**
DJIBOUTI					0.000	0.000		0.000	0.000	**0.000**
EGYPT	0.500	1.300	0.000	**1.800**	84.000	55.500	1.000	1.000	86.800	**58.300**
IRAQ	34.000	1.200	0.000	**35.200**	61.220	40.220	0.000	0.000	96.420	**75.420**
JORDAN	0.400	0.500	0.220	**0.680**	0.200	0.200	0.000	0.000	0.880	**0.880**
KUWAIT	0.000	0.000	0.000	**0.000**	0.000	0.000	0.020	0.020	0.020	**0.020**
LEBANON	4.100	3.200	2.500	**4.800**	0.037	-0.393	0.000	0.000	4.837	**4.407**
LIBYA	0.100	0.500	0.000	**0.600**	0.000	0.000	0.000	0.000	0.600	**0.600**
MAURITANIA	0.100	0.300	0.000	**0.400**	11.000	11.000	0.000	0.000	11.400	**11.400**
MOROCCO	23.000	10.000	3.000	**30.000**	0.000	0.000	0.000	0.000	30.000	**30.000**
OMAN	0.930	0.955	0.900	**0.985**	0.000	0.000	0.000	0.000	0.985	**0.985**
QATAR	0.001	0.050	0.000	**0.051**	0.001	0.000	0.002	0.002	0.054	**0.053**
SAUDI ARABIA	2.200	2.200	2.000	**2.400**	0.000	0.000	0.000	0.000	2.400	**2.400**
SOMALIA	5.700	3.300	3.000	**6.000**	9.740	9.740	0.000	0.000	15.740	**15.740**
SUDAN	28.000	7.000	0.000	**35.000**	119.000	53.500	0.000	0.000	154.000	**88.500**
SYRIA	4.800	4.200	2.000	**7.000**	37.730	17.910	1.350	1.350	46.080	**26.260**
TUNISIA	2.310	1.210	0.000	**3.520**	0.600	0.600	0.000	0.000	4.120	**4.120**
U.A.E.	0.150	0.120	0.120	**0.150**	0.000	0.000	0.000	0.000	0.150	**0.150**
YEMEN	4.000	1.500	1.400	**4.100**	0.000	0.000	0.000	0.000	4.100	**4.100**
ARAB REGION				**132.686**	**199.190**	**187.640**	**1.350**	**0.000**	333.226	**320.326**

Table (5) Renewable Water Resources Estimates Used in Current Study for the Arab Region

	Annual Average Precipitation		External Renewable Water Resources				Gross Water Resources
			Surface Water (Km^3/Y)		Groundwater (Km^3/Y)		Total
	mm	Km^3/Y	IN	OUT	IN	OUT	Km^3/Y
ALGERIA	68	162.90	0.300	0.600	0.000	0.000	**162.600**
BAHRAIN	70	0.05	0.000	0.000	0.112	0.000	**0.161**
DJIBOUTI	147	3.40	0.000	0.000	x	0.000	**3.400**
EGYPT	18	18.10	55.500	0.000	0.000	0.000	**73.600**
IRAQ	154	67.70	40.220	0.000	0.000	0.000	**107.920**
JORDAN	94	8.43	0.200	0.000	0.000	0.000	**8.630**
KUWAIT	176	3.14	0.000	0.000	0.020	0.000	**3.160**
LEBANON	827	8.60	0.000	0.640	0.000	0.310	**7.650**
LIBYA	26	46.10	0.000	0.000	0.000	0.000	**46.100**
MAURITANIA	99	101.90	11.000	0.000	0.000	0.000	**112.900**
MOROCCO	336	150.00	0.000	0.300	0.000	0.000	**149.700**
OMAN	54	17.00	0.000	0.000	0.000	0.000	**17.000**
QATAR	75	0.83	0.000	0.000	0.000	0.000	**0.825**
SAUDI ARABIA	59	126.80	0.000	0.000	0.000	0.000	**126.800**
SOMALIA	253	161.30	9.740	0.000	0.000	0.000	**171.040**
SUDAN	436	1092.60	110.000	55.500	x	x	**1147.100**
SYRIA	252	46.60	35.510	18.200	1.350	0.250	**65.010**
TUNISIA	207	33.90	0.600	0.000	0.000	0.000	**34.500**
U.A.E.	100	8.36	0.000	0.000	0.000	0.000	**8.360**
YEMEN	170	89.80	0.000	0.000	x	0.000	**89.800**
ARAB REGION	***3621***	***2148***	***188***	***0***	***1.350***	**0.000**	**2170.095**

Table (6) Sectoral Abstractions for the Arab Region

	Sectoral Abstractions									Source of Abstractions	
	Irrigation		Domestic		Industry		Sub Total		Natural (ET)	Non-conventional (Km^3/Y)	Renewable Sources (Km^3/Y)
	%	Km^3/Y	%	Km^3/Y	%	Km^3/Y	%	Km^3/Y	Km^3/Y		
ALGERIA	60	2.700	25	1.125	15	0.675	100	4.500	8.000	0.064	12.436
BAHRAIN	56	0.134	39	0.093	4	0.010	100	0.239	0.000	0.148	0.091
DJIBOUTI	87	0.007	13	0.001	0	0.000	100	0.008	0.000	0.000	0.008
EGYPT	86	47.730	6	3.330	8	4.440	100	55.500	0.000	1.637	53.863
IRAQ	92	39.376	3	1.284	5	2.140	100	42.800	1.136	0.000	43.936
JORDAN	75	0.738	22	0.216	3	0.030	100	0.984	0.351	0.224	1.111
KUWAIT	60	0.323	37	0.199	2	0.011	100	0.538	0.000	0.533	0.005
LEBANON	68	0.879	28	0.362	4	0.052	100	1.293	2.173	0.002	3.464
LIBYA	87	4.002	11	0.506	2	0.092	100	4.600	3.011	4.310	3.301
MAURITANIA	92	1.500	6	0.098	2	0.033	100	1.630	4.077	0.002	5.705
MOROCCO	92	10.161	5	0.552	3	0.331	100	11.045	24.356	0.003	35.397
OMAN	94	1.150	5	0.061	2	0.024	100	1.223	0.000	0.061	1.162
QATAR	74	0.211	23	0.066	3	0.009	100	0.285	0.000	0.166	0.119
SAUDI ARABIA	90	15.316	9	1.532	1	0.170	100	17.018	0.405	14.530	2.893
SOMALIA	97	0.786	3	0.024	2	0.016	100	0.810	1.667	0.000	2.477
SUDAN	94	16.732	4	0.712	1	0.178	100	17.800	185.783	0.000	203.583
SYRIA	94	13.545	4	0.576	2	0.288	100	14.410	10.089	2.186	22.313
TUNISIA	88	2.706	9	0.277	3	0.092	100	3.075	5.267	0.028	8.314
U.A.E.	67	1.412	24	0.506	9	0.190	100	2.108	0.000	1.987	0.121
YEMEN	92	2.697	7	0.205	1	0.029	100	2.932	8.158	0.010	11.080
ARAB REGION		***162.106***		***11.726***		***8.809***		***182.798***	***254.474***	***25.894***	***411.378***

Table (7) Abstractions from Non-Conventional and Non Renewable Sources in the Arab Region

	Withdrawals (Irrigation + Domestic + Industrial) (Km3/Y)	Non-Conventional & Fossil Water Depletion (as % of Withdrawals)					Total of NonRenewable & Non Conventional Supplies (Km^3/Y)
		Desalination	Waste Water Treatment	Total Non-Conventional	Groundwater Depletion	Total Non Renewable (%)	
ALGERIA	4.500	0.00	0.00	1.42	0.00	1.42	0.064
BAHRAIN	0.239			21.79	40.20	61.99	0.148
DJIBOUTI	0.008			1.33		1.33	0.000
EGYPT	55.500	0.05	0.40	0.45	2.50	2.95	1.637
IRAQ	42.800					0.00	0.000
JORDAN	0.984			5.32	17.50	22.82	0.224
KUWAIT	0.538	42.94	9.67	52.61	46.50	99.11	0.533
LEBANON	1.293			0.16		0.16	0.002
LIBYA	4.600			3.70	90.00	93.70	4.310
MAURITANIA	1.630			0.10	x	***0.10***	*0.002*
MOROCCO	11.045			0.03		0.03	0.003
OMAN	1.223			4.90	x	***5.00***	*0.061*
QATAR	0.285			43.50	14.90	58.40	0.166
SAUDI ARABIA	17.018	4.20	1.28	5.48	79.90	85.38	14.530
SOMALIA	0.810			0.01		0.01	0.000
SUDAN	17.800			0.00		0.00	0.000
SYRIA	14.410		2.57	2.57	12.60	15.17	2.186
TUNISIA	3.075			0.92		0.92	0.028
U.A.E.	2.108	18.26	5.12	23.38	70.90	94.28	1.987
YEMEN	2.932			0.34		0.34	0.010
ARAB REGION	***182.798***						**25.894**

Table (8) Land Use for the Arab Region

	Population (Million)	Total Country Area	Irrigated Crop Area		Rainfed Crops Area	Total Cropland Area	Natural Forest Area	Natural Pasture	Total Vegetation Cover	Desert Area
			Land	Harvested						
	1995	Km^2	Km^2	Km^2	Km^2	Km^2	Km^2	Km^2	Km^2	Km^2
ALGERIA	27.900	2,381,740	5,555	*7,600*	28,112	33,667	13,760	4,413	51,840	2,329,900
BAHRAIN	0.564	0,695	0,032	0,032	0,000	0,032	0,000	0,000	0,032	0,664
DJIBOUTI	0.577	23,200	0,004	0,004	0,000	0,004	0,220	0,000	0,224	22,980
EGYPT	62.900	1,001,450	32,460	53,789	0,000	32,460	0,000	0,000	32,460	968,990
IRAQ	20.400	438,320	35,250	x	2,052	37,302	0,690	3,501	41,493	396,827
JORDAN	5.400	89,210	0,643	0,690	1,508	2,151	0,220	0,000	2,371	86,839
KUWAIT	1.550	17,820	0,048	0,048	0,000	0,048	0,000	0,000	0,048	17,772
LEBANON	3.000	10,400	0,875	0,875	1,019	1,894	0,390	0,000	2,284	8,116
LIBYA	5.400	1,759,540	4,700	x	18,116	22,816	1,900	0,000	24,716	1,734,824
MAURITANIA	2.270	1,025,520	0,492	1,349	1,549	2,041	5,540	0,000	7,581	1,017,939
MOROCCO	27.028	446,500	12,582	10,730	59,728	72,310	35,140	86,271	193,721	252,779
OMAN	2.163	312,500	0,616	0,071	0,000	0,616	0,000	0,000	0,616	311,885
QATAR	0.551	11,000	0,125	0,088	0,000	0,125	0,000	0,000	0,125	10,875
SAUDI ARABIA	17.880	2,149,690	16,080	16,080	0,000	16,080	2,210	0,000	18,290	2,131,400
SOMALIA	9.250	637,660	2,000	x	8,000	10,000	7,500	0,000	17,500	620,160
SUDAN	28.000	2,505,810	19,462	x	56,561	76,023	414,100	843,222	1,333,345	1,172,465
SYRIA	14.660	185,180	10,130	12,040	39,285	49,415	0,920	3,286	53,621	131,559
TUNISIA	8.896	163,610	3,850	3,080	38,928	42,778	3,540	0,000	46,318	117,292
U.A.E.	1.904	83,600	0,667	0,545	0,000	0,667	0,000	0,000	0,667	82,933
YEMEN	14.501	527,970	4,815	x	5,721	10,537	0,090	41,750	52,377	475,593
ARAB REGION	**255**	**13,771,415**	**150,385**		**260,578**	**410,963**	**486,220**	**982,443**	**1,879,626**	**11,891,793**

Table [9] Land Use and Vegetation Cover for the Arab Region

	Total Country Area	Irrigated Crops Area	Rainfed Crops Area	Total Cropland Area	Natural Forest Area	Natural Pasture	Total Vegetation Cover	Desert Area
	Km^2	Km^2	Km^2	Km^2	Km^2	Km^2	Km^2	Km^2
ALGERIA	2,381,740	5,555	28,112	33,667	13,760	4,413	47,427	2,334,313
BAHRAIN	0,695	0,032	0,000	0,032	0,000	0,000	0,032	0,664
DJIBOUTI	23,200				0,220	0,000		23,200
EGYPT	1,001,450	32,460	0,000	32,460	0,000	0,000	32,460	968,990
IRAQ	438,320	35,250	2,052	37,302	0,690	3,501	37,992	400,328
JORDAN	89,210	0,643	1,508	2,151	0,220	0,000	2,371	86,839
KUWAIT	17,820	0,048	0,000	0,048	0,000	0,000	0,048	17,772
LEBANON	10,400	0,875	1,019	1,894	0,390	0,000	2,284	8,116
LIBYA	1,759,540	4,700	18,116	22,816	1,900	0,000	24,716	1,734,824
MAURITANIA	1,025,520	0,492	1,549	2,041	5,540	0,000	7,581	1,017,939
MOROCCO	446,500	12,582	59,728	72,310	35,140	86,271	107,450	339,050
OMAN	312,500	0,616	0,000	0,616	0,000	0,000	0,616	311,885
QATAR	11,000	0,125	0,000	0,125	0,000	0,000	0,125	10,875
SAUDI ARABIA	2,149,690	16,080	0,000	16,080	2,210	0,000	18,290	2,131,400
SOMALIA	637,660	2,000	8,000	10,000	7,500	0,000	17,500	620,160
SUDAN	2,505,810	19,462	56,561	76,023	414,100	843,222	490,123	2,015,687
SYRIA	185,180	10,130	39,285	49,415	0,920	3,286	50,335	134,845
TUNISIA	163,610	3,850	38,928	42,778	3,540	0,000	46,318	117,292
U.A.E.	83,600	0,667	0,000	0,667	0,000	0,000	0,667	82,933
YEMEN	527,970	4,815	5,721	10,537	0,090	41,750	10,627	517,343
ARAB REGION	**13,771,415**	**150,381**	**260,578**	**410,959**	**486,220**	**982,443**	**896,959**	**12,874,456**

Table (10) Water Requirements for Different Land Use for the Arab Region

	Irrigated Crops Abstraction	Rainfed Crops Abstraction	Total Crop Abstraction	Natural Forest Abstraction	Natural Pasture	Rainfed Vegetation Abstraction	Total Vegetation Abstraction
	Km^3	Km^3	Km^3	Km^3	Km^3	Km^3	Km^3
ALGERIA	2.700	4.782	7.482	2.575	0.643	8.000	10.700
BAHRAIN	0.134	0.000	0.134	0.000	0.000	0.000	0.134
DJIBOUTI	0.007	0.000	0.007	0.000	0.000	0.000	0.007
EGYPT	47.730	0.000	47.730	0.000	0.000	0.000	47.730
IRAQ	39.376	0.401	39.777	0.148	0.587	1.136	40.512
JORDAN	0.738	0.303	1.041	0.049	0.000	0.351	1.089
KUWAIT	0.323	0.000	0.323	0.000	0.000	0.000	0.323
LEBANON	0.875	1.529	9.034	0.644	0.000	2.173	9.678
LIBYA	4.002	2.699	6.701	0.311	0.000	3.011	7.013
MAURITANIA	1.500	0.826	2.326	3.251	0.000	4.077	5.577
MOROCCO	10.161	8.442	18.603	5.463	10.451	24.356	34.517
OMAN	1.150	0.000	1.150	0.000	0.000	0.000	1.150
QATAR	0.211	0.000	0.211	0.000	0.000	0.000	0.211
SAUDI ARABIA	15.316	0.000	15.316	0.405	0.000	0.405	15.721
SOMALIA	0.786	1.100	1.886	0.567	0.000	1.667	2.453
SUDAN	16.732	8.510	25.242	68.532	108.741	185.783	202.515
SYRIA	13.545	9.193	22.738	0.237	0.659	10.089	23.634
TUNISIA	2.706	4.788	7.495	0.479	0.000	5.267	7.974
U.A.E.	1.412	0.000	1.412	0.000	0.000	0.000	1.412
YEMEN	2.697	1.122	3.819	0.020	7.016	8.158	10.855
ARAB REGION	**168.731**	**43.696**	**212.426**	**82.682**	**128.097**	**254.474**	**423.205**

Table (11) Water Resources Balance in the Arab Region

	Precipitation	Gross Renewable Water Resources	Total Abstractions From Renewable Resources	Evaporation & Unused Water
	Km^3	Km^3	Km^3	Km^3
ALGERIA	162.90	**162.600**	12.436	**150.164**
BAHRAIN	0.05	**0.161**	0.091	**0.070**
DJIBOUTI	3.40	**3.400**	0.008	**3.392**
EGYPT	18.10	**73.600**	53.863	**19.737**
IRAQ	67.70	**107.920**	43.936	**63.984**
JORDAN	8.43	**8.630**	1.111	**7.519**
KUWAIT	3.14	**3.160**	0.005	**3.155**
LEBANON	8.60	**7.650**	3.464	**4.186**
LIBYA	46.10	**46.100**	3.301	**42.799**
MAURITANIA	101.90	**112.900**	5.705	**107.195**
MOROCCO	150.00	**149.700**	35.397	**114.303**
OMAN	17.00	**17.000**	1.162	**15.838**
QATAR	0.83	**0.825**	0.119	**0.706**
SAUDI ARABIA	126.80	**126.800**	2.893	**123.907**
SOMALIA	161.30	**171.040**	2.477	**168.563**
SUDAN	1092.60	**1147.100**	203.583	**943.517**
SYRIA	46.60	**65.010**	22.313	**42.697**
TUNISIA	33.90	**34.500**	8.314	**26.186**
U.A.E.	8.36	**8.360**	0.121	**8.239**
YEMEN	89.80	**89.800**	11.080	**78.720**
ARAB REGION	***2148***	***2336.256***	***411.378***	***1924.878***

Depleted non-renewable groundwater figures are also included when available. The main climatological, geographic and soil features required by the assessment model are presented in **Figures (11 to 14)** as regional coverage layers for the precipitation, Solar Radiation, Soil Holding Capacity, Land use, and stream flows. Moreover, **Figures (15 to 36)** represent national coverage layers for each country including all water balance components.

Historically, the first half of the twentieth century marked the colonial control of most of the Arab Region (British, French, and Italian). The colonial regimes directed water management development towards serving its own strategic objectives as expressed, for example, in the suppression of industrialization and expansion of cotton grown areas in Sudan and Egypt along with the associated irrigation measures. Some hydraulic control works were established in that era, for example the old Aswan Dam in Egypt, some channel routing in the Nile basin and the Maghreb, and dredging of the main Egyptian drains.

From early 1950s onward, the countries of the region gained their independence. This witnessed a shift towards proper water management which became a pre-requisite for satisfying the ambitious national development plans that targeted enhanced agricultural production, support of industrialization, provision of safe drinking water, sanitation, and other infrastructure services, all of which resulted in an escalating demand for water. Following the discovery of oil in the Gulf countries and Libya, enormous development schemes in agriculture, urbanization and industry sectors were implemented. Nevertheless, the rapidly increasing population, which doubled in about 30 years, expanding urbanization, lack of financial resources and external debt in non- oil producing countries, wars and political instabilities were major impeding factors towards proper water management. Unfortunately, recognition of effective environmental protection and management were lagging behind the main development programs. During the last decade, the First and Second Gulf Wars have seriously affected the economy of West Asia. Phased socioeconomic development plans had to be considerably reviewed resulting in remarkable reduction, or delay in executing the scheduled water development implemented schemes. Not to mention the severe damages that affected the hydraulics and irrigation structures in Iraq, which should enjoin protection during war as stated by International Laws. Surface water resources in Syria, Iraq and Palestine were reduced due to the conflicts concerning the water allocations of the rivers, and aquifers shared with neighboring countries. This has led to 30-40 per cent postponement of planned agricultural schemes.

Water quality in the region was greatly related to the available socio-economic conditions. Environmental problems related to pathogenic contamination of perennial streams and aquatic macrophytes were recognized at the late 1960s, oxygen depletion and overloading with biodegradable wastes were addressed as of the seventies. Problems related to eutrophication (mainly in lakes) aroused in the 1980s, and pollution with heavy metals and other industrial effluents were seriously considered in the 1990s.

As stated earlier, the Arab region is dominated by hyper arid to arid conditions which express the physical constrain for water availability, except for narrow coastal strips in the Maghreb, East Mediterranean, and Northern Iraq. The average amount of rain received by the Arab Region is estimated at 2148 Km^3/year, out of which 378 Km^3/year occur in the countries of West Asia. About 50 % of the rain fall occurs in Sudan. The average annual precipitation for the Arab nations vary considerably between 18 mm/year in Egypt, and 827 mm/year in Lebanon and averages at 156 mm/year (FAO, 1995, 1997).

The average annual flow of rivers and recharge to groundwater as a result of endogenous precipitation (commonly known as Internal Renewable Water Resources (IRWR)) for the Arab Region are estimated at 146.5 Km^3/year. About 70 % of the region's IRWR are generated in three countries, namely Iraq, Sudan, and Morocco [Table (2)]. The average Arabian per capita share of IRWR changed from 1911 m3/cap/y in 1950 to 540 m3/cap/y in 1998, and is expected to drop to 240 m3/cap/y in 2050. International river flows make up significant inputs to water resources in the Arab Region. These are:

1. The White Nile (originating from the equatorial lakes) crossing the southern Sudanese border,
2. The Blue Nile and the Atbara river (originating from Ethiopian Plateau) crossing the Sudanese eastern border,
3. The Senegal river (originating in Senegal) flowing along the southern border of Mauritania,
4. The Shebelli and Juba rivers (originating from Ethiopian Plateau) flowing to the Indian ocean through Somalia,
5. The Euphrates river (originating in Turkey) crossing the Syrian northern border, and
6. The Tigris river (originating in Turkey along with some tributaries originating in Iran).

More than half of the available actual renewable water resources (ARWR) are being generated outside the Arab Region. No significant trans-boundary groundwater flow is being detected for the region.

The accumulative Actual Renewable Water Resources (ARWR, which includes both, internally generated freshwater and water resources from external origins), with no double counting, is estimated at 223 Km^3/year for the Arab African nations. The Asian Arab countries posses a total of 112.8 Km^3/year of ARWR (ACSAD, 1997; Al-Zubari,1997). In 1950, the average annual share per inhabitant of ARWR was exceeding 4000 m^3/cap/year for the Arab Region. The later share decreased dramatically to 1312 m^3/cap/year in 1995, 1233 m^3/cap/year in 1998, and is projected to drop to 547 m^3/cap/year by year 2050. Tremendous deviation around the average is experienced by different sub regions and nations. Kuwait, for example, has a share of 11 m^3/cap/year of renewable water resources, while Mauritania enjoins a share which exceeds 4500 m^3/cap/year. As of 1998, only seven countries are exceeding the threshold of 1000 m^3/cap/year. These are: Iraq, Mauritania, Sudan, Somalia, Lebanon, and Syria. Morocco is barely at the limit. The situation will be further deteriorating by year 2050 where all the

Arab countries will be experiencing water stress and water scarcity except for Mauritania, Iraq and Sudan. If we consider the current status water development potential to prevail, the latter countries will also be subject to water stress. Egypt and Mauritania account for as much as 97% dependency on freshwater originating from out of country water resources. Syria exhibits a dependency of about 70%, while Sudan, and Somalia show about 60 % dependency. The formerly mentioned rivers in addition to seasonal streams and ephemeral wadies constitute the major surface water resources in the Arab Region. Figure (9) shows the

Renewable groundwater resources are in the form of shallow alluvial aquifers recharged from the main rivers in the region or directly from precipitation in limited coastal areas. These include the Nile valley (all through its course) and Nile Delta, tropical areas in Sudan, Jezira and Wadi Batin aquifers in Iraq, Tihama alluvials of Yemen and Saudi Arabia, scattered strips along the Southern and Eastern Mediterranean coast. In the Sahara Desert, the major water resources are the combined Nubian Sandstone and Continental Intercalaire nonrenewable aquifers, which extend from Egypt to Mauritania. The Nubian Sand Stone Aquifer, is a non-rechargeable basin, that was filled up during the humid periods of pluvial age, 8000 years BC and beyond. The basin, which is shared by four nations (Egypt, Libya, Sudan, and Chad) exhibits an areal extent of 2,350 Km^2, and posses a maximum reservoir capacity of 150,000 Km^3. Geologically, this reservoir is made up of continental sand stones of Mesozoic and Cambro ordivician which extends all through the Sahara Desert and the Arab Peninsula (from the Atlantic Ocean to the Arabian Gulf).

As indicated by ESCWA, UNEP, and IDB (1996), about 20 different aquifer system are prevailing throughout the Asian Arabian countries and comprising semi-confined/ shallow aquifers, and deep confined aquifer systems of different geological formations. Eight of these basins are considered as shared aquifers. The Dammam aquifer, the Aruma limestone aquifer, and Umm-er-Radhuma aquifer are among the major groundwater basins in the sub-region. Although recharge is better in the Mashreq sub-region, deep aquifers at the Arabian Peninsula sub-region have by far greater reserves of fossil water. Ground water reserves in the West Asian sub-region are roughly estimated as 143.8 Km^3. In 1995 Saudi Arabia alone abstracted about 14.66 Km^3 from these reserves. Recharge to groundwater is estimated at 4.535 Km^3 and 7.515 Km^3 for the Arabian Peninsula and the Mashreq sub-regions, respectively.

At present, groundwater resources in the Arab Region, in general, and in the Arabian Peninsula in particular, are under critical conditions as volumes withdrawn far exceed their natural recharge resulting in a continuous decline in groundwater levels and quality deterioration in most of the countries due to sea water and connate waters encroachment. The use of groundwater in Syria increased by 0.5 per cent annually in the period between 1976-1985 and by 7 per cent per year between 1989-1993 largely due to the decrease in surface water availability (SME/UNDP, 1997). Also, it is estimated that the water table in the Gaza Strip aquifer is dropping at a rate of 10-20 cm/year.

There is also, growing evidence of ground water depletion in Syria and projections suggest that on the basis of current rates of increase overall demand will outstrip supply by 2005 (MSE/UNDP, 1997).

If over-drafting continues, eventually these resources will be lost due to quality degradation and would result in further reduction to the limited arable lands in these countries due to their salinization. There are many efforts that have been undertaken in these countries to increase groundwater recharge (e.g., artificial recharge dams), and to reduce groundwater withdrawal by relying on non-conventional water resources (desalination plants and recycling wastewater), or by water conservation measures in the different consuming sectors (modernizing irrigation methods, reducing subsidies, legislation, public awareness campaigns, etc.).

Moreover, the Arab Region, at large, is characterized by a complex network of wady systems. These wadies are subject to concurrent flash flooding events where a relatively high intensity precipitation occurs over a short period of time. This results into sudden and considerable surface runoff. Most of the runoff is lost through evaporation and discharge to nearby seas or oceans. However, at the same time, these events may significantly contribute to recharge of groundwater at various locations. It is highly recommended to initiate a regional program to address the assessment of groundwater resources related to such wady systems, and to evaluate the development potential for these resources, which are expected to be considerable, should they be properly managed.

The water demand in the region is steadily increasing at alarming rates, thus placing an exceeding pressure on the amount of water available. The Arab population has been abstracting a total of about 195 Km^3/y of freshwater as of 1995 [Tables (3,4,5)]. About 15 % of this amount is being attributed to depletion of fossil water and to non conventional sources. For the Arab African sub region, the total freshwater withdrawals are estimated at 98 Km^3/year, or 107% of its Internal Renewable Water Resources, and 44% of its Actual Renewable Water Resources, out of which 55.1 Km^3/y or a contribution of 57% is withdrawn by Egypt (which annually withdraws almost all of its resources). As for the sectoral water uses in the sub-region, on average, irrigation consumes about 88% of withdrawals, while industry and domestic sectors consume 7% and 5% respectively. The reason that only half of the actual resources is being consumed is partially attributed to the physical and financial inaccessibility to proper water management, and partially to the need for better indicator that takes into account, among several factors, the amount of resources lost by evapotranspiration, interception, and consumption by forests and natural vegetation.

Non-conventional water sources are used by some countries in the African sub-region to meet their water demands. These include desalination and reuse of treated municipal waste water. According to a 1993 figure, an estimate of 491 million m^3/year of non-conventional yield was recorded for the Arab African Region, out of which 225 million m^3/year were generated in Egypt and 170 million m^3/year in Libya. In Egypt, 4.0 Km^3/year of agriculture drainage water are reused after mixing with freshwater to satisfy some of the country's agricultural water demand. Depletion of fossil water resources and over-extraction of renewable groundwater is widely practiced in Libya.

In 1995, more than 91 % of the water demand in the West Asian sub-region was used in the agricultural sector, while 7% for domestic purposes, and 1.1 % for industry (ACSAD, 1997). In the Arabian Peninsula (GCC countries), out of the 0.918 km^3 of treated waste water per annum, only about 0.4 km^3 are being tertiary-treated and used for irrigating non-edible and fodder crops as well as for landscaping. About 60 % of the partially treated wastewater is dumped into the sea or low lands. In the Mashreq, about 0.2 km^3 of wastewater is used annually for irrigation purposes.

Desalination plants in the GCC countries (47 in operation) were built since 1970 to provide domestic water supply to large coastal cities and inland major municipalities. The desalination capacity of these plants (1.6 Km^3/y) accounts for 60 % of the total World's capacity, and covers about 50 % of the domestic water supply. Desalination plants capacity is expected to reach 3 Km^3/y by the year 2020. However, these plants are associated with the environmental problems of the disposal of the heated brine byproduct (Al - Zubari, 1997) which have not been sufficiently investigated yet. In the Mashreq few small desalination plants exist in Jordan, Lebanon and Syria with a total of 7.5 Mcm annual productions. Similarly, it is anticipated that recycled treated wastewater volumes would increase to about 3 Km^3/y by the year 2020, to be used mainly as a substitute for groundwater in irrigation in GCC countries.

Many of the countries of the region have undertaken major water development projects related to water resources management. Among the key projects that have been completed, or underway or planned for the future are:

1. The construction of a series of dams for flood control and flow regulation with an overall dam capacity of about 200 Km^3 (169 Km3 corresponds to the Aswan High Dam, 11 Km^3 corresponds to the 34 dams in Morocco, and 8.8 Km^3 as for the 4 main dams in Sudan, 14 Km^3 for Thawra Dam on the Euphrates in Syria, Tharthar barage and Saddam Dam on the Tigris). Along the years this resulted in the reduction of the amount of freshwater flowing to the seas and oceans.
2. The great man made river in Libya to convey 2 Km3/year of fossil water from the southern dessert to the northern coast.
3. Construction of the world's greatest assembly of desalination plants at the GCC countries.
4. The greater Cairo Wastewater Project to collect and treat effluents corresponding to more than 7 million inhabitants.
5. Groundwater recharging schemes and conjunctive use models in Tunisia and Egypt
6. Al-Salam canal in Egypt to deliver mixed agricultural drainage water and freshwater from Eastern Delta to Northern Sinai.
7. Future completion of the Jongli canal in Sudan to divert 10 Km3/year out of the Sudds, normally lost to evaporation.

8. Recent implementation of demand management measures and integrated water resources management principles.

In recent years, the water quality in the region has received considerable attention. In the Maghreb countries, Tunisia, Algeria and Morocco have started regular surveys of groundwater quality as of the 1990s. Morocco is also conducting intensive reservoir eutrophication studies and Algeria is developing a network for monitoring of surface water quality. Major water quality problems in the Maghreb area include; high salinity of non-perennial rivers (up to 5 g/l detected in Tunisia), high Total Suspended Solids in rivers during the peak flows (reaching 50 g/l), excessive total bed load (erosion rates of 1000 t/km2/year, which contribute to siltation of reservoirs), and high Fluoride content in localized groundwater sites in Morocco. Human induced pollution include; pathogenic pollution of water resources as a result of untreated municipal waste water effluents (supplies to the city of Algiers). Nitrate pollution of groundwater from fertilizers is recorded in Morocco and in the Mitidja Plain of Algeria where one third of monitored wells exceed the 50 mg/l standard for Nitrates. Cadmium-rich water releases from Phosphate mines (Mitidja plain) and eutrophication of dam reservoirs (Morocco) are also common problems. Over extraction of shallow groundwater along the Mediterranean coast alarmingly accelerates salt water intrusion (Libya, Tunisia).

Water quality monitoring in the North-Eastern African sub region is mainly concentrated in Egypt where programs for monitoring surface and groundwater were established in the 1990s through the Ministry of Water Resources and Irrigation, Ministry of Health, Ministry of State for Environmental Affairs, and the Egyptian Environmental Affairs Agency (EEAA). The construction of the High Aswan Dam at the upstream border of Egypt resulted in successful irrigation development projects in Egypt and Sudan. It also provided the necessary supplies during the drought period of the 1980s and equally furnished the necessary relief during excessive floods in the end of the 1990s. However, it contributed to rising of the water table in Upper Egypt and in the Delta thus stimulating water logging and increased groundwater and soil salinity. Since 1999, the direct disposal of untreated industrial effluents to the Nile has been banned. The Nile branches experience more oxygen depletion which may reach a DO value of 3 at the far downstream end presenting potential hazard to aquatic organisms. Excessive application of nitrate and phosphate fertilizers represents another source of pollution. Water hyacinth flourishes at the downstream of waterways due to excessive amount of nutrients which leads to clogging of canals. However, weed control programs have been effectively implemented. Concentration of DDT, Endrin, BHC,.etc, have been well below permissible values. The northern wetlands are experiencing eutrophication at many locations.

In Sudan, alarming phytoplankton levels, water hyacinth, and high sediment load carried by surface waters constitute main problems for water management, treatment, and result in high reservoir siltation rates. Insufficient potable water supplies, and wastewater collection and treatment facilities lead to potential health hazards. Water quality data for Somalia and Djibouti are very limited if any.

The quality of groundwater in West Asia sub region has deteriorated due to the continuous over-drawing of the shallow and deep aquifers. This has led to sea water intrusion along the shoreline causing salinization of the coastal agricultural lands. Consequently, agricultural production has been reduced, and arable lands in some locations were completely lost. For example, it is estimated that the saline interface between sea and ground water advances at an annual rate of 75-130 meters in Bahrain (UNEP/ESCWA, 1991).

In the Mashreq sub-region, dumping of raw and partially treated wastewater from agriculture, industry and municipalities in water courses has caused deep concern over the health impacts, and has subjected agricultural lands and water resources to severe pollution, especially during low discharge periods. Contamination of the underlying shallow aquifers was evident, thus causing serious health hazards. It is reported that nitrate concentration in some wells used for domestic purposes in Gaza Strip may reach up to 40 ppm (Zarzour *et. al.,* 1994) which represent four times the limits set by WHO (10 ppm Nitrate-N). River basins in the countries of this sub-region have shown such symptoms (Hamad, *et al*, 1996; MSE/UNDP, 1997).

The legal framework governing the management of shared water resources in the region has not been comprehensively addressed. As various countries of the region (and outside the region) intensify their water development efforts to meet growing demands, then competition among the sharing riparian will increase. Hence, a framework for cooperation in the management of shared water resources should be developed in the coming years. Environmental concerns over transboundary pollution transport through watercourses are becoming one of the highest priority issues in the international community. In the Arab Region, where more than half of the available renewable water resources flow from outside its boundaries, transboundary pollution of shared watercourses presents a possible future threat. Agricultural expansion projects along the upstream of the Euphrates River, for example, may cause substantial deterioration in the water quality further downstream. Measures to prevent, reduce, and preserve freshwater quality need to be urgently established and monitored through bilateral, multilateral, or regional agreements. The threats to contamination of shared groundwater aquifers, by mining industries, illegal dumping of hazardous wastes, excessive exploitation, and other man made activities, should be equally considered.

The recorded figures for access to safe drinking water are highly variant from one reference to the other. Libya, Tunisia, and the GCC countries exhibit the highest percentage of population with access to safe drinking water (more than 90%) and also to sanitation services (WRI 1998). The lowest accessibility to both services is encountered in Somalia, Djibouti, and Yemen. Massive investments have been diverted towards establishment of sanitation systems in Egypt in the last ten years. The national trend for treatment of wastewater has shifted from activated sludge techniques, since the sixties, towards stabilization ponds that are widely established in the 1990s.

Environmental problems related to municipal wastewater in rural communities are mainly due to the fact that sanitation services lag behind water supply services by 10 years or more.

In general, increased salt content of surface and groundwater, salt water intrusion along the coastal zones, high bed and suspended sediment load in some rivers, reservoir sedimentation, pathogenic contamination of some shallow aquifers, and eutrophication of wetlands are the major identified and expected water quality problems up to year 2010. Trace elements pollution and pathogenic pollution may exhibit further complications by year 2010 if municipal and industrial wastewater are disposed in waterways without treatment. Threats of depletion and contamination of fossil waters are highly probable by year 2010 unless preventive programs are applied. Integration of the technical, hydrological, economic, environmental, social, and legal aspects into a coherent framework of Integrated Water Resources Management (IWRM) is inevitable to confront the chronicle water scarcity in the region.

Finally, the interdisciplinary nature of water problems requires new methods to integrate the technical, hydrological, economic, environmental, social, and legal aspects into a coherent framework of IWRM. A balanced approach between water supply and water demand management should be achieved. Water security and food security are to be closely linked. Moreover, it is at the basin level that hydrologic, agronomic, and socio-economic relationships can be integrated into a comprehensive modeling framework and, as a result, policy instruments, which are designed to make more rational economic use of water resources, are likely to be applied at this level. The Arab Region has started to create the enabling environment for IWRM including formulation of the legal framework governing development and preservation of freshwater resources, and the institutional framework for conducting such an approach. However, the level of enforcement of regulations and the appropriate operation of institutions is still subject to various constraints. Capacity building requirements, institutional fragmentation, the need for better information exchange and processing, lack of finance and incentives, and the need to mobilize the political will, continue to represent major challenges to the progress in implementing IWRM. The Arab Region needs to urgently consider the implementation of a mega scale economic programme, similar to the Marshal programme which has been implemented throughout Europe, after the Second World War. Water resources will play a major role in shaping such programme.

Assessment and reporting on access to drinking water and sanitation services represents an important step towards achieving the water-related Millennium Development Goals (MDGs).

To Achieve the MDGs of reducing by half the people with no access to drinking water by 2015, 83 million people in Arab region need to be supplied with safe water, while 83 million people will still remain with no access. Figure (7) shows the percentage of population without access to safe water in each Arab country.

To Achieve the MDG of reducing by half the people with no access to Proper Sanitation by 2015, 96 million people need to be provided with sanitation services, while 96 million people will still remain with no Access. Figure (8) shows the percentage of population without access to sanitation services in each Arab country.

The above numbers are estimated according to the published data. However this assessment needs to be revisited according to actual definitions of the MDGs for water supply and sanitations.

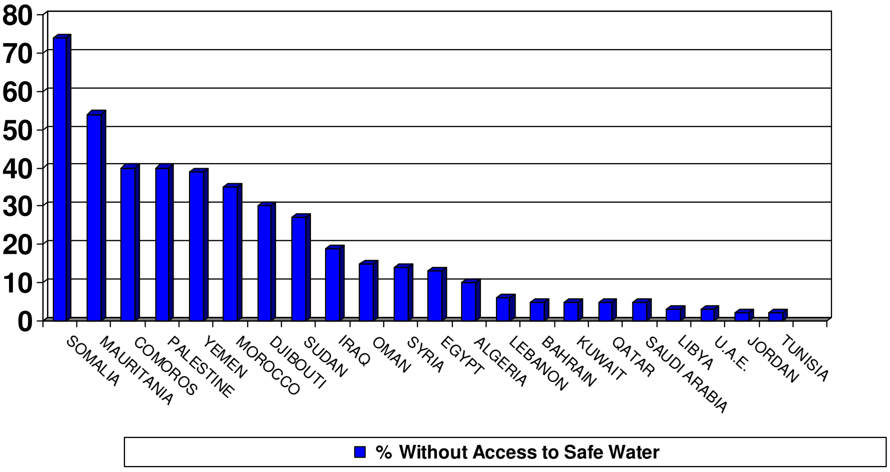


Figure (7): % Arab Countries Population without Access to Safe Drinking Water

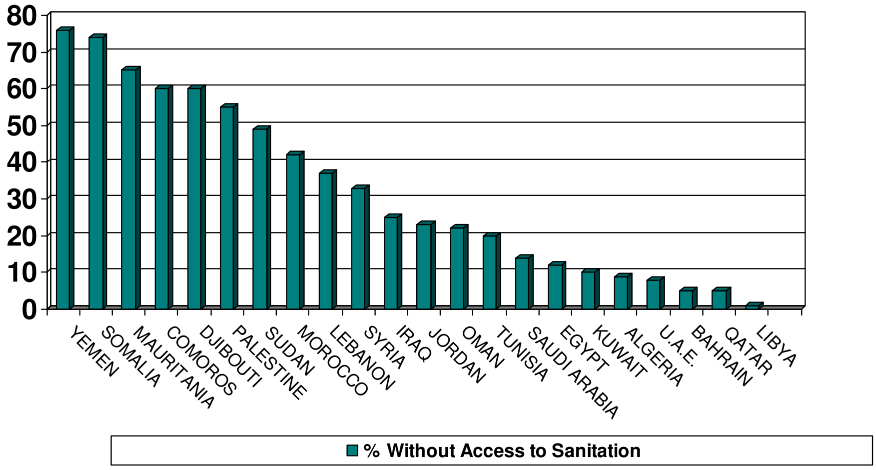


Figure (8): % Arab Countries Population Without Access to Proper Sanitation

Figure (9) shows the per capita annual renewable water resources for year 2000 and projected for year 2025. This information is based on the published assessments which mostly consider renewable water resources as the available surface water without taking into consideration any other forms of renewable water such as groundwater recharge and the portion of rainwater that feeds directly into forests, pasture, and other rainfed agriculture.

Figure (10) shows a comparison between the per capita renewable water resources from the published assessments and the new assessment presented in this report for the 2000 per capita national water use taking into consideration the water resources contributing to the different sectors including irrigation ,domestic, industrial, rainfed agriculture, forests, and pasture land water use.

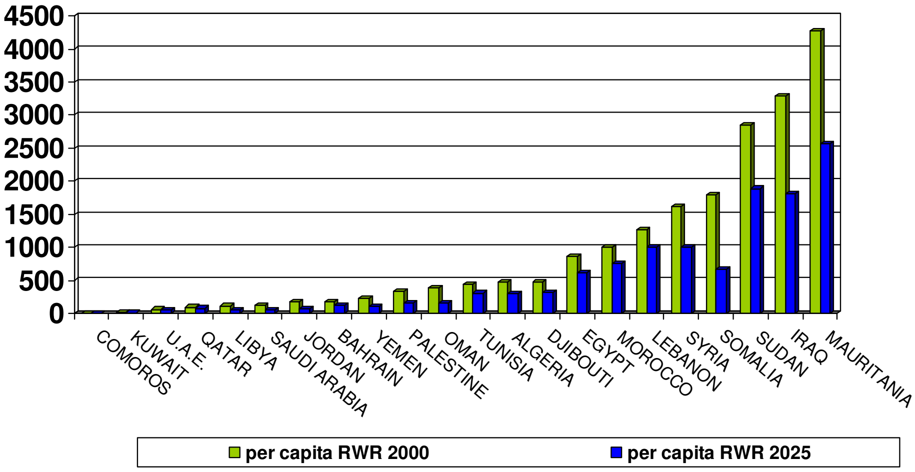


Figure (9):Annual Renewable Water Resources in the Arab Region (m^3/cap/year)

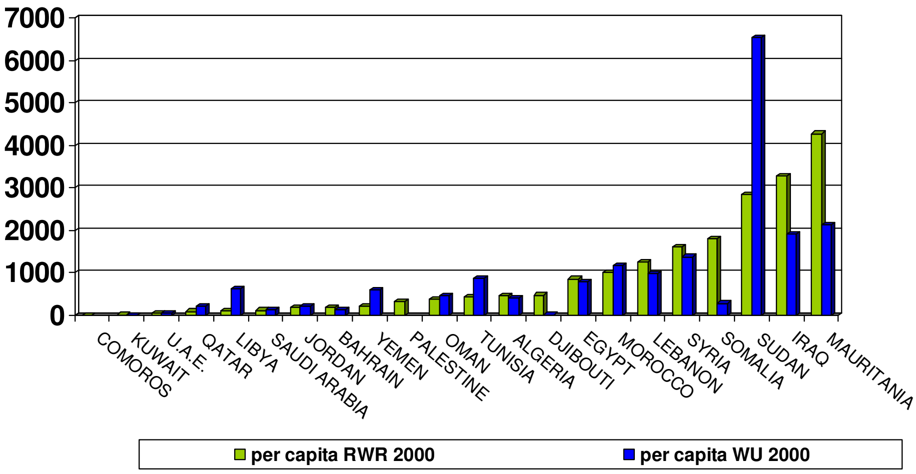


Figure (10): % Annual Water Resources versus Water Uses in Arab Region (m^3/cap/year)

STATE OF THE WATER IN THE ARAB COUNTRIES (A NATIONAL PERSPECTIVE)

SAUDI ARABIA

Saudi Arabia occupies the bulk of the Arabian Peninsula with a total area of 2.25 km2 located in south west of Asia. The coast line in the Red Sea and the Arabian Gulf is about 2,640 km long. The total population is about 23 million of which about 7 million foreign nationals. The population density is about 10 inhabitant/km2.

The climate in Saudi Arabia is generally harsh, with great temperature extreme. It is mostly dry desert. The average annual rainfall is 110 mm/year. While some of the South Western mountains receives up to 600 mm of annual precipitation. Flash floods occur in many parts of Saudi Arabia due to heavy rain in short periods. The average annual surface runoff for the whole country is (2BM3) billion cubic meters. More than (223) dams have been constructed for various purposes (i.e. flood control, irrigation, water supply and groundwater recharge) the total storage capacity of these dams is (835 mm3) million cubic meters. There are (17) dams under construction with capacity totaling (979 mm3).

The total annual renewable water consumption is about (8 BM3). The non-renewable water consumption is about (12.4 BM3/year) which comes from (9) primary aquifers and (13) secondary aquifers. Agriculture consumes about 85% of the total water consumption in the country while municipal and industrial water demand uses the remaining 15%.

Saudi Arabia is the largest user of sea water desalination technology. Desalinated water is used for domestic purposes only. The production of desalination station is about (3 mm3/day).

Saudi Arabia is implementing a plan to reclaim most of the treated wastewater to be used for agriculture, industry and land scaping the daily treated wastewater is about (335,000 m3).

The total irrigated area in the country is about (1.1) million hectares.

Republic of Yemen

The average annual rainfall is about 170 mm, varying between less than 50 mm in the coastal areas and the eastern desert to 200-400 mm in the highlands and increases along the western slopes of the central highlands to reach up to 1000 mm in some spots. Rainfall occurs mainly during the spring (March – April) and summer (June –August) months.

There are four major drainage areas in Yemen, namely the Red Sea, the Golf of Aden, the Arabian Sea, and the Rub Al-Khali. These drainage areas are further divided into 14 major water basins.

The total actual renewable water resources is estimated at 2.5 km3/y, which translates into a per capita share of only 130 m3/y. Given the high population growth rate, the per capita share of renewable water resources is projected to further decline to around 75 m3/y by 2025.

The actual fresh water withdrawal is estimated at 3.5 km3/y, resulting in an annual deficit of 1.0 km3/y. This deficit is largely satisfied from fossil groundwater aquifers. Water use in Yemen is characterized by:

  93% agriculture
  7% domestic and industry

Land Use Patterns in the Arab Region

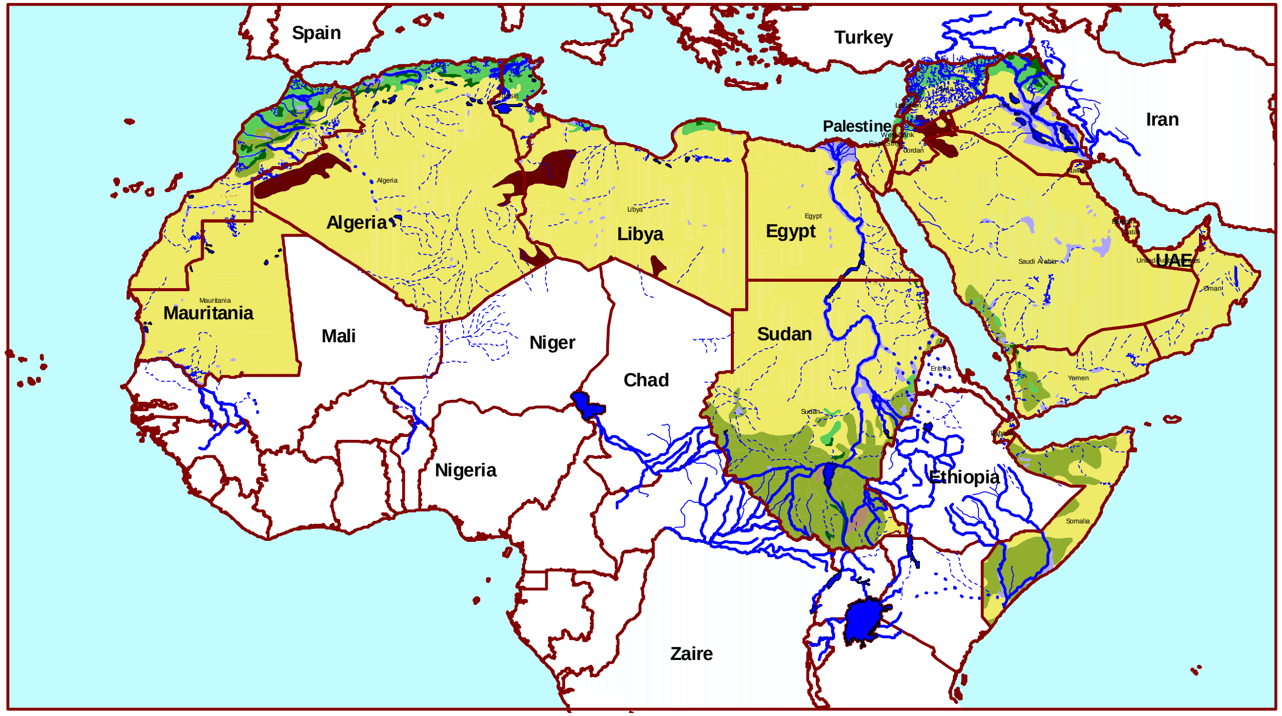


Figure (11) Land Use Pattern in the Arab Region

Precipitation Patterns in the Arab Region

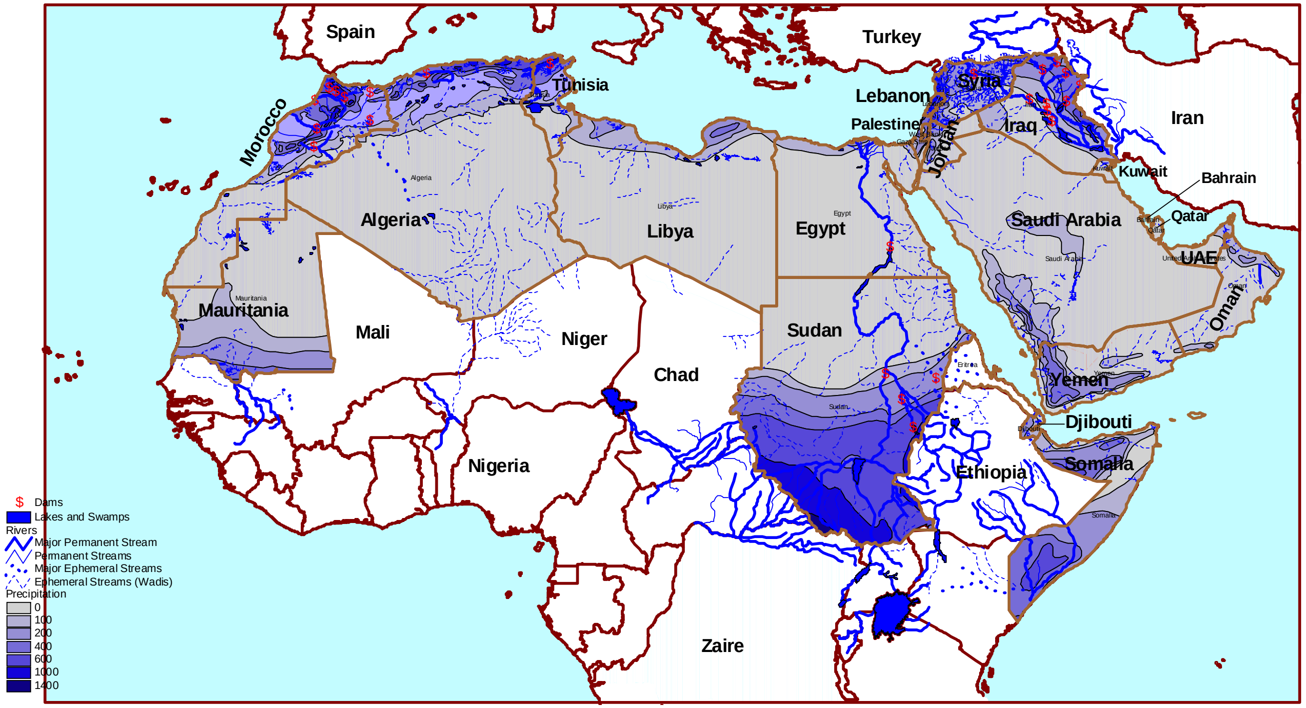


Figure (12) Precipitation Pattern in the Arab Region

Soil Water Holding Capacity in the Arab Region

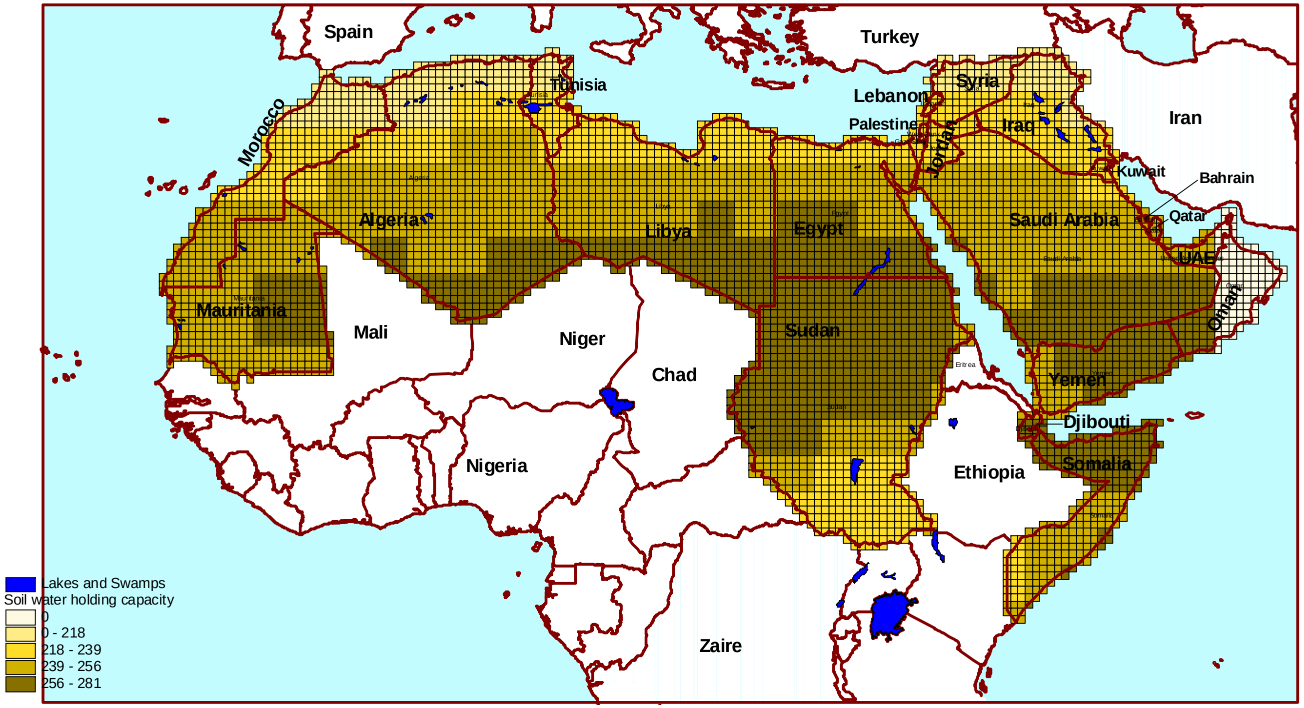


Figure (13) Soil Water Holding Capacity in the Arab Region

Solar Radiation in the Arab Region

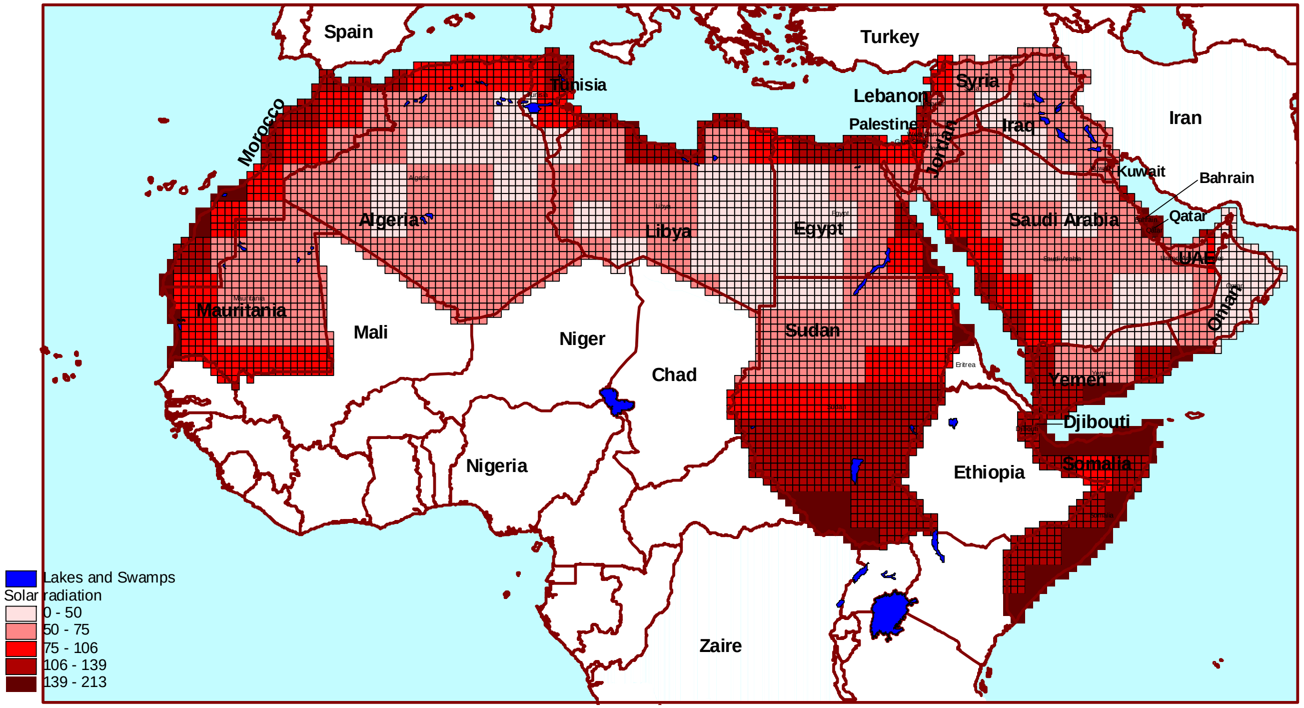


Figure (14) Solar Radiation in the Arab Region

Land Use Patterns in the Arab Region

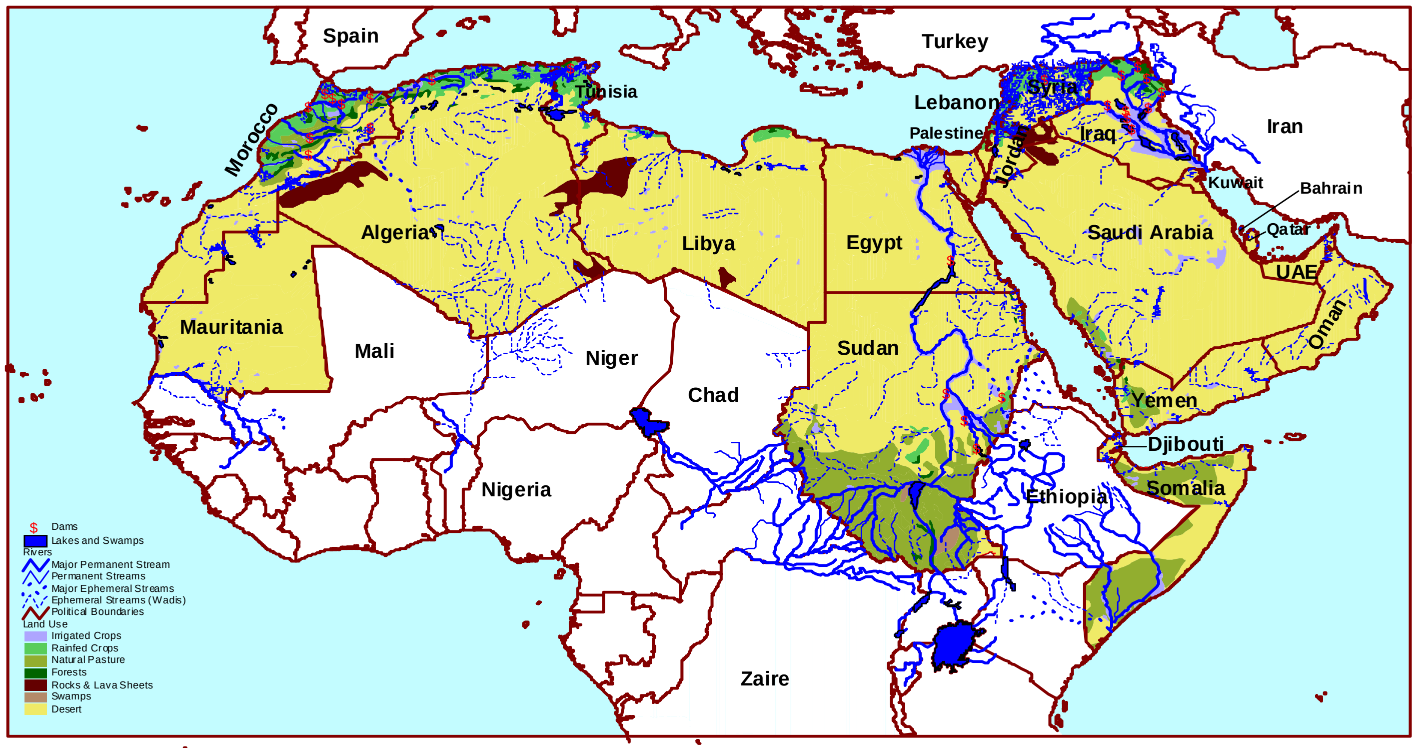


Figure (11) Land Use Pattern in the Arab Region

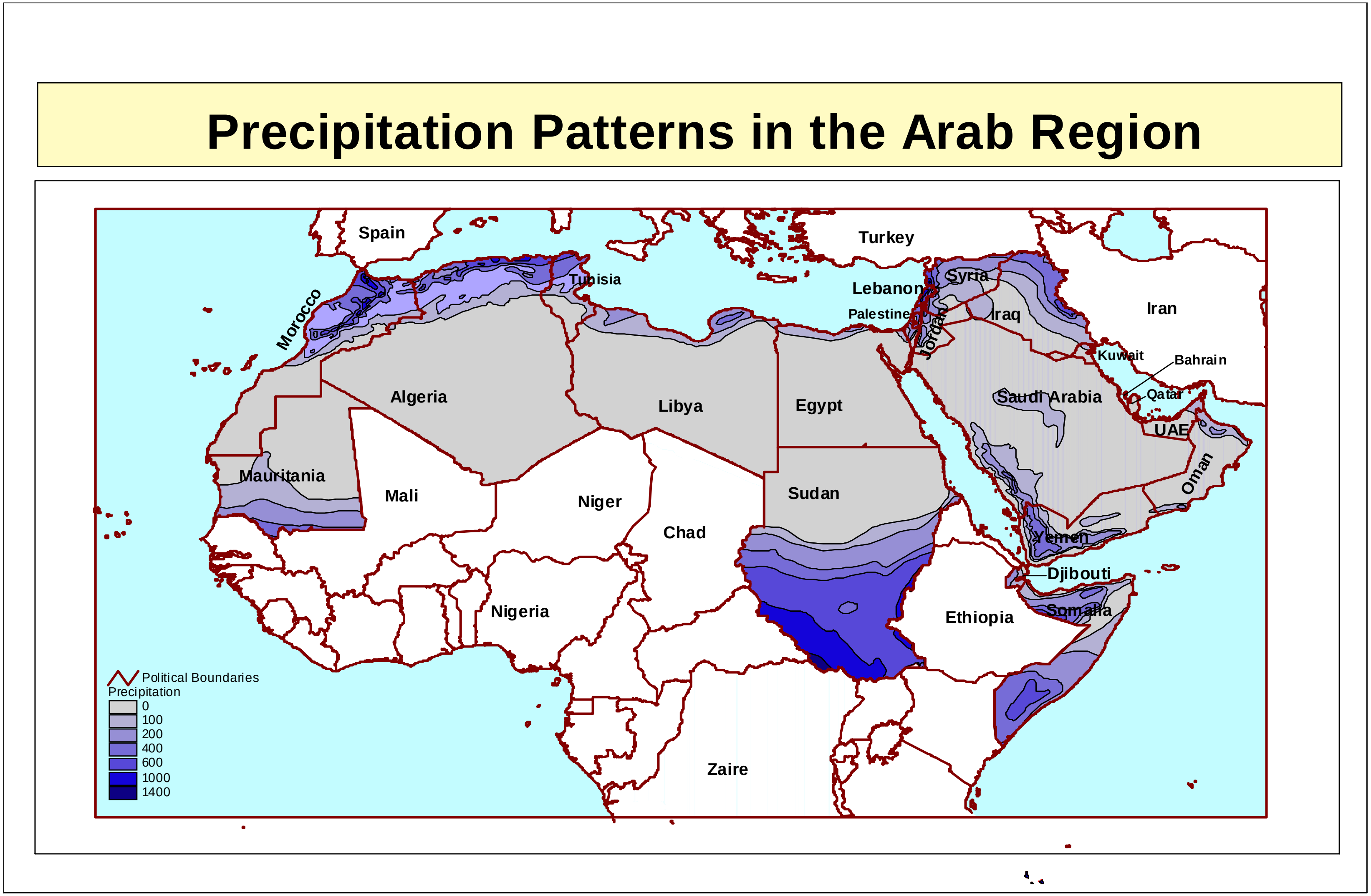


Figure (12) Precipitation Pattern in the Arab Region

Soil Water Holding Capacity in the Arab Region

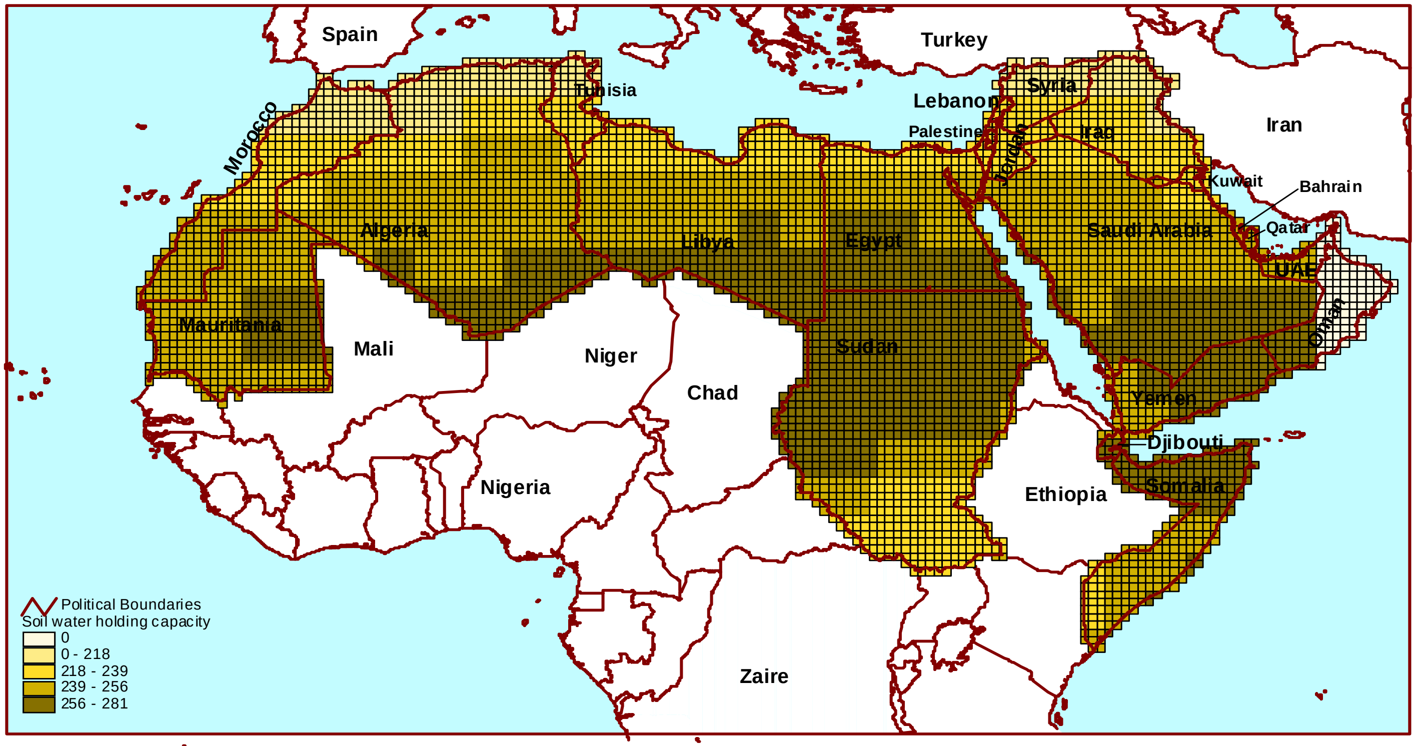


Figure (13) Soil Water Holding Capacity in the Arab Region

ALGERIA

The average annual rainfall is about 68 mm varying considerably from zero in the southern dessert to 1500 mm at the northeastern coastal area. Precipitation, which mainly occurs in winter and early spring, is highly irregular and accounts for 13.9 km^3/y of internal renewable water resources. Transboundary incoming surface flow (from Tunisia and Morocco) is estimated at 0.4 km^3/y and the safe extract of non renewable fossil water is around 3.5 km^3/y. The total actual renewable water resources is 14.3 km^3/y as of 1995 where the total population is projected to be 28 million inhabitant, thus generating a per capita share of ARWR of 512 m^3/y. The potentially available water at the northern part is estimated at 8.1 km^3, out of which 1.6 km^3 is attributed to groundwater, and 6.5 km^3 is surface water which needs regulation by dams. The total annual freshwater withdrawal is 4.5 km^3/y (180 m^3/cap/y) as of 1990, 60% of which is directed to agriculture, 25% to domestic and 15% to industry. The irrigation potential based on ARWR is estimated at 510,000 ha. The water supply coverage (1985) is assessed as 85% in urban communities and 56% of rural population.

Population growth at a rate of 2.3 %, increased demand for food, attempts for industrialization, along with the frequent occurrence of extended dry periods are all putting pressure towards advances in water resource management. Recent political instability, on the other hand, diverted the attention off proper environmental management of resources. Major changes during the last ten years include the establishment of a series of dams with a total dam capacity of 1.2 km^3. At the beginning of the 1990s a program was set forward for the rehabilitation and extension for existing irrigation schemes to achieve a total area of 500,000 ha of equipped and irrigated land by the year 2010.

Dam reservoir sedimentation is identified as a main environmental problem which reaches more than 95% of siltation at some locations. Soil salinization tends to be of primary concern during the last decade characterized by extended dry periods. Water purification techniques are below standard and poor drinking water is a leading cause of disease and infant morality. Alarming pollution of the water reserves at Mitjdja, the main supply for the capitol, is encountered due to municipal and industrial wastes along with agricultural drainage. Nitrate concentration in some wells reached 100 mg/l in 1988. Special development programs devoted to enhancing drinking water quality and sanitation services are expected to be due by year 2010.

WATER RESOURCES OF Algeria

Water Resources In

Precipitation	=	162.900 km3/y
Run off	=	0.300 km3/y
GW	=	0.000 km3/y
SUM	=	163.200 km3/y

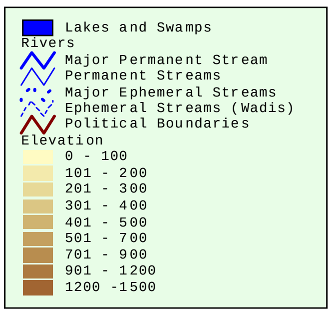
Water Resources Out

Run off	=	0.600 km3/y
GW	=	0.000 km3/y
SUM	=	0.600 km3/y
Evaporation + Unutilized Water	=	150.100 km3/y

Beneficial Abstractions

Irrigation	=	2.700 km3/y
Domestic	=	1.125 km3/y
Industrial	=	0.675 km3/y
Sum	=	4.500 km3/y
[Rain Fed Agriculture + Pasture + Forests] Natural (ET)	=	8.000 km3/y

Total Crop Land	33,667 Km2
Irrigated Land	5,555 Km2
Rain Fed Crop Land	28,112 Km2
Natural Forest Area	13,760 Km2
Natural Pasture	4,413 Km2



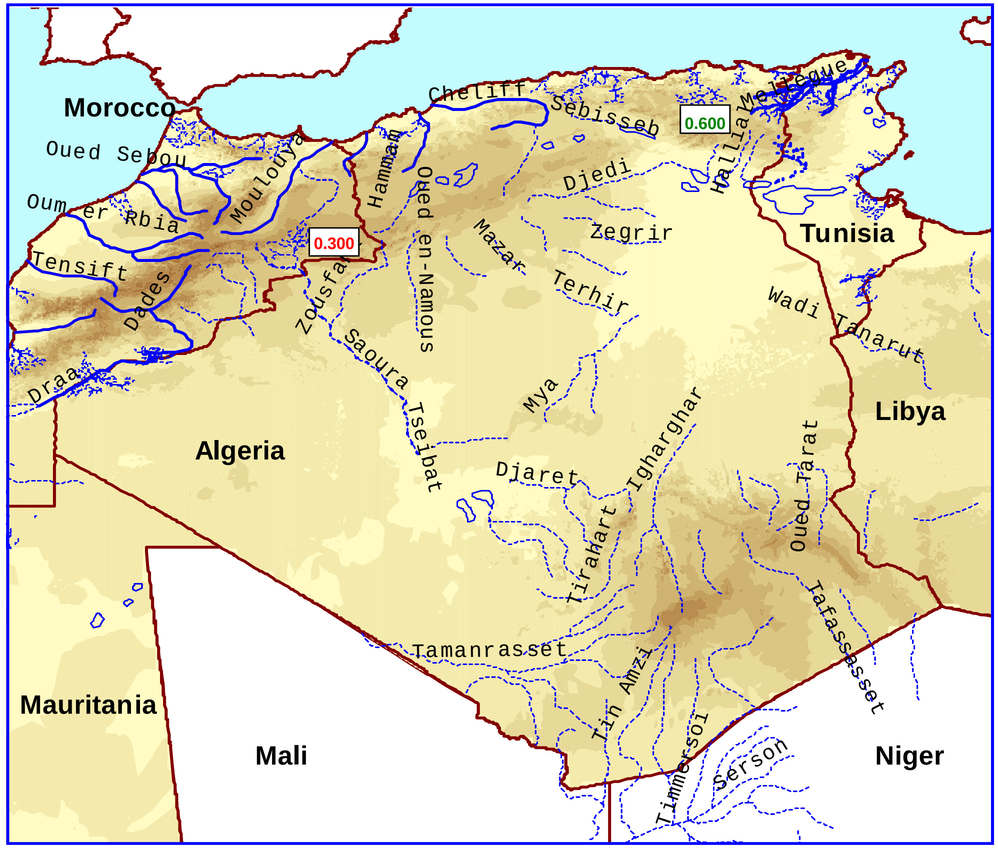


Figure (15) Water Resources of Algeria

BAHRAIN

The average annual rainfall is about 70.6 mm. The precipitation season extends from November to April. There are no perennial streams in Bahrain and the total annual surface runoff is estimated to be about 0.004 km^3/yr. Transboundary incoming groundwater inflow (from Saudi Arabia) is estimated at about 0.112 km^3/y under steady-state conditions (before 1965) and this figure is considered to be the safe groundwater yield in Bahrain. The internal renewable water resources account for 0.004 km^3/y as of 1995 and the total actual renewable water resources are estimated at only 0.116 km^3/y as of 1995.

Total population is projected to be 564 000 inhabitant (1995) , thus generating a per capita share of ARWR of 206 m^3/y. The population growth at a rate of 4% , will decrease per capita share of ARWR and led to general reduction of the cultivated lands. The total annual freshwater withdrawal is 0.239 km^3/y (465 m^3/cap/y) as of 1990, about 56% of which for irrigation and livestock watering, about 40% to domestic and about 4% to industry.

Non-conventional water sources accounted for almost 22 % in the total water withdrawal in 1991. The total quantity of desalinated water used in 1991 was 44.1 million m^3/y. About 45 million m3/y of wastewater as of 1991 was treated, 8 million m3/y of which was used for irrigation, while the rest was discharged to the sea. The irrigation potential based on ARWR is estimated at 4,230 ha. The water supply coverage (1995) is assessed as 100% in urban communities and rural population.

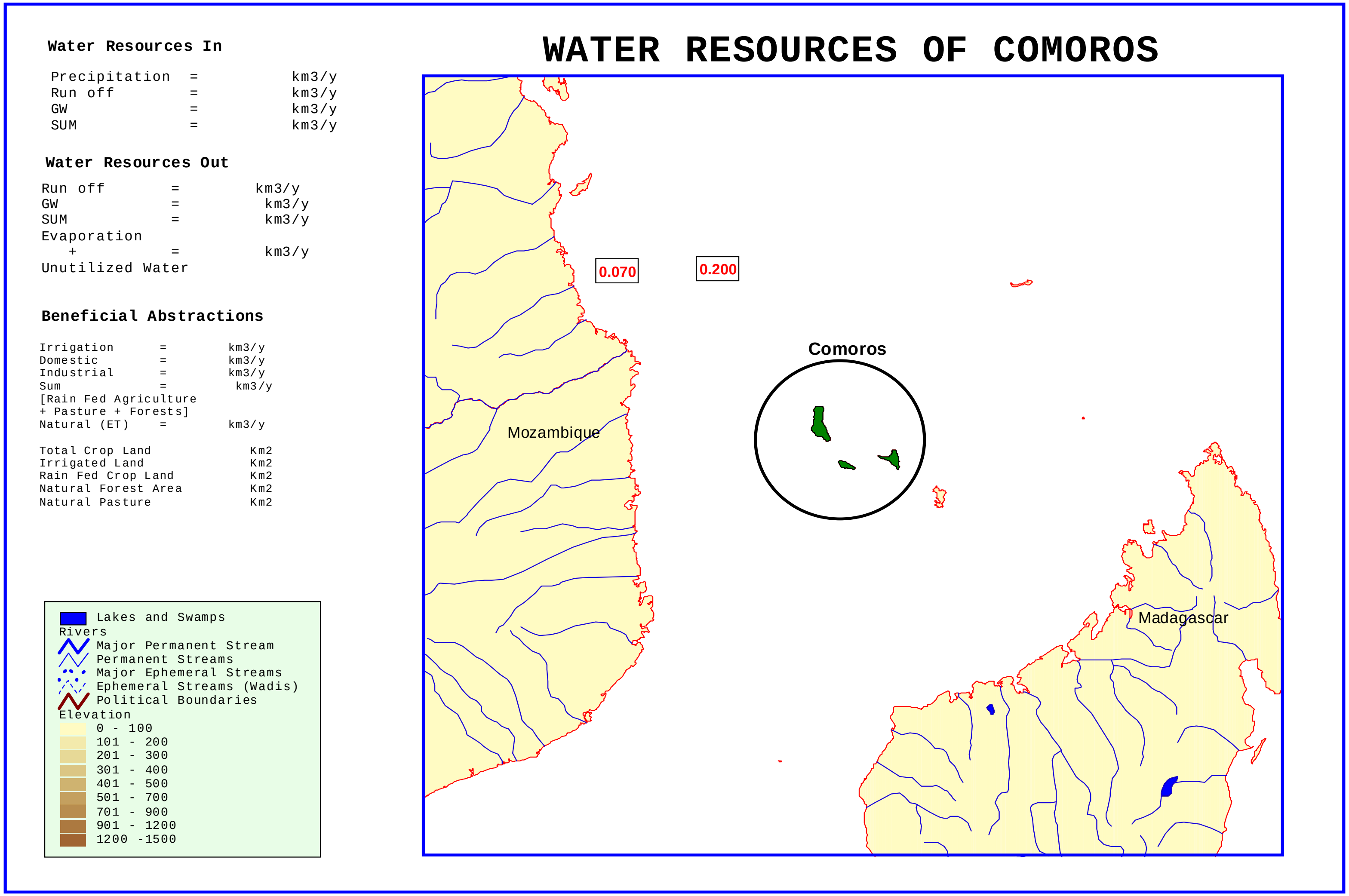


Figure (16) Water Resources of Comoros

COMOROS

The average annual rainfall on the islands is about 900 mm varying considerably with space and time. Most of the rainfall occurs between November and April. Internal renewable water resources are estimated at 1.0 km^3/y. The total actual renewable water resources is considered also to be 1.0 km^3/y as of 1991 where the total population is projected to be 0.45 million inhabitant, thus generating a per capita share of ARWR of 2283 m^3/y. The available surface water resources are very limited on the Grande-Comore island due to very high soil permeability. The other two major islands have surface runoffs. However, as a result of deforestation and urbanization the available surface conveying routes decreased from 42 in 1925 to about 19 in1992 thus presenting a potential threat. The total water managed area in 1987 is estimated as 130 ha while the irrigation potential is estimated as 303 ha. The water supply coverage (1990) is assessed as 11% in urban communities and 61% of rural population.

Inaccessibility of water resources in many locations of the islands as a result of its geology is a major constraint against the efficient utilization of available resources. Three irrigation projects are being currently conducted.

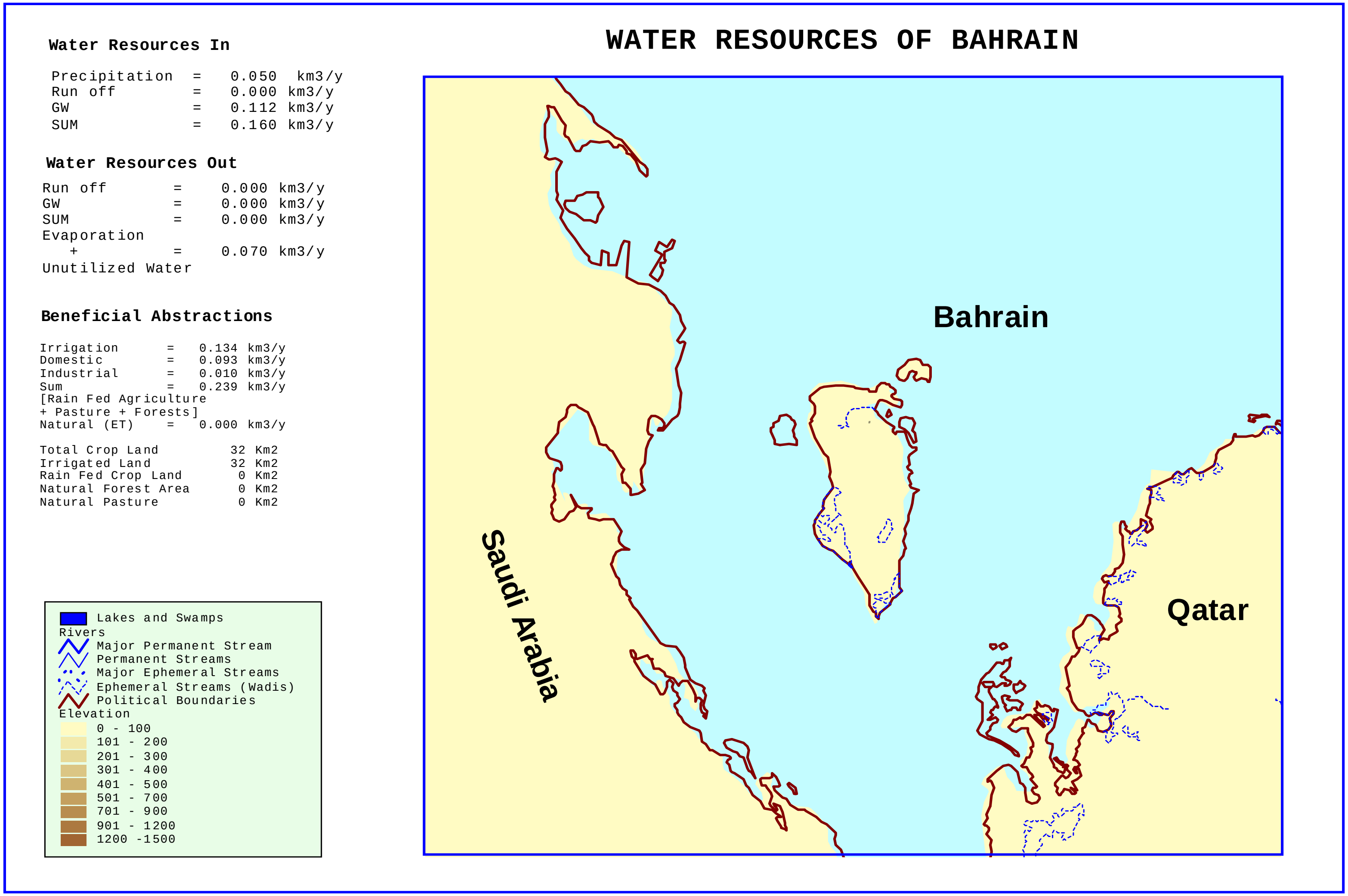


Figure (17) Water Resources of Bahrain

DJIBOUTI

The average annual rainfall is about 147 mm varying from 50 mm in the northeast to 300 mm at the western region. Irregular precipitation allows for few days of surface runoff to occur after events of heavy rainfall. The catchment system is divided into two zones, one draining to the sea (45%), while the other draining to the western plains (55%). The internal renewable water resources are estimated at 0.3 km^3/y. A transboundary incoming surface flow (from Ethiopia) is estimated at 2 km^3/y of saline water which is not beneficial without further treatment. The total actual renewable water resources is thus considered as 0.3 km^3/y as of 1995 where the total population is projected to be 0.58 million inhabitant, thus generating a per capita share of ARWR of 520 km^3/y. The groundwater resources in general suffer from excessive salinity and high Boron content except for the northwestern part of the country.

The total annual freshwater withdrawal is 0.0075 km^3/y (20 $m^3/cap/y$) as of 1985, 86% of which is directed to agriculture and 14% to domestic. The irrigation potential based on ARWR is estimated at about 700 ha, while currently about 407 ha are cultivated and supplied by water through shallow wells. The water supply coverage (1985) is assessed as 50% in urban communities and 21% of rural population.

Political dependence of the country on the status neighboring countries and the African horn is reflected on management of resources. Djibouti's environment is generally harsh and is poorly endowed with natural resources. However, the government has identified environmental protection as one of the aims for the development plan for 1991-2000 with special emphasis on adequate water supplies. Better use of limited surface runoff and development of irrigation in the wadies is expected by year 2010.

Water Resources In

```
Precipitation   =   3.400  km3/y
Run off         =   0.000 km3/y
GW              =   0.000 km3/y
SUM             =   3.400 km3/y
```

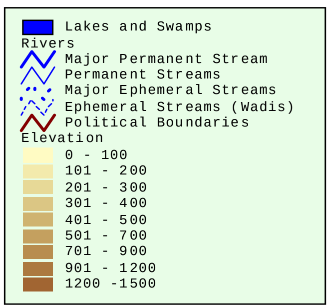
Water Resources Out

```
Run off         =    0.000 km3/y
GW              =    0.000 km3/y
SUM             =    0.000 km3/y
Evaporation
   +            =    3.392 km3/y
Unutilized Water
```

Beneficial Abstractions

```
Irrigation       =  0.007 km3/y
Domestic         =   .001 km3/y
Industrial       =  0.000 km3/y
Sum              =  0.008 km3/y
[Rain Fed Agriculture
+ Pasture + Forests]
Natural (ET)     =  0.000 km3/y

Total Crop Land        407 Km2
Irrigated Land         407 Km2
Rain Fed Crop Land       0 Km2
Natural Forest Area    220 Km2
Natural Pasture          0 Km2
```



WATER RESOURCES OF DJIBOUTI

Figure (18) Water Resources of Djibouti

Egypt

The average annual rainfall is about 18 mm mainly occurring at the northern coast. In the southern Upper Egypt, Sinai, and along the Red sea coast events of measurable rainfall are encountered once every two years, sometimes developing into very short, but destructive, flash floods. Precipitation which occurs in winter and late autumn accounts for 1.8 km^3/y of internal renewable water resources out of which 1.3 km^3/y is recharging shallow aquifers, and 0.5 km^3/y supplying surface water resources.

Out of the Nile's average natural flow of 84 km^3/y reaching Aswan, a transboundary incoming surface flow from Sudan of 55.5 km^3/y is allowed to pass according to the Nile water agreement. The agreement allocates the former share (of 55.5 km^3/y) to Egypt and a share of 18.5 km^3/y to Sudan, while about 10 km^3/y is lost in evaporation from the high dam reservoir. A speculated and doubtful figure of 1 km^3/y of renewable groundwater is sometimes claimed to enter the country. The total actual renewable water resources is considered as 58.3 km^3/y as of 1995 where the total population is projected to be 63 million inhabitant, thus generating a per capita share of ARWR of 926 m^3/y. About 97% of Egypt's ARWR is being generated outside its borders.

Egyptian extensive efforts to meet the water demands resulted in a total water development potential of 63.5 km^3/y as of year 1995 which is divided as:

- 56.0 km^3/y from surface water resources,
- 1.3 km^3/y from renewable groundwater resources,
- 2.0 km^3/y from non-renewable groundwater resources,
- 4.0 km^3/y from reuse of agriculture drainage water, and
- 0.2 km^3/y from reused treated municipal waste water.
- 0.025km^3/y of desalinated water as of 1992 (estimated as 0.06km^3/y in 1996).

The annual water use (1995) is estimated as 60.3 km^3/y including 1.8 km^3/y for navigation, 1.0 km^3/y for commercial, energy, recreational, and other purposes. The total annual freshwater withdrawal (following the convention used in this report) will be 57.7 km^3/y (916 m^3/cap/y) as of 1995, 83.2% of which is utilized by agriculture, 5.5% by domestic sector and 9.8% consumed by industry. Evaporation losses from the 31,000 Km long water conveyance network is estimated at 2 km^3/y. Water resources management, hydraulic control, channel design, distribution networks, and water discharge monitoring has been practiced by Egyptians for over 4000 years. The total dam capacity in 1992 is about 169 km^3 mainly attributed to the reservoir of the Aswan high dam. About 90% of the Nile's hydro-potential has been exploited to generate 11 Twh. The total water managed area in 1993 is 3.25 million ha representing all of the cultivated area. The irrigation potential is estimated as 4.4 million ha. Agricultural drainage through primitive pumping stations and excavation of main drains has been practiced in Egypt as early as 1898. Evidence from history extend to even far beyond this date.

Ditch drainage was introduced in 1938 followed by sub-surface drainage in 1942. The drainage network has been projected to cover 90% of the cultivated area in 1993. The water supply coverage (1990) is assessed as 90% in urban communities and 45% of rural population. The total amount of produced waste water in 1993 is 3.4 km^3/y out of which 0.65 km^3/y is treated and 0.2 km^3/y is reused. The fresh water annual fish catch is estimated at 240,000 metric tons/yr.

The attempt for

- ambitious improvements in the level of economic growth,
- struggle for a solid national industrial base,
- shift towards privatization,
- renovation of the countries infrastructure, and
- development of agriculture in an attempt to meet the increasing demands of the growing population

has all resulted into a lot of environmental impacts, sometimes positive and in many times negative, on the available natural resources with water being the most effected resource. Over exploitation of ground water resources over the last 10 years has led to notable depletion of these resources at the oasis of the western desert. Over extraction from the delta shallow aquifer led to increased water salinisation and to the inland advancing of the salt water interface at alarming rates.

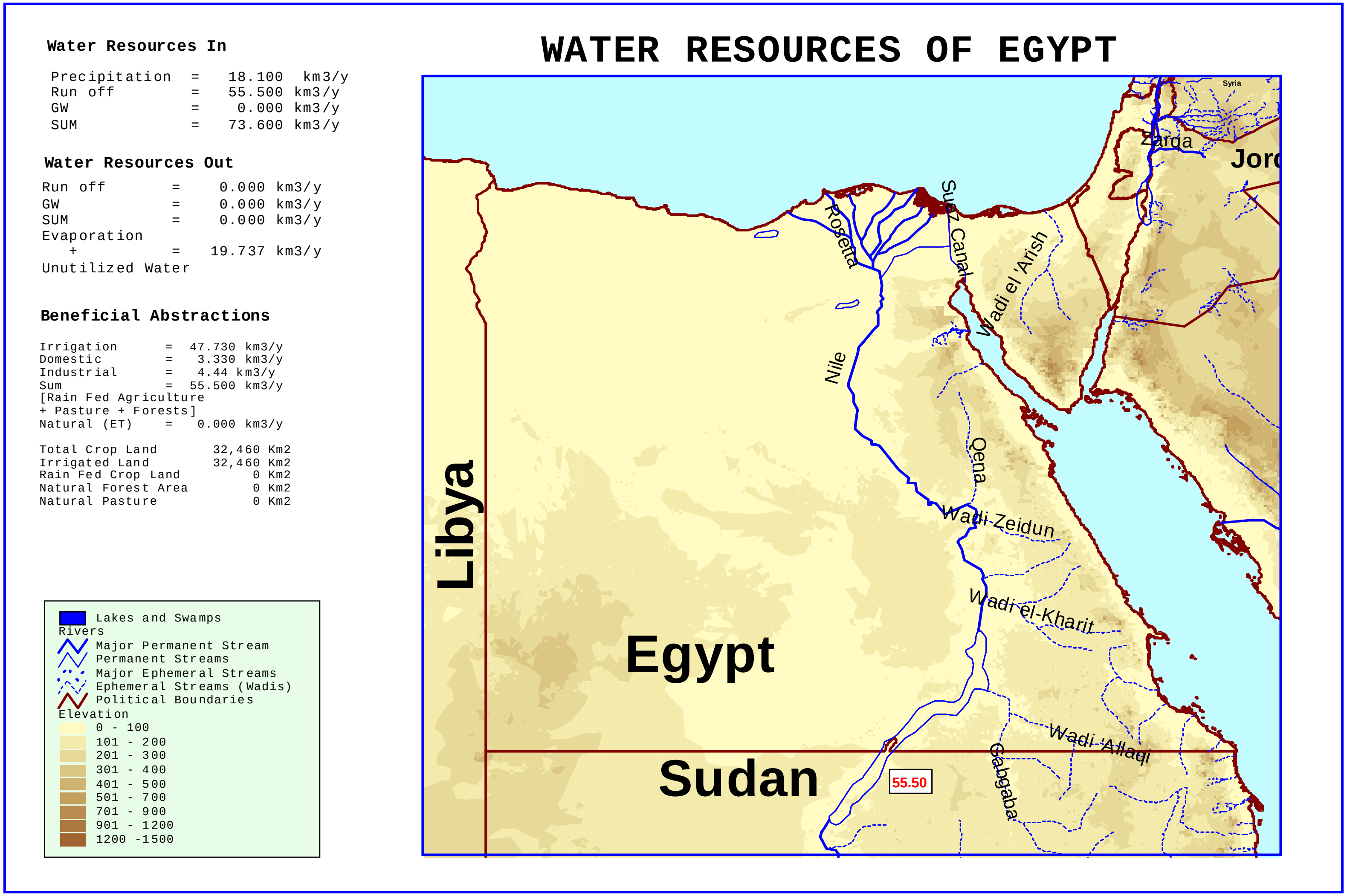


Figure (19) Water Resources of Egypt

IRAQ

The population of Iraq is estimated to be 26.3 million as of 2003. Average population density is estimated at 61/km^2. The average population growth before the sanctions was estimated at 3.6 percent, this rate has been greatly reduced by emigration and severe economic hardship, reaching a low of 2.76 percent in 2003.

The average annual rainfall is about 154 mm which exhibits considerable spatial variation due to the large area of the country and the different climatic regimes prevailing at different regions. Rainfall varies from less than 100 mm/y over 60% of the country in the south up to 1200 mm/y in the north-east. Precipitation mainly occurs in winter from December to February (or November to April in the mountains). Internal renewable water resources are estimated at about 35 km^3/y.

Water resources are abundant in Iraq: the Tigris and Euphrates Rivers supply the major share of irrigation water for agriculture production in the country at 77 billion m^3 in good years and 44 billion m^3 in drought years. Rainfall in Iraq provides some 50 percent of the water supply flowing into the Tigris and contributes 10 percent of the flow into the Euphrates. The average annual flow of the Euphrates as it enters Iraq is estimated at 30 km^3, with a fluctuating annual value ranging from 10 to 40 km^3. Unlike the Tigris, the Euphrates receives no tributaries during its passage in Iraq.

Water availability and sanitation are major problems for post war Iraq. Insufficiency existed even before the recent occupation: access rates to potable water in cities and rural areas were reported at 92 percent and 46 percent respectively. Water Treatment Plant (WTP) efficiency rates were reportedly 60 percent and water loss rates were 30 percent and many rural communities were dependent upon unprotected sources. As a result, domestic per capita share of clean water in urban areas (other than Baghdad) was only 110 litres per day in 2000 (a decrease from 250-300 litres in the 1990s), and became only 65 litres per day in rural areas.

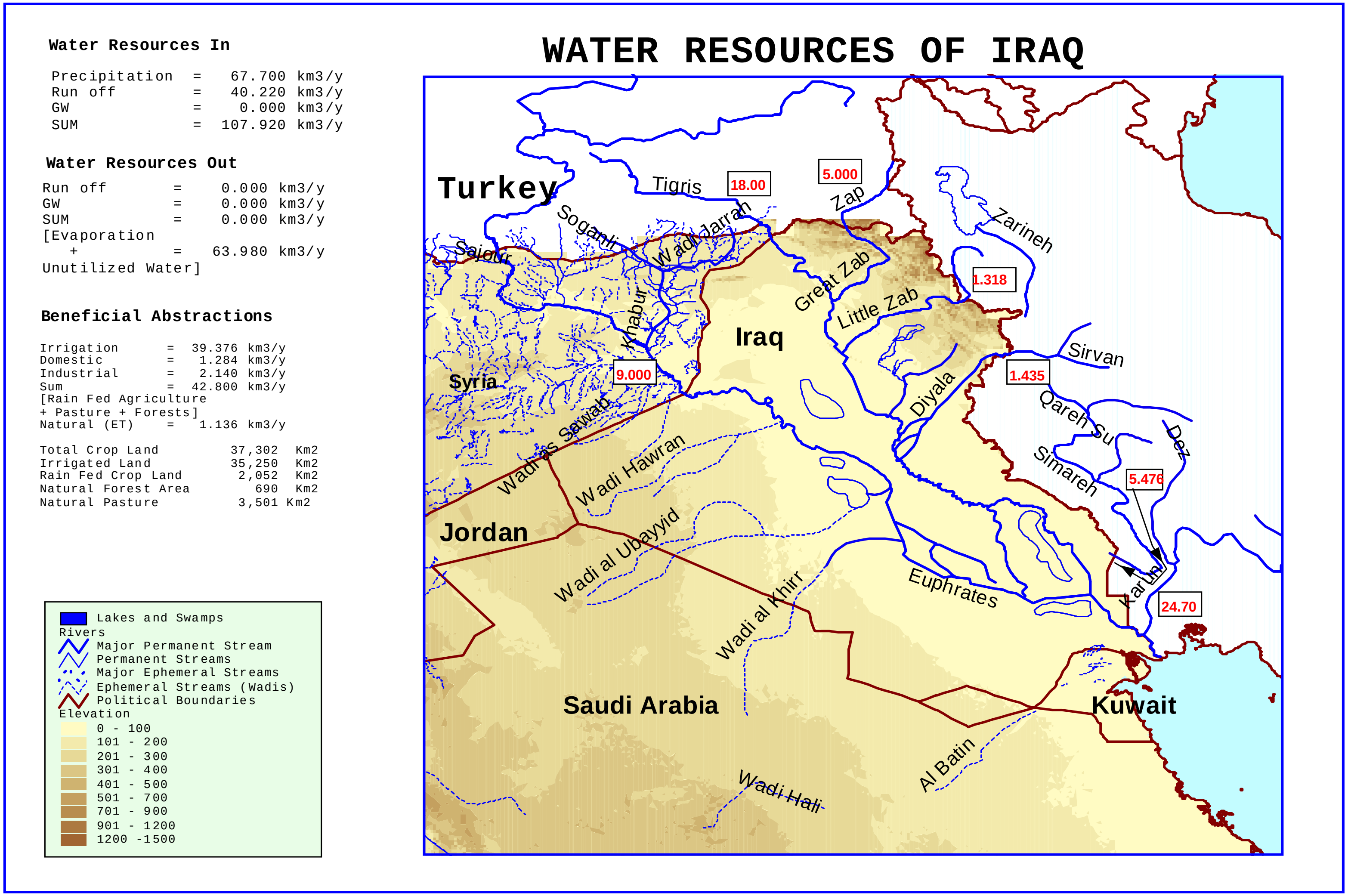


Figure (20) Water Resources of Iraq

JORDAN

The average annual rainfall is about 94 mm varying considerably from 50 mm in the eastern and southern dessert to 650 mm at the northern highlands. Precipitation, which mainly occurs in winter, is highly irregular and accounts for 8.43 km^3/y of internal renewable water resources is estimated at 0.68 km^3/y as of 1995.
The largest transboundary incoming surface flow (from Syria, Yarmouk river) is estimated recently at 0.2 km^3/y after the upstream Syrian development works. The Yarmouk river is account for about 40 % of the surface water resources of Jordan. Other major basins include Zarqa, Jordan rivere side wadis, Mujib, the Dead Sea, Hasa and Wadi Araba.
The internal renewable groundwater is estimated at .5 km^3/y and the safe extract of groundwater is around 0.275 km^3/y. The average groundwater depletion is estimated at 0.172 km^3/y. The total actual renewable water resources is 0.88 km^3/y as of 1995 where the total population is projected to be 5.5 million inhabitant, thus generating a per capita share of ARWR of 161 m^3/y.
The total annual freshwater withdrawal is 1 km^3/y (246 m^3/cap/y) as of 1990, 75% of which is directed to agriculture, 22% to domestic and 3% to industry. The irrigation potential based on ARWR is estimated at 85,000 ha.

Total dam capacity is estimated at 0.14 km^3/y. The King Talal dam on the Zarqa river is the largest dam in Jordan and has a capacity of 0.08 km^3/y.

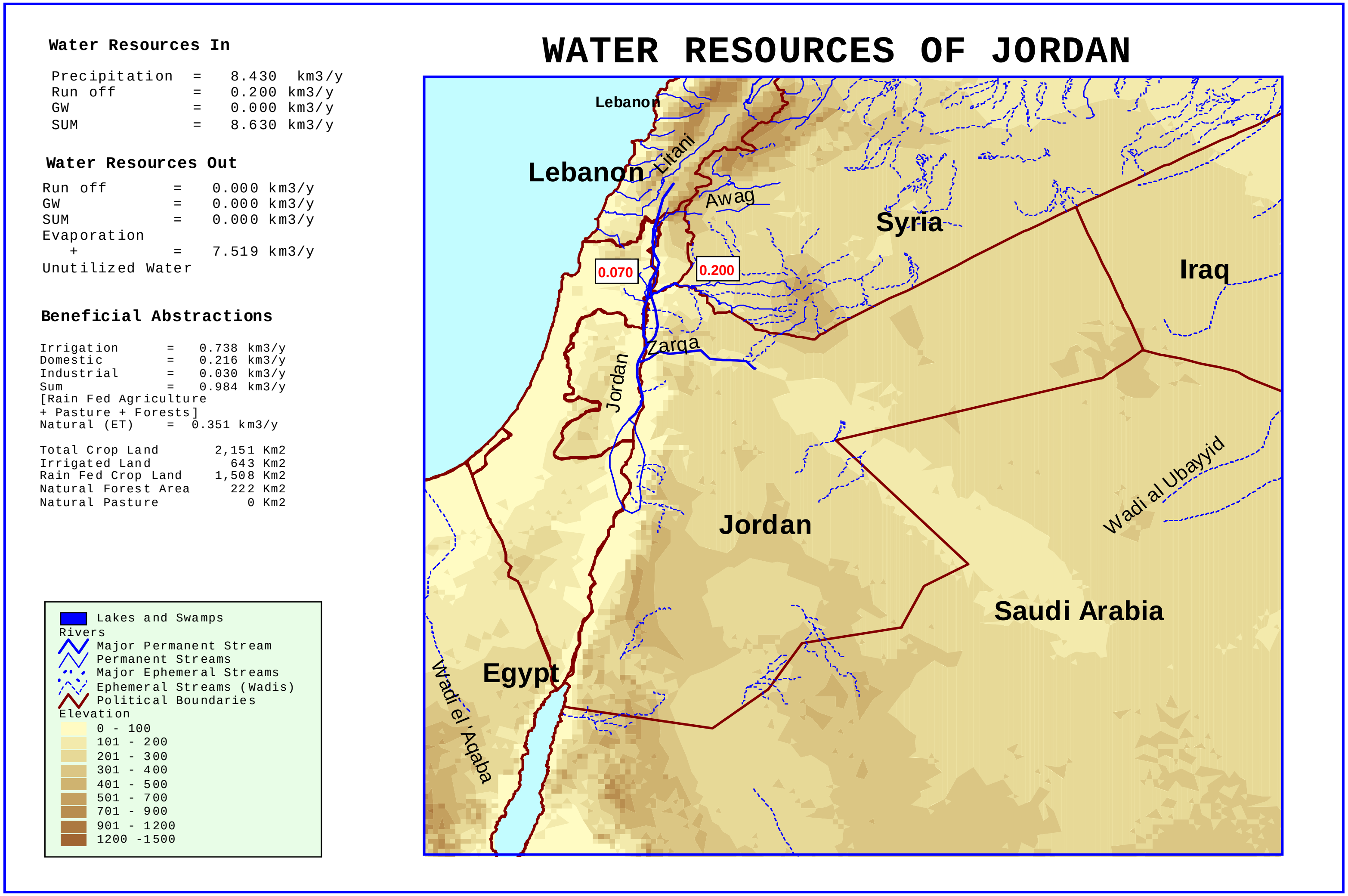


Figure (21) Water Resources of Jordan

KUWAIT

The average annual rainfall is about 176 mm which gives about 3.1 km^3 Precipitation, mainly occurs from October to May. Only small part of the rain water contribute to the groundwater due to the high evaporation. There are two major aquifers: the Kuwait group (upper layer) and the Damman group (lower layer). Transboundary incoming groundwater inflow (lateral under-flow from Saudi Arabia) is estimated at about 0.02 km^3/y. The groundwater in Kuwait can be classified into three categories according to salinity:

- < 1 000 PPM for drinking and domestic purposes
- 1 000 - 10 000 for irrigation
- > 10 000 for special cases only

The groundwater quality and quantity are deteriorating because of continuous groundwater depletion. The actual renewable water resources, as of 1995, is 0.02 km^3/y where the total population is 1.5 million inhabitant, thus generating *per capita share of ARWR of only 13 m^3/y.*

The total freshwater withdrawal is estimated at 0.54 km^3/y (348 m^3/cap/y) as of 1993, 60.2% of which is diverted to agriculture and livestock, 37.4% to domestic sector, and 2.4% to industry. The total freshwater withdrawal sources are distributed as:

- 47% from groundwater,
- 43% from desalination, and
- 10% from treated wastewater.

The irrigation potential based on ARWR is estimated at 4,770 ha. The origin of irrigation water is 61 from groundwater, 25 from wastewater reuse, and 14 from desalination.

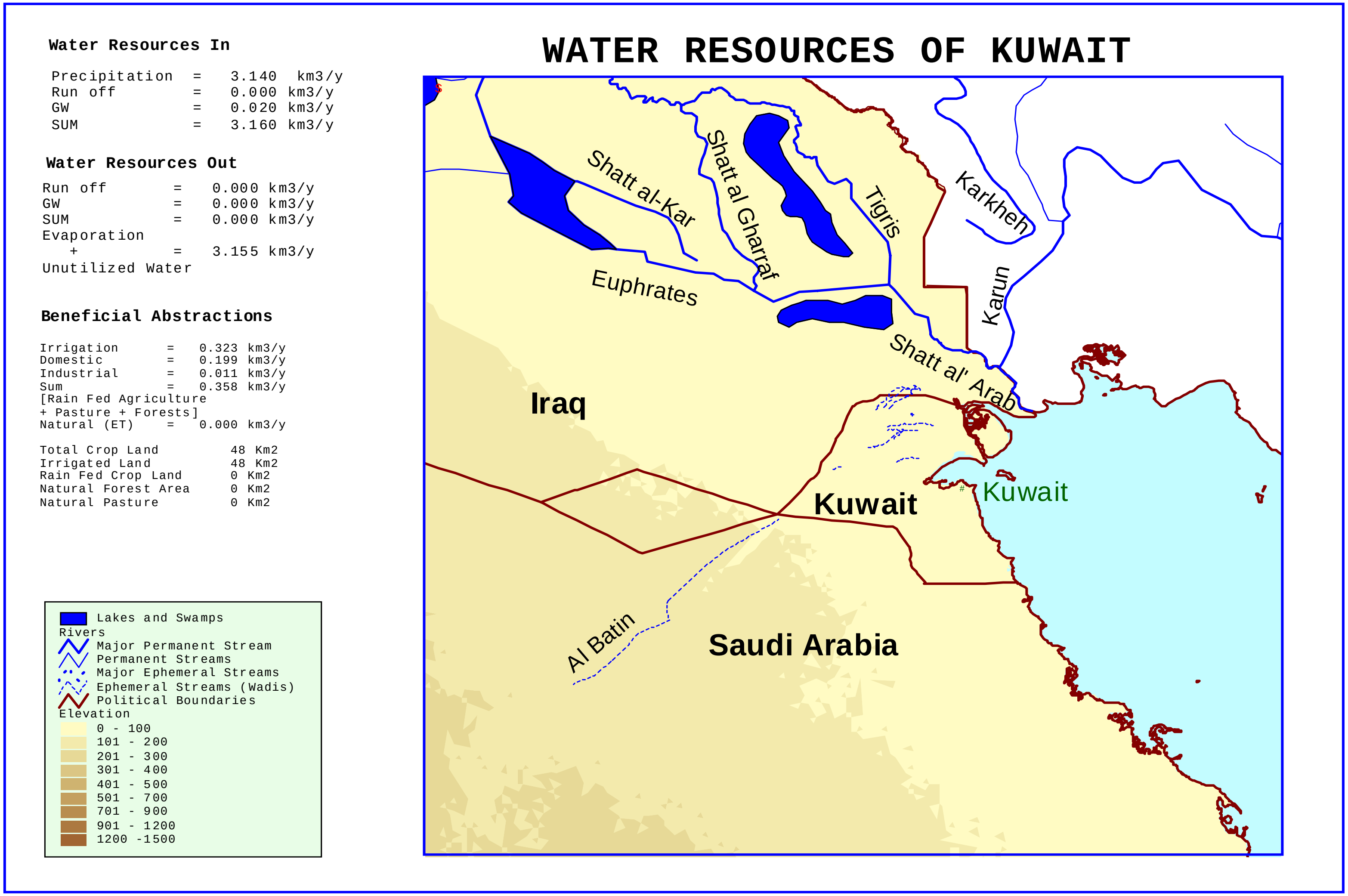


Figure (22) Water Resources of Kuwait

LEBANON

The average annual rainfall is about 823 mm varying from 600 – 900 mm along the coastal zones to 1,400 mm on the high mountains and decreasing to 400 mm in the eastern parts and less than 200 mm in the north-east. Precipitation mainly occurs between October and April. The surface water in Lebanon can be divided into five regions:the El Assi (Orontes) river basin in the north, the Litani river basin it the east and south, the Hasbani river basin south east, all the remaining major coastal river basins, and all the remaining small in between scattered subcatchments.
Transboundary out going surface flow to Syria is estimated at 0.510 km^3/y through the El-Assi (Orontes) river and bordering El Kebir River. Surface water flow contributed to Jordan River is estimated at 0.138 km^3/y. Estimated average annual groundwater outflow is 1.03 km^3 divided as 0.13 km^3/y to Syria, 0.18 to south Lebanon and 0.72 to the sea.
The annual Internal renewable water resources are estimated at 4.8 km^3/y. The total actual renewable water resources is considered 4.4 km^3/y as of 1995 where the total population is projected to be 3 million inhabitant, thus generating a per capita share of ARWR of 1465 m^3/y.

The total dam capacity in 1995 is about 0.25 km^3. Large dames in Lebanon include Karaoun dam on the Litani river, the Bisri dam on the Awali river, and the Kardalé dam on the middle reach of the Litani river. The total annual freshwater withdrawal is 1.293 km^3 (444 m^3 /cap/y) as of 1994, and divided as follows:

- 68% agriculture,
- 28% domestic uses, and
- 4% industrial uses

WATER RESOURCES OF LEBANON

Water Resources In

```
Precipitation   =    8.600  km3/y
Run off         =    0.000 km3/y
GW              =    0.000km3/y
SUM             =    8.600 km3/y
```

Water Resources Out

```
Run off         =    0.640 km3/y
GW              =    0.310 km3/y
SUM             =    0.950 km3/y
Evaporation
   +            =    4.184 km3/y
Unutilized Water
```

Beneficial Abstractions

```
Irrigation      =    0.879  km3/y
Domestic        =    0.362  km3/y
Industrial      =    0.052  km3/y
Sum             =    1.293  km3/y
[Rain Fed Agriculture
+ Pasture + Forests]
Natural (ET)    =    2.173  km3/y

Total Crop Land        1,894 Km2
Irrigated Land           875 Km2
Rain Fed Crop Land     1,019 Km2
Natural Forest Area      390 Km2
Natural Pasture            0 Km2
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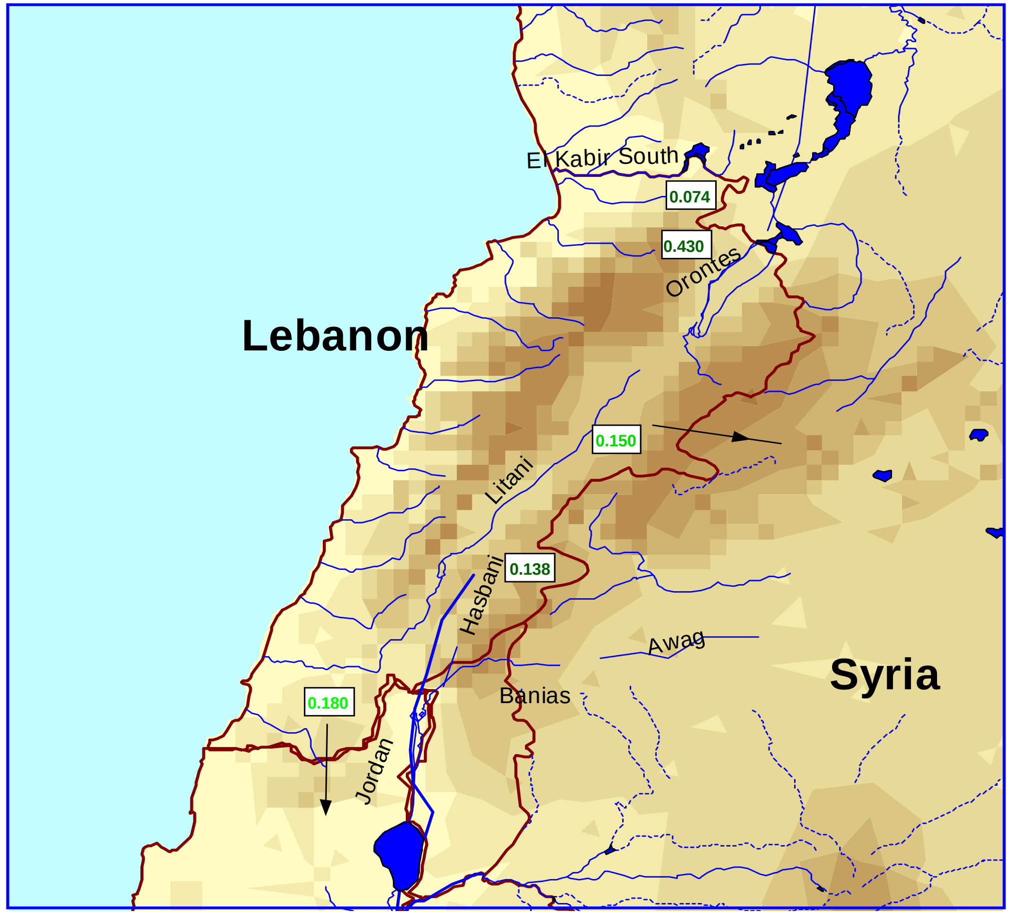


Lakes and Swamps
Rivers
Major Permanent Stream
Permanent Streams
Major Ephemeral Streams
Ephemeral Streams (Wadis)
Political Boundaries
Elevation
0 - 100
101 - 200
201 - 300
301 - 400
401 - 500
501 - 700
701 - 900
901 - 1200
1200 -1500

Figure (23) Water Resources of Lebanon

LIBYA

The average annual rainfall is about 26 mm with *only 7% of the total area subjected to 100 mm/y of rain or more*. The areas suitable for rain-fed agriculture are very limited. Precipitation, mainly occurs in winter, accounts for 0.6 km^3/y of Internal renewable water resources. Surface runoff generated by rain flow is estimated at 0.2 km^3/y out of which 0.1 km^3/y contributes to evaporation losses and ground water recharge. Rechargeable ground water aquifers occur only along the north eastern zone where a considerable part is lost to the sea and through evaporation. The actual renewable water resources, as of 1995, is 0.6 km^3/y where the total population is 5.4 million inhabitant, thus generating *per capita share of ARWR of only 111 m^3/y*.

The total freshwater withdrawal is estimated at 4.6 km^3/y (880 m^3/cap/y) as of 1994, 87% of which is diverted to agriculture, 6% to domestic sector, and 9% to industry. Freshwater is mainly supplied through the extraction of fossil water from the Paleozoic and Mesozoic sand stone formations south of the 29 th parallel. Annual unconventional water sources include 0.07 km^3/y of desalinated water (directed towards domestic and industrial usage) and 0.036 km^3/y of reused water. The total freshwater withdrawals sources are distributed as:

- 95% from groundwater,
- 2.5% from surface runoff,
- 1.5% from desalination, and
- 1% from waste water reuse.

The irrigation potential based on ARWR is estimated at 40,000 ha located in the coastal areas. The water supply coverage is estimated as 100% in urban communities and 80% of rural population as of 1990.

Politically driven actions/reactions, isolation attempts, and the international embargo supported by the western communities, all impose serious constrains which hinder the effective development of the country including its various sectors, despite the availability of financial resources. Major changes during the last ten years include the establishment of sixteen dams with a total dam capacity of 0.387 km^3/y to manage surface runoff. The great man made river is a gigantic project aiming at conveying 2 km^3/y of fossil-extracted water through the desert to the northern regions to serve irrigation purposes. The first of five phases of the project was accomplished. The third phase of the project is expected by the year 2010.

Extensive extraction of groundwater from the coastal zones led to a considerable deterioration of the water quality due the reduction of groundwater level and the inland advancing of the salt water interface at a rate of 100 to 250 m/yr. Complete contamination and salinisation of the coastal aquifers is expected by the beginning of the twenty first Century should the current extraction rates continue.

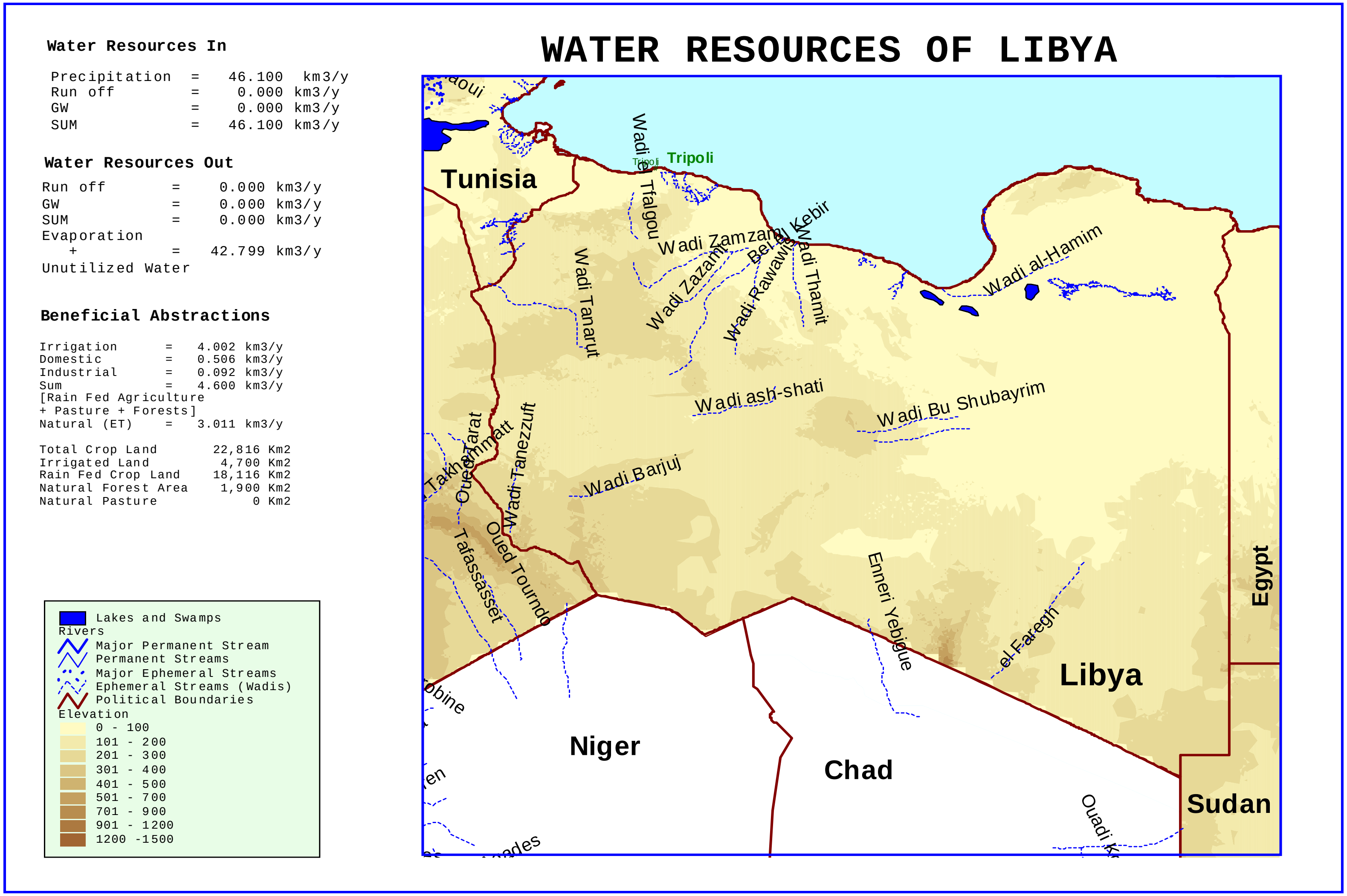


Figure (24) Water Resources of Libya

MAURITANIA

The average annual rainfall is about 99 mm varying considerably from less than 20 mm in the north to more than 500 mm in the south east. Precipitation mainly occurs for three months on the average. Internal renewable water resources are estimated as 0.4 km^3/y of which 0.1 km^3/y are attributed to surface runoff and 0.3 km^3/y are due to ground water. The Senegal River runs along the southern border presenting, along with its tributaries on the right bank, the dominating hydrographic system of Mauritania. The total actual renewable water resources is 11.4 km^3/y as of 1995 where the total population is projected to be 2.3 million inhabitant, thus generating a per capita share of ARWR of 5013 m^3/y. The total dam capacity is 0.9 km^3 in 1994.

Unconventional water resources include 1.7 million m^3/y of desalination water. The total annual freshwater withdrawal is 1.6 km^3/y (923 m^3/y /cap/yr) as of 1985 and divided as follows

- 92% agriculture,
- 6% domestic uses, and
- 2% industrial uses

The irrigation potential based on ARWR is estimated at 170,000 ha out of which 5,000 ha are oasis where irrigation is supplied through manual extraction from shallow wells. The water supply coverage (1990) is assessed as 67% in urban communities and 65% of rural population. It is estimated that 34% of the urban population have access to sanitation as of 1985.

The annual demographic growth at a rate of 2.7 % along with escalating demand for food, and requirements for fulfilling the national development plans are reflected in serious attempts for better management of water resources. High costs of irrigation development, weak support to the private sector, and inadequate organization of the operation of irrigation schemes are the main restraining factors. Insufficient and irregular rainfall and surface flows in the wades along with inconvenient accessibility to river water are also identified as main problems facing water resource management. Major changes during the last ten years include the inception of effective exploitation of the countries rich fisheries, where the average annual freshwater fish catch is estimated at 5300 tons as of 1992. Very high evaporation estimated at 3000 mm/y contributes to a major loss of water resources. A total of 3750 water points for supply of drinking water to rural communities is expected by year 2000. Programs for extending coverage of water supply and sanitation are expected to cover most of the population by year 2010.

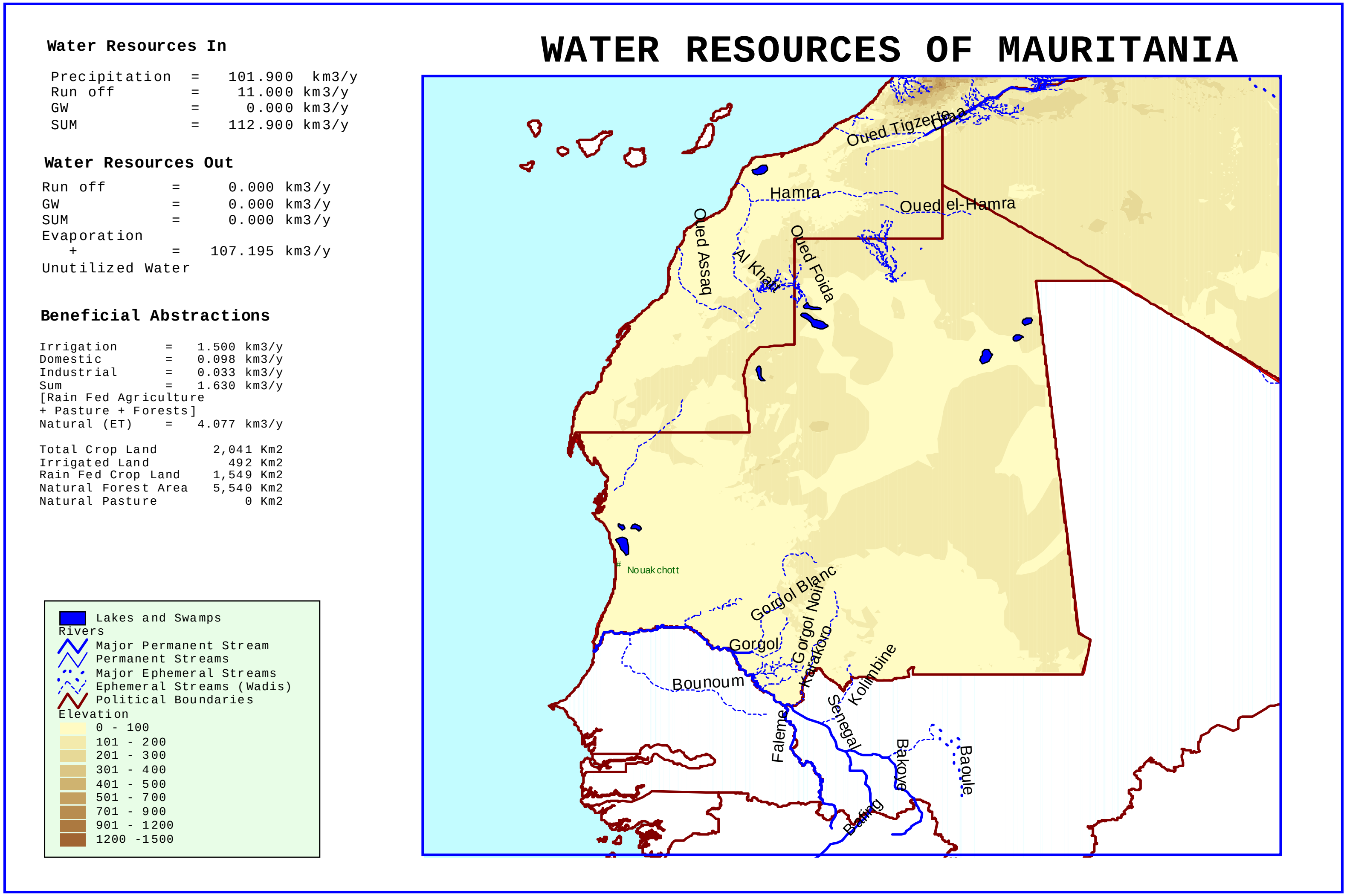


Figure (25) Water Resources of Mauritania

MOROCCO

The average annual rainfall is about 340 mm varying from more than 450 mm in the north to less than 150 mm in the southeast. More that 50% of the rainfall occur over 15 % of the country's area. Transboundary out going surface flow to Algeria is estimated at 0.3 km^3/y. Internal renewable water resources are estimated at 30.0 km^3/y. The total actual renewable water resources is considered also 30.0 km^3/y as of 1995 where the total population is projected to be 27 million inhabitant, thus generating a per capita share of ARWR of 1110 m^3/y. The available resources representing water development potential is estimated at 21 km^3/y out of which 5 km^3/y is attributed to groundwater, and 16 km^3/y is surface water which needs regulation by dams. The total dam capacity in 1990 is about 11 km^3 corresponding to 34 operating dams. The total annual freshwater withdrawal is 11 km^3 (436 m^3 /cap/y) as of 1991, and divided as follows:

- 92% agriculture,
- 5% domestic uses, and
- 3% industrial uses

Of the 11 km^3/y of fresh water withdrawal, km^3/y is attributed to surface water and 3.5 km^3/y is extracted from groundwater. The total water managed area in 1989 is 1.26 million ha representing only 17% of the cultivated area. The irrigation potential based on water development potential is estimated as 1.65 million ha. The hydroelectric production in 1991 is measured as 1,500 GWh contributing to 30% of the national energy production. In 1990, 0.23 km^3/y of water is used for hydropower and 150 km^3/y for environmental protection (wadis). The water supply coverage (1990) is assessed as 100% in urban communities and 18% of rural population. In 1990 the total number of water points in rural areas is 236,000 corresponding to 1 water point per 50 inhabitants of which 91% where supplied through wells, 8% through springs , and 1% through surface water. However, about 82% of the water points are delivering non-potable water.

Population growth at a rate of about 2.1 %, increased demand for food, drinking, industrial, and agricultural purposes are persisting factors pushing for better management water resource. Although the water demand is globally satisfied, specific areas already suffer from water scarcity, especially during the dry season. The general national policy for increasing water availability is based on two lines of actions, namely achieving more control of surface water and surface storage through dam regulation, and expansion of groundwater extraction. Major emphasis has been put on the construction of regulating dams and development of large irrigation schemes since the early 1960s. At the beginning of the 1992 a national program was set forward (targeting year 2000) for the equipment of an area of 250,000 ha controlled by dams.

Improvement of performance of old schemes through rehabilitation of equipment is included in the plan. A 30 year proposed development plan is targeting the exploitation of 14 km^3/y of surface water and another 14 km^3/y of ground water through the construction of 60 new dams and establishment of a wide network of deep wells. As of 1995 a new Water Law has been effective. An extensive program, starting 1996, is put into action to ensure proper water supply quality for rural areas By year 2004. Land erosion and dam reservoir sedimentation are identified as major environmental problems. Reservoir sedimentation is estimated as 50 million km^3/y in 1994 and is expected to reach 100 km^3/y by the onset of twenty first century. Pollution of surface water due to municipal and industrial waste discharges has been magnified during the drought periods of 1979 - 1984, and 1991 - 1995. Also water quality deterioration due to the excessive application of fertilizers and pesticides has been recently detected (1996).

Water Resources In

Precipitation	=	150.000	km3/y
Run off	=	0.000	km3/y
GW	=	0.000	km3/y
SUM	=	150.000	km3/y

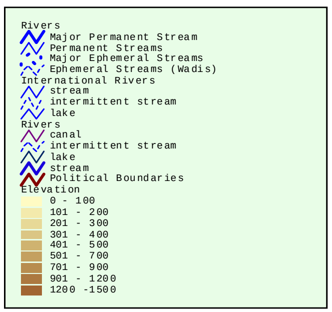
Water Resources Out

Run off	=	0.300	km3/y
GW	=	0.000	km3/y
SUM	=	0.300	km3/y
Evaporation + Unutilized Water	=	114.303	km3/y

Beneficial Abstractions

Irrigation	=	10.161	km3/y
Domestic	=	0.552	km3/y
Industrial	=	0.331	km3/y
Sum	=	11.045	km3/y
[Rain Fed Agriculture + Pasture + Forests] Natural (ET)	=	24.356	km3/y

Total Crop Land	72,310 Km2
Irrigated Land	12,582 Km2
Rain Fed Crop Land	59,728 Km2
Natural Forest Area	35,140 Km2
Natural Pasture	86,271 Km2



WATER RESOURCES OF MOROCCO

Figure (26) Water Resources of Morocco

OMAN

The average annual rainfall is about 55 mm varying from more than 300 mm in the mountain areas to less than 20 mm in the internal desert regions. The rainfall occurs during the winter (November-April) in the north part, while seasonal summer storms (June-September) accrue in the south part and some internal parts. Internal renewable water resources are estimated at 0.985 km^3/y. The total actual renewable water resources is considered also 0.985 km^3/y as of 1995 where the total population is projected to be 2.2 million inhabitant, thus generating a per capita share of ARWR of 455 m^3/y. Groundwater recharge is estimated at 0.955 km^3/y. The total dam capacity in 1996 is about 0.058 km^3 corresponding to 15 operating dams since 1985. The total annual freshwater withdrawal is 1.223 km^3 (728 m^3 /cap/y) as of 1991, and divided as follows:

- 94% agriculture,
- 4.5% domestic uses, and
- 1.5% industrial uses

Of the 0.058 km^3/y of produced wastewater, only 0.028 km^3/y was treated in 1995. In addition desalinated water was estimated at 0.034 km^3/y as of 1995. In Oman, all agriculture is irrigated. The equipped area is estimated at 61,550 ha. There are no adequate data to estimate the irrigation potential.

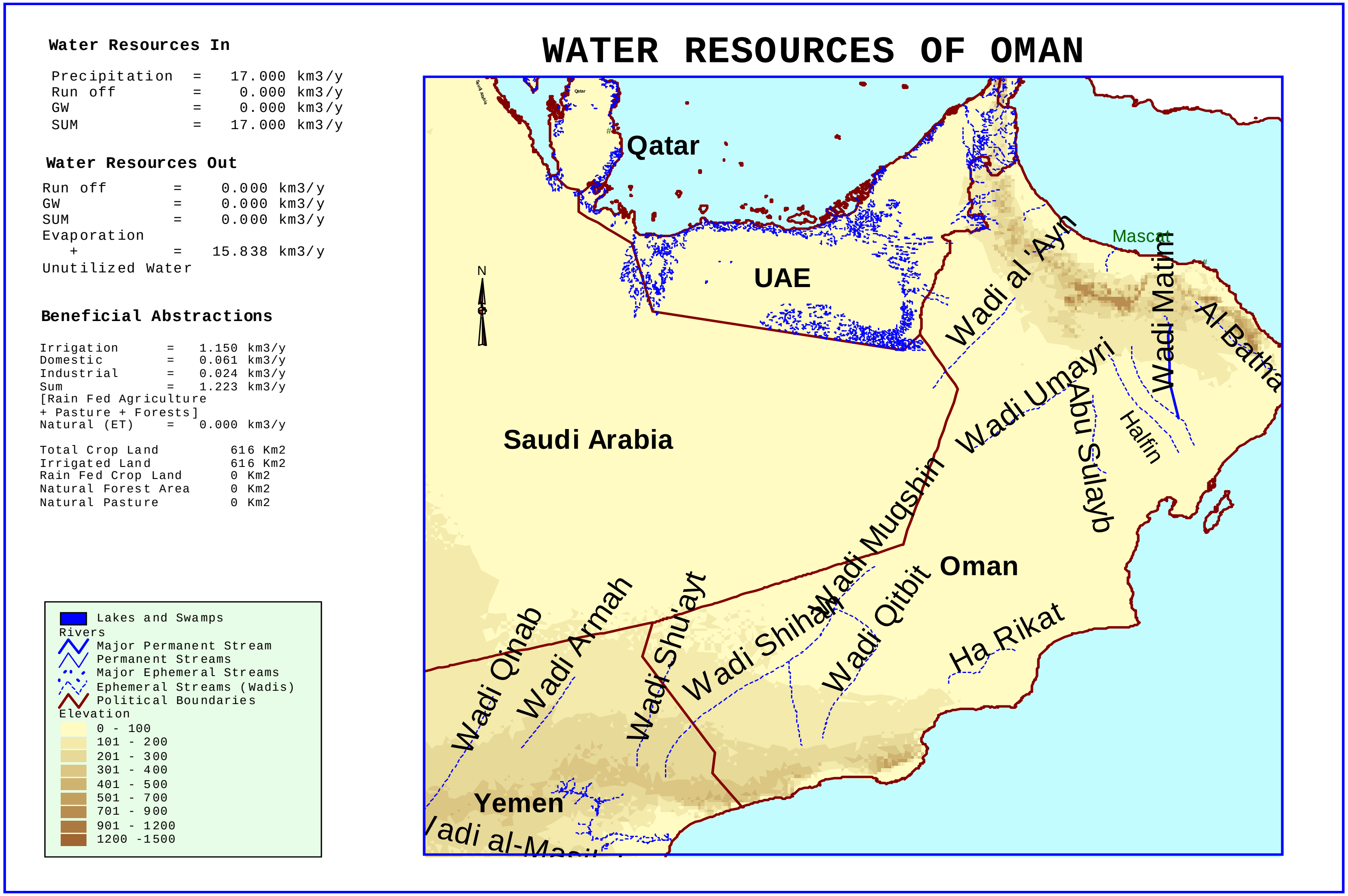


Figure (27) Water Resources of Oman

PALESTINE

Population is the main factor affected water deterioration in the Gaza Strip and West Bank. In year 2003, population reached 1.3 millions in the Gaza Strip and about 2.3 millions in West Bank. The temperature and precipitation vary with altitude, warm to hot summers, cool to mild winters.

Groundwater is the main resource of water in the Gaza Strip. The annual groundwater abstraction is estimated at 150 Mm3, where 62 Mm3 is used for domestic needs in the Gaza Strip. The aquifer safe yield is only 60Mm3/year.

The main Gaza Aquifer is a continuation of the shallow sandy/sandstone coastal aquifers of Israel. About 2200 wells tap this aquifer with depths mostly ranging between 25 and 30 meters. Its annual safe yield is 60 – 65 MCM, however the aquifer has been over pumped by a rate of 90-100 MCM/Yr in order to meet Israeli settlers and Palestinian water needs. The Mountain Aquifer in the West Bank is mostly recharged from rainfall on the west Bank Mountains of heights greater than 500 meters above mean Sea level. The annual renewable freshwater of this aquifer ranges from 600 MCM according to different Israeli and Palestinian sources.

Average precipitation for Upper Jordan and Lake Tiberias averages 1,600 mm and 800 mm respectively. Lower basin, around the Dead sea has a desert climate characterized by scarce rainfall. The Jordan River is progressively more saline and less usable towards the Dead sea. The Jordan River system satisfies about 50% of Israel's and Jordan's water demand; Lebanon and Syria are minor users, meeting 5% of their combined demands via the Jordan.

One of the major impediments to developing a sound Palestinian water policy has been Israeli control over the water resources in Palestine which has affected adversely the development of a consistent supply, maintenance of quality, and improvements in systems.

WATER RESOURCES OF PALESTINE

Water Resources In

Precipitation	=	km3/y
Run off	=	km3/y
GW	=	km3/y
SUM	=	km3/y

Water Resources Out

Run off	=	km3/y
GW	=	km3/y
SUM	=	km3/y
Evaporation +	=	km3/y
Unutilized Water		

Beneficial Abstractions

Irrigation	=	km3/y
Domestic	=	km3/y
Industrial	=	km3/y
Sum	=	km3/y
[Rain Fed Agriculture + Pasture + Forests] Natural (ET)	=	0.351 km3/y

Total Crop Land	Km2
Irrigated Land	Km2
Rain Fed Crop Land	Km2
Natural Forest Area	Km2
Natural Pasture	Km2

Figure (28) Water Resources of Palestine

QATAR

The average annual rainfall is about 75 mm varying from 40 mm in the south to over 80 mm in the north. More that 80% of the rainfall occurs between October and March. Precipitation, mainly occurs in winter from November to April.

Internal renewable water resources are estimated at 0.051 km^3/y of which 0.001 km^3/y are attributed to surface water, and 0.05 km^3/y to ground water recharge. The total actual renewable water resources is considered also 0.053 km^3/y as of 1995 where the total population is projected to be 0.5 million inhabitant, thus generating a per capita share of ARWR of 96 m^3/y.

Non-conventional water sources accounted for almost 42 % in the total water withdrawal in 1994. The total quantity of desalinated water used in 1994 was 98.6 million m^3/y. About 25.2 million m3/y of wastewater as of 1994 was treated. The irrigation potential based on ARWR is estimated at 12,520 ha.

The total annual freshwater withdrawal is 0.285 km^3 (528 m^3/cap/y) as of 1994, and divided as follows:

- 74% agriculture,
- 23% domestic uses
- 3% industrial uses

The groundwater extraction is estimated at 0.188 km3 while the annual recharge is about 0.050 km3 and the safe yield is 0.045 km3. Desalinated water is the main source of Qatar's drinking water. The irrigation potential based on ARWR is estimated as 12,520 ha as of 1993. The origin of irrigation water is 94% from groundwater and 6% from treated wastewater.

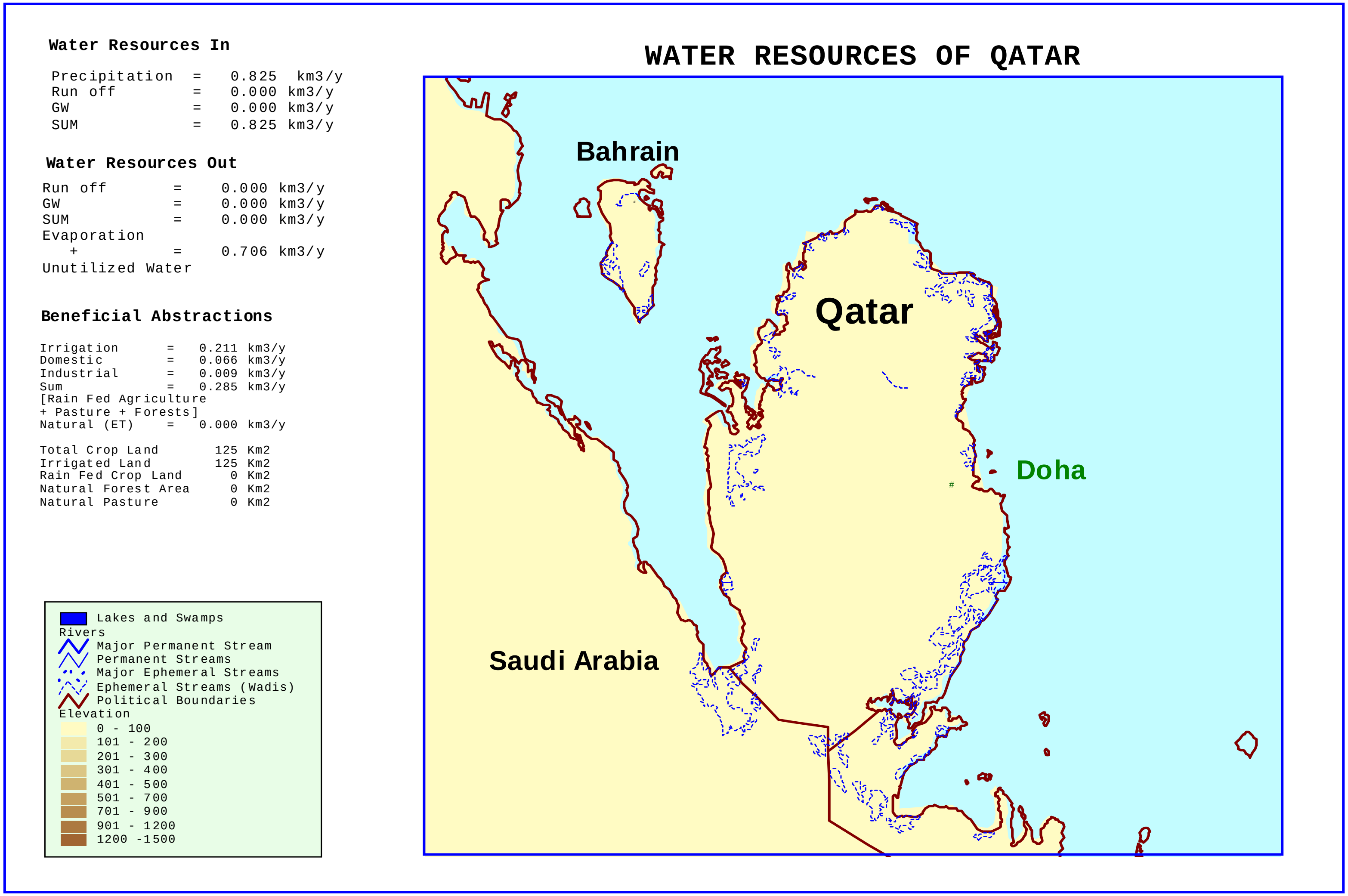


Figure (29) Water Resources of Qatar

SAUDI ARABIA

Saudi Arabia occupies the bulk of the Arabian Peninsula with a total area of 2.25 km2 located in south west of Asia. The coast line in the Red Sea and the Arabian Gulf is about 2,640 km long. The total population is about 23 million of which about 7 million foreign nationals. The population density is about 10 inhabitant/km2.

The climate in Saudi Arabia is generally harsh, with great temperature extreme. It is mostly dry desert. The average annual rainfall is 110 mm/year. While some of the South Western mountains receives up to 600 mm of annual precipitation. Flash floods occur in many parts of Saudi Arabia due to heavy rain in short periods. The average annual surface runoff for the whole country is (2BM3) billion cubic meters. More than (223) dams have been constructed for various purposes (i.e. flood control, irrigation, water supply and groundwater recharge) the total storage capacity of these dams is (835 mm3) million cubic meters. There are (17) dams under construction with capacity totaling (979 mm3).

The total annual renewable water consumption is about (8 BM3). The non-renewable water consumption is about (12.4 BM3/year) which comes from (9) primary aquifers and (13) secondary aquifers. Agriculture consumes about 85% of the total water consumption in the country while municipal and industrial water demand uses the remaining 15%.

Saudi Arabia is the largest user of sea water desalination technology. Desalinated water is used for domestic purposes only. The production of desalination station is about (3 mm3/day).

Saudi Arabia is implementing a plan to reclaim most of the treated wastewater to be used for agriculture, industry and land scaping the daily treated wastewater is about (335,000 m3).

The total irrigated area in the country is about (1.1) million hectares.

Water Resources In

```
Precipitation  =   126.800  km3/y
Run off        =     0.000 km3/y
GW             =     0.000 km3/y
SUM            =   126.800 km3/y
```

Water Resources Out

```
Run off        =    0.000 km3/y
GW             =    0.000 km3/y
SUM            =    0.000 km3/y
Evaporation
   +           =  123.907 km3/y
Unutilized Water
```

Beneficial Abstractions

```
Irrigation       =  15.316 km3/y
Domestic         =   1.532 km3/y
Industrial       =   0.170 km3/y
Sum              =  17.018 km3/y
[Rain Fed Agriculture
+ Pasture + Forests]
Natural (ET)     =  0.405 km3/y

Total Crop Land        16,080 Km2
Irrigated Land         16,080 Km2
Rain Fed Crop Land          0 Km2
Natural Forest Area     2,210 Km2
Natural Pasture             0 Km2
```

Lakes and Swamps
Rivers
Major Permanent Stream
Permanent Streams
Major Ephemeral Streams
Ephemeral Streams (Wadis)
Political Boundaries
Elevation
0 - 100
101 - 200
201 - 300
301 - 400
401 - 500
501 - 700
701 - 900
901 - 1200
1200 -1500

WATER RESOURCES OF SAUDI ARABIA

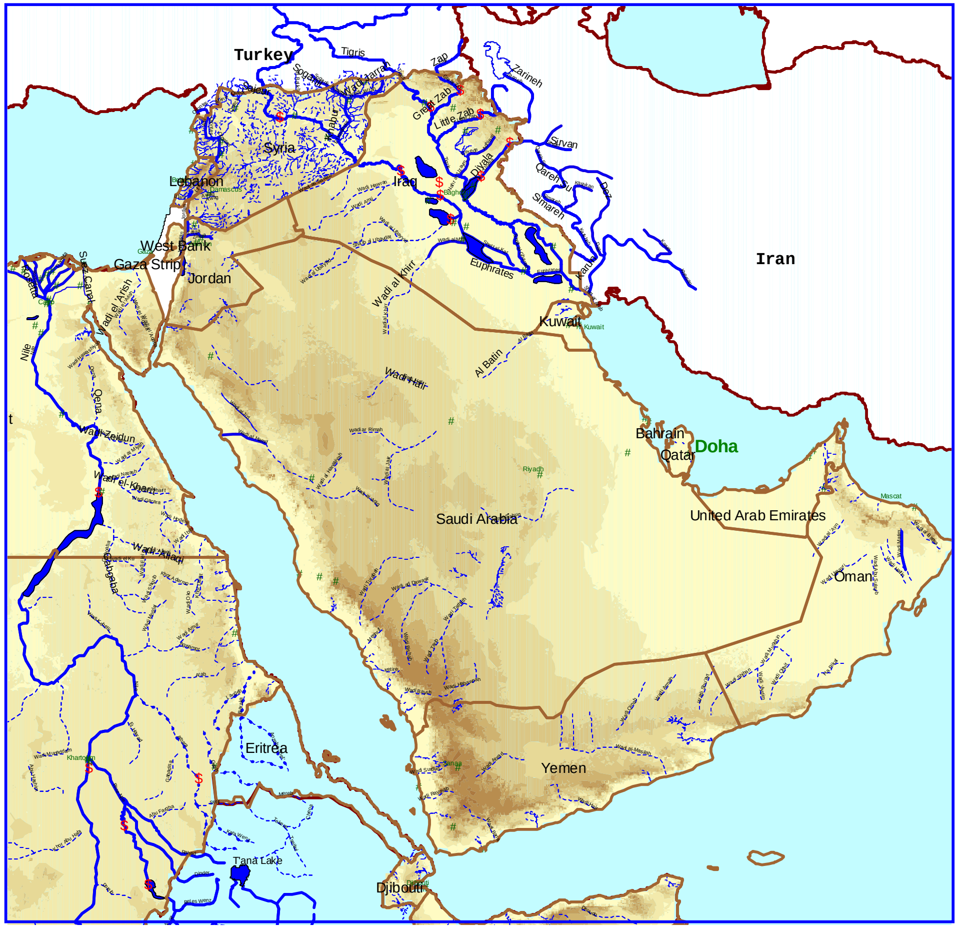


Figure (30) Water Resources of Saudi Arabia

SOMALIA

The average annual rainfall is about 253 mm varying between less than 250 mm in the north to about 400 mm in the south and 700 mm in the southwest. The rainfall distribution is bi-modal and occurs mostly between mid April to June, and again between October to December. Somalia exhibits regular periods of drought. Trans-boundary incoming surface flow from Ethiopia is estimated at 9.74 km^3/y. The internal renewable water resources are estimated at 6.0 km^3/y. The total actual renewable water resources is 15.74 km^3/y as of 1995 where the total population is projected to be 9.3 million inhabitant, thus generating a per capita share of ARWR of 1702 m^3/y.

The Shebelli and Juba rivers, originating and extracting more than 90% of their discharge from Ethiopia while draining in the south-east towards the Indian ocean, constitute the main surface water conveyers in Somalia. The rivers are poorly managed and they loose most of their carrying capacity as a result of percolation, overbank spillage due to limited conveyance capacity and water abstraction. Availability of groundwater is very limited due to limited potential for recharge except for few locations in the northern region wadis. No major hydraulic regulation of the rivers are present, however, a 200 million m^3 off-stream storage exists at Johar.

The total annual freshwater withdrawal is 0.87 km^3/y (99 $m^3/cap/y$) as of 1987, and divided as follows:

- 97% agriculture,
- 3% domestic uses, and

The irrigation potential is estimated at 240,000 ha. In 1984 the total water managed area is 200,000 ha, out of which only 50,000 ha had controlled irrigation. The water supply coverage (1990) is assessed as 50% in urban communities and 29% of rural population.

Somalia is still suffering from the consequences of the civil war that persisted for more than a decade in the 1980s and 1990s. Agonized by tribal conflicts, stressed by poverty, and subjected to repeated famine during the drought periods, the country is facing serious challenges to implement development plans to encounter the escalating demands of the population growing at a rate of 3%. However, development and control of water resources is the key to any successful future progress.

A proposed short-term plan for water management, conducted by the World Bank in 1987 includes rehabilitation of existing irrigation schemes, completion of the water master plan for the Shebelli and Juba rivers, and allocation of legal water rights as immediate remidiations. The long term plan includes the construction of the Baarhere dam on the Juba river, and the establishment of the Duduble reservoir to control the Shebelli river.

actual renewable water resources is thus considered to be 88.5 km^3/y as of 1995 where the total population is projected to be 28 million inhabitant, thus generating a per capita share of ARWR of 3150 km^3/y. However, the available resources representing water development potential is estimated by the Sudanese Ministry of Irrigation and Water Resources at only 23.4 km^3/y, out of which 97% is attributed to surface water, while 68 km^3/y is attributed to evaporation from swamps. The Sudd region in the South, on the white Nile, represents a great wet land which is a mere flat maze of channels, lakes and swamps. Only half the amount of water entering the Sudds is estimated to flow out of it. The total dam capacity in 1995 is about 8.8 km^3 corresponding to 4 large dams, 2 on the Blue Nile, one on Atbara river and one constructed on the White Nile.

The total annual freshwater withdrawal is 17.8 km^3/y (633 m^3/cap/y) as of 1995, 94% of which is utilized by agriculture, 4% by domestic sector and 1% consumed by industry. The total water managed area in 1989 is 1.95 million ha representing 26% of the cultivated area. The irrigation potential based on water development potential is estimated as 2.8 million ha exclusive of any development likelihood for the Sudd area. The water supply coverage (1990) is assessed as 85% in urban communities and 35% of rural population. In 1990, 14% of rural population and 55% of total population are estimated to have access to sanitation. The annual average freshwater fish production is estimated at 31,000 metric tons.

Sudan posses enormous natural resources, mainly water and land, which are mostly underutilized. Poverty and lack of proper development technologies are only part of the major concerns confronting the country. Population growth at a rate of about 2.8 %, increased demand for food, domestic and agricultural water demands are all requiring better management of water resources. The political instabilities at the south, and the international sanctions posed against Sudan and supported by the USA during the 1990s are major impeding factors against sustainable development. The former, along with the ban on the transfer of technology and restrictions on exports has led to a continuous devaluation of the local currency and consequently a multi-folder increment in the costs of development. A major constraint to irrigation development is identified as the ineffective removal of silt and weeds from irrigation channels which is reflected in the continuous shrinkage of cultivable areas. Landmarks in water resources management throughout the previous five decades has been the construction of four dams for flood control and irrigation regulation. However, reservoir siltation is a persisting problem.

A gigantic pilot development project, in cooperation with Egypt, is the construction of the Jonglei canal to divert about 10 km^3/y of the White Nile flow to the downstream, by passing the major river spills and evaporation losses through the Sudds. The canal has been designed for an overall length of 360 Km and average width of 50 m. Construction began in 1978 but was stopped in 1983, after 240 Km due to civil unrest in the region aggravated by external political forces. Speculations about the negative environmental impacts of the project have been raised, however, an overall evaluation strongly recommends the project implementation.

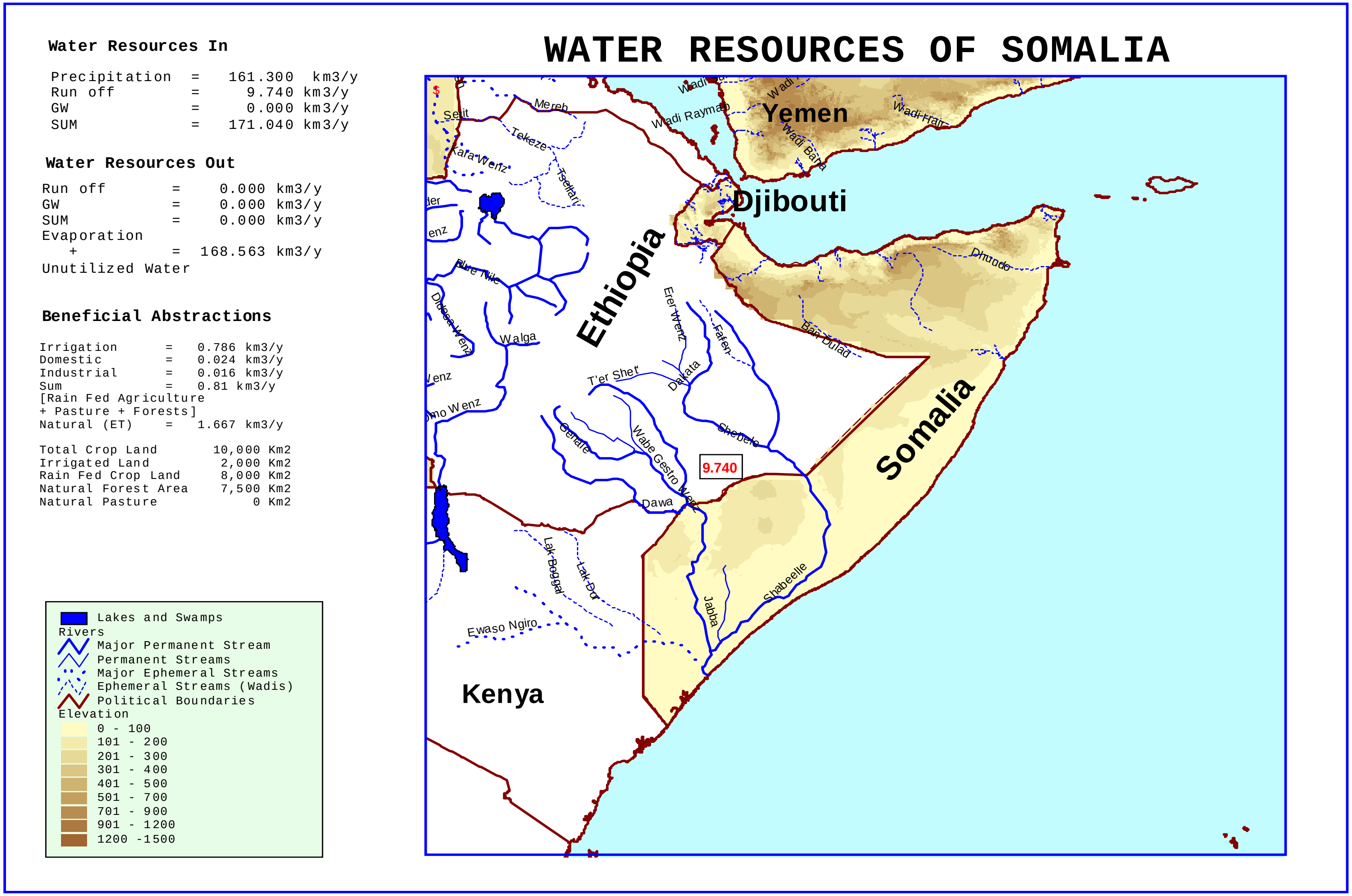


Figure (31) Water Resources of Somalia

SYRIA

The coastal climate is Mediterrnean, with mild, wet winters and dry, hot summers. The annual rainfall ranges from 100 to 150 mm the north-west, 150 to 200 mm from the south towards the central and east-central areas, 300 to 600 mm in the plains and along the foothills in the west, and 800 to 1000 mm along the coast, increasing to 1400 mm in the mountains. The Average annual rainfall in Syria is 252 mm giving 46.6 km^3. Total population of Syria is estimated at 14.6 million (1995), of which 48% is rural, Actual population growth is 3.3%.

The total annual freshwater withdrawal is 14.41 km^3 (1017 m^3/cap/y) as of 1990, and divided as follows:

- 94% agriculture,
- 4% domestic uses, and
- 2% industrial uses

Groundwater recharge is about 4.2 km^3/y, of which 2 km^3/y discharges into rivers as spring water. Total groundwater inflow has been estimated at 1.35 km^3/y, of which 1.2 km^3 from Turkey and 0.15 km^3 from Lebanon.

There are 141 dams in Syria with a total storage capacity of 15.8 km^3. It forms the Al-Assad lake with a storage capacity of 11.2 km^3. There are also five lakes in Syria, the largest being lake Jabboul near Alepo with a surface area of about 239 km^2. Lake Qattineh near Homs is the main perennial lake in Syria.

WATER RESOURCES OF SUDAN

Water Resources In

```
Precipitation  =   1092.600 km3/y
Run off        =    110.000 km3/y
GW             =        x   km3/y
SUM            =   1202.600 km3/y
```

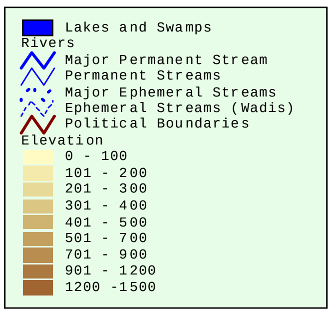
Water Resources Out

```
Run off        =    55.500 km3/y
GW             =       x     km3/y
SUM            =    55.500 km3/y
Evaporation
   +           =    30.80 km3/y
Unutilized Water
```

Beneficial Abstractions

```
Irrigation       =  16.732 km3/y
Domestic         =   0.712 km3/y
Industrial       =   0.178 km3/y
Sum              =  17.800 km3/y
[Rain Fed Agriculture
+ Pasture + Forests]
Natural (ET)     = 185.783 km3/y

Total Crop Land         76,023 Km2
Irrigated Land          19,462 Km2
Rain Fed Crop Land      56,561 Km2
Natural Forest Area    414,100 Km2
Natural Pasture        843,222 Km2
```



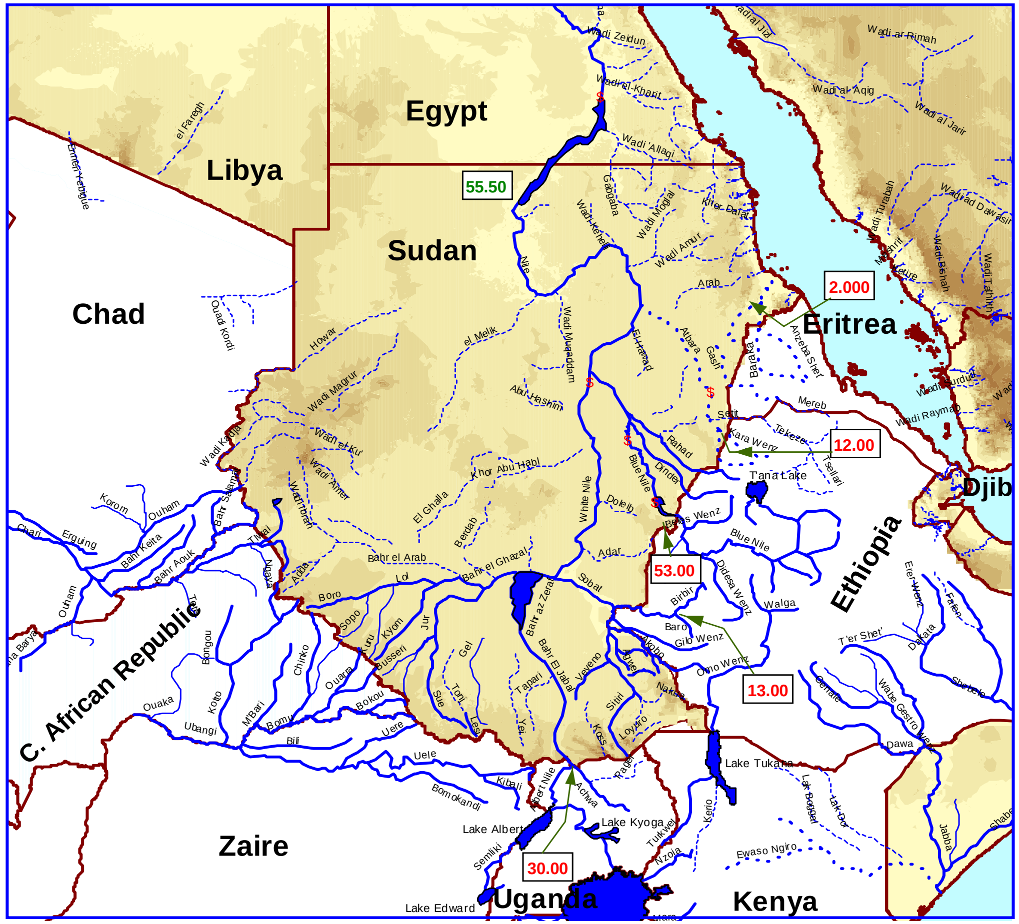


Figure (32) Water Resources of Sudan

TUNISIA

The average annual rainfall is about 207 mm varying from more than 1500 mm in the north to less than 100 mm in about 50% of the country. More that 80% of the rainfall occurs between October and March. Transboundary incoming flow from Algeria is estimated at 0.6 km^3/y. Internal renewable water resources are estimated at 3.52 km^3/y of which 2.31 km^3/y are attributed to surface water, and 1.21 km^3/y to ground water. The total actual renewable water resources is considered also 4.12 km^3/y as of 1995 where the total population is projected to be 8.9 million inhabitant, thus generating a per capita share of ARWR of 463 m^3/y. The available surface water resources being exploited as of 1995 is estimated at 1.5 km^3/y and is expected to reach 2.1 km^3/y by year 2010. The ground water resources are estimated as 0.67 km^3/y extracted from pheriatic aquifer of depth below 50 m, and 0.54 km^3/y extracted from renewable deep aquifers of depths exceeding 50 m. Potential for extraction of fossil water is estimated at 0.63 km^3/y. The total dam capacity in 1991 is about 1.51 km^3 corresponding to 18 large operating dams and 22 hillside dams.

The total annual freshwater withdrawal is 3.1 km^3 (382 m^3/cap/y) as of 1990, and divided as follows:

- 88% agriculture,
- 9% domestic uses, and
- 11% industrial uses

However, the amount of water withdrawn is a direct function of the rainfall intensity and distribution. Of the 3.1 km^3/y of fresh water withdrawn, only 1.9 km^3/y are being actually utilized. The total water managed area in 1991 is 0.385 million ha, 90% of which is under full or partial control irrigation schemes. The average annual growth of irrigation development is about 2% indicating achievement of full potential by year 2010. The irrigation potential based on ARWR is estimated as 0.563 million ha. The water supply coverage (1990) is assessed as 91% in urban communities and 65% of rural population. It is estimated that 72% of the total population have access to sanitation.

Limited water resources, stressed per capita share, and hazards of future water scarcity along with continual growth of population and extended demand for food, drinking, industrial, agricultural and development plans in general are driving forces for preserving existing resources and optimizing the benefits through integrated management of water resource. Since gaining its dependence in the 1950s, Tunisia has expanded considerable effort for establishing an industrial and agricultural-led infrastructure. In the 1990s, the national development programs are closely coupled with environmental protection programs.

Since the beginning of the 1980s, reuse of treated wastewater has been adopted to provide additional potential water resources. In 1993, 96 millions

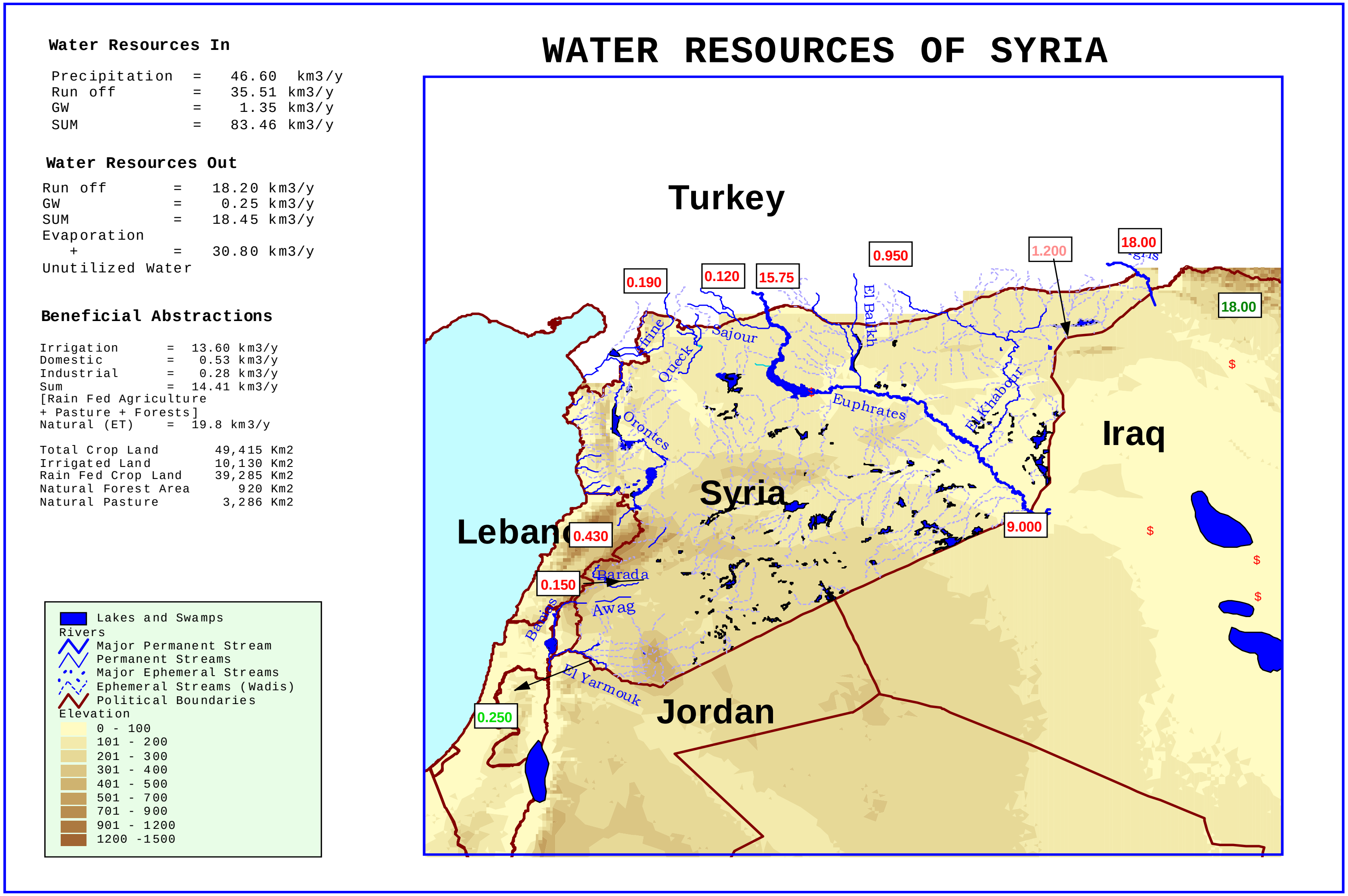


Figure (33) Water Resources of Syria

SUDAN

The average annual rainfall is about 436 mm which exhibits considerable spatial variation due to the large area of the country and the different climatic regimes prevailing at different regions. Rainfall varies from 20 mm/y in the north to more than 1600 mm/y in the south and on the average accounts for 1092 km^3/y of projected precipitation. Internal renewable water resources are estimated at only 35 km^3/y (3% of total precipitation).

Incoming transboundary water resources are estimated at 110 km^3/y out of which 108 km^3/y are supplying the Nile. Of the 108 km^3/y of Nilotic in-flow, 78 km^3/y are estimated to be drained from Ethiopia and 30 km^3/y are originating from the equatorial lakes. The average annual Nile flow at Aswan, on the Sudano-Egyptian border, is about 84 km^3/y, out of which more than 80% is occurring between August and October. According to the Nile water agreement a share of 18.5 km^3/y is attributed to Sudan and a share of 55.1 km^3/y is assigned to Egypt, while about 10 km^3/y is attributed to evaporation from the high dam reservoir.

The origins of the Nile spring out of two major sources: the Equitorial Lakes Plateau, and the Ethiopian Plateau. The ***Equatorial Lakes Plateau*** comprises a number of great lakes, namely:

- Basin of ***Lakes Victoria and Kioga*** supplying the ***Victoria Nile***,
- Basin of ***Lakes George & Edward*** and the ***Semiliki River*** connecting Lake Edward to Lake Albert, and
- Basin of Lake Albert out of which the ***Albert Nile*** originates and is joined by torrential streams to form what is known as ***Bahr El Gabal*** river which enters Sudan.

The basin of the ***Ethiopian Plateau*** includes:

- Basin of ***Sobat*** River
- Basin of the ***Blue Nile***, and
- ***Basin of*** Atbara ***River***

Bahr El-Gabal crossing the southern boarders of Sudan flows through the swampy areas known as the ***Sudd*** where it confluences with ***Bahr El-Gazal*** River from the west then ***Sobat*** River from the east. The formed water way known as the ***White Nile***, is joined by the ***Blue Nile*** further north at the Sudan's capitol Khartoum. About 1550 Km to the south of the Sudano-Egyptian boundaries, the ***Atbara River*** Joins the Nile supplying about 12 km^3/y.

The seasonal rivers of ***Gash and Baraka*** in eastern Sudan have a violent water flow in the rainy period from July to September and the flow is divided between canals that form a fertile delta area (spate irrigation). The total of waste water has been treated out of which 20 millions are adopted for reuse. Unconventional water resources also include 8.3 million m^3 of desalinated water. Conjunctive use of surface water and groundwater has been successfully adopted to pilot areas in wadis.

Increasing the storage potential through groundwater recharge has also been practiced in the 1990s. The general national policy for increasing water availability is based on development of irrigation schemes, adaptation of water saving techniques, and encouraging the reuse of waste water. It is expected that 90% of the surface water resources and 100% of the groundwater will be utilized by year 2010, through the construction of 21 dams, 235 hillside dams, and 610 deep pipe wells. A monitoring system has been set for all irrigation schemes of potential salinisation effects where the salinity of irrigation water is between 1.5 and 4.0 g/l.

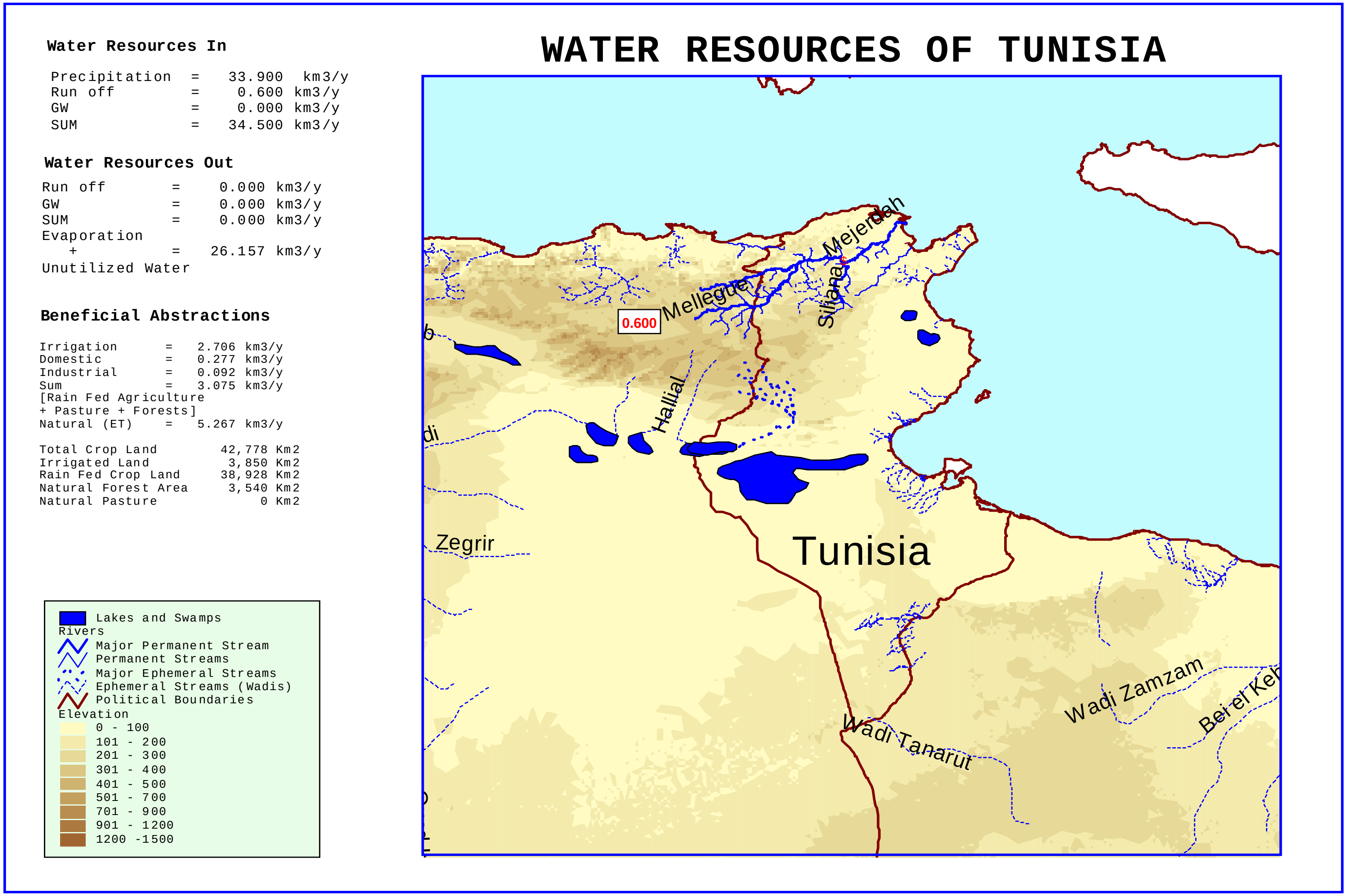


Figure (34) Water Resources of Tunisia

UNITED ARAB EMIRATES

The average annual rainfall is about 100 mm varying from less than 40 mm in southern desert to about 160 mm in the north-eastern mountains. Most of the rainfall occurs between October and March. Heavy rainfall occasionally occurs during spring and summer. The areas suitable for rain-fed agriculture are very limited. Precipitation, varies over space and time, accounts for 0.15 km^3/y of Internal renewable water resources. The average annual groundwater recharge is about .12 Km^3. Rechargeable ground water aquifers occur mainly from infiltration from the river beds. In year 1995 the total groundwater abstraction is estimated at 1.6 Km^3, which mean that the groundwater depletion was almost 1.5 Km^3. The over-extraction of groundwater resources has led to a lowering of the water table by more than one meter on average during the last two decades, while sea water intrusion is increasing in the coastal areas. The actual renewable water resources, as of 1995, is 0.15 km^3/y where the total population is 1.9 million inhabitant, thus generating *per capita share of ARWR of only 79 m^3/y*.

The total freshwater withdrawal is estimated at 2.8 km^3/y as of 1995, 62 % of which is diverted to agriculture, 24% to domestic sector, 9.5% to industry, and 5% to landscaping. The total freshwater withdrawals sources are distributed as:

- 76% from groundwater,
- 19% from desalination, and
- 4% from waste water reuse.

There are about 35 dams and embankments of various dimaension. They are mainly built for recharge purposes and to provide protection against damage caused by flash floods. The total storage capacity of these dames is estimated at 0.08 Km^3. The irrigation potential can be estimated at 66,682 ha.

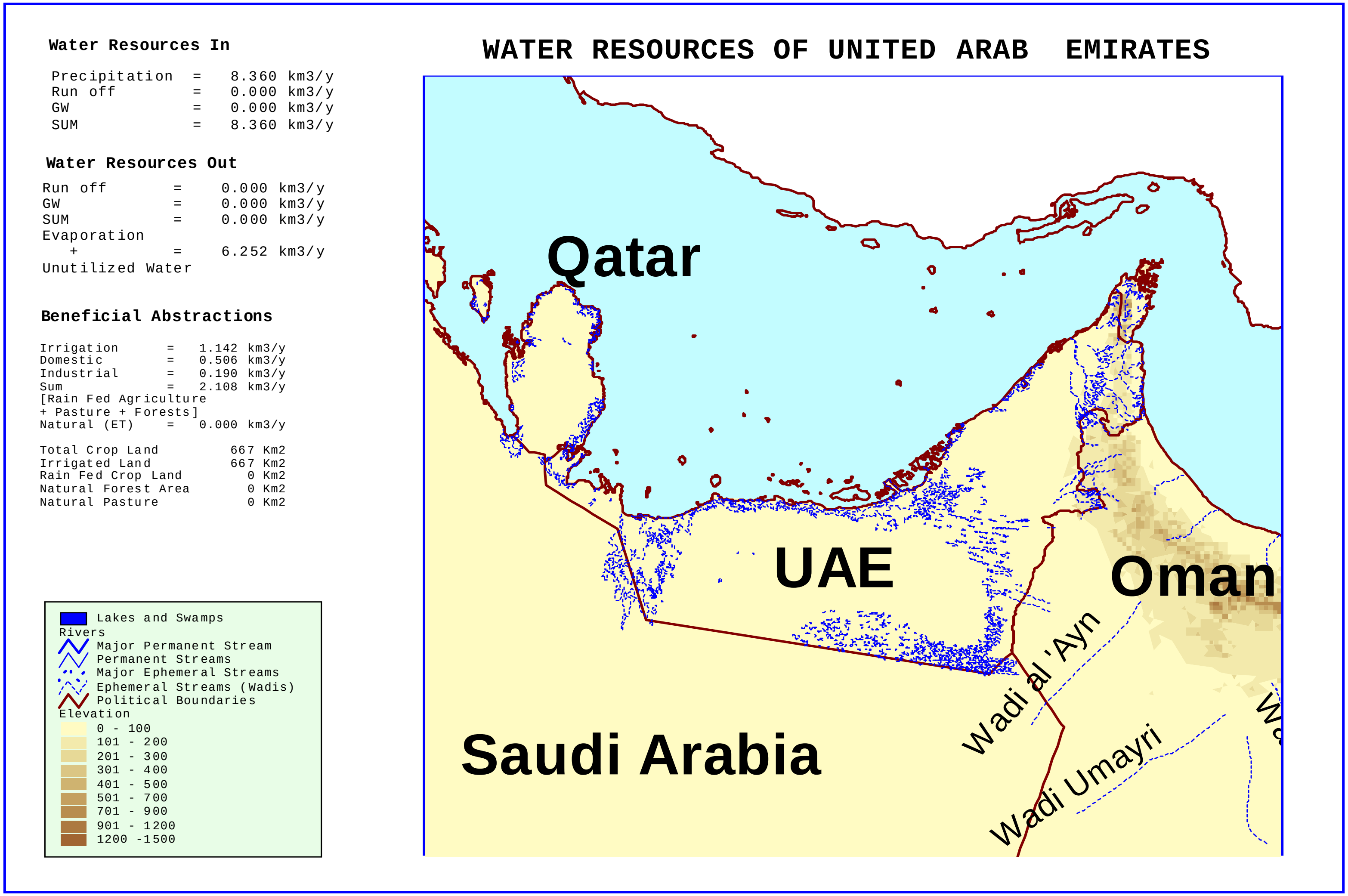


Figure (35) Water Resources of United Arab Emirates

Republic of <u>Yemen</u>

The average annual rainfall is about 170 mm, varying between less than 50 mm in the coastal areas and the eastern desert to 200-400 mm in the highlands and increases along the western slopes of the central highlands to reach up to 1000 mm in some spots. Rainfall occurs mainly during the spring (March – April) and summer (June –August) months.

There are four major drainage areas in Yemen, namely the Red Sea, the Golf of Aden, the Arabian Sea, and the Rub Al-Khali. These drainage areas are further divided into 14 major water basins.

The total actual renewable water resources is estimated at 2.5 km3/y, which translates into a per capita share of only 130 m3/y. Given the high population growth rate, the per capita share of renewable water resources is projected to further decline to around 75 m3/y by 2025.

The actual fresh water withdrawal is estimated at 3.5 km3/y, resulting in an annual deficit of 1.0 km3/y. This deficit is largely satisfied from fossil groundwater aquifers. Water use in Yemen is characterized by:

93% agriculture
7% domestic and industry

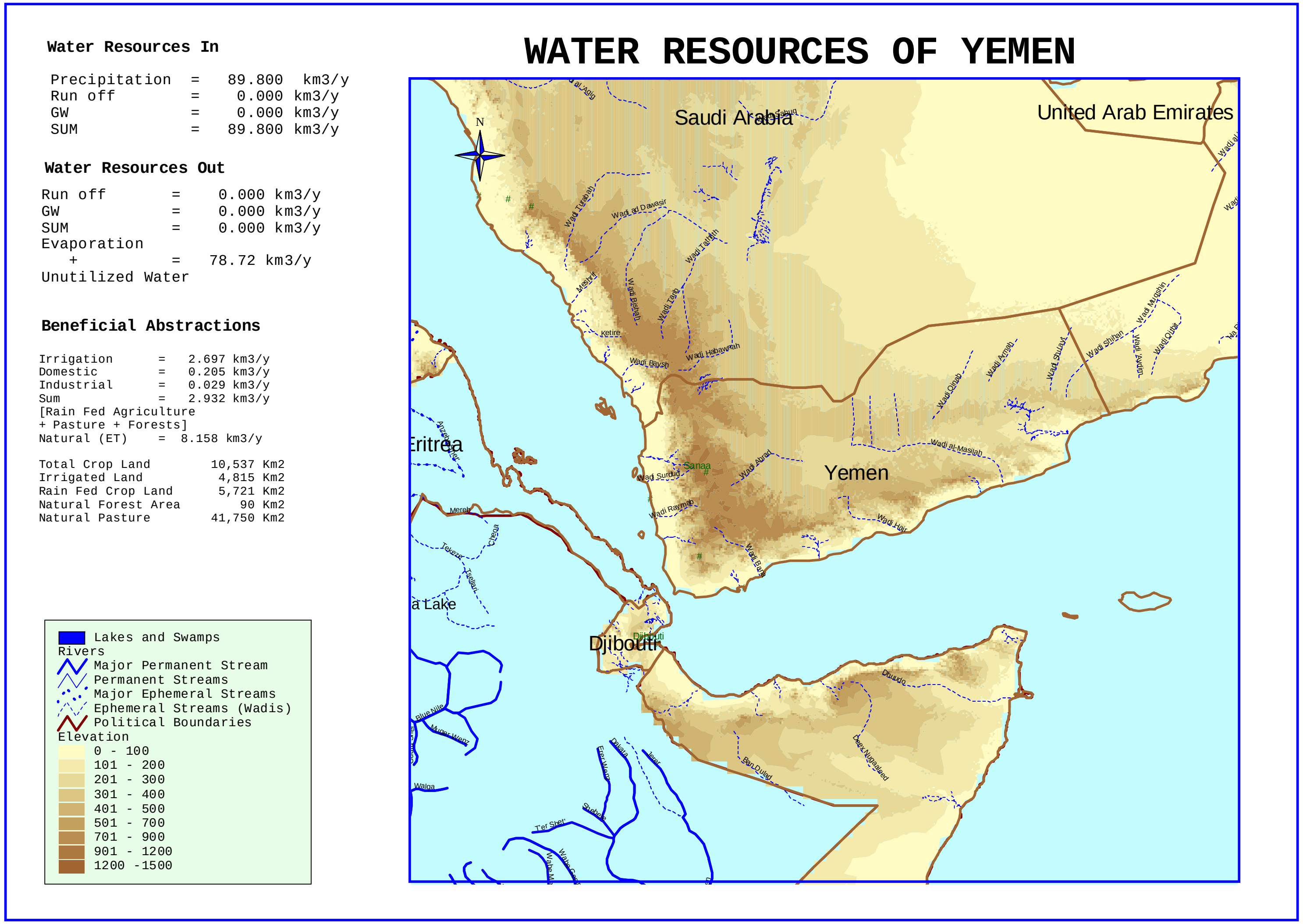


Figure (36) Water Resources of Yemen

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Figure (11) Land Use

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