



United Nations  
Educational, Scientific and  
Cultural Organization

منظمة الأمم المتحدة  
للتربية والعلم والثقافة

Cairo  
Office

مكتب  
القاهرة



الشبكة العربية للبيئة والتنمية

## **ECOHYDROLOGY IN BIOSPHERE RESERVES FOR ARAB DRYLANDS**

**PROF. WAFAA MAHROUS AMER**

**PROFESSOR OF BOTANY - FACULTY OF SCIENCE- CAIRO UNIVERSITY**

**DR. MOHAMED ELSAYED GAMIL**

**PROFESSOR OF ENVIRONMENTAL EDUCATION - AIN SHAMS UNIVERSITY  
ENVIRONMENTAL EDUCATION ADVISER OF THE LEAGUE OF ARAB STATES**

**TECHNICAL ADVISER OF RAED**

**A COMMISSIONED PAPER PREPARED FOR UNESCO CAIRO OFFICE**

**JANUARY, 2010**

**The designations employed and the presentation of material through the publication do not imply the expression of any opinion whatsoever on the part of UNESCO concerning the legal status of any country, territory, city or its authorities, or concerning the delimitation of its frontiers or boundaries.**

## **PREFACE**

Water in the Arab world is a source of major social and economic problems stemming from scarcity, variability, unreliable services and environmental damage. The situation is likely to become even worse in the near future, unless the current practices change. By 2050 the quantity of water per capita will fall by half, water equality among people and countries will further deteriorate, and more aquifers will become depleted. Climatic changes are predicted to worsen the problems by increasing temperatures and causing more droughts and floods.

While water professionals have been advocating comprehensive water policy reforms for years, and many countries have improved their water policy institutions. However some of the most politically sensitive elements of reform remain untouched, among them are the concept and the practices of the integrated water resources management (IWRM).

This paper is prepared for UNESCO CAIRO OFFICE to highlight the concepts of Integrated Water Management (IWRM) especially in Protected Areas (PAs) of the Arab Drylands.

### **This paper aims:**

- To explain the main characteristics of the protected areas (PAs), and give more details about their functions.
- To highlight the practices of integrated water resources management (IWRM) in protected areas.
- To identify in depth the applications and models of IWRM on Eco-system with special focus on protected areas in the Arab world.
- To articulate the basic elements and lessons learned from such practices and the best models.
- To figure out the challenges facing IWRM in drylands eco-systems in the Arab world.
- To list the practical recommendations that can be provided to major stakeholders (governments, international organizations, local communities, private sector ..... etc.) for the future implementation of IWRM in protected areas in the Arab world.

### **This paper includes five Chapters**

#### **Chapter I:**

Discusses the definition of Ecohydrology and its main pillars in drylands, characteristics and classification of the protected areas in the Arab world.

**Chapter II:**

Deals with integrated water resources management (IWRM) in the protected areas of the Arab world, its definition, the current practices, gaps, and models in addition to assessment of the current practices in the field of (IWRM; if any) in the protected areas representative case studies were chosen from the Arab countries: Tunisia, Jordan, Egypt, Morocco, Palestine, Yemen, and Saudi Arabia.

**Chapter III:**

Define the strengths and weaknesses of IWRM, current practices in PAs, including the basic elements, challenges, and difficulties facing the application of IWRM in Arab Protected Areas (PAs).

**Chapter IV:**

Deals with the best practices and models of IWRM and Tunisian's experience in water resources mobilization and management as a best practices and model in the Arab Aridlands.

**Chapter V:**

Recommendations and proposals concerning legislative actions, the role of sustainable environmental education in achieving IWRM for PAs, also the role of private sector in partnership to achieve the integrated water management, demands and initiatives from the international organizations and the needed community participation and actions.

## **ACKNOWLEDGMENT**

The Arab Network for Environment and Development "RAED" is appreciating the continuous support, guidance and facilities offered by UNESCO Cairo office during preparation of this paper. RAED also, thanks the authors Dr. Wafaa M. Amer (Professor of Botany - Faculty of Science- Cairo University) and Dr. Mohamed El-Sayed Gamil (Professor of Environmental Education - Ain Shams University) who helped to make this publication possible. We are looking forward to translate this paper into Arabic and will be published shortly to increase its benefit.

Thanks are also due to Dr Youssef A.Hamdi, Former Deputy Director of ARC for revising the text.

## Table of Contents

Page

### **CHAPTER I: ECOHYDROLOGY OF DRYLANDS AND PROTECTED AREAS IN THE ARAB WORLD**

#### **"OVERVIEW"**

1.1	Ecohydrology .....	11
1.2	The Main Pillars of Ecohydrology in Dry Lands .....	11
1.3	Ecohydrology Reserves in the Arab World.....	15
1.4	Characteristics of the Protected Areas and their Environmental Functions.....	21
1.5	Types of Protected Area in the Arab World .....	22
1.6	Protected Area in the Arab World.....	23

### **CHAPTER II: INTEGRATED WATER RESOURCES MANAGEMENT "IWRM" IN THE PROTECTED AREAS OF THE ARAB WORLD.**

2.1	Definition and the status of Integrated Water Resource Management (IWRM) in protected areas in the Arab World .....	73
2.2	The current practices, gaps and models used for integrated water management in dry lands ecosystems .....	75
2.3	Models for better conserving freshwater within protected areas .....	78
2.4	Assessment of the best practices in the field of IWRM in Protected areas "Case studies from the Arab countries" .....	79

### **CHAPTER III: IDENTIFICATION OF THE STRENGTHS AND WEAKNESSES OF THE IWRM CURRENT PRACTICES IN PROTECTED AREAS (PAS)**

3.1	The basic elements and challenges to the application of IWRM in Arab World.....	101
3.2	Difficulties encountered with the application of IWRM in PAs:.....	102
3.3	Topics for assessment of the current (or future) application of IWRM in protected areas.....	104

### **CHAPTER IV: THE BEST PRACTICES AND MODELS OF IWRM: TUNISIA'S EXPERIENCE IN WATER RESOURCE MOBILIZATION AND MANAGEMENT**

4.1.	Introduction.....	105
4.2.	Water problem in Tunisia .....	105
4.3.	Water management in Tunisia .....	106
4.4.	Best practices and models for IWM in Arab Biosphere Reserves.....	109
4.5.	Water management in Drava River Basin, a trans-boundary project .....	109

### **CHAPTER V: RECOMMENDATIONS AND PROPOSALS**

5.1	Legislative and Executive Actions by Governance.....	111
5.2	The Role of Environmental Education in Achieving Integrated Water Management for PAs.....	111
5.3	The Role of Private Sector in Partnership to Achieve the Integrated Management.....	111
5.4	Demands and Initiatives for the International Organizations .....	112
5.5	Community Participation and Actions .....	112

<b>CONCLUDING REMARKS .....</b>	<b>113</b>
---------------------------------	------------

<b>REFERENCES.....</b>	<b>115</b>
------------------------	------------

## List of Figures

<b>Figure 1: The integration of hydrology and ecosystem science involves different concepts for each type of ecosystem. (After Nuttel 2002) .....</b>	<b>12</b>
<b>Figure 2: Water resources in Arab countries. (World Bank 1991, 1992, 1992–93 &amp; 2001).....</b>	<b>17</b>
<b>Figure 3: Population growth for the Arab Countries (after: CEDARE &amp; Arab Water Council, 2007) .....</b>	<b>18</b>
<b>Figure 4: Annual renewable fresh water per capita in the Arab countries, 1990 to 2025. (Source: Engelman &amp; LeRoy 1993.) .....</b>	<b>20</b>
<b>Figure 5: Diagram showing the detention (after: El-Barbary &amp; Sallam 2004).....</b>	<b>76</b>
<b>Figure 6: Diagram showing the detention basins and wetlands practice .....</b>	<b>77</b>
<b>Figure 7: Diagram showing the restoration of the natural vegetation channels.....</b>	<b>77</b>
<b>Figure 8: Water storage dam in Morocco mountain area .....</b>	<b>79</b>
<b>Figure 9: Lake Ichkeul, Tunisia. The lake badly deteriorated as the result of the construction of three dams on rivers supplying it and its marshes. The dams cut off almost all inflow of fresh water, causing a destructive increase in the salinity of the lake and marshes. ....</b>	<b>80</b>
<b>Figure 10: Yemen protected area.....</b>	<b>87</b>
<b>Figure 11: Sites in which the IWRM project was implemented in Manzala Lake .....</b>	<b>88</b>
<b>Figure 12: District Decision Support Systems (DSS) for irrigation and Drainage Water .....</b>	<b>89</b>
<b>Figure 13: Small Scale Solar Unit at Omayed Biosphere .....</b>	<b>90</b>
<b>Figure 14: Delivery of water to households in Omayed Biosphere Reserve.....</b>	<b>91</b>
<b>Figure 15: Controlled water extraction from a well in Abu Saafa, Elba protectorate, adjusted for drip irrigation.....</b>	<b>91</b>
<b>Figure 16: Water dam in Abu Saafa, Elba protectorate .....</b>	<b>92</b>
<b>Figure 17: Showing Zaranik protectorate area .....</b>	<b>96</b>
<b>Figure 18 : Water Balance of Al-Zaranik Wetland .....</b>	<b>97</b>

## List of Table

<b>Table 1: Surface and groundwater availability in some of the Arab countries (m3 per year)....</b>	<b>16</b>
<b>Table 2: Protected areas in Algeria .....</b>	<b>24</b>
<b>Table 3: Protected areas in Bahrain.....</b>	<b>30</b>
<b>Table 4 : Protected areas in Djibouti .....</b>	<b>31</b>
<b>Table 5: Protected areas in Egypt .....</b>	<b>32</b>
<b>Table 6: Protected areas in Iraq .....</b>	<b>35</b>
<b>Table 7: Protected areas in Jordan .....</b>	<b>37</b>
<b>Table 8: Protected areas in Kuwait .....</b>	<b>39</b>
<b>Table 9: Protected areas in Lebanon.....</b>	<b>40</b>
<b>Table 10: Protected areas in Libya.....</b>	<b>42</b>
<b>Table 11: Protected areas in Mauritania .....</b>	<b>43</b>
<b>Table 12: Protected areas in Morocco.....</b>	<b>44</b>
<b>Table 13: Protected areas in Oman .....</b>	<b>50</b>
<b>Table 14: Protected areas in Qatar .....</b>	<b>51</b>
<b>Table 15: Protected areas in Somalia.....</b>	<b>52</b>
<b>Table 16: Protected areas in Saudi Arabia.....</b>	<b>53</b>
<b>Table 17: Protected areas in Sudan.....</b>	<b>61</b>
<b>Table 18: Protected areas in Syria.....</b>	<b>64</b>
<b>Table 19: Protected areas in Tunisia.....</b>	<b>65</b>
<b>Table 20: Protected areas in Yemen.....</b>	<b>71</b>
<b>Table 21: Monthly Rainfall Depth and Volume over the Wetland.....</b>	<b>96</b>
<b>Table 22: Average Daily, Monthly, and Volume of Evaporation .....</b>	<b>98</b>
<b>Table 23: Water Balance of Al-Zaranik Wetland.....</b>	<b>99</b>

## Executive Summary

This study was prepared for UNESCO CAIRO OFFICE, highlights the Integrated Water Resources Management (IWRM) in Protected Areas (PAs) of the Arab countries. The problem of water shortage in the Arab countries is predicted to become worse in the near future. By 2050 the water availability per capita will fall by half, both water quality and equality will be affected and aquifers will become depleted. Climatic changes are predicted to worsen the problems by increasing temperatures and causing more droughts and floods.

Accordingly, water professionals have been advocating comprehensive efforts to water reform in many countries. This includes: improvement of water polices, capacity building for the water related institutions, participation of private sector and finally it is reasonable to speak about Integrated Water Resources Management (IWRM). **This paper comes in five chapters namely:**

**Chapter I:** is dealing with the definition of "Ecohydrology" and its three main pillars in Drylands. **The first** is hydrological: quantification of the hydrological cycle in a certain basin. **The second** is ecological: The integrated processes at river basin scale that can be steered in such a way to enhance the basin's carrying capacity and its ecosystem services. And **the third** is ecological engineering: regulation of hydrological and ecological processes, based on an integrated system approach. Ecohydrology reserves in the Arab World were also outlined including: precipitation, ground water and the amount of water available per capita. Water crisis in the Arab world deserves additional research and attention and the region will suffer from a water shortage estimated at 261 billion cubic meters by 2030, with per capita Arab consumption less than 700 cubic meters annually. This chapter ended by an overview on the names, categories, function and characteristics of the protected areas in the 22 Arab countries.

**Chapter II:** Models for better conserving freshwater within protected areas, water storage in Morocco mountain area is a mentioned example. Assessment of the best practices in the field of IWRM within PAs in Arab countries were defined namely: Ichkeul Nation Park (Tunisia); Azraq Oasis (Jordan); Water management in Yemen; Manzala Lake, El Omayed Biosphere Reserve, Al Zaranik wetland and Elba protectorate (Egypt); PREM project in Morocco; Marj Sanour Watershed Development in Jenin (Palestine); and the IWRM in Saudi Arabia.

**Chapter III:** Strengths, weaknesses, current practices, and the difficulties encountered the application of IWRM in PAs were reviewed. Among the difficulties are: 1) difficulties related to the value of water; 2) difficulties related to information management in PAs; 3) difficulties related to legislations addressed to the PAs; 4) difficulties related to organization management, capacity building and research needed. Topics for assessment of the current (or future) application of IWRM in protected areas is presented: 1) who and how we can assess the IWRM and identify the best practices? 2) What indicators should be used to assess the best IWRM? and 3) Do we have enough knowledge to already adapt management? Etc...

**Chapter IV:** Deals with the best practices and models of IWRM Tunisia's experience in water resources mobilization and management as the best model for water management in the Arab World is reviewed. This chapter includes: water problems, management, policies, models, water projects, and the beneficiaries' participation in Tunisia. The application of IWRM in Tunisian Biosphere Reserve was also mentioned. This chapter ended by Water management project applied for Tisza River Basin in European countries, as an example of the trans-boundary water bodies.

**Chapter V:** Recommendations and proposals concerning legislative actions, the role of sustainable environmental education in achieving IWRM for PAs, the role of private sector in partnership to achieve the integrated water management, demands and initiatives from the international organizations and the community participation and actions.

**The study is supported** by 18 explanatory Figures; 23 tables , concluding remarks and the list of both text and electronic references, including the latest reference appears in the world about water in the Arab countries (Louati & Bucknall 2009 - World bank publication, 2009).

## الإيكوهيدرولوجيا للمحميات الطبيعية في المناطق الجافة العربية

أعدت هذه الدراسة بناءً على طلب مكتب اليونسكو الإقليمي بالقاهرة. ليهتم بموضوع الإدارة المتكاملة للمياه في المحميات الطبيعية بالدول العربية. وقد أصبح من المعلوم أن مشكلة نقص المياه في الدول العربية توشك بأن تصبح أكثر سوءاً في القريب العاجل. فإن نصيب الفرد من المياه بحلول عام 2050 سوف يقلص الي النصف في المنطقة العربية كما يتبع هذا النقص تدهور في نوعية المياه وعدالة توزيعها فيما بين الأفراد وكذلك بين المناطق المختلفة بالقطر الواحدة.

إضافة إلى ذلك فإن المخزون الجوفي للمياه معرض أيضاً للضوب. فالتغيرات المناخية المتوقعة تنذر بتفاقم هذه المشكلة وخاصة مع زيادة درجة الحرارة وزيادة المناطق المعرضة للجفاف والسيول. وهذا يستوجب بذل جهد من المتخصصين في مجال المياه في الدول العربية لتحسين وإعادة صياغة السياسات المائية التي من شأنها تعظيم الاستفادة من كل قطرة ماء. ويرافق ذلك تطبيق برامج لبناء القدرات ومن هنا أصبح لزاماً على الدول العربية أن تتبنى مفهوم الإدارة المتكاملة للمياه وتعمل علي تطبيق الأنشطة الداعمة لها.

### وتقع هذه الدراسة في خمسة فصول هي على التوالي:

**الفصل الأول :** يهتم هذا الفصل بتعريف مصطلح الإيكوهيدرولوجيا وركائز هذا العلم في المناطق الجافة. الركيزة الأولى هي **الإيكوهيدرولوجيا:** تهتم بتقدير دورة المياه في حوض نهر معين. والركيزة الثانية **الإيكولوجيا:** وتهتم بالكفاءة الاستيعابية لحوض هذا النهر وتحسين ذلك بطرق تخدم البيئة. أما الركيزة الثالثة فهي **الهندسة الإيكولوجية:** وهي عملية تنظيم لمراحل الهيدرولوجيا مع الإيكولوجيا في نظم متكاملة. كما تضمنت الدراسة المخزون الإيكوهيدرولوجي في الوطن العربي بما يشمل من مياه سطحية وجوفية ونصيب الفرد منها. وتنبه الدراسة على أن الأزمة المائية يجب أن توضع في بؤرة الاهتمام البحثي. وينتهي هذا الفصل باستعراض أسماء محميات الوطن العربي وتقسيماتها ووظائفها ومميزاتها في الاثنين والعشرين دولة عربية.

**الفصل الثاني:** يتناول هذا الفصل أفضل الممارسات في مجال صون المياه العذبة بالمحميات الطبيعية. وقد ذكر مثال على ذلك تخزين المياه بالمناطق الجبلية بالمغرب. وتناولت الدراسة تقييم أفضل الممارسات في مجال الإدارة المتكاملة للمياه بمحميات الوطن العربي وشمل هذا التقييم محميات عديدة منها: المنتزه القومي بأشكول (تونس)، واحة الأزرق (الأردن)، الإدارة المائية باليمن ، ومن مصر أوردت الدراسة العديد من الأمثلة هي: محمية بحيرة المنزلة (محمية المحيط الحيوي) - محمية الزرائيق للأراضي الرطبة - محمية علبة. ومن المغرب تناولت الدراسة

مشروع بريم (PREM)، مرج سنور بجنين فلسطين وانتهى الفصل بلمحة عن الإدارة المتكاملة للمياه بالمملكة السعودية.

**الفصل الثالث:** تناول هذا الفصل بالشرح والإيضاح نقاط القوة والضعف في الممارسات الحالية للإدارة المتكاملة للمياه في محميات الوطن العربي. وكذلك المشاكل التي تعيق تطبيق هذه الإدارة. تعددت هذه المشاكل فمنها على سبيل المثال وليس الحصر: (1) مشاكل تسعير المياه، (2) مشاكل إدارة المعلومات بالمحميات، (3) مشاكل قانونية وتشريعية، (4) مشاكل تتعلق بنظم الإدارة المؤسسية وبناء القدرات والأبحاث المطلوبة وما إلى ذلك. وانتهى هذا الفصل باستعراض النقاط التي يجب أخذها في الاعتبار عند تقييم النظم الحالية (أو المستقبلية) للإدارة المتكاملة للمياه بالمحميات الطبيعية. ومن هذه النقاط: (1) كيف يمكن تقييم الإدارة المتكاملة للمياه؟ ومن سوف يحكم على ما هي أفضل الممارسات من عدمه؟؛ (2) ما هي المؤشرات التي تحكم جودة هذه الممارسات؟؛ (3) هل لدينا المعارف اللازمة التي تمكننا من تفعيل هذه الإدارة؟.

**الفصل الرابع:** تناول هذا الفصل بالتفصيل والتقييم عناصر الإدارة المتكاملة للمياه بالوطن العربي وهي حالة الجمهورية التونسية كمثال يُحتذى به لأفضل الممارسات علي مستوي البلد وتمت الإشارة الي إدارة المياه في متنزه أشكول. وإنتهى هذا الفصل بمثال لإدارة المياه العابرة للحدود ومثال ذلك حوض نهر تسيزا في أوربا.

**الفصل الخامس:** يتناول هذا الفصل التوصيات واقتراحات للتشريعات والإجراءات التي يجب أن تُطبق في مجال الإدارة المتكاملة للمياه بالمحميات الطبيعية يُضاف إلى ذلك دور التعليم البيئي المستديم وكذلك مساهمة القطاع الخاص في هذه الإدارة مع معرفة احتياجات هذه المناطق وإشراك المؤسسات الدولية والمجتمع المحلي في تفعيل هذه الإدارة.

وقد تم تدعيم هذه الدراسة بعدد ثمانية عشر شكلاً توضيحياً و23 جداولاً ومختصراً لأهم توصيات الدراسة وقائمة من المراجع التي استعان بها الباحثون من مصادر ورقية وإلكترونية. كما اطلعت هذه الدراسة على أحدث الدراسات التي صدرت في هذا الموضوع وكانت تحت عنوان: "المياه في الوطن العربي - الآمال والابتكار في إدارة المياه" والتي صدرت آخر عام 2009 بتمويل من البنك الدولي.

# CHAPTER I

## ECOHYDROLOGY OF DRYLANDS AND PROTECTED AREAS IN THE ARAB WORLD

### "OVERVIEW"

#### 1.1 Ecohydrology

##### 1.1.1 Definition

The term Ecohydrology is derived from the Greek word "oikos" meaning house (hold) and the "hydro" meaning water"; and finally "logia" meaning the science branch. Ecohydrology is an interdisciplinary field studying the interactions between water and ecosystems. These interactions may take place within water bodies, such as rivers and lakes, or land, forests, deserts, on other terrestrial ecosystems.

##### 1.1.2 Research in Ecohydrology

Areas of research in Ecohydrology include transpiration and plant water use, adaptation of organisms to their water environment, influence of vegetation on stream flow and function, and feedbacks between ecological processes and the hydrological cycle. Hydrologic cycle, describes the continuous movement of water on, above, and below the surface on the earth. This flow is altered by ecosystems at several points. Transpiration from plants provides the majority of flow of water to the atmosphere. Water is influenced by vegetative cover as it flows over the land surface, while river channels can be formed by the vegetation within them. Ecohydrologists study both terrestrial and aquatic systems, in terrestrial ecosystems such as forests, deserts, and savannas. The interactions among vegetation, the land surface, and the groundwater are the main focus. In aquatic ecosystems such as rivers, streams, lakes, and wetlands emphasis is placed on how water chemistry, geomorphology, and hydrology affect their structure and function.

Ecohydrology research also aims to provide expertise, updating of the information based on research, scientific collaboration, education and awareness of actual world information on water considering the surrounding environment especially in Arid lands among of them our Arab world is facing a lot of challenges: rainfall scarcity, changes in land use and the recent topic classified under the global climate change.

#### 1.2 The Main Pillars of Ecohydrology in Dry Lands

##### 1.2.1 The pillars of Ecohydrology are expressed in three subsequent components as follows:

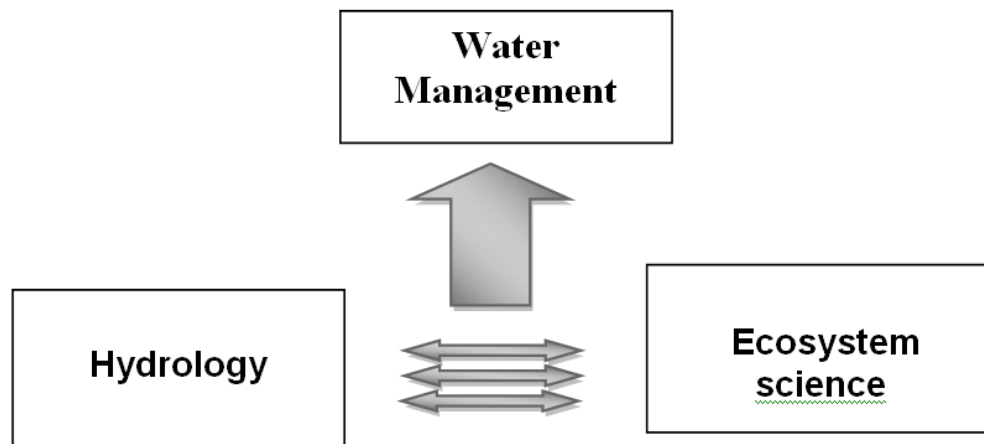
- (a) **Hydrological:** The quantification of the hydrological cycle in a certain basin should be a template for functional integration of hydrological and the associated biological processes.
- (b) **Ecological:** "The integrated processes at river basin scale can be steered in such a way as to enhance the basin's carrying capacity and its ecosystem services.

- (c) **Ecological Engineering:** The regulation of hydrological and ecological processes, based on an integrative system approach Integrated Water Basin Management (IWBM).

i.e Zalewski *et al.*, (1997) expression as testable hypotheses :

- (a) **H1:** Hydrological processes generally regulate biota
- (b) **H2:** Biota can be shaped as a tool to regulate hydrological processes
- (c) **H3:** These two types of regulations (H1 & H2) can be integrated with hydro-technical infrastructure to achieve sustainable water and ecosystem services.

Traditional water management depends on information derived from hydrological science. A holistic approach to water management similarly depends on integrated study of hydrological and the related ecological processes. However, science alone does not determine management. Other factors, besides scientific knowledge must be combined to determine the overall approach to water management. Therefore, Ecohydrology is either an overarching paradigm for water management, or it is the study of the interaction of hydrological and the related ecological processes (Fig. 1).



**Figure 1:** The integration of hydrology and ecosystem science involves different concepts for each type of ecosystem. (After Nuttel 2002)

### 1.2.2 Soil Moisture Dynamics and Plant Growth

Soil moisture is a general term describing the amount of water present in the plant-root zone, or unsaturated portion of soil below ground. Since the biological processes in plants depend on this water thus soil moisture is integral to the study of Ecohydrology. In arid and semi-arid areas, like Arab world, vegetation (type, density and distribution) is directly related to the water availability. Plants play an important role in extraction of water from the soil. When insufficient soil water is available, a water-stressed condition occurs. Plants under water stress decrease both their transpiration and photosynthesis through a number of responses. This decrease in transpiration and carbon dioxide flux have an impact on surrounding climate and weather.

Soil moisture is generally described as water content ( $\theta$ ), or saturation (S) These terms are related by porosity ( $n$ ), through the equation  $\theta = nS$ . The changes in soil moisture over time are known as soil moisture dynamics.

Ecohydrological theory also shows the importance on time and space relationships. Hydrology, in particular timing of precipitation events, can be a critical factor in the way an ecosystem evolves over time. Arab lands are characterized by dry summers and wet winters. If the vegetation has a summer growing season, it often experiences water stress, even though the total precipitation throughout the year may be moderate. Ecosystems in these regions have typically evolved to support high water demand grasses in the winter, when water availability is high and drought-adapted trees (xeric species) in the summer, when it is low. Vegetation density (spacing of plants) is controlled by water availability. In dry ecosystems, trees are typically located further apart from each other (e.g. western desert, Egypt) than they would be in well-watered areas (e.g. rainy forest).

### 1.2.3 The Fundamental Equation in Ecohydrology (<http://en.wikipedia.org/wiki/Ecohydrology>)

A fundamental equation in Ecohydrology is the water balance at a point in the landscape. A water balance states that the amount water entering the soil must be equal to the amount of water extracted from the soil plus the amount added to the soil-stored water. The water balance has four main components: infiltration of precipitation into the soil, evapo-transpiration, and leakage of water into deeper portions of the soil not accessible to the plant, and runoff from the ground surface. It is described by the following equation:

$$nZ_r \frac{ds(t)}{dt} = R(t) - I(t) - Q[s(t), t] - E[s(t)] - L[s(t)]$$

The terms on the left hand side of the equation describe the total amount of water contained in the rooting zone. This water, accessible to vegetation, has a volume equal to the porosity of the soil ( $n$ ) multiplied by its saturation ( $s$ ) and the depth of the plant's roots ( $Z_r$ ). The differential equation  $ds(t)/dt$  describes how the soil saturation changes over time. The terms on the right hand side describe the rates of rainfall ( $R$ ), interception ( $I$ ), runoff ( $Q$ ), evapo-transpiration ( $E$ ), and leakage ( $L$ ). These are typically given in millimeters per day (mm/d). Runoff, evaporation, and leakage are all highly dependent on the soil saturation at a given time.

### 1.2.4 Ecohydrology and Social Sciences (Lemos, *et al.* 2007):

The evolution of the concept of Ecohydrology reflects the scope of issues discussed above in connection to the production of "usable" knowledge and its application in the context of IWRM. The following revision of Ecohydrology conceptual and operational models of integration of the discipline into society and the role of social sciences draws both on the preliminary conclusions

of a consultative workshop convened to assess this issue (UNESCO 2005) and the analysis of this Task Force.

Conceptually defined as an integrated approach to freshwater ecosystem management and restoration, Ecohydrology is organized as a problem solving approach discipline. Ecohydrology relies on the scientific understanding of ecosystem properties so that these can be used as tools for sustainable water management (Zalewski 2002). Part of the evolution of Ecohydrology as a discipline is the understanding of how ecosystem properties that are connected to hydrology have been negatively affected by human action. Number of societal activities are directly or indirectly affect freshwater ecosystem properties including: the direct affectation of water flow by the construction of dams, the channeling of rivers, or the construction of hydroelectric facilities; agricultural practices, expanding the agricultural frontier through drainage of wetlands, or the survival practices among densely populated poor peasant populations; the expansion of potable water wells, sewage systems, linear developments such as roads and the emission of urban pollutants affecting surface and/or underground water flows. In summary, Ecohydrology is an integrated scientific discipline oriented to the solution of hydrology and water ecosystem problems that have originated in the transformation of ecosystems as a result of anthropogenic threats. However, although Ecohydrology as a scientific discipline aims to find solutions to the decline in water resources through improved ecosystem management or restoration, it has so far evolved with a "blind spot" to the understanding and management of the societal processes that are the root causes of ecosystem transformation (Zalewski 2002).

Ecohydrology demonstration projects clearly recognize the social dimension of specific water management problems affecting the studies site positively or negatively. However the specific operational presentation of the problem through hypothesis is restricted to ecosystem functioning. Thus, we may characterize Ecohydrology as a multi disciplinary "supply side" approach to solving water management problems. As indicated by the consultative workshop, so far "fundamental aspects of social, cultural, political interactions affecting water use and conservation have been virtually absent from the Ecohydrology approach" (UNESCO 2005).

Ecohydrology has yet to validate multi or trans-disciplinary research models that demonstrate ways to integrate the social sciences. Validation of these models will have to be tested by the capacity of Ecohydrology to produce "usable" knowledge that responds to stakeholders and decision makers at multiple levels. Decision makers requiring practical knowledge of Ecohydrology solutions are policy makers and water users. There is a need to link the study of Ecohydrology solutions to human livelihoods and the sustainable use and conservation of biodiversity (UNESCO 2005).

The incorporation of social sciences into the Ecohydrology approach should be assessed by its yield of effective water management decision support tools. This will clearly require from Ecohydrology scientists the will to engage local society in planning processes for freshwater ecosystem management, and therefore engage specialized social science knowledge related to the nature of these kinds of processes. Scientifically, designed demonstration projects should

demonstrate the priorities for integration and how to incorporate the social sciences in ways that are effective and meaningful to both research communities and to stakeholders.

Among the several social science resources that will be necessary to incorporate, a central one will be the family of methods for participatory planning processes. A possible future scenario for Ecohydrology trained practitioners could be an appreciation and understanding of the need for active stakeholder participation as a means to obtain more relevant research questions, more meaningful results for decision-makers and innovations in water management that are grounded in society's values (Forester 1999). At this level, an interdisciplinary dialogue about modalities and methods of incorporation between natural and social scientists cooperating within the Ecohydrology approach could be encouraged in order to promote integrated conceptualization.

Involving the social sciences will also include the understanding of power relations affecting directly or indirectly ecosystem processes that connect to water as well as the more explicit use, access, and control of water at a range of different scales, from state institutions to households or other intermediate water related institutions. Mapping site-specific governance systems, legal systems, and decision-making or policy networks will be a fundamental role of social science in Ecohydrology. Understanding the history of dynamic change in these structures of power relations and environmental governance institutions will also improve our understanding of extant institutions governing water management decisions.

The role of integrating the social sciences will be not only to identify or describe problems in these sets of sub disciplines, but to interpret these problems in terms of their implications for ecosystem management. Therefore, the building of a robust social science component in Ecohydrology aims to create conditions for a meaningful dialogue between natural and social scientists regarding the definition of Ecohydrology problems, hypothesis and potential solutions to freshwater ecosystem management and restoration that include managing social causes of system stressors.

### **1.3 Ecohydrology Reserves in the Arab World**

Within the Arab region there are, no wide divergences of water sources. The available water resources in any of the Arab countries, is restricted as only two types: 1) surface water originated from rainfall on the country boundaries or comes from other county in River the named trans-boundary water. and 2) the underground water, which is derived locally within the country or area borders ( e.g. Socotra island in Yemen) or fossil water which developed in ancient geologic eras (e.g. Aquifer in western Egyptian desert extended also to Libya and Sudan also is a trans-boundary type of water source). Generally some Arab countries as Morocco, Lebanon and parts of Algeria are relatively well watered, but others as: Libya, Egypt and Saudi Arabia are very poorly served. This also holds true for the sub-regions of the Arab world; which located among the hyper arid region of the world. Water withdrawals in a number of Arab countries have already exceeded the actual renewable supplies, while others are at the limit. Moreover, some countries of the Maghreb (e.g. Tunisia) are facing severe regional deficits even if, in total, they are actually in surplus.

### 1.3.1 Water Reserves

#### (a) Precipitation

Annual average precipitation of the region is estimated at 2200 billion cubic meters (bcm) per year, and almost 90% of the countries in the region receive an average annual rainfall of less than 250 mm. A high proportion of all rainfall falls on tracts which cannot be cultivated because of the steepness or roughness of the terrain, and as a consequence the proportion of rainfall, which forms reservoirs of valuable soil moisture, represents only a tiny proportion of the depth of water naturally precipitated. Only about 1.0 to 10.0 % of the total rainfall in the different countries of the region becomes available as soil moisture ends up in tissues of vegetation and crops of economic significance.

#### (b) Ground water

The Arab region has massive groundwater reserves, shallow and deep, renewable and fossil. They became accessible on a large scale several decades ago with the emergence of technologies to detect and extract them. For many years now, groundwater has been a major segment of the region's water budget. Unfortunately, it is too expensive to appraise both the quantity and quality of large-scale aquifers and there are no comprehensive and reliable data on the extent and usability of the region's groundwater (UN 1982, Lloyd, 1990 and Abdel Mageed, 1995) indicated that the region has groundwater aquifers with a potential of 7734 bcm of fossil water at depths ranging from 1000-2000 meters while renewable recharge for the whole region is estimated at 42 cm per annum. Table 1 shows the availability of surface and ground water in Arab countries.

**Table - 1: Surface and groundwater availability; in some of the Arab countries (m<sup>3</sup> per year); "2nd World Water Development Report, World Water Assessment Programme (WWAP), UNESCO, 2006"**

Country	Population (2005)	TARWR /Capita	Surface Water	Ground Water	Overlap (SW-GW)	Total Use
	thousands	m <sup>3</sup> /yr	%	%	%	%
Algeria	32.339	440.0	12.0	92.0	6.0	42.0
Bahrain	739	157.0	3.0	0.0	0.0	258.0
Djibouti	712	420.0	100.0	5.0	5.0	3.0
Egypt	73.390	790.0	1.0	2.0	0.0	118.0
Palestine	1.376	41.0	0.0	82.0	0.0	-
Iraq	25.856	2.920	45.0	2.0	0.0	57.0
Jordan	5.614	160.0	45.0	57.0	25.0	115.0
Kuwait	2.595	8.0	0.0	0.0	0.0	2.227
Lebanon	3.708	1.190	93.0	73.0	57.0	31.0
Libya	5.659	106.0	33.0	83.0	17.0	802.0

<b>Mauritania</b>	<b>2.980</b>	3.830	1.0	3.0	0.0	15.0
<b>Morocco</b>	<b>31.064</b>	930.0	76.0	34.0	10.0	44.0
<b>Oman</b>	<b>2.935</b>	340.0	94.0	97.0	91.0	137.0
<b>Qatar</b>	<b>619</b>	86.0	2.0	94.0	0.0	554.0
<b>Saudi Arabia</b>	<b>24.919</b>	96.0	92.0	92.0	83.0	722.0
<b>Somalia</b>	<b>10.312</b>	1.380	40.0	23.0	21.0	23.0
<b>Sudan</b>	<b>34.333</b>	1.880	43.0	11.0	8.0	58.0
<b>Syria</b>	<b>18.223</b>	1.440	18.0	16.0	8.0	76.0
<b>Tunisia</b>	<b>9.937</b>	460.0	68.0	32.0	9.0	60.0
<b>UAE</b>	<b>3.051</b>	49.0	100.0	80.0	80.0	1.538
<b>Yemen</b>	<b>20.733</b>	198.0	98.0	37.0	34.0	162.0

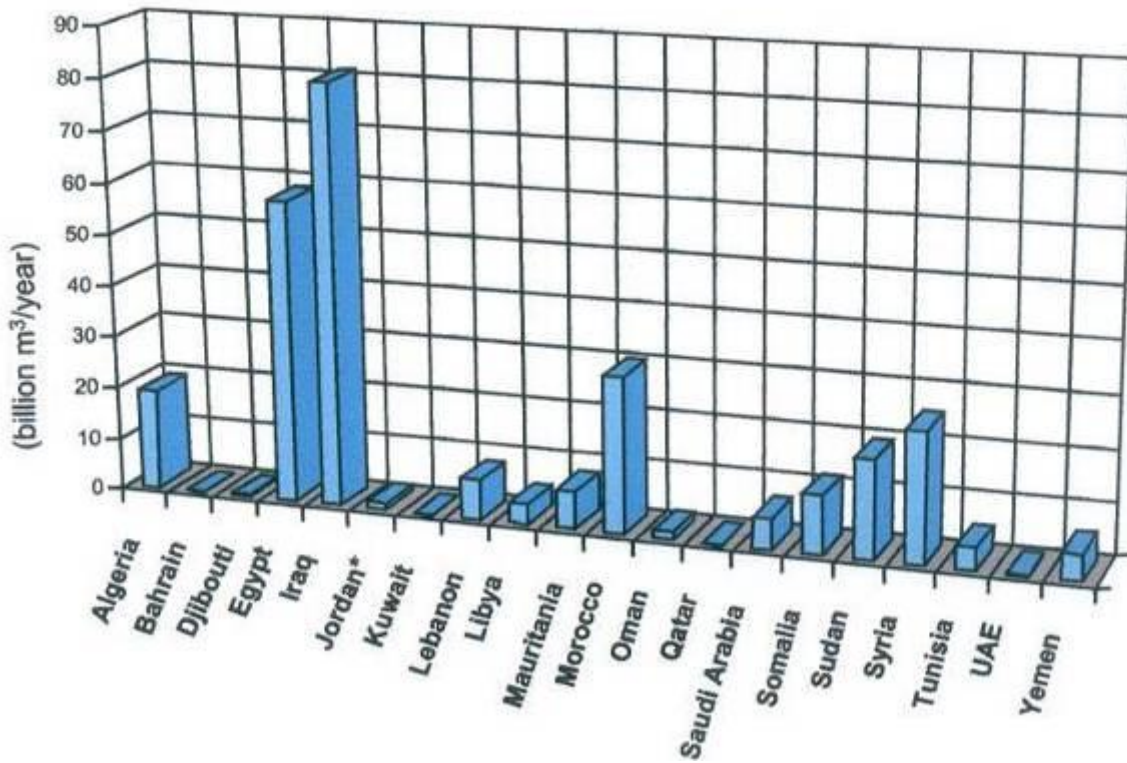


Figure 2: Water resources in Arab countries. (World Bank 1991, 1992, 1992–93 & 2001)

### (c) Water Desalination

Desalination plays an important role in supplementing water supply to countries of the region. The Arab World has the largest users of desalination in the Middle East, and plants with the largest production capacity in the world have been built. Among of the characteristic countries in this field

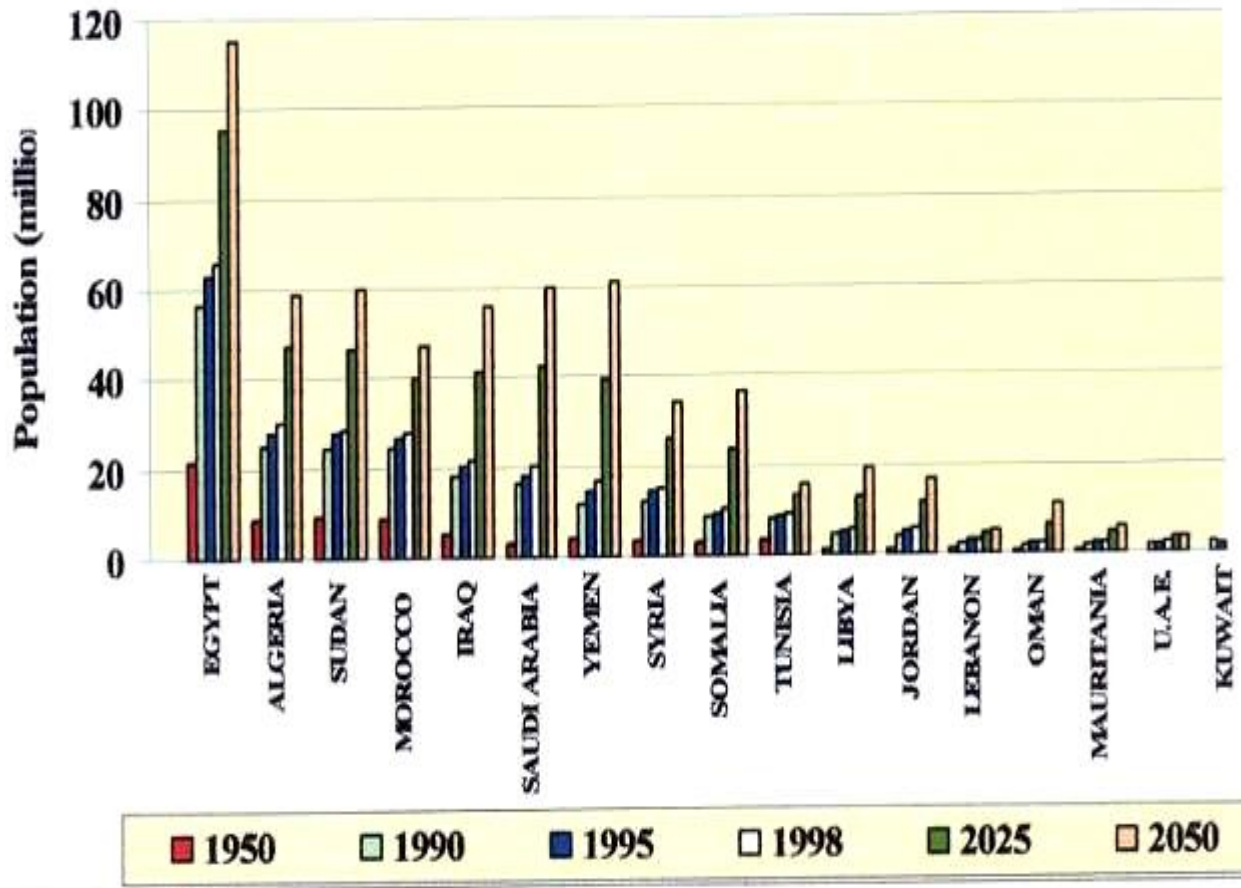
are: Kuwait, Qatar and Saudi Arabia, These countries produce alternative water supply for all domestic water production. In Bahrain and Saudi Arabia desalinated water (40-65%) and groundwater (35-60%) are used for their domestic water supply (FAO Aquastat, 1997).

### **1.3.2 Water Crisis in the Arab World**

With the daily increase in demand for fresh water, the majority of Arab countries suffer from chronic water shortages, reflected in the inadequacy of quantity, the reduction in quality and the shortage in availability. Reports by the United Nations and specialized international bodies and organizations confirm the escalation of the water crisis in the Arab world due to increased demand and limited resources and further aggravated by the continued pollution of rivers, lakes and water channels. This raises serious questions about the future of the water crisis in the Arab world and its political and security implications, as well as the strategic policies and plans put in place by Arab governments to solve the dilemma and the possible scenarios for the development of the crisis in which time plays a crucial role.

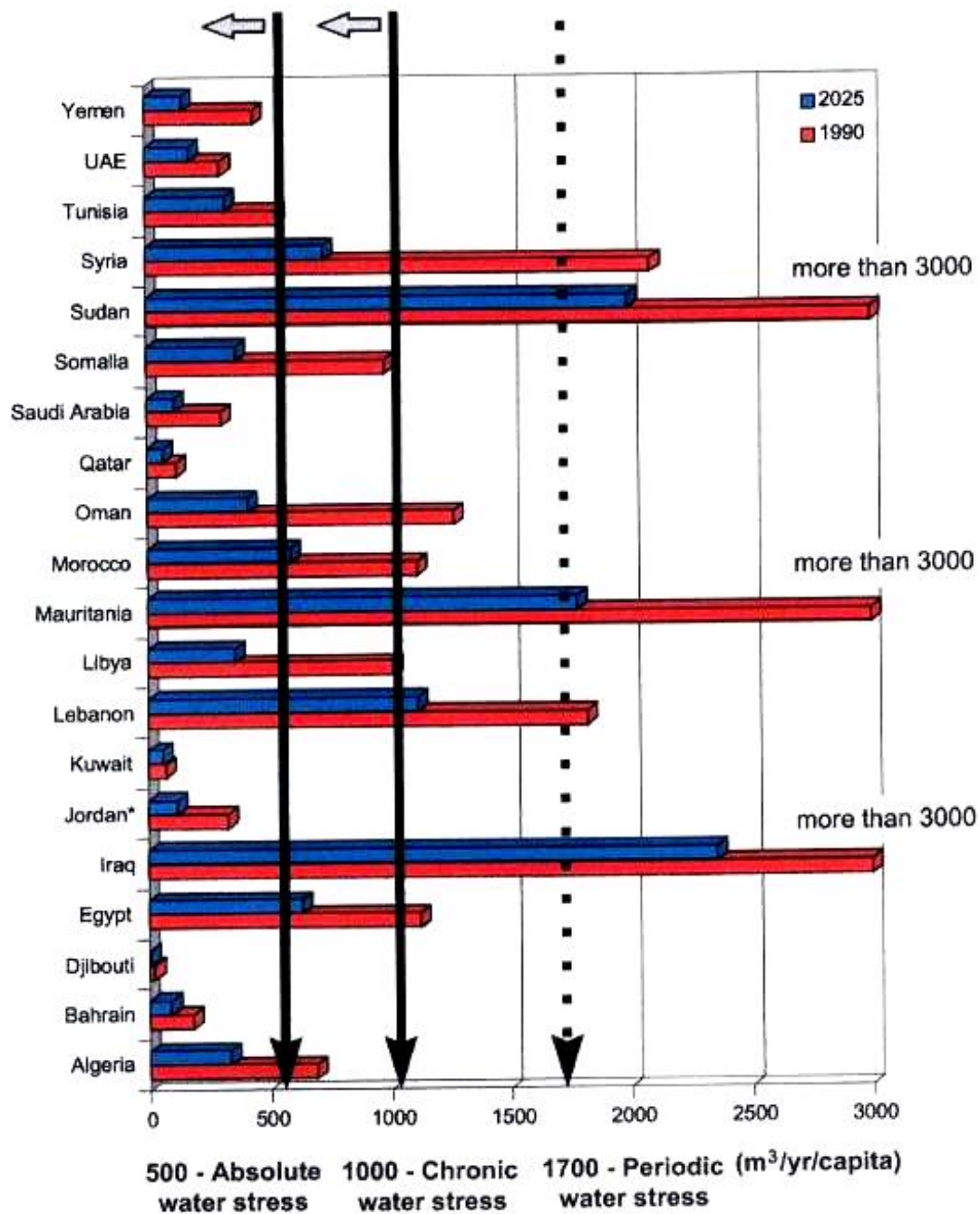
On the global level, only 2.5% of the earth's water is fresh water, two-thirds of which is trapped in frozen ice layers. Therefore, fresh water supplies available to mankind constitute only 0.08% of the earth's total water supplies. On the Arab level, the issue appears even more critical. The World Water Development Report, published by the United Nations in March 2003, indicates that Kuwait, Gaza, United Arab Emirates and Qatar are among those nations with the lowest per capita fresh water supplies. Scientific agencies and international organizations classify some 11 Arab nations among those countries with "scarce water supplies", while the number of Arab countries in this category is expected to rise to 17 countries by the year 2025 (Abu Zeid & Hamdy, 2002).

## POPULATION OF ARAB COUNTRIES



**Figure 3:** Population growth for the Arab Countries (after: CEDARE & Arab Water Council, 2007)

The discussion surrounding the water crisis in the Arab world deserves additional research and attention. The water crisis future scenarios in the Arab world indicate that the region will suffer from a water shortage estimated at 261 billion cubic meters by 2030, with per capita Arab consumption less than 700 cubic meters annually (Fig. 4) sixty percent of Arab water supplies come from external regions, shared with countries with which Arab states are in conflict, and with increased demand due to the growth in the Arab population which is expected to reach 381 million people by 2020,(Fig. 3). Conflicts arising from the division of water resources in the Arab world become a very likely scenario in the future. The solution for the water crisis in the Arab world is possible, according to the United Nations' special envoy for water issues, but "this requires a political will and expenditures ranging between \$50 billion and \$100 billion annually" (Abu Zeid & Hamdy 2002) .



**Figure 4:** Annual renewable fresh water per capita in the Arab countries, 1990 to 2025. (Source: Engelman & LeRoy 1993.)

## **1.4 Characteristics of the Protected Areas and their Environmental Functions**

### **1.4.1 Definition**

Protected areas are recognized by IUCN (1994) as areas: of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means.

Thus protected areas represent special places in the world which are managed for conservation purposes. The current global system comprises some 30,000 sites, covering 13.2 million square kilometers (more than the combined area of China and India). Each of these sites contains a unique combination of biological, ecological and cultural features. Together they play a key role in conserving natural ecosystems and, when managed effectively, contribute substantially to biodiversity conservation. While protected areas in the past have tended to be considered as separate entities, good practice now recommends that they be planned and managed as a system and indeed this is specifically required under Article 8 of the Convention on Biological Diversity (CBD). It should be noted, therefore, that much of the discussion in this publication is as relevant to the level of a protected area system as to individual protected areas.

### **1.4.2 Function of the Protected Areas**

Protected areas are, of course, important because of the critical role they play in biodiversity conservation. This role is recognized by most countries including the 177 Parties to the CBD. As noted, Article 8 obliges Parties to establish a system of protected areas to conserve biodiversity, but also to develop guidelines for the management of such areas and promote appropriate development adjacent to protected areas.

Commitments such as these assist in the conservation of global biodiversity by making clearer the responsibilities of governments for protected area systems “Article 8 of the CBD calls for cooperation among Parties in providing financial support for protected area systems”. Hence there is a global mandate for protected areas and a specific responsibility for ensuring that these areas are properly financed. But new obligations outlined in such global agreements already strain tight protected area budgets. As well as biodiversity conservation, protected areas are important for other significant reasons. They ensure the continued flow of ecosystem services, such as the provision of clean water and the protection of soil resources. They provide significant economic benefits to surrounding communities and contribute to spiritual, mental and physical well being. Protected areas also help fulfill an ethical responsibility to respect nature and provide opportunities to learn about nature and the environment. Each of these values of protected areas is important and should be taken into account in:

- Developing a financial plan, scientific research
- Wilderness protection
- Preservation of species and genetic diversity

- Maintenance of environmental services
- Protection of specific natural and cultural features
- Tourism and recreation
- Education
- Sustainable use of resources from natural ecosystems
- Maintenance of cultural and traditional attributes

### **1.5 Types of Protected Area in the Arab World**

The World Conservation Union (IUCN) defines a Protected Area as: "An area of land and/or sea especially dedicated to the protection of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means". Marine Protected Area (MPA) is defined by IUCN as: "any area of intertidal or sub-tidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features which, has been reserved by law or other effective means to protect part or the entire enclosed environment with all its elements". According to IUCN (1998), protected areas are divided into six types, depending on their objectives:

#### **The six management categories of protected areas are:**

##### **Category I: Nature Reserve**

- (a) An area of land and/or sea possessing some outstanding or representative ecosystems, geological or physiological features and/or species available primarily for research and/or environmental monitoring.
- (b) A wilderness area is a large area of unmodified or slightly modified land and/or sea retaining its natural character and influence without permanent or significant habitation which is protected and managed so as to preserve its natural condition.

##### **Category II: National Park**

A natural area of land and/or sea designated to (a) protect the ecological integrity of one or more ecosystems for present and future generations; (b) exclude exploitation or inimical occupation to the purposes of the area; and (c) provide foundation for spiritual, scientific, educational, recreational, and visitor opportunities all of which must be environmentally and culturally compatible.

##### **Category III: Natural Monument**

An area containing one or more specific natural or natural/cultural feature, which is of outstanding or unique value because of its inherent rarity, representative or aesthetic qualities or cultural significance.

**Category IV:** Habitat/Species Management Area

An area of land and/or sea subject to active intervention for management purposes so as to ensure the maintenance of habitats and/or to meet the requirements of specific species.

**Category V:** Protected Landscape/Seascape

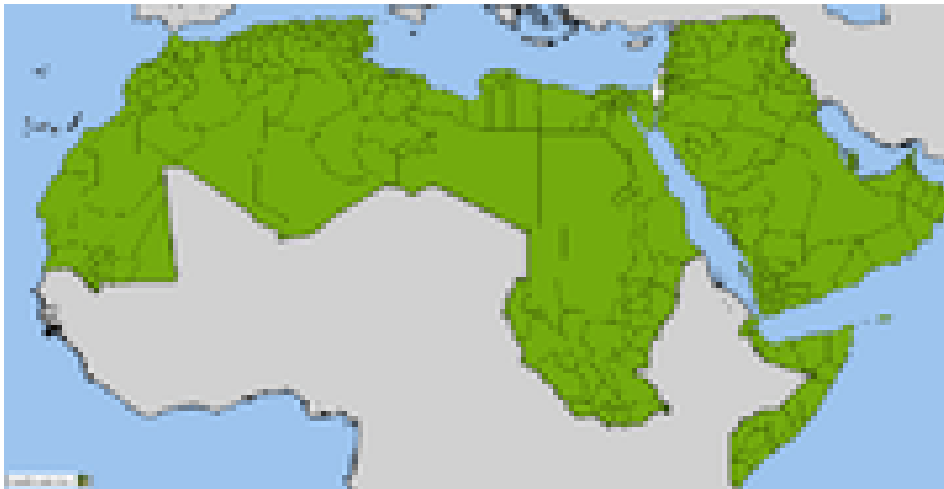
An area with coast and sea, where the interaction of people and nature over time has produced an area with significant aesthetic (ecological and/or cultural value) and often with high biological diversity. Safeguarding the integrity of this traditional interaction is vital to the protection, maintenance and evolution of such an area.

**Category VI:** Managed Resource Protected Area

An area containing predominantly unmodified natural systems managed to ensure long term protection and maintenance of biological diversity while providing at the same time a sustainable flow of natural products and services to meet community needs.

**1.6 Protected Area in the Arab World**

**(Countries are arranged alphabetically)**



## 1.6. Protected Area in the Arab World (Countries are arranged alphabetically)

### 1. Algeria



There are 104 designated protected areas in Algeria. Out of this number, 53 are of national importance, and 61 are internationally important protected areas (Table 2). Among the nationally important protected areas there are 27 established and 26 still recommended or proposed (♣) protected areas (World Database on Protected Areas (WDPA); Feb. 2010- <http://www.wdpa.org/>).

**Table - 2: Protected areas in Algeria**

Site Name	National Designation	Year established	Marine / Terrestrial	Area Size (ha)
1. Adrar ♣	Nature Reserve	-	Terrestrial	-
2. Ahaggar	IUCN-II	1987	Terrestrial	4500000.0
3. Akfadou ♣	Nature Reserve	1996	Terrestrial	2115.0
4. Babor	IUCN-Ia	1931	Terrestrial	3416.0
5. Bechar ♣	Nature Reserve	-	Terrestrial	-
6. Belezma	IUCN-II	1984	Terrestrial	26250.0
7. Beni-Salah	IUCN-Ia	1985	Terrestrial	2000.0
8. Bibas ♣	Hunting Reserve	-	Terrestrial	-
9. Boumerdes ♣	Breeding Station	1985	Both	10000.0
10. Chrea	IUCN-II	1983	Terrestrial	26587.0
11. Djebel Aissa ♣	National Park	-	Terrestrial	3000

<b>Site Name</b>	<b>National Designation</b>	<b>Year established</b>	<b>Marine / Terrestrial</b>	<b>Area Size (ha)</b>
12. Djelfa	IUCN-IV	1983	Terrestrial	32000.0
13. Djurdjura	IUCN-II	1983	Terrestrial	18500.0
14. Edough ♣	National Park	-	Terrestrial	3000.0
15. El Kala	IUCN-V	1983	Both	80000.0
16. El Kala ♣	Marine Park	-	Marine	-
17. Gouraya	IUCN-II	1983	Both	3200.0
18. Iles Agueli ♣	National Park	-	Terrestrial	-
19. Iles Habibas	Marine Nature Reserve	2003	Both	2740.0
20. Jijel	Marine Park	-	Marine	600.0
21. La Salamandre ♣	National Park	-	Terrestrial	-
22. Lac Tonga	Other Area	1983	Terrestrial	2392.0
23. Laghouat ♣	Nature Reserve	-	Terrestrial	-
24. Macta	IUCN-Ia	1977	Terrestrial	19750.0
25. Mascara	IUCN-IV	1985	Both	6000.0
26. Mergueb	IUCN-Ia	-	Terrestrial	12500.0
27. Mostaganem	Other Area	1985	Terrestrial	-
28. Moulay Ismail	Other Area	-	Terrestrial	1000.0
29. Naama ♣	National Park	-	Terrestrial	-
30. Ouarsenis	IUCN-II	1924	Terrestrial	1030.0

<b>Site Name</b>	<b>National Designation</b>	<b>Year established</b>	<b>Marine / Terrestrial</b>	<b>Area Size (ha)</b>
31. Oued Namous ♣	Nature Reserve	-	Terrestrial	-
32. Peninsula de Collo ♣	Other Area	-	Both	-
33. <u>Reghaia</u>	Breeding Station	1983	Both	130.0
34. Saharan Atlas ♣	National Park	1984	Terrestrial	4000.0
35. Sebket of Touggourt ♣	Nature Reserve	-	Terrestrial	-
36. Senalba ♣	National Park	-	Terrestrial	-
37. Seraidi P	Regional Park	1928	Terrestrial	3000.0
38. Setif	Other Area	1985	Terrestrial	
39. Sidi Bel-Abbes ♣	National Park	-	Terrestrial	-
40. Taghit ♣	Nature Reserve	-	Terrestrial	-
41. Tamanrasset ♣	National Park	-	Terrestrial	-
42. Tassili N'Ajjer	IUCN-II	1986	Terrestrial	7200000.0
43. Taza	IUCN-II	1983	Both	3200.0
44. Tenes ♣	Marine Park	1984	Marine	-
45. Theniet el Had	IUCN-II	1983	Terrestrial	3426.0
46. Tigzirt ♣	National Park	-	Terrestrial	-
47. Tindouf ♣	Nature Reserve	-	Terrestrial	10000.0
48. Tipasa-Chenoua Terrestrial and Marine ♣	Park	-	Both	5000.0

<b>Site Name</b>	<b>National Designation</b>	<b>Year established</b>	<b>Marine / Terrestrial</b>	<b>Area Size (ha)</b>
49. Tipaza Chenoua ♣	National Park	-	Terrestrial	5000.0
50. <u>Tlemcen</u>	National park	1993	Terrestrial	8225.0
51. Tlemcen	Breeding Station	1985	Terrestrial	10000.0
52. Tlemcen	IUCN-IV	1983	Terrestrial	10000.0
53. Zana ♣	Nature Reserve	-	Terrestrial	1000.0
54. Aulnaie de Aïn Khia	Wetlands of International Importance (Ramsar)	2003	Terrestrial	180.0
55. Banc des Kabyles (Jijel)	Barcelona Convention	-	Terrestrial	600.0
56. Chott Aïn El Beïda	Wetlands of International Importance (Ramsar)	2004	Terrestrial	6853.0
57. Chott de Zehrez Chergui	Wetlands of International Importance (Ramsar)	2003	Terrestrial	50985.0
58. Chott de Zehrez Gharbi	Wetlands of International Importance (Ramsar)	2003	Terrestrial	52200.0
59. Chott Ech Chergui	Wetlands of International Importance (Ramsar)	2001	Terrestrial	855500.0
60. Chott El Beïdha-Hammam Essoukhna	Wetlands of International Importance (Ramsar)	2004	Terrestrial	12223.0
61. Chott El Hodna	Wetlands of International Importance (Ramsar)	2001	Terrestrial	362000.0
62. Chott Melghir	Wetlands of International Importance (Ramsar)	2003	Terrestrial	551500.0
63. Chott Merrouane et Oued Khrouf	Wetlands of International Importance (Ramsar)	2001	Terrestrial	337700.0
64. Chott Oum El Raneb	Wetlands of International Importance (Ramsar)	2004	Terrestrial	7155.0
65. Chott Sidi Slimane	Wetlands of International Importance (Ramsar)	2004	Terrestrial	616.0

<b>Site Name</b>	<b>National Designation</b>	<b>Year established</b>	<b>Marine / Terrestrial</b>	<b>Area Size (ha)</b>
<b>66.</b> Chott Tinsilt	Wetlands of International Importance (Ramsar)	2004	Terrestrial	2154.0
<b>67.</b> Chrea	UNESCO-MAB Biosphere Reserve	2002	Terrestrial	36985.0
<b>68.</b> Complexe de zones humides de la plaine de Guerbes-Sanhadja	Wetlands of International Importance (Ramsar)	2003	Marine	42100.0
<b>69.</b> Dayet El Ferd	Wetlands of International Importance (Ramsar)	2004	Terrestrial	3323.0
<b>70.</b> <u>Djurdjura</u>	UNESCO-MAB Biosphere Reserve	1997	Terrestrial	35660.0
<b>71.</b> El Kala	UNESCO-MAB Biosphere Reserve	1990	Both	76438.0
<b>72.</b> Garaet Annk Djemel et El Merhsel	Wetlands of International Importance (Ramsar)	2004	Terrestrial	18140.0
<b>73.</b> Garaet El Taref	Wetlands of International Importance (Ramsar)	2004	Terrestrial	33460.0
<b>74.</b> Garaet Guellif	Wetlands of International Importance (Ramsar)	2004	Terrestrial	2400.0
<b>75.</b> Gouraya	UNESCO-MAB Biosphere Reserve	2004	Terrestrial	2080.0
<b>76.</b> Grotte karstique de Ghar Boumâaza	Wetlands of International Importance (Ramsar)	2003	Terrestrial	20000.0
<b>77.</b> Gueltates Afilal	Wetlands of International Importance (Ramsar)	2003	Terrestrial	20900.0
<b>78.</b> Habibas Islands	Barcelona Convention	2005	Marine	2740.0
<b>79.</b> La Réserve Naturelle du Lac des Oiseaux	Wetlands of International Importance (Ramsar)	1999	Terrestrial	120.0
<b>80.</b> La Vallée d'Iherir	Wetlands of International Importance (Ramsar)	2001	Terrestrial	6500.0
<b>81.</b> Lac de Fetzara	Wetlands of International Importance (Ramsar)	2003	Terrestrial	20680.0

<b>Site Name</b>	<b>National Designation</b>	<b>Year established</b>	<b>Marine / Terrestrial</b>	<b>Area Size (ha)</b>
<b>82.</b> Lac de Télamine	Wetlands of International Importance (Ramsar)	2004	Terrestrial	2399.0
<b>83.</b> Lac Oubeira	Wetlands of International Importance (Ramsar)	1983	Both	3160.0
<b>84.</b> Le Cirque de Aïn Ouarka	Wetlands of International Importance (Ramsar)	2003	Terrestrial	2350.0
<b>85.</b> Les Gueltates d'Issakarassene	Wetlands of International Importance (Ramsar)	2001	Terrestrial	35100.0
<b>86.</b> Les Salines d'Arzew	Wetlands of International Importance (Ramsar)	2004	Both	5778.0
<b>87.</b> Marais de la Macta	Wetlands of International Importance (Ramsar)	2001	Marine	44500.0
<b>88.</b> Marais de la Mekhada	Wetlands of International Importance (Ramsar)	2003	Marine	8900.0
<b>89.</b> Oasis de Moghrar et de Tiout	Wetlands of International Importance (Ramsar)	2003	Terrestrial	195500.0
<b>90.</b> Oasis de Ouled Saïd	Wetlands of International Importance (Ramsar)	2001	Terrestrial	25400.0
<b>91.</b> Oasis de Tamantit et Sid Ahmed Timmi	Wetlands of International Importance (Ramsar)	2001	Terrestrial	95700.0
<b>92.</b> Oglat Ed Daïra	Wetlands of International Importance (Ramsar)	2004	Terrestrial	23430.0
<b>93.</b> Réserve Intégrale du Lac El Mellah	Wetlands of International Importance (Ramsar)	2004	Both	2257.0
<b>94.</b> Réserve Intégrale du Lac Tonga	Wetlands of International Importance (Ramsar)	1983	Both	2200.0
<b>95.</b> Réserve Naturelle du Lac de Béni-Bélaïd	Wetlands of International Importance (Ramsar)	2003	Marine	600.0
<b>96.</b> Réserve Naturelle du Lac de Réghaïa	Wetlands of International Importance (Ramsar)	2003	Marine	842.0

Site Name	National Designation	Year established	Marine / Terrestrial	Area Size (ha)
97. Sebkha d'Oran	Wetlands of International Importance (Ramsar)	2001	Marine	56870.0
98. Sebkhet Bazer	Wetlands of International Importance (Ramsar)	2004	Terrestrial	4379.0
99. Sebkhet El Hamiet	Wetlands of International Importance (Ramsar)	2004	Terrestrial	2509.0
100. Sebkhet El Melah	Wetlands of International Importance (Ramsar)	2004	Terrestrial	18947.0
101. Tassili n'Ajjer	World Heritage Convention	1982	Terrestrial	8000000.0
102. Tassili N'Ajjer	UNESCO-MAB Biosphere Reserve	1986	Terrestrial	7200000.0
103. Taza	UNESCO-MAB Biosphere Reserve	2004	Terrestrial	3573.0
104. Tourbière du Lac Noir	Wetlands of International Importance (Ramsar)	2003	Terrestrial	5.0

## 2. Bahrain



There are 6 designated protected areas in Bahrain. Out of this number, 4 are of national importance, and two are internationally important (Table 3). All were established protected areas (World Database on Protected Areas (WDPA); Feb. 2010- <http://www.wdpa.org/>).

**Table - 3: Protected areas in Bahrain**

Site Name	National Designation	Year established	Marine/ Terrestrial	Area Size (ha)
1. Al-Areen Wildlife Park and Reserve	IUCN-IV	1979	Terrestrial	800.0
2. Arad Bay	IUCN-II	2003	Terrestrial	500.0

Site Name	National Designation	Year established	Marine/ Terrestrial	Area Size (ha)
3.Hawar Islands	Wetlands of International Importance (Ramsar)	1997	Marine	5200.0
4.Ras Sand Mangrove	IUCN- Ia	1986	Both	50.0
5.Hawar Islands	IUCN-II	2003	Both	5150.0
6.Tubli Bay	Wetlands of International Importance (Ramsar)	1997	Marine	1610.0

### 3. Djibouti



There are 4 designated protected areas in Djibouti. Out of this number, 3 are of national importance, and one is internationally important (Table 4). One protected areas is recommended or proposed (♣), the rest were designated protected areas (World Database on Protected Areas (WDPA); Feb. 2010- <http://www.wdpa.org/>).

**Table - 4 : Protected areas in Djibouti**

Site Name	National Designation	Year established	Marine/ Terrestrial	Area Size (ha)
1. Maskali Sud	IUCN- Ia	1980	Marine	300.0
2. Musha	IUCN-VI	1972	Marine	1000.0
3. Unnamed Reserve ♣	Ornithological Reserve	-	Terrestrial	76.41
4. Haramous-Loyada	Wetlands of International Importance (Ramsar)	2002	Marine	3000.0

## 4. Egypt



Based on the Egyptian Environmental Affairs Agency (EEAA) awareness file distributed 2010, the number of the established protected areas to this date are 27 comprises 15% of the Egyptian area. EEAA planned to add more protected areas (14 sites are recommend ♣ to be declared as protected areas; Table 5), to increase the percentage to 20% of Egyptian area to 2017. EEAA awareness file, present Siwa as one protected area however, the World Database on Protected Areas (WDPA) present it as three separate protected areas (Siwa East, Siwa West and Siwa Middle; Table 5). Similar uncertain data were observed in case of Elba and El Omayed protected areas where each was classified under one type of protected areas in the EEAA awareness file and both were classified under two types of protected areas in the WDPA. For example: El Omayed protected area was classified under IUCN-IV and established 1986 in addition to, UNESCO-MAB Biosphere Reserve type and established in 1981 as shown in Table (5) ; this topic still needs clarification and data revising between these two organizations (EEAA and WDPA).

Table (5), outlined 32 established protected areas (as mentioned in the WDPA World Database on Protected Areas-WDPA; Feb. 2010- <http://www.wdpa.org/>). Out of this number 27 are of national importance, and five are internationally important protected areas.

**Table - 5: Protected areas in Egypt**

Site Name	National Designation	Year established	Marine/ Terrestrial	Area Size (ha)
1. Abu Gallum	IUCN-VI	1992	Both	41880.13
2. Ashtum El Gamel	IUCN-VI	1998	Both	17116.00
3. El Dababia	Natural Monument	2007	Terrestrial	100000.0
4. El Ahrash (El-Ahrash)	IUCN-V	1996	Terrestrial	338.00

<b>Site Name</b>	<b>National Designation</b>	<b>Year established</b>	<b>Marine/ Terrestrial</b>	<b>Area Size (ha)</b>
5. El Bourollus	IUCN-VI	1998	Both	91083
6. El Omayed	IUCN-IV	1986	Both	6901.0
7. Elba	IUCN-II	1986	Both	3035067.00
8. Hasana Dome	Natural Monument	1989	Terrestrial	100.00
9. Nabq	IUCN-VI	1992	Both	50077
10. River Nile islands	IUCN-V	1998	Terrestrial	669000.0
11. Petrified Forest	IUCN-V	1989	Terrestrial	604.0
12. Qarun	IUCN-VI	1989	Terrestrial	134027.0
13. Ras Mohammed	IUCN-II	1983	Both	78844.0
14. Salouga and Ghazal	IUCN-V	1986	Terrestrial	40.60
15. Siwa East	IUCN-VI	2002	Terrestrial	594789.0
16. Siwa Middle	Natural Monument	2002	Terrestrial	9893.0
17. Siwa West	IUCN-VI	2002	Terrestrial	164111.0
18. St Catherine	IUCN-VI	1988	Terrestrial	471257.0
19. Taba	IUCN-V	1998	Both	269822.0
20. Wadi Al Alaqi	IUCN-VI	1996	Terrestrial	2262929.0
21. Wadi Degla	IUCN-V	1999	Terrestrial	5771.0
22. Wadi El Assuti	Habitat/Species Management Area	1989	Terrestrial	3530.0.
23. Wadi El Gemal -	National Park	2003	Both	679000.0

Site Name	National Designation	Year established	Marine/ Terrestrial	Area Size (ha)
Hamata				
24. Wadi el Rayan	IUCN-VI	1989	Terrestrial	351268.0
25. Wadi Sannur Cave	IUCN-V	1992	Terrestrial	1256.0
26. White Desert	Natural Monument	2002	Terrestrial	31260.7.0
27. Zaranik	IUCN-IV	1996	Both	25000.0
28. Lake Burullus	Wetlands of International Importance (Ramsar)	1988	Both	46200.0
29. Lake Bardawil	Wetlands of International Importance (Ramsar)	1988	Marine	59500.0
30. El Omayed	UNESCO-MAB Biosphere Reserve	1981	Terrestrial	75800.0
31. Wadi Al-Hitan (Whale Valley)	World Heritage Convention	2005	Terrestrial	25900.0
32. Wadi Allaqi	UNESCO-MAB Biosphere Reserve	1993	Terrestrial	2380000.0
33. El Salum ♣	Wetlands	-	Both	145000.0
34. El Qatara Depression ♣	Wetlands	-	Terrestrial	2290000.0
35. Um El Dabadiab ♣	Nature Reserve	-	Terrestrial	230000.0
36. Korkor and Dongol Oases ♣	Nature Reserve	-	Terrestrial	430000.0
37. Ras El Hekma ♣	Nature Reserve	-	Both	15000.0
38. El Shwela ♣	Nature Reserve	-	Terrestrial	22500.0
39. El Kasr ♣	Heritage Site	-	Terrestrial	370000.0

Site Name	National Designation	Year established	Marine/ Terrestrial	Area Size (ha)
40. Gabal El Shaieb ♣	Nature Reserve	-	Terrestrial	430000.0
41. Wadi Qena ♣	Nature Reserve	-	Terrestrial	590000.0
42. Galala El Qblia ♣	Nature Reserve	-	terrestrial	430000.0
43. Ras Shokier Salt Marsh ♣	Wetland	-	Terrestrial	7500.0
44. El Qusaima ♣	Nature Reserve	-	Terrestrial	40000.0
45. El Maghara ♣	Natural Monument	-	Terrestrial	90000.0
46. Wadi Gerafi ♣	Nature Reserve	-	Terrestrial	110000.0

## 5. Iraq



Iraq has no protected areas legislation; some conservation areas have been recommended, but all are wetland areas in the Tigris/Euphrates marshes; with none of the mountains being selected (Davis, *et al.* 1994). There are 13 designated protected areas in Iraq. Out of this number, 12 are of national importance, and one is internationally important protected areas (Table 6). 6 out of the 13 recorded protected areas are recommended or proposed (♣) while 7 were established protected areas (World Database on Protected Areas -WDPA; Feb. 2010- <http://www.wdpa.org/>).

**Table - 6: Protected areas in Iraq**

Site Name	National Designation	Year established	Marine / Terrestrial	Area Size (ha)
1. Dar Bandar Bazyan	IUCN-IV	1980	Terrestrial	75.0

2. Days al Ta'min	IUCN-IV	1980	Terrestrial	80.0
3. Hajran/Arbil	IUCN-IV	1980	Terrestrial	90.0
4. Habbaniya lake ♣	Protected Area	-	Terrestrial	-
5. Hor al Hammar marshes ♣	Protected Area	-	Terrestrial	270000.0
6. Hor Suweicha wetland ♣	Protected Area	-	Terrestrial	30000.0
7. Nasiriya marshes ♣	Protected Area	-	Terrestrial	-
8. Sab al- Nisan	IUCN-IV	1978	Terrestrial	21.0
9. Sanjar/Ninwa	IUCN-IV	1981	Terrestrial	90.0
10. Shatra marshes ♣	Protected Area	-	Terrestrial	-
11. Wadi Tharthar lake and marshes ♣	Protected Area	-	Terrestrial	320000.0
12. Zawayta/Dahuk	IUCN-IV	1980	Terrestrial	110.0
13. Hawizeh Marsh (Haur Al-Hawizeh)	Wetlands of International Importance (Ramsar)	2008	Terrestrial	137700.0

## 6. Jordan



There are 24 designated protected areas in Jordan. Out of this number, 22 are of national importance, and two are internationally important protected areas (Table7). 9 out of the 24 recorded protected areas are recommended or proposed (♣) while 15 were established protected areas (World Database on Protected Areas -WDPA; Feb. 2010- <http://www.wdpa.org/>).

**Table - 7: Protected areas in Jordan**

Site Name	National Designation	Year established	Marine / Terrestrial	Area Size (ha)
1. Abu Rukbah ♣	Wildlife Reserve	-	Terrestrial	41000.0
2. Ajloun	IUCN-IV	1988	Terrestrial	1200.0
3. Aqaba	IUCN-IV	1997	Both	4000.0
4. Azraq Desert	IUCN-IV	1987	Terrestrial	30000.0
5. Azraq Wetland	IUCN-IV	1987	Terrestrial	30000.0
6. Bayir ♣	Wildlife Reserve	-	Terrestrial	44000.0
7. Burqu	IUCN-V	1993	Terrestrial	95000.0
8. Dana	IUCN-IV	1989	Terrestrial	31000.0
9. Dibeen ♣	National Park	1998	Terrestrial	8000.0
10. Ghor Fifa ♣	Wildlife Reserve	-	Terrestrial	-
11. Jabal Masadi ♣	Wildlife Reserve	-	Terrestrial	-
12. Jarba ♣	Wildlife Reserve	-	Terrestrial	-
13. Jordan River	Wildlife Reserve	1998	Terrestrial	500.0
14. Mujib	IUCN-IV	1985	Terrestrial	20500.0
15. Petra	IUCN-V	1968	Terrestrial	12200.0
16. Qatar ♣	Wildlife Reserve	1989	Terrestrial	5000.0
17. Rajil ♣	Wildlife Reserve	-	Terrestrial	68000.0
18. Shaumari	IUCN-IV	1975	Terrestrial	2200.0

19. Wadi Mujib	Wildlife Reserve	1987	Terrestrial	21200.0
20. Wadi Rum	IUCN-V	1965	Terrestrial	720000.0
21. Yarmouk River ♣	Wildlife Reserve	1998	Terrestrial	500.0
22. Zai	IUCN-V	-	Terrestrial	-
23. Azraq Oasis	Wetlands of International Importance (Ramsar)	1977	Terrestrial	1200.0
24. Dana	UNESCO-MAB Biosphere Reserve	1998	Terrestrial	30800.0

## 7. Juzur al-Qumur



Juzur al-Qumur comprised of three main islands in addition to group of smaller ones. All these islands are volcanic. Now there is no protected areas were declared in this country, however, the government planned to declare *Mohely* as marine protected area in *Tumasho* Island; other in *Kumoro* Island and *Karathara* volcano in the same island. The fourth is a protected area for a Marine Turtle.

## 8. Kuwait



There are 19 designated protected areas in Kuwait. All these protected areas are of national importance (Table 8). 12 out of the 19 recorded protected areas are recommended or proposed (♣) while 7 were established protected areas (World Database on Protected Areas -WDPA; Feb. 2010-<http://www.wdpa.org/>).

**Table - 8: Protected areas in Kuwait**

Site Name	National Designation	Year established	Marine / Terrestrial	Area Size (ha)
1. Al-Batin desert ♣	Park	-	Terrestrial	-
2. Al-Khiran desert ♣	Park	-	Both	-
3. Dawhat Al Zorq ♣	Nature Reserve	-	Terrestrial	-
4. Doha	Protected Area	1990	Both	450.0
5. Failaka island	Nature Reserve	1990	Both	800.0
6. Getty reef ♣	Nature Reserve	-	Both	-
7. Indries Rock ♣	Nature Reserve	-	Terrestrial	-
8. Jahra pool	IUCN-IV	1990	Terrestrial	250.0
9. Jal Az-Zor	National Park	1990	Both	25000.0
10. Khawr Mufattah	Protected Area	1990	Both	-
11. Kubbar (Jazirat Kubbar) ♣	Protected Area	-	Both	600.0
12. Naval Base reef ♣	Nature Reserve	-	Both	-
13. Oit'at Mudayrah ♣	Nature Reserve	-	Terrestrial	-
14. Oit'at Urgfijan ♣	Nature Reserve	-	Terrestrial	-
15. Qaru ♣	Marine Park	-	Marine	-
16. Sulaybia Experimental Station SR	Scientific Reserve	1979	Both	2000.0
17. Umm Al-Aish Rock ♣	Nature Reserve	-	Terrestrial	-

18. Umm al-Maradim	Marine Park	1977	Marine	-
19. Um-Niqqa desert P ♣	Nature Reserve	-	Both	-

## 9. Lebanon



There are 20 designated protected areas in Lebanon. Among of this number; 15 are nationally and five are internationally designated protected areas (Table 9). 8 out of the 20 are recommended or proposed (♣) while 16 were established protected areas (World Database on Protected Areas (WDPA; Feb. 2010- <http://www.wdpa.org/>). Davis, *et al.* (1994), mentioned that the *Cedrus* forest reserves in Lebanon receives no conservation measures to protect the remaining trees and the other habitats deemed worthy of conservation.

**Table - 9: Protected areas in Lebanon**

Site Name	National Designation	Year established	Marine/ Terrestrial	Area Size (ha)
1. Ain Zhalta ♣	Forest Reserve	-	Terrestrial	-
2. Ammiq Swamps	National Park	1999	Terrestrial	1500.0
3. Arz Bcharreh	Protection/Protected Zone	1043	Terrestrial	-
4. Arz Tannourine ♣	Forest Reserve	-	Terrestrial	-
5. Barouk ♣	Forest Reserve	-	Terrestrial	-
6. Barouk Cedar Forest ♣	National Park	-	Terrestrial	30000.0
7. Bentaël	Private Protected Area	1987	Terrestrial	200.0
8. Bentaël Nal Pationark ♣	Bird Reserve	-	Terrestrial	810.0
9. Foret des Cedres de Dieu	Forest Reserve	1880	Terrestrial	646.0

10. Horsh Ehdén	Reserve	1992	Terrestrial	-
11. Jabal el Qaraqif ♣	Forest Reserve	-	Terrestrial	-
12. Khallet Khazen Farm and Natural Reserve ♣	Private Protected Area	-	Terrestrial	202.0
13. Mashgara (Machgharah)	IUCN-II	1988	Terrestrial	3500.0
14. Palm Island	Nature Reserve	1992	Both	500.0
15. Qaraoun Lake ♣	National Park	-	Terrestrial	-
16. Ammiq Wetland	Wetlands of International Importance (Ramsar)	1999	Terrestrial	280.0
17. Deir el Nouriyeh cliffs of Ras Chekaa	Wetlands of International Importance (Ramsar)	1999	Marine	-
18. Palm Islands Nature Reserve	Wetlands of International Importance (Ramsar)	2001	Marine	415.0
19. Shouf	Wetlands of International Importance (Ramsar)	2005	Terrestrial	52260.0
20. Tyre Beach	Wetlands of International Importance (Ramsar)	1999	Marine	380.0

## 10. Libya



Table (10) outlined 26 designated protected areas in Libya. Out of this number, 24 are of national and two are internationally (Ain Elshakika and Ain Elzarga) important protected areas. 16 out of the 26 are recommended or proposed (♣) while 10 were established protected areas (World Database on Protected Areas -WDPA; Feb. 2010- <http://www.wdpa.org/>).

**Table - 10: Protected areas in Libya**

Site Name	National Designation	Year established	Marine / Terrestrial	Area Size (ha)
1. Ain Zayanah ♣	Protected Area	-	Terrestrial	50.0
2. Ajdabiya Marsh ♣	Protected Area	-	Terrestrial	70000.0
3. Al Jaghbub Oasis ♣	Protected Area	-	Terrestrial	-
4. Benghazi ♣	Nature Reserve	-	Both	50.0
5. Bier Ayyad	IUCN- IV	1976	Terrestrial	2000.0
6. El Kauf	National Park	1987	Both	32000.0
7. Garabulli	Protected Area	1982	Both	15000.0
8. Giarabub ♣	Protected Area	-	Terrestrial	-
9. Jalo ♣	Protected Area	-	Terrestrial	
10. Karabolli	National Park	1992	Both	15000.0
11. Kouf	National Park	1979	Both	35000.0
12. Kufrah Oasis ♣	Protected Area	-	Terrestrial	-
13. Naggaza ♣	National Park	-	Terrestrial	-
14. Nefhusa	IUCN-IV	1978	Terrestrial	20000.0
15. Oasis of Ghat ♣	Protected Area	-	Terrestrial	-
16. Ouau en Namu lakes ♣	Protected Area	-	Terrestrial	30.0
17. Qaminis and Tukrah salines ♣	Protected Area	-	Terrestrial	-

18. Rajma ♣	National Park	-	Terrestrial	-
19. Sebkha el Sahel ♣	Protected Area	-	Terrestrial	-
20. Serir ♣	Protected Area	-	Terrestrial	-
21. Taizerbo ♣	Protected Area	-	Terrestrial	30
22. Tripoli	Nature Reserve	1978	Terrestrial	870.0
23. Wadi Kham ♣	Protected Area	-	Terrestrial	-
24. Zellaf	IUCN- IV	1978	Terrestrial	100000.0
25. Ain Elshakika	Wetlands of International Importance (Ramsar)	2000	Both	33.0
26. Ain Elzarga	Wetlands of International Importance (Ramsar)	2000	Both	50.0

## 11. Mauritania



Table (11) listed seven protected areas out of them 2 (Banc d'Arguin & Diawling) of national and five are of international importance established protected areas (World Database on Protected Areas-WDPA; Feb. 2010- <http://www.wdpa.org/>).

**Table - 11: Protected areas in Mauritania**

Site Name	National Designation	Year established	Marine/ Terrestrial	Area Size (ha)
1. Banc d'Arguin National Park	World Heritage Convention	1989	Both	1200000.0
2. Chat Tboul	Wetlands of International Importance (Ramsar)	2000	Marine	15500.0
3. Delta du Fleuve Sénégal	UNESCO-MAB Biosphere Reserve	2005	Terrestrial	-

(Mauritania)				
4. Parc National du Banc d'Arguin	Wetlands of International Importance (Ramsar)	1982	Both	117300.0
5. Parc National du Diawling	Wetlands of International Importance (Ramsar)	1994	Both	15600.
6. Banc d'Arguin	IUCN-II	1978	Both	1207500
7. Diawling	IUCN-II	1990	Both	13000

## 12. Morocco



To 1994 as mentioned by Davis, *et al.* (1994), 12.5% of the High Atlas was protected or in the process of being protected within nature reserves or national parks. In addition, all forested areas are legally protected. Recently, the data recorded in the World Database on Protected Areas (WDPA; Feb. 2010- <http://www.wdpa.org/>); as shown in table (12), 80 protected areas are listed, out of them 53 national and 27 are internationally important designated protected areas. 20 of them are recommended or proposed (♣) and 60 were established protected areas.

**Table - 12: Protected areas in Morocco**

Site Name	National Designation	Year established	Marine / Terrestrial	Area Size (ha)
1. Affenourir	IUCN-IV	1943	Terrestrial	280.0
2. Aguelmam Tifounassine ♣	Nature Reserve	-	Terrestrial	25.0
3. Aguelman Azigza ♣	National Park	-	Terrestrial	60.0
4. Aguelman Sidi Ali ♣	Hunting Reserve	-	Terrestrial	250.0

5. Al Hoceima	National Park	2004	Both	43382.3
6. Bokkoyas	Biological Reserve	1986	Both	43000.0
7. Bokkoyas	Marine Reserve	1986	Marine	-
8. Bou Tferda ♣	National Park	-	Terrestrial	2000.0
9. Bouarfa	Permanent Hunting Reserve	1967	Terrestrial	220000.0
10. Dayet Aaoua	Hunting Reserve	-	Terrestrial	30.0
11. Dayet Afougha	Hunting Reserve	-	Terrestrial	24.0
12. Dayet Agoulman	Hunting Reserve	-	Terrestrial	141.0
13. Dayet el Hachlef	Hunting Reserve	-	Terrestrial	202.0
14. Dayet Ifrah	Hunting Reserve	-	Terrestrial	191.0
15. El Holba ♣	Nature Reserve	-	Terrestrial	-
16. El Merja (Sidi Moussa region) ♣	Nature Reserve	-	Terrestrial	-
17. Ifrane	IUCN-V	-	Terrestrial	54000.0
18. Ifrane ♣	Natural Park	-	Terrestrial	54000
19. Ile de Skhirate	IUCN-IV	1962	Both	3.0
20. Ile d'Essaouira (Ile de Mogador)	Reserve	1978	Both	10.0
21. Iriki	IUCN-IV	1967	Terrestrial	10000.0
22. Iriki ♣	National Park	-	Terrestrial	-
23. Iriqui	National Park	1994	Terrestrial	123000.0

24. Khnifiss/Puerto Cansado	IUCN-Ia	1962	Both	6500.0
25. Lac Iseli	Nature Reserve	-	Terrestrial	221.0
26. Lac Tislit ♣	Nature Reserve	-	Terrestrial	83.0
27. Merja Daoura (Merja Sidi Mohammed Ben Mansour) NR ♣	Nature Reserve	-	Terrestrial	8000.0
28. Merja Douyet Royal HR	Private Reserve	-	Terrestrial	85.0
29. Merja Zerga	IUCN-Ia	1987	Both	7000.0
30. Mouley Bousalham	Hunting Reserve	1987	Terrestrial	7000.0
31. Nador ♣	Nature Reserve	-	Both	10000.0
32. Oualidia et Sidi Moussa ♣	Reserve	-	Both	-
33. Oualidia lagoon	Hunting Reserve	-	Both	-
34. Oued Chebeika ♣	Nature Reserve		-	Both
35. Oued Loukkos ♣	Nature Reserve	-	Terrestrial	-
36. Oued Massa	IUCN-Ib	-	Terrestrial	460.0
37. Parc de Haut Atlas Oriental ♣	National Park	-	Terrestrial	40000
38. Rio Martine lagoon ♣	Reserve	-	Terrestrial	3000
39. Sebket Sidi Bou Areg ♣	Nature Reserve	-	Both	-
40. Sebket Zima ♣	Nature Reserve	-	Terrestrial	-
41. Sidi Boughaba	IUCN-IV	1946	Both	5600.0

42. <u>Sidi Boughaba</u>	IUCN-Ia	1951	Both	560.0
43. Sidi Chiker (M'Sabih Talaa)	Permanent Hunting Reserve	1952	Both	1987.0
44. Sidi Rahat ♣	Nature Reserve	-	Terrestrial	-
45. Souss-Massa	IUCN-V	1991	Both	33800.0
46. Takherkhort	Permanent Hunting Reserve	1967	Terrestrial	1230.0
47. Talassantane	IUCN-Ib	1972	Terrestrial	2603.0
48. Talassantane ♣	National Park	-	Terrestrial	60000
49. Tazekka	National Park	1950	Terrestrial	580.0
50. Tidhirine	IUCN-IV	1951	Terrestrial	-
51. Tidhirine (Tidiquin)	National Park	-	Terrestrial	-
52. Toubkal	IUCN-V	1942	Terrestrial	38000.0
53. Zemzem	Forest Sanctuary (Zakaznik)	1978	Terrestrial	10000.0
54. Aguelmams Sidi Ali – Tifounassine	Wetlands of International Importance (Ramsar)	2005	Terrestrial	600.0
55. Archipel et dunes d'Essawira	Wetlands of International Importance (Ramsar)	2005	Both	4000.0
56. Arganeraie	UNESCO-MAB Biosphere Reserve	1998	Terrestrial	2568780.0
57. Baie d'Ad-Dakhla	Wetlands of International Importance (Ramsar)	2005	Both	40000.0
58. Baie de Khnifiss	Wetlands of International Importance (Ramsar)	1980	Both	20000.0

59. Barrage Al Massira	Wetlands of International Importance (Ramsar)	2005	Terrestrial	14000.0
60. Barrage Mohammed V	Wetlands of International Importance (Ramsar)	2005	Terrestrial	5000.0
61. Cap des Trois Fourches	Wetlands of International Importance (Ramsar)	2005	Both	5000.0
62. Complexe de Sidi Moussa-Walidia	Wetlands of International Importance (Ramsar)	2005	Both	10000.0
63. Complexe du bas Loukkos	Wetlands of International Importance (Ramsar)	2005	Both	3600.0
64. Complexe du bas Tahaddart	Wetlands of International Importance (Ramsar)	2005	Both	11000.0
65. Embouchure de la Moulouya	Wetlands of International Importance (Ramsar)	2005	Both	3000.0
66. Embouchure de l'oued Dr'a	Wetlands of International Importance (Ramsar)	2005	Both	10000.0
67. Embouchures des oueds Chbeyka-Al Wa'er	Wetlands of International Importance (Ramsar)	2005	Both	8000.0
68. Intercontinental BR of the Mediterranean	UNESCO-MAB Biosphere Reserve	2006	Terrestrial	-
69. Lac d'Afenhourir	Wetlands of International Importance (Ramsar)	1980	Terrestrial	800.0
70. Lacs Isly-Tislite	Wetlands of International Importance (Ramsar)	2005	Terrestrial	800.0
71. Marias et côte du Plateau de Rmel	Wetlands of International Importance (Ramsar)	2005	Both	1300.0

72. Merja Sidi Boughaba	Wetlands of International Importance (Ramsar)	1980	Both	650.0
73. Merja Zerga	Wetlands of International Importance (Ramsar)	1980	Both	7300.0
74. Moyenne Dr'a	Wetlands of International Importance (Ramsar)	2005	Terrestrial	45000.0
75. Oasis de Sud Marocain	UNESCO-MAB Biosphere Reserve	2000.0	Terrestrial	7185371.0
76. Oasis du Tafilalet	Wetlands of International Importance (Ramsar)	2005	Terrestrial	65000.0
77. <u>Sebkha Bou Areg</u>	Wetlands of International Importance (Ramsar)	2005	Both	14000.0
78. Sebkha Zima	Wetlands of International Importance (Ramsar)	2005	Terrestrial	760.0
79. Zones humides de l'oued El Maleh	Wetlands of International Importance (Ramsar)	2005	Both	1200.0
80. Zones humides de Souss-Massa	Wetlands of International Importance (Ramsar)	2005	Both	1000.0

### 13. Oman



The references mentioned different numbers for the protected areas in Oman, it reached 17 protected areas (<http://www.alreem.com/protected/pro-ref.asp>). Conversely the World Database on Protected Areas (WDPA); Feb. 2010- <http://www.wdpa.org/>); as shown in table (13) only four established protected areas are mentioned. Out of them 3 are of national and one of international importance. On the other hand, Davis, *et al.* (1994), mentioned that in 1984 proposals for several protected areas for Dhofar including Jebel Omar (58000 km<sup>2</sup>), Jebel Semhan (346000 km<sup>2</sup>) and the coast east of Dhofar were formulated by IUCN; up till now, non of these protected areas are

established referring to the World Database on Protected Areas (WDPA; Feb. 2010-<http://www.wdpa.org/>); .

**Table - 13: Protected areas in Oman**

Site Name	National Designation	Year established	Marine/ Terrestrial	Area Size (ha)
1. Ad Dimaniyat Islands	Nature Reserve	1996	Both	20300.0
2. Al Saleel	National Park	1997	Terrestrial	22000.0
3. Arabian Oryx	Sanctuary	1994	Terrestrial	2478540.0
4. Arabian Oryx Sanctuary	World Heritage Convention	1994	Terrestrial	250000.0

## 14. Palestine



There is no available complete data for the authors about the Palestinian protected areas. The requested data also is missing from the World Database on Protected Areas (WDPA); Feb. 2010-<http://www.wdpa.org/>. Conversely, the website of El-Reem protected areas in the Arab world (<http://www.alreem.com/protected/pro-ref.asp>) showed that there are five protected areas in Palestine namely: Ain al-Fashkha (2 500.0 ha) ; Um Al-Rehaan (2500.0 ha); Um Al-Safa forest (3500.0); Wadi Alkaf (2500.0) and Wadi Alkalat (5000.0 ha).

## 15. Qatar

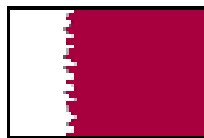


Table (14) in the there are four protected areas. Al Wabra is a recommended (♣), and three were established protected area World Database on Protected Areas (WDPA); Feb. 2010-  
<http://www.wdpa.org/>.

**Table - 14: Protected areas in Qatar**

Site Name	National Designation	Year established	Marine / Terrestrial	Area Size (ha)
1. Al Shahaniyah Park	IUCN- IV	1979	Terrestrial	50.0
2. Al Wabra ♣	Private Ranch	-	Terrestrial	-
3. Khor Al Udeid Fish Sanctuary	Protected Area	1993	Both	12000.0
4. Ras Ushairij Gazelle Conservation Park	Breeding Station	1991	Both	1619.0

## 16. Somalia



To 1994 as mentioned by Davis, *et al.* (1994), there is no functioning nature reserve in Somalia. Recently, the data recorded in the World Database on Protected Areas (WDPA); Feb. 2010-  
<http://www.wdpa.org/> ; as shown in (Table 15), are 25 national protected areas were mentioned, 18 of them are recommended (♣) protected areas and seven were established. No record about for the internationally important protected areas.

**Table - 15: Protected areas in Somalia**

Site Name	National Designation	Year established	Marine/ Terrestrial	Area Size (ha)
1. Alifuuto (Arbowerow)	IUCN-IV	-	Terrestrial	180000
2. Angole Farbiddu ♣	National Park	-	Terrestrial	-
3. Awdhegle-Gandershe ♣	National Park	-	Both	80000
4. Boja Swamps ♣	Wildlife Reserve	-	Terrestrial	110000
5. Bushbush	Game Reserve	1969	Both	334000
6. Bushbush	Control hunting area	1969	Both	334000
7. Daalo Forest ♣	National Park	-	Both	251000
8. Eji-Oobale ♣	Wildlife Reserve	-	Terrestrial	-
9. Far Libah ♣	Wildlife Reserve	-	Terrestrial	-
10. Far Wamo ♣	Wildlife Reserve		Terrestrial	140000
11. Gaan Libaah ♣	National Park	-	Terrestrial	50000
12. Geedkabeheleh	IUCN-IV	1969	Terrestrial	10360
13. Gezira Lagoon ♣	National Park	-	Both	5000
14. Har Yiblana ♣	National Park	-	Terrestrial	-
15. Haradere-Awale Rugno ♣	Wildlife Reserve	-	Terrestrial	250000
16. Harqan Dalandoole ♣	Wildlife Reserve	-	Terrestrial	800000
17. Hobyo ♣	Wildlife Reserve	-	Terrestrial	250000
18. Jowhar	IUCN-IV	1969	Terrestrial	-

19. Jowhar-Warshek ♣	National Park	-	Both	220000
20. Juba Left	Controlled Hunting Area	1969	Terrestrial	-
21. Lag Badana-Bushbush ♣	National Park	-	Both	334000
22. Lag Dere ♣	National Park	-	Terrestrial	500000
23. Las Anod-Taleh-El Chebet ♣	National Park	-	Terrestrial	800000
24. Mogadishu	IUCN-IV	1969	Terrestrial	-
25. Zeila ♣	Wildlife Reserve	-	Both	400000

## 17. Saudi Arabia



The following (Table 16), outlines 128 protected areas in Saudi Arabia. Out of the 128 protected areas, there are 104 designated or recommended (♣), in addition to 4 were established protected areas. All the listed protected areas are of national importance and no internationally important protected areas (World Database on Protected Areas (WDPA); Feb. 2010-<http://www.wdpa.org/>).

**Table - 16: Protected areas in Saudi Arabia**

Site Name	National Designation	Year established	Marine / Terrestrial	Area Size (ha)
1. Abu Ali/Dawhat and Dafi Musallamiyah complex ♣	Other Area	-	Both	-
2. Abu Duda ♣	Other Area	-	Both	-
3. Ad-Dahna (Hawmat an-Niyyan) ♣	Nature Reserve	-	Terrestrial	130000.0

4. Ad-Dahna Waterfall ♣	Protected Area	-	Terrestrial	500.0
5. Al Hair Wetland	IUCN-IV	1988	Terrestrial	500.0
6. Al Hasani and Libana Islands ♣	Other Area	-	Both	-
7. Al Hassa/ Uqair National Recreation Area	National Recreation Area	1960	Terrestrial	64272.0
8. Al Muwailih ♣	Other Area	-	Both	-
9. Al Uqayr Bay ♣	Other Area	-	Both	-
10. Al Wahbah ♣	Natural Monument	-	Terrestrial	200000.0
11. Al-Ahsa ♣	Protected Area	-	Both	270000.0
12. Al-Haram al-Madani ♣	Inviolable Sanctuary	-	Terrestrial	-
13. Al-Haram al-Makki ♣	Inviolable Sanctuary	-	Terrestrial	-
14. Al-Hawtah ♣	Nature Reserve	-	Terrestrial	180000.0
15. Al-Hijr ♣	Protected Landscape	-	Terrestrial	180000.0
16. Al-Jandaliyah	Protected Area	1995	Terrestrial	116000.0
17. Al-Khunfah	Protected Area	1987	Terrestrial	2045000.0
18. Al-Mansuriyah and Al-Hair Dam Bird S ♣	Bird Sanctuary	-	Terrestrial	2000.0
19. Al-Wahba ♣	Other Area	-	Terrestrial	200000.0
20. Al-Wajh Bank ♣	Other Area	-	Both	284000.0
21. Aqabat ash-Sha'ar ♣	Nature Reserve	-	Terrestrial	60000.0

22. Arabiyah Island ♣	Other Area	-	Both	-
23. Ar-Rub'al-Khali	Wildlife Management Area	1994	Terrestrial	64000000.0
24. Ash-Shu'aybah and Mastaba ♣	Other Area	-	Both	10000.0
25. Asir	National Park	-	Terrestrial	450000.0
26. At Tawil ♣	Other Area	-	Terrestrial	130000.0
27. Ath Thamamah ♣	Other Area	-	Terrestrial	75000.0
28. Ath-Thumamah ♣	Managed Nature Reserve	-	Terrestrial	75000.0
29. At-Tawil ♣	Managed Nature Reserve	-	Terrestrial	130000.0
30. At-Taysiyah	IUCN- VI	1995	Terrestrial	426200.0
31. At-Tubayq	IUCN- III	1989	Terrestrial	1220000.0
32. Coastline south of Sharm Zubeir ♣	Other Area	-	Both	-
33. Dahl Maaqala ♣	Protected Area	-	Terrestrial	100.0
34. Dawat Ad-Dafl, Dawat Al-Musallamiyah and Coral Islands	Marine Wildlife Sanctuary	1995	Both	210000.0
35. Dhahran	IUCN- VI	-	Terrestrial	100.0
36. Farasan Islands	Protected Area	1996	Both	331000.0
37. Ghubbat Bal'aksh ♣	Other Area	-	Both	3300.0
38. Gulf Conservation Area	IUCN- II	1995	Terrestrial	230000.0

39. Haramil Island ♣	Other Area	-	Both	-
40. Harqus Island ♣	Other Area	-	Both	-
41. Harrat al-Harrah	IUCN-IV	1987	Terrestrial	1377500.0
42. Harrat ar-Raha ♣	Nature Reserve	-	Terrestrial	250000.0
43. Hawtat Bani Tamin national Ibex Hima	Other Area	1988	Terrestrial	236900.0
44. Hema Hureimla National Park ♣	National Park	-	Terrestrial	-
45. Hima Huraymila'	National Park	-	Terrestrial	-
46. Humaydah Beach ♣	Other Area	-	Both	-
47. Huraymila' ♣	Hima Traditional Reserve	-	Terrestrial	-
48. Ibex Reserve (Hawtat Bani Tamin)	Protected Area	1988	Terrestrial	236900.0
49. Jabal Aja ♣	Protected Area	-	Terrestrial	200000.0
50. Jabal al-Lawz/Hisma ♣	Nature Reserve	-	Terrestrial	197500.0
51. Jabal Athrab ♣	Nature Reserve	-	Terrestrial	60000.0
52. Jabal Dibbagh ♣	Nature Reserve	-	Terrestrial	60000.0
53. Jabal Ibrahim/Wadi Buwwah ♣	Protected Area	-	Terrestrial	70000.0
54. Jabal Ral ♣	Hima Traditional Reserve	-	Terrestrial	3600.0
55. Jabal Salma ♣	Nature Reserve	-	Terrestrial	60000.0
56. Jabal Shada ♣	Nature Reserve	-	Terrestrial	5000.0

57. Jabal Tuwayq ♣	Nature Reserve	-	Terrestrial	100000.0
58. Jabel Ibrahim Wadi Buwwah ♣	Protected Area	-	Terrestrial	70000.0
59. Jabul Letub ♣	National Nature Reserve	-	Both	8900.0
60. Jana Island ♣	Other Area	-	Both	-
61. Jeddah Salt Marshes ♣	Other Area	-	Both	10000.0
62. Jibal al-Humrah/Riyadh Jabal Mukallibah ♣	Nature Reserve	-	Terrestrial	200000.0
63. Jurayd Island ♣	Other Area	-	Both	-
64. Karan Island ♣	Other Area	-	Both	-
65. Khawr al Ja'afirah Area and Islands ♣	Protected Area	-	Both	-
66. Khawr Itwad ♣	Other Area	-	Both	7000.0
67. Khawr Nahoud ♣	Other Area	-	Both	3300.0
68. Khawr Wahlan ♣	Other Area	-	Both	2700.0
69. Khaybar Saltmarshes ♣	Nature Reserve	-	Terrestrial	100.0
70. Khor Al W-ahla ♣	Other Area	-	Both	-
71. Khor Amiq and Raqa ♣	Other Area	-	Both	-
72. Kurayn Island ♣	Other Area	-	Both	-
73. Layla Lakes ♣	Nature Reserve	-	Terrestrial	12000.0
74. Mahazat-as-Sayd	IUCN-IV	1988	Terrestrial	219000.0

75. Majami'al-Hadb	IUCN-IV	1993	Terrestrial	340000.0
76. Maqna North Beach ♣	Other Area	-	Both	-
77. Marqa Island ♣	Other Area	-		-
78. Marsa al Usalla ♣	Other Area	-	-	-
79. Marsa Umm Misk ♣	Other Area	-	Both	-
80. Mastura Beach ♣	Other Area	-	Both	-
81. Mersa as Sarraj ♣	Other Area	-	Terrestrial	20000.0
82. Mersa Tawil ♣	Other Area	-	Both	-
83. Nafud al-'Urayq	IUCN-IV	1995	Terrestrial	190000.0
84. Najran Desert ♣	Nature Reserve	-	Terrestrial	700000.0
85. North and South Sharm Wasm and Al Quhma and Qadimbal Is. ♣	Other Area	-	Both	-
86. North Inner Farasan Bank Reefs and Islands ♣	Other Area	-	Both	-
87. North Outer Farasan Bank Reefs and Islands ♣	Other Area	-	Both	-
88. Northern Wildlife Management Zone	IUCN-IV	1988	Terrestrial	10087500.0
89. Oreste Point ♣	Other Area	-	Both	-
90. Qalib Island Chain ♣	Other Area	-	Both	-
91. Qaryat al Fau Al-Arid ♣	Nature Reserve	-	Terrestrial	1150000.0

92. Qishran ♣	Other Area	-	Both	-
93. Ras Abu Madd to Sharm Hasi ♣	Other Area	-	Both	-
94. Ras Baridi and Sharm al Khaur ♣	Other Area	-	Both	3000.0
95. Ras Hatiba ♣	Other Area	-	Both	45000.0
96. Ras Suwayhil ♣	Other Area	-	Both	26700.0
97. Rawdat Khuraym ♣	Nature Reserve	-	Terrestrial	140000.0
98. Raydah	IUCN-II	1989	Terrestrial	900.0
99. Safaniya/Manifa bay complex ♣	Other Area	-	Both	-
100.Saja/Umm ar-Rimth	IUCN-IV	1995	Terrestrial	719000.0
101.Shada ♣	IUCN-V	-	Terrestrial	-
102.Sharm Dum-agma and Sharm Antar ♣	Other Area	-	Both	7000.0
103.Sharm Habban to Sharm Munaybirah ♣	Other Area	-	Both	-
104.Sharm Yahar to Saharm Jubba ♣	Other Area	-	Both	-
105.Sharm Yanbu ♣	Other Area	-	Both	5000.0
106.Sharm Zubayr ♣	Other Area	-	Both	8000.0
107.Shi'b Abu al-Liqah and Shi'b al-Kabir ♣	Other Area	-	Both	14000.0

108. Shib Al Kabir ♣	Other Area	-	Both	-
109. Shi'b Green Reef Complex ♣	Other Area	-	Both	-
110. South Gulf of Salwah ♣	-	-	Both	-
111. South Jizan Beach ♣	-	-	Both	-
112. South Qunfidah ♣	-	-	Both	-
113. Tabuk Wetlands ♣	Bird Sanctuary	-	Terrestrial	1000.0
114. Tarut Bay Complex ♣	Other Area	-	Both	-
115. Umm al-Qamari Islands	IUCN-II	1977	Both	200.0
116. Umm Lajj ♣	Other Area		Both	-
117. 'Uruq Bani Ma'arid ♣	IUCN-II	1994	Terrestrial	550000.0
118. Wadi an-Naaman/Wadi Wajj ♣	Natural Reserve	-	Terrestrial	30000.0
119. Wadi Hizmah ♣	Protected Area	-	Terrestrial	270000.0
120. Wadi Jawrah (Mimusops Grove)	IUCN-IV	1996	Terrestrial	25.0
121. Wadi Jizan Reservoir Bird ♣	Bird Sanctuary	-	Terrestrial	7000.0
122. Wadi Murwani ♣	Nature Reserve	-	Terrestrial	125000.0
123. Wadi Qirshah	Protected Landscape	-	Terrestrial	62500.0
124. Wadi Rabigh ♣	Nature Reserve	-	Terrestrial	250000.0
125. Wadi Turabah ♣	Nature Reserve	-	Terrestrial	8000.0

126. Wadi Ulayb ♣	Nature Reserve	-	Terrestrial	1500.0
127. Yanbu City Conservation Area ♣	Other Area	-	Both	-
128. Yanbu Coastal Conservation Area ♣	IUCN-II	-	Terrestrial	-

## 18. Sudan



To 1994 as mentioned by Davis, *et al.* (1994), no legal protection for some of the important floristic areas Imatong Mountain and Jebel Marra are among of them. Recently, the data recorded (Table 17) in the World Database on Protected Areas (Feb. 2010- <http://www.wdpa.org/>); there are 44 protected areas. Among of this number 40 are nationally and 4 are internationally important protected areas. Out of the 44 protected areas there are sixteen designated or recommended (♣), in addition to 28 were established protected areas.

**Table - 17: Protected areas in Sudan**

Site Name	National Designation	Year established	Marine/ Terrestrial	Area Size (ha)
1. Abraç, El Deib and Gebel Elba Area	Conservation Area	1984	Both	-
2. Ashana	IUCN- VI	1939	Terrestrial	90000.0
3. Badinglo	IUCN- II	1986	Terrestrial	1650000.0
4. Bengangai	IUCN- VI	1939	Terrestrial	17000.0
5. Boma	IUCN- II	1986	Terrestrial	2280000.0
6. Boro ♣	Game Reserve	-	Terrestrial	150000.0

7. Chelkou	IUCN- VI	1939	Terrestrial	550000.0
8. Dinder	IUCN- II	1935	Terrestrial	1000000.0
9. Erkawit	IUCN- VI	1939	Terrestrial	82000.0
10. Erkawit Sinkat	IUCN- VI	1939	Terrestrial	12000.0
11. Ez Zeraf	IUCN- VI	1939	Terrestrial	970000.0
12. Imatong Mountains ♣	Nature Conservation Area	-	Terrestrial	100000.0
13. Jebel Aulia Dam ♣	Bird Sanctuary	-	Terrestrial	100000.0
14. Jebel Elba ♣	Nature Conservation Area	-	Terrestrial	480000.0
15. Jebel Hassania	National Park	2003	Terrestrial	-
16. Jebel Marra massif ♣	Nature Conservation Area	-	Terrestrial	150000.0
17. Juba	IUCN- VI	1939	Terrestrial	20000.0
18. Kidepo	IUCN- VI	1975	Terrestrial	120000.0
19. Lake Abiad ♣	Bird Sanctuary	-	Terrestrial	500000.0
20. Lake Ambadi ♣	Nature Conservation Area	-	Terrestrial	150000.0
21. Lake Keilak ♣	Bird Sanctuary	-	Terrestrial	3000.0
22. Lake Kundi ♣	Bird Sanctuary	-	Terrestrial	2000.0
23. Lake No ♣	Nature Conservation Area	-	Terrestrial	100000.0
24. Lake Nubia ♣	Bird Sanctuary	-	Terrestrial	10000.0
25. Lantoto ♣	National Park	-	Terrestrial	76000.0
26. Mashra ♣	Game Reserve	-	Terrestrial	450000.0

27. Mbarizunga	IUCN- VI	1939	Terrestrial	1000.0
28. Mongalla	IUCN- VI	1939	Terrestrial	7500.0
29. Mukawwar ♣	Managed Nature Reserve	-	Both	30000.0
30. Nimule	IUCN- II	1954	Terrestrial	41000.0
31. Numatina	IUCN- VI	1939	Terrestrial	210000.0
32. Port Sudan ♣	Marine National Park	-	Marine	100000.0
33. Radom	IUCN- II	1980	Terrestrial	1250000.0
34. Rahad	Game Reserve	1994	Terrestrial	350000.0
35. Sabaloka	IUCN- VI	1996	Terrestrial	116000.0
36. Sanganeb Atoll	IUCN- II	1991	marine	1200.0
37. Shambe	IUCN- II	1985	Terrestrial	62000.0
38. Southern	IUCN- II	1939	Terrestrial	2300000.0
39. Suakin Archipelago ♣	National Park	-	Terrestrial	150000.0
40. Tokor	IUCN- VI	1939	Terrestrial	630000.0
41. Dinder National Park	UNESCO-MAB Biosphere Reserve	1979	Terrestrial	890.0
42. Dinder National Park (DNP)	Wetlands of International Importance (Ramsar)	2005	Terrestrial	1084600.0
43. Radom National Park	UNESCO-MAB Biosphere Reserve	1979	Terrestrial	1250000.0
44. Sudd	Wetlands of International Importance(Ramsar)	2006	Terrestrial	5700000.0

## 19. Syria



There are 18 designated protected areas in Syria, half of them are recommended (♣) and the others were established as protected areas. Among of this number, 17 are nationally and one has international importance (Table 18). There is no protected areas legislation in Syria to 1994 as mentioned by (Davis, *et al.* 1994). However, the Ministry of Agriculture Directorates of Forests and Afforestation has designated a significant amount of protected forests and is at present setting up *Cedrus* forest reserves in the Jabal an Nusayriyah (Davis, *et al.* 1994).

**Table - 18: Protected areas in Syria**

Site Name	National Designation	Year established	Marine/ Terrestrial	Area Size (ha)
1. Abu Kubeiss	Protected Area	1999	Terrestrial	11000.0
2. Aburejumain ♣	Protected Area	-	Terrestrial	22500.0
3. Al Sha'ara	Protected Area	1998	Terrestrial	1000.0
4. Cedar - Fir	Protected Area	1996	Terrestrial	1350.0
5. Fanar Ibn Hani	Protected Area	2000	Marine	1000.0
6. Ferunluk	Protected Area	1999	Terrestrial	1500.0
7. Ghab lake ♣	Protected Area	-	Terrestrial	320.0
8. Jabal Abou Rojmen ♣	Designation not known	2002	Terrestrial	60000.0
9. Khatounia lake ♣	Protected Area	-	Terrestrial	1200.0
10. Muzaireeb lake ♣	Protected Area	-	Terrestrial	50.0
11. Om Al Toyour ♣	Protected Area	1999	Marine	1000.0

12. Quttina lake ♣	Protected Area	-	Terrestrial	6000.0
13. Ras El Bassit	Protected Area	1999	Marine	3000.0
14. Sabkhat al Jabboul	Protected Area	1972	Both	320.0
15. Showla (Choula)	Game Management Area	1983	Terrestrial	22000.0
16. Showla (Choula) ♣	Nature Reserve	-	Terrestrial	22000.0
17. Wadi el-Azib (Ghrib) ♣	Game Management Area	-	Terrestrial	24200.0
18. Sabkhat al-Jabbul Nature Reserve	Wetlands of International Importance (Ramsar)	1998	Terrestrial	10000.0

## 20. Tunisia



Table (19), outlined that there are 87 protected areas in Tunisia. Among of these protected areas, 59 are nationally important and 28 are of international importance. Out of the 87 protected areas, 24 are still recommended or proposed (♣) and 63 were established protected areas. These data were mainly based on the data outlined by the World Database on Protected Areas (WDPA; Feb. 2010- <http://www.wdpa.org/>).

**Table - 19: Protected areas in Tunisia**

Site Name	National Designation	Year established	Marine/ Terrestrial	Area Size (ha)
1. Ain Baccouch	Faunal Reserve	1992	Terrestrial	90.0
2. Ain Chrichira	Natural Reserve	1993	Terrestrial	122.0
3. Archipel de la Galite ♣	IUCN-IV	1980	Marine	450.0

4. Bahira El-Bibane	Wetland Zone of National Importance	1948	Terrestrial	30000.0
5. Bou-Hedma	IUCN-II	1980	Terrestrial	16488.0
6. Boukornine	IUCN-II	1987	Terrestrial	1939.0
7. Cap Bon peninsula ♣	Nature Reserve	-	Both	-
8. Chambi	IUCN-II	1980	Terrestrial	6723.0
9. Chott El Djerid	Wetland Zone of National Importance	1949	Terrestrial	70000.0
10. Chott el Fedjadj ♣	Nature Reserve	-	Terrestrial	30000.0
11. Complexe des Iles Kneiss	Natural Reserve	1993	Terrestrial	5850.0
12. Dar Chichou	IUCN-IV	1964	Terrestrial	100.0
13. Dar Fatma ♣	Nature Reserve	-	Terrestrial	3.0
14. Dgebel Serj	Natural Reserve	1993	Terrestrial	93.0
15. Dghoumes ♣	Designation not known	1994	Terrestrial	10000.0
16. Djebel Bargou ♣	Nature Reserve	-	Terrestrial	-
17. Djebel Bouramli	Natural Reserve	1993	Terrestrial	50.0
18. Djebel Khroufa	Natural Reserve	1993	Terrestrial	125.0
19. Djebel Marchana ♣	Nature Reserve	-	Terrestrial	-
20. Djebel Ousselat ♣	Nature Reserve	-	Terrestrial	-
21. Djebel Ressay ♣	Nature Reserve	-	Terrestrial	-
22. Djebel Serdj ♣	Nature Reserve	1993	Terrestrial	93.0

23. Djebel Touati	Natural Reserve	1993	Terrestrial	960.0
24. Djebel Zaghouan ♣	Nature Reserve	-	Terrestrial	-
25. El-Feidja	IUCN-II	1990	Terrestrial	2637.0
26. Etella	Natural Reserve	1993	Terrestrial	95.0
27. Golfe de Bou Grara ♣	Nature Reserve	-	Both	50000.0
28. Grotte de Chauve souris d'El Haouaria	Natural Reserve	1993	Terrestrial	1.0
29. Hamada-Sidi Toui ♣	Reserve	1966	Terrestrial	12000.0
30. Ichkeul	National Park	1980	Both	12600.0
31. Ile Chikly	Natural Reserve	1993	Terrestrial	3.0
32. Iles Kneiss	Nature Reserve	1993	Both	5580.0
33. Iles Kneiss et vasières du Golf	Wetland Zone of National Importance	1979	Terrestrial	14000.0
34. Jenein-oued Ouni ♣	Bird Reserve	-	Terrestrial	360000.0
35. Kechem el Kelb	Natural Reserve	1970	Terrestrial	307.0
36. Kerkennah isles ♣	Nature Reserve	1954	Both	2500.0
37. Lac Bizerte ♣	Nature Reserve	-	Terrestrial	15000.0
38. Lac de Rades et Salines	Wetland Zone of National Importance	1980	Terrestrial	3000.0
39. Lac de Tunis ♣	Natural Reserve	1973	Both	3000.0
40. Medjerda Estuary ♣	Nature Reserve	1972	Both	7500.0
41. M'hibeus	Faunal Reserve	1970	Terrestrial	370.0

42. Nefta oasis ♣	Nature Reserve	-	Terrestrial	-
43. OM. Chieh ♣	Designation not known	1994	Terrestrial	12000.0
44. Orbata	Faunal Reserve	1967	Terrestrial	260.0
45. Salines de Thyna	Wetland Zone of National Importance	1980	Both	860.0
46. Sebkhah Halk el Menzel	Wetland Zone of National Importance	1987	Terrestrial	1500.0
47. Sebkhah El Khalij (Golfe de Gabès) ♣	Designation not known	1987	Terrestrial	400.0
48. Sebkhah Kelbia	Natural Reserve	1993	Terrestrial	8000.0
49. Sebkhah Ariana	Wetland Zone of National Importance	1980	Terrestrial	3200.0
50. Sebkhah El-Djem	Wetland Zone of National Importance	1980	Terrestrial	3000.0
51. Sebkhah es Sedjoumi	Wetland Zone of National Importance	1979	Terrestrial	3000.0
52. Sebkhah Kelbia	Wetland Zone of National Importance	1948	Terrestrial	15000.0
53. Sebkhah Kourzia ♣	Wetland Zone of National Importance	1987	Terrestrial	1200.0
54. Sebkhah Sidi Mansour	Nature Reserve	-	Terrestrial	10000.0
55. Sebkhah-Sidi-El-Hani	Wetland Zone of National Importance	1954	Terrestrial	35000.0
56. Sidi Toui ♣	National Park	-	Terrestrial	6315.0
57. Tabarka ♣	National Park	-	Terrestrial	-
58. Tourbière de Dar. Fatma	Natural Reserve	1993	Terrestrial	15.0
59. Zembra and Zembretta	IUCN-II	1977	Both	5095.0
60. Ain Dahab	Wetlands of International Importance (Ramsar)	2007	Terrestrial	560.0

61. Archipel de la Galite	Barcelona Convention	2001	Marine	2715.0
62. Archipel des Kneiss	Barcelona Convention	2001	Marine	5850.0
63. Bahiret el Bibane	Wetlands of International Importance (Ramsar)	2007	Terrestrial	39266.0
64. Barrage Lebna	Wetlands of International Importance (Ramsar)	2007	Terrestrial	1147.0
65. Chott El Jerid	Wetlands of International Importance (Ramsar)	2007	Terrestrial	586187.0
66. Djerba Bin El Ouedian	Wetlands of International Importance (Ramsar)	2007	Both	12082.0
67. Djerba Guellala	Wetlands of International Importance (Ramsar)	2007	Both	2285.0
68. Djerba Ras Rmel	Wetlands of International Importance (Ramsar)	2007	Both	1856.0
69. Garaet Sidi Mansour	Wetlands of International Importance (Ramsar)	2007	Terrestrial	2426.0
70. Ichkeul	Wetlands of International Importance (Ramsar)	1980	Terrestrial	12600.0
71. Ichkeul National Park	World Heritage Convention	1980	Both	12600.0
72. Iles Kneiss avec leurs zones intertidales	Wetlands of International Importance (Ramsar)	2007	Both	22027.0
73. Iles Zembra et Zembretta	UNESCO-MAB Biosphere Reserve	1977	Marine	791.0
74. Lac et Tourbière de Mejen Ech Chitan	Wetlands of International Importance (Ramsar)	2007	Terrestrial	7.0
75. Lagune de Ghar el melh et Deta de al Mejerda	Wetlands of International Importance (Ramsar)	2007	Both	10168.0
76. Lagunes du Cap Bon oriental	Wetlands of International Importance (Ramsar)	2007	Terrestrial	504.0
77. Les Tourbières de Dar Fatma	Wetlands of International Importance (Ramsar)	2007	Terrestrial	13.0

78. Parc national de Djebel Bou-Hedma	UNESCO-MAB Biosphere Reserve	1977	Terrestrial	16988.0
79. Parc national de Djebel Chambi	UNESCO-MAB Biosphere Reserve	1977	Terrestrial	43723.0
80. Parc national de l'Ichkeul	UNESCO-MAB Biosphere Reserve	1977	Terrestrial	14100.0
81. Salines de Thyna	Wetlands of International Importance (Ramsar)	2007	Both	3343.0
82. Sebkhet Kelbia	Wetlands of International Importance (Ramsar)	2007	Terrestrial	8732.0
83. Sebkhet Noual	Wetlands of International Importance (Ramsar)	2007	Terrestrial	17060.0
84. Sebkhet Sejoumi	Wetlands of International Importance (Ramsar)	2007	Terrestrial	2979.0
85. Sebkhet Soliman	Wetlands of International Importance (Ramsar)	2007	Terrestrial	880.0
86. Zembra and Zembretta	Barcelona Convention	2001	Marine	5095.0
87. Zones Humides Oasiennes de Kelibi	Wetlands of International Importance (Ramsar)	2007	Terrestrial	3419.0

## 21. United Arab Emirates



There are four National Parks (Ain al Faydah (Fazyad); Jebel Hafit-Ain al Faydah; Mushrif and Mushrif National Park). One Marine National Park (Ganadah lagoon (Ras Ganadah) and mangrove). Eight Nature Reserves among of them: Al Awir Al Ain, Al Khawanij, Al Maha, Hatta, Khor Kalba, Nadd Al Sheba and Ra's al Khaymah. Three Private Reserves: Abu al Abyadh island; Al Maktoum palace and Umm al-Qaiwain lagoon & island. One Landscape Protected Area: Al Jazirah al Hamra. Three Wildlife Sanctuaries: Jabal Ali; Khor Dubai Marshes and Ras Al Khawr. Three Bird Sanctuaries: Arzaneh islands; Qarnein islands and Zirkuh island. In addition to, other protected

areas: Hammanya lagoon; Khawr Ajman; Ra's al Khaymah and Wadi Wurrayah; these data mainly based on World Database on Protected Areas- (WDPA; Feb. 2010: <http://www.wdpa.org/>).

## 22. Yemen



To 1994 as mentioned by Davis, *et al.* (1994), there is no areas of nature conservation value are protected by law in Yemen. However, a network of reserves has been recommended by UNEP/IUCN. This includes several sites in the highlands among of them: Mahwit woodlands, Jebel Bura's Valley woodlands, Jebel an Nabi Shu'ayb and Tiaz woodlands and the Shibam/Kawkaban escarpment (Davis, *et al.* 1994). Recently, the data recorded (Table 20) in the World Database on Protected Areas (WDPA; Feb. 2010- <http://www.wdpa.org/>); are 5 nationally designated or recommended (♣), three were established protected areas two of them are of international importance (Socotra Archipelago and Socotra Archipelago); in addition to the one national important protected area (Socotra island).

**Table - 20: Protected areas in Yemen**

Site Name	National Designation	Year established	Marine/ Terrestrial	Area Size (ha)
1. Bura Community Protected Area ♣	Protected Area	-	Terrestrial	-
2. Dhamar Montane Plains Mahjur Traditional Reserve ♣	Reserve	-	Terrestrial	-
3. Jabal Bura valley forest ♣	National Park	-	Terrestrial	300.0
4. Ras Isa ♣	Marine Park	-	Marine	
5. Socotra island	Protected Area	1996	Both	362500.0
6. Zuqur islands ♣	Marine National Park	-	Marine	-
7. Socotra Archipelago	UNESCO-MAB Biosphere	2003	Terrestrial	2681640.0

	Reserve			
8. Socotra Archipelago	World Heritage Convention	2008	Terrestrial	2151418.0

## CHAPTER II

### INTEGRATED WATER RESOURCES MANAGEMENT "IWRM" IN THE PROTECTED AREAS OF THE ARAB WORLD.

#### 2.1 Definition The status of Integrated Water Resource Management (IWRM) in protected areas in the Arab World

##### 2.1.1 Integrated Water Resource Management (IWRM)

**Integrated Water Resource Management (IWRM)** is a systematic approach to planning and management that considers a range of supply and demand-side processes and actions, and participation of stakeholder in decision processes. IWRM facilitates adaptive management by continually monitoring and reviewing water resource situations. To plan effectively, utilities must engage their customers and external regulators when assessing the potential impacts of climatic changes on their water systems. IWRM is a useful way to use water in a more sustainable way.

To articulate the supply- and demand-side processes and actions, IWRM must simultaneously address the two distinct systems that shape the water management landscape. Factors related to the biophysical system, namely: climate, topography, land cover, surface water hydrology, groundwater hydrology, soils, water quality and ecosystems that control water availability and movement. Factors related to the socio-economic management system, driven largely by human demand for water, shape how available water is stored, allocated and delivered within or across watershed boundaries. Increasingly, operational objectives of the installed hydraulic infrastructure constructed as part of the management system seek to balance water for human use and water for environmental needs. In Europe, for example, the EU Water Framework Directive obligates water utilities to cooperate in river basin management efforts to achieve good ecological and water-quality status for rivers and lakes. Thus, integrated analysis of the natural and managed systems is argued to be the most useful approach to evaluate management alternatives.

This type of analysis relies upon the use of hydrologic modeling tools that simulate physical processes including precipitation; evapo-transpiration, runoff, infiltration, etc. In managed systems, analysis must also occur.

##### 2.1.2 Principals of the Integrated Water Resources Management (Lemos, *et al.* 2007):

The implementation of IWRM has sought to integrate not only across the many disciplines needed to understand complex problems related to water use and conservation but also to design and implement institutions that are democratic, economically viable, responsive to future change, and

that lead to long-term sustainability. As a management model, IWRM is inspired by three key principles of good governance:

- The ecological principle for integrating water management around river basins rather than independent institutional users, with land and water governance integrated for environmental reasons.
- The institutional principle for basing resource management on dialogue among all stakeholders through transparent and accountable institutions.
- The economic principle for making more use of incentives and market-based principles to improve the efficiency of water as an increasingly scarce resource.(UNDP 2006).

IWRM also advocates management that respects ecological limits of available water, not only considering the water efficiency but also water equity among the beneficiaries and its sustainability. These goals have been accomplished by the implementation of mechanisms of water governance that have included different levels of integration practices. These comprehensive water reforms usually include:

- (a) Reframing water from a common public good to one with economic value. In consequence, water reforms have adopted different levels of water privatization that ranged to the creation of bulk water permit and charging systems (i.e. Brazil) to full-fledged water markets (i.e. Chile);
- (b) Creation of watershed/catchments level management councils that may include a wide range of stakeholders such as direct water users, public officials, NGOs, social movements, etc.;
- (c) Decentralization of water institutions to lower levels of management (the subsidiary principle) usually at the watershed scale;
- (d) Design and implement institutional arrangements that foster the integration across scales of governance and resource use and that take into consideration ecological limits. These include river basin plans, water zoning and creation of ecosystem protection areas;
- (e) Emphasis on the use of techno-science and local indigenous knowledge in the management of water reform.

Water management experiments including some or all of the characteristics described above have been implemented in several parts of the world with mixed results (Wester, *et al.* 2003; Bauer 2004; Lemos & Oliveira 2004). However, overall reforms hold great promise of building water systems capacity to respond to and to address some of the most pressing water problems including scarcity, pollution and potential negative impacts of global climate change (UNDP 2006).

### **2.1.3 Integrated Water Resource Management in protected areas**

Over the past two decades, water management in the Arab region has been strongly influenced by the idea of integrated water resource management (IWRM). This process advocated new

approaches for the assessment, management, and development of freshwater resources. However, IWRM in protected areas the processes attempt to provide holistic solutions to water issues and still need commitment of governments and communities to adopt new approaches and back them by substantial and immediate investments, public awareness campaigns, technology development, capacity building programs, and legislative and institutional changes.

**IWRM in Protected Areas** is vital topic because water resources play a critical environmental role, through conservation of the biological elements. This issue is an urgent topic in Arab countries, related to its location in either the arid or hyper-arid zone, depend on seasonal rainfall, have very few rivers—some of which carry runoff from other countries.

**Climatic changes:** are recent challenge newly developed, which poses additional challenges for IWRM: “Water managers have long dealt with changing demands for water resources. To date, water managers have typically assumed that the natural resource base is reasonably constant over the medium term and, therefore, that past hydrological experience provides a good guide to future conditions. Climatic changes challenge these conventional assumptions and may alter the reliability of water management systems.”

**Rain fall decline:** Arab countries, in the 2008 IPCC report anticipates declining rainfall (–10 % –25 %) declining soils moisture (–5 % –10 %), declining runoff (–10 % –40 %), and increasing evaporation (+5 % +20 %). The future is likely to experience more competition and conflict among countries, sectors, communities, and individuals over water. The farmer lobby likely will demand more water, arguing that crop needs increase with temperature and rainfall variability. Urban water utilities will demand more water to meet the needs of growing, more prosperous populations. Finally, increased environmental flows will continue to be necessary for rivers and streams to maintain and regenerate themselves.

**Agriculture** (which utilizes 80 % –90 % of water in most of the Arab countries) will not enjoy guaranteed water supply at past historical quantities. If there is increased variability in rainfall increased requirements for municipal and industrial use will cut into agriculture’s water share. Farmers' performance will have to change water usage patterns at a time when plant water requirements are increasing. For areas that already are operating with far less water than is required, changing water use patterns will make management more difficult. For areas whose supplies currently are adequate, the entirely new challenge of managing alternating abundance and scarcity will arise.

## **2.2 The current practices, gaps and models used for integrated water management in dry lands ecosystems**

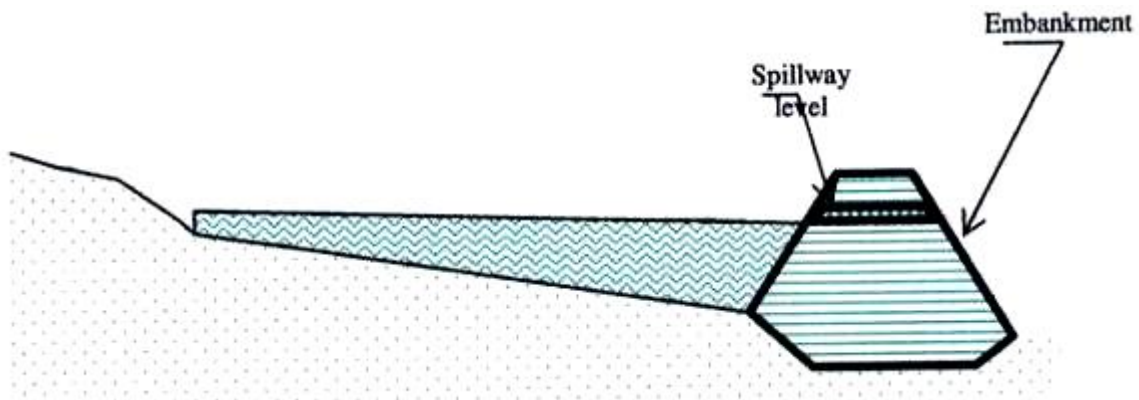
### **2.2.1 Rainfall management practices in dry lands**

**Detention Basins:** provide one means of managing storm water. Detention basin can range from as simple a structure as the backwater effect behind a highway or road culvert, up to a large

reservoir with sophisticated control devices. Detention is holding runoff for a short time before releasing it to the natural watercourse. The terms "detention" and "retention" are often misused; retention is the holding of water in a storage facility for a considerable length of time, for aesthetic, agricultural, consumptive, or other uses. The water might never be discharged to a natural watercourse, but instead be consumed by plants, evaporation, or infiltration into the ground as ground water (El-Barbary & Sallam 2004).

On-site detention of rainfall water is storage of runoff on or near the site where precipitation occurs. In some applications, the runoff may first be conducted short distances by collector sewers located on or adjacent to the site of the detention facility. The concept of detaining runoff and releasing it at a regulated rate is an important principle in storm water management. In areas having appreciable topographic relief, detention storage attenuates peak flow rates.

There are several considerations involved in the design of storm water detention facilities. These are: the selection of a design rainfall event, the volume of storage needed, the maximum permitted release rate, pollution control requirement, and design of the outlet works for releasing the detained water.

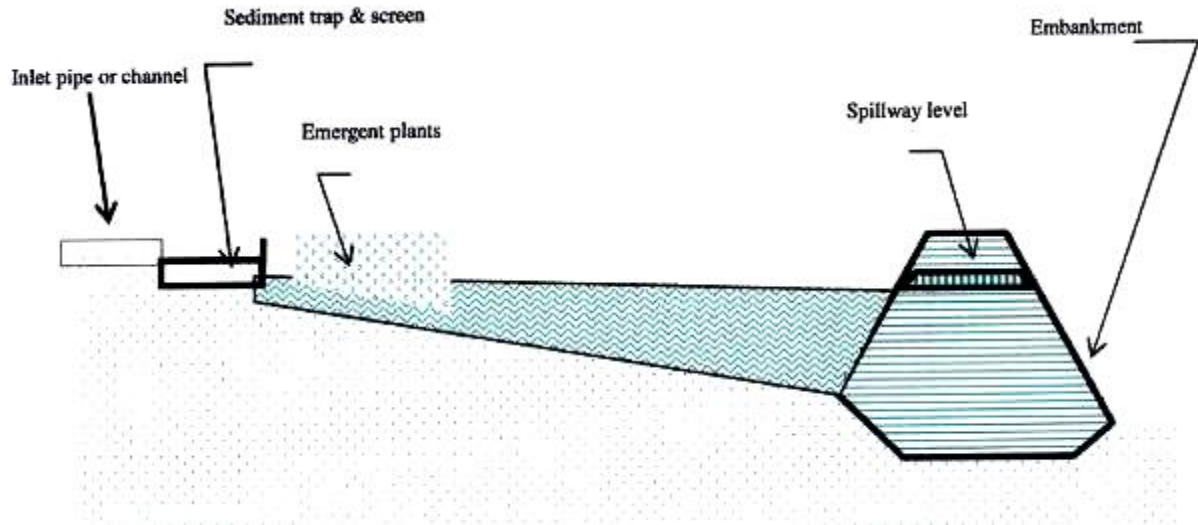


**Figure 5:** Diagram showing the detention (after: El-Barbary & Sallam 2004).

Detention basins comprise an impoundment created by an embankment or excavation, and by restriction of their outlet flow capacity (**Fig. 6**). Detention basins are also being adopted for water quality enhancement and as part of a wider pollution control treatment train. Attention is required in their design to ensure the safe spillage of excess flows, such that life and property are not at risk downstream, and to ensure the requirement of community safety. Also attention is required to the potential for flood impacts resulting from their backwater effects. Properly designed extended detention basins can achieve significant pollutant removals. The combined use of detention basins as flood and pollutant controls can yield economic benefits in terms of delay of costly hydraulic infrastructure enlargement downstream and the provision of alternative water pollution interception measures.

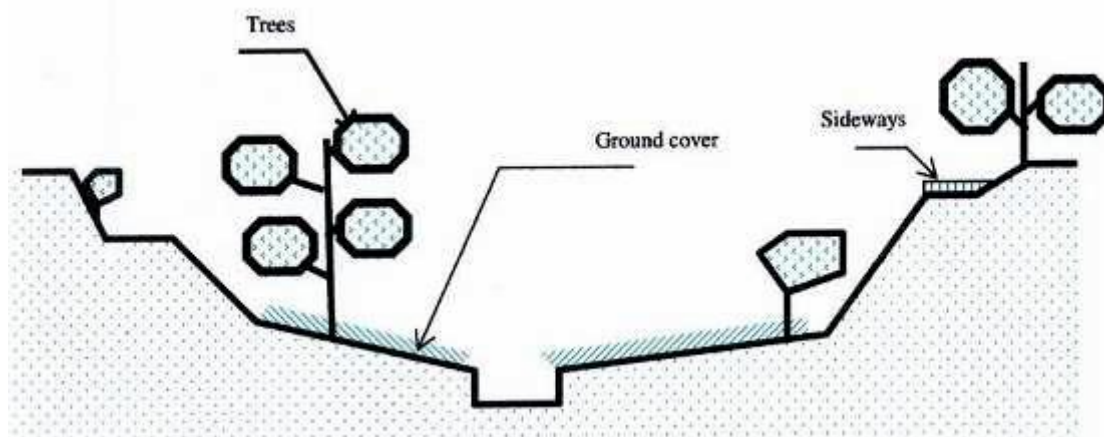
**Retention Basins, ponds and wetlands:** Retention ponds are small lakes with a permanent pool of water and some emergent vegetation, while wetlands are shallow basins with most of the

surface covered by emergent vegetation (Fig.6). Sediment interception prior to discharge into ponds or wetlands is required in order to protect the emergent and submerged plants, hold off the need for costly dredging, and to protect the landscape quality (El-Barbary & Sallam 2004).



**Figure 7:** Diagram showing the detention basins and wetlands practice (after: El-Barbary & Sallam 2004).

The retention of water enables settling of suspended materials that are associated with and adsorbed by active sediments, and interception and take-up by emergent and submerged plants. There has been extensive application of this practice in many countries. The community perceived ponds and wetlands as valuable conservation and landscape features, attracting a diverse range of water birds and aquatic biota. Open space requirements and hydraulic backwater impacts should be taken into consideration when applying this technique.



**Figure 8:** Diagram showing the restoration of the natural vegetation channels (after: El-Barbary & Sallam 2004)

The purpose is to restore natural stream channels and floodways within urban areas to secure economies, retard discharges, reduce peak flows, and enhance the interception of suspended solids and nutrients (**Fig.7**). Also to maximize use of rainfall water and open space and landscape values. Control is required over the rate of sediment deposition, to ensure the viability of grass and other ground covers. The application of this practice is gaining acceptance, in view of its enhancement of adjacent land values, more environmentally sympathetic treatment, and the open space values it affords. Unless the flow channel incorporates capacity for sediment transport, there will be a requirement to intercept storm water sediment prior to discharge into the natural stream, in order to sustain channel grass cover. This practice represents a low cost solution as compared to concrete channels. It affords maximum benefit, enhanced land, open space and recreation values (**El-Barbary & Sallam 2004**).

### **2.2.2 Gaps**

The natural processes of rainfall interception by vegetation and natural depressions, together with soil infiltration and storage and groundwater recharge/discharge, largely determine the rate of water discharge relative to rainfall depth. It has been found that significant amount of rainfall and flash floods are available, while water gap exists in most Arab countries especially by 2025. Rainfall can be reliably harvested and used in many countries adding some millions m<sup>3</sup>/yr to the Arab water resources. Detailed records of rainfall and flash floods are needed to better estimate the amount of water and to adopt appropriate water harvesting technology. Capacity building programmes for the local inhabitants as well as additional legislations and agreements still needed.

### **2.3 Models for better conserving freshwater within protected areas**

Protected areas managers should initiate and participate in freshwater conservation actions within their country or region. Managers of the protected areas have an obligation to lead efforts to conserve fresh water for the biodiversity sustainability, especially for the freshwater species. The threats to freshwater biodiversity are being exacerbated by increasing global demand for water, irrigated agricultural products and hydroelectricity. There are solutions, and as park advocates and managers there are many practical things we can do to promote sustainable management of the basins (or catchments or watersheds) upstream from parks to secure the water flows needed to fulfill our mission to conserve freshwater as well as all other biodiversity issues. There are three models for better conserving freshwater habitats within protected areas which are:

#### **(a) Better planning for water resources**

Good planning for freshwater in protected areas can ensure protected areas are in the right place (water storage in Morocco mountain area is an example; **Fig.8**) to better conserve biodiversity and to maintain the hydrological cycle needed to ensure these parks are resilient. The key elements include:

- Defining representative freshwater habitats and species needs;

- Maintaining connectivity by protecting stream corridors; and
- Protecting altitudinal gradients and entire catchments as free flowing.

**(b) River basin management**

Ensuring that: a) A right quality and quantity of water reaches the protected area at the right time. b) Water availability and distribution equity between the stakeholders, c) Conserving and rehabilitating river corridors, managing fishing, and d) reducing sources of pollution.

**(c) Securing environmental flows**

Maintaining the right water through the protected area is essential for conserving freshwater biodiversity.

**The key points are to know among of them:**

- What natural values you are trying to conserve?
- What sort of water flows are needed to achieve their conservation,
- Agreements between government and users to deliver the right quality and quantity of water at the proper times.

**To Secure the Water Flow:**

- Maintaining a major tributary stream as free flowing to provide natural variability in water flows; and
- Using small, in-channel dams to either push smaller volumes of water out over floodplains.



**Figure 9:** Water storage dam in Morocco mountain area

**2.4 Assessment of the best practices in the field of IWRM in Protected areas "Case studies from the Arab countries"**

**2.4.1 Ichkeul Nation Park, Tunisia (<http://www.eoearth.org/article>):**

Ichkeul Nation Park (37° 10'N, 09° 40'E) is a World Heritage Site located in northern Tunisia. Lake Ichkeul (Fig.9) is the last of a chain of shallow freshwater lakes which once extended all along the northern African seaboard. The lake and its surrounding marshes are important for the extremely high numbers of wintering Palaearctic waterfowl: ducks, geese, storks and pink flamingos among others which feed and nest there. It is eutrophic and brackish, but seasonally expanded by floodwaters.



**Figure 10:** Lake Ichkeul, Tunisia. The lake badly deteriorated as the result of the construction of three dams on rivers supplying it and its marshes. The dams cut off almost all inflow of fresh water, causing a destructive increase in the salinity of the lake and marshes. (Source U.S./Japan ASTER Science Team and NASA/GSFC/METI/ERSDAC/JAROS)

**(a) The Statues of Water in this Protected Area:**

Construction of three dams on rivers supplying the lake has cut off almost all the fresh water inflow, causing a destructive increase in their salinity. Reed beds, sedges and other fresh-water species have been replaced by halophytes, causing a sharp reduction in the numbers of migratory birds which depended on the former habitat; all reed-dependent species such as purple heron, purple gallinule and reed warblers have disappeared. There is also agricultural encroachment onto the marshes.

Lake Ichkeul is badly deteriorated as the result of the construction of three dams on rivers supplying it and its marshes. These dams cut off almost all inflow of fresh water, causing a destructive increase in the salinity of the lake and marshes. The two ASTER 3-2-1 RGB composites depict vegetation in shades of red. In 2005 (bottom) the water level is higher than 2001 (top), but a large part of the lake appears red due to the presence of aquatic plants. (Source: NASA /GSFC /METI /ERSDAC /JAROS . and U.S./Japan ASTER Science Team)

In 1996 the Park was inscribed on the List of World Heritage in Danger. However, in June 1998 the IUCN observed that the salinity of the lake water may have exceeded any chance of recovering the World Heritage values of the site. IUCN expressed its concern at the slow pace and lack of effectiveness of the rehabilitation program by the State Party and the World Heritage Committee recommended an expert mission to investigate the development of

additional measures to rehabilitate Ichkeul and to determine the progress of mitigation by the Tunisian authorities.

**(b) Conservation Value**

Garaet Ichkeul is the last of a chain of lakes which used to extend across the north African littoral and one of the four most important remaining wetlands in the western Mediterranean Basin. The national park was created to safeguard this wetland with its diversity of terrestrial and aquatic ecosystems. The lake and marshes are of particular importance for the extremely high numbers of wintering Palaearctic waterfowl which still totaled over 90,000 in 1999/2000 and included globally threatened species. The park also protects important fossil mammal deposits and is scenically beautiful. Decreasing the freshwater supply will eventually convert it into a seawater lagoon.

**(c) Conservation Management of water resources**

A management plan developed in 1977 was incorporated into the National Park statutes. The most important objectives were to control the water level and salinity of the lake and to maintain and develop the pondweed *Potamogeton*, the major food source for wintering and migrating waterfowl. The EEC and the French Ministry of the Environment, funded a management study between 1982 and 1985 by University College, London, the IWRB, the Tour du Valat station and consultant engineers SOGREAH to counter the effects of dams and canalizing on the lake and marshland. This initiated designs for a sluice on Oued Tindja to control water salinity by restricting seawater entry and containing the loss of freshwater which was built by 1996. It condemned the dredging and embankment of the Joumine and Malah canals which dry out the marshes, encourage halophyte growth and access by poachers, and recommended a visitor center and cleaning up pollution from the hammams.

In 1996 the Tunisian Ministry of the Environment commissioned a report on measures to reverse the degradation; some have been taken. Three smaller proposed dams have been canceled for the time being, water from existing dams is to be released to the lake and a pumped supply from Sidi EI-Barrak dam (127 km west) may be made available but the necessary pumping station had not been built by 2002. The quarries are to be closed and water treatment plants installed for nearby towns. Government action is to include agreement among the six departments responsible for making decisions about the area of the Park, for water supply, rural engineering, fishing, grazing and agriculture, forestry, local populations and environmental planning. The canals were to be filled in and the marsh restored. A scientific committee from all the researchers studying the park was to be convened. Monitoring of the water, Lake siltation, flora and bird species were to be continued and the analyzed information made available to decision-makers. A government report of 2001 summarizing measures for the lake's protection was taken by the IUCN as the basis for establishing the appropriate conditions for annual monitoring and rehabilitation, for which funding was requested; and in

2003 the Tunisian government asked the IUCN and the Centre for Mediterranean Cooperation for help in restoring the lake with funding from UNESCO.

**(d) Management Constraints**

The site was placed on the List of World Heritage Sites in Danger in 1996 because dams built upstream had cut off nearly all the flow of fresh water to the lake. This had greatly increased its salinity, dried up the marshes allowing livestock to degrade them, and caused a very serious loss of biological diversity. It altered the food chain by greatly reducing the area of *Potamogeton* - in 1988/9, from 3,000 to 500 ha. With replacement at the same time of *Scirpus maritimus* and *Phragmites* by more salt tolerant species, there was a potential loss of 20 percent of the marshland food plants. Reed-dependent species have disappeared with the lakeshore reed beds, and the number of migrating birds has declined. Wintering waterfowl and greylag goose numbers have decreased from 200,000 to 50,000 and 20,000 to less than 1,000 respectively.

The park director still lacks sufficient authority, budget, clear park boundaries, a trained and uniformed staff and an updated management plan. An adequately funded administrative structure advised by a team of scientists is needed to implement the integrated management plan drawn up by the ANPE report team and monitor development. A workshop was held in January 2003 to develop the options for a sustainable future for the lake which again emphasized the need for an enforceable management plan, and the installation of a water regime favorable to the lake. However, the Ministry of Water Resources could only promise 20-25 million m<sup>3</sup>, a quarter of that needed.

There are still six government departments with different responsibilities for and attitudes towards the Park. The marsh canals are un-reclaimed through fear of the effect on groundwater, and stone quarries which provide work but have degraded much of the south side of the Park still operate. The families (~1000 people) squatting in the park are still the cause of overgrazing and land clearance. The whole area is under threat from commercial fishing, logging, poaching, agricultural expansion, and pollution by pesticides, fertilizers and tourism. After heavy winter rain, the ecosystem partially recovers and the number of birds wintering in the west end of the lake increases, but numbers are still low. However, the whole area of and around both lake and mountain, the bird populations and the World Heritage status of the Park all remain at risk from the effects of global warming, lack of rainfall and inadequate mitigation.

**2.4.2 The Azraq Oasis; Jordan (After: Osborne 1981).**

• **Introduction**

The Azraq Oasis (<http://www.aaas.org>), in Jordan is an example of the potential for success of environmental rehabilitation efforts. The major determinants of this success were national and international support, the availability of adequate financial resources, proper/management of

available supplies of water, and, above all, the willingness to act to preserve the natural environment. Azraq is, in general, a water surplus area. Its wetlands have fallen victim to escalating water needs in the water-scarce country of Jordan. Ever-increasing demands for water in the country, and particularly in the rapidly growing city of Amman, resulted in large-scale pumping from the Azraq Basin. Pumping for urban needs escalated from about two million cubic meters (m<sup>3</sup>) in 1979 to about 25 million m<sup>3</sup> in 1993. A huge expansion in agriculture in the region drained an additional 25 million m<sup>3</sup> per year from the basin. This level of exploitation is approximately double the proven annual natural recharge of 25 million m<sup>3</sup> per year, clearly highlighting the major cause of the environmental degradation that the area has been suffering. The roots of the problem lie in part in the country rapid population increase and its changes in lifestyle.

- **The Azraq Oasis ( Jordan )**

The Azraq Oasis, or Azraq Wetlands Reserve, is a unique ecosystem in a fragile environment, lying at the heart of the Azraq Basin and covering some 12,710 km<sup>2</sup>. This region is characterized by desert conditions, low rainfall (not exceeding 50 mm per year), and a high evaporation rate (around 3,000 mm annually). Seasonal Khamasine winds blow into the area. The highest recorded temperature is 47 °C; the lowest is -5 °C.

Azraq area contains a wealth of biodiversity and habitats, and the richest habitat of all exists in its wetlands. Despite its desert location the oasis contains a variety of habitats and micro-habitats that are found only in wetland environments. The diversity of habitats attracted a multiplicity of organisms that are extremely tolerant to the desert conditions, forming one of the most unusual ecosystems in the world.

Three major sub-ecosystems exist in the Wetland Reserve: a lake ecosystem with fresh waters; a marsh ecosystem with moderately saline waters and soils; and a mudflat ecosystem, known as the Qaes, with highly saline waters and soils.

The freshwater ecosystem is an outstanding and unique habitat, containing a variety of animal and plant species. The marsh region that surrounds the pools also contains diverse life forms, which came into existence as a result of restoration efforts. The Qacs is barren and unproductive. The fact that three sub-systems meet and interact in such a relatively small area adds to the importance of this site. The lack of ecological barriers among the different sub-habitats makes it feasible for the species to occupy their respective niches without restrictions.

- **Water in Azraq Oasis "overview"**

Major changes have occurred regarding the ecological status of the wetlands as a result of the massive extraction of ground water from the Azraq aquifers. The main purpose of this extraction was to supply Amman with drinking water. Irrigation was another significant source of demand.

The over-pumping that escalated during the 1980s and 1990s caused a continuous drop in the underground water table (2.5 to six meters). The natural discharge rate of the four main springs fell rapidly, from 10.5 million m<sup>3</sup> per year in 1981 to less than one million cubic meters in 1991. The

two northern springs dried up completely in 1987, and the southern springs finally ceased to flow in August 1992. By December 1992 the Azraq wetlands were completely dry. The rehabilitation efforts of the Azraq Project, especially the cleaning and dredging work, increased the flow of the springs again. However, the increase is very slight, amounting to less than 200,000 m<sup>3</sup> per year.

The result of this degradation was a total collapse of the whole ecosystem. An important factor that contributed to the degradation of the wetland ecosystem was the increase in the salinity of the underground waters, which varied between 1,200 and 3,000 parts per million. The existence of a deep saline underground aquifer in the area caused irreversible changes in the ecological features of the area as a whole.

The extraction of ground water in and around the oasis for agricultural practices has increased rapidly in recent years, and has been largely uncoordinated and uncontrolled. The widespread use of the brackish water for irrigation may well cause even more severe salinity.

- **Water management in Azraq Oasis**

Thus the Azraq Oasis Conservation Project was born, beginning its activities in early 1994. Major efforts were concentrated on securing adequate amounts of water to launch the rehabilitation process. As the hydrogeological system of waters of the oasis are but a part of the larger hydrological system of the basin, achieving a proper understanding of the water dynamics in the whole Azraq Basin was an unavoidable prerequisite. The lakes in the oasis represent the intersection of the underground water table with the areas topography. Extensive research also demonstrated that the lakes represent the center of the water basin. Underground water veins as well as the surface runoff that flows in wadis all end in the wetlands the lowest point within the Azraq Basin.

Additional research demonstrated that the waters of the Azraq Basin are not only the major environmental media for the wetland reserve, but are also one of the major sources of supply for the biggest city in Jordan, Amman. Amman receives over 25 percent of its potable water from Azraq. Research also proved that the waters of the Azraq Basin are salinizing at an alarming rate. Hydrological studies demonstrated that a saline front, located to the northeast of the oasis, is rapidly advancing toward the fresh waters of Azraq. The hydrostatic barrier separating the two qualitatively distinct waters of Azraq is moving rapidly in favor of the saline water. The main cause of this phenomenon is the over-pumping of fresh water. There is a real possibility that the waters of Azraq could go completely saline.

The solution came through environmental planning and proper administration of the available environmental opportunities of water. The implementation had geographic and administrative dimensions. The basic idea was to use available water with careful attention to timing and location in order to achieve the environmental rehabilitation of the oasis and preservation of the water basin.

After extensive and thorough investigation of the hydrogeological system, a series of scenarios were prepared. All scenarios were based on the idea of reverse pumping of waters to the epicenter

of the water basin, represented by the lakes themselves. These plans were submitted to the Ministry of Water and Irrigation, which is responsible for all the waters of the whole country. After intensive negotiations and scientific debates, the Ministry agreed to reverse pump 1.5 to two million cubic meters of water per year to the lakes through the existing pipe network.

The source of the waters pumped to the oasis has been a well field belonging to the Water Authority, located in a relative water surplus area about 12 kilometers to the north of the wetlands. Experimental pumping started in June 1994 and reached full capacity in September of the same year. In addition, extensive rehabilitation and clean-up operations for the major springs in the lakes were conducted. Many of the wadis leading to the reserve were cleaned and deepened to enable channeling of as much of the surface runoff as possible during the rainy season.

Towards the end of October, the water table in the lakes started rising, and parts of the oasis started to come back to life. Beginning in November the rainy season of 1994-95 was above normal, and over ten million cubic meters of water reached the wetlands almost twice the annual average of surface runoff. The next season (1995-1996) was a declared national drought. The area received less than 30 mm of rain in total for the season. Nevertheless, because of the rehabilitation efforts, a large portion of the wetlands remains in an environmentally and ecologically healthy state, with the water covering over 3.5 km<sup>2</sup> in the marshes and lakes.

- **Benefits and Achievements of the IWRM in Azraq area** (Fariz & Hatough-Boura 1997)
  1. An adequate amount of water was secured to revive and rehabilitate the Azraq wetland ecosystem and its biodiversity.
  2. The water quality of the Azraq Basin was enhanced, as the advance of the saline front was slowed. Today the danger of the complete salinization of the Azraq Basin is much lower.
  3. An incremental minimization of pumping was attained. The ideal solution of bringing pumping down to the systems natural safe yields was not attained, yet it is a change in the right direction. The precedent of reverse pumping to save the Azraq water supply and ecosystem has been established.
  4. Positive socioeconomic trends among the local community have been attributed to the rehabilitation of the oasis. Increasing numbers of tourists are visiting the area, and numerous companies have expressed interest in investing in tourism and eco-tourism.
  5. The local people, after a lengthy period of frustration, were empowered and started to participate in the overall socioeconomic development of the area. With the support of the Azraq Oasis Conservation Project, a grassroots movement known as the Friends of Azraq Society was established primarily aimed at environmental preservation and achievement of local socioeconomic stability.

- **Lessons and experience of the Azraq Oasis management Project:**

1. Population pressures and escalating demands for water can lead to severe abuse of the available finite environmental resources, even to the point of irreversibility.
2. The knowledge availability is an essential issue for to proper action.
3. Involvement of local people in environmental management is one of the prerequisites for success, not only to implement projects, but also to preserve achievements and make them enduring.
4. Engineering solutions, such as those implemented in Azraq, can yield enormous socioeconomic results, especially in terms of raising public awareness and empowerment of local populations.
5. National and international support in administrative and financial terms is valuable in achieving remarkable results. In frustrated environments and communities, outside intervention may be needed to create change. Nevertheless, while initiation of projects using international money can trigger some changes, it is vitally important to keep the momentum through the support of national organizations and local people.
6. Issues of environmental rehabilitation are inseparable from water/population dynamics and other socioeconomic issues, particularly in arid regions, and should be handled in a comprehensive manner.

### **2.4.3 Water management in Yemen**

Yemen's ancient terrace systems and historical dams provide excellent examples of traditional watershed management, reducing soil erosion and slowing damaging run-off, aiding infiltration to groundwater and streams, and retaining water and providing high yielding agricultural land for the farmer. However, modern Yemen has proven not so good at dealing with public goods and externalities. Modern Yemeni communities have no tool to manage the classic watershed management trade off between upstream and downstream interests. As a result, there are frequent signs of catchment deterioration affecting both land and water: erosion, deforestation, groundwater depletion, saline intrusion, dried up springs, and flood events.

- **Yemen Protected Area**

Yemen is facing a water crisis. Environmental degradation is causing the disappearance of natural habitats and unique biodiversity, from especially the wetlands, at an alarming rate. Most Yemenis live in rural areas and are dependent on the use of natural resources, especially water for agriculture, which form the basis of Yemen's national economy. This means that the depletion or degradation of these resources have serious implications for the livelihoods of a sizable majority of the population.

Yemen's fragile Aden wetlands has significantly changed the way people, from senior Government officials to marshland residents, view the importance of this endangered ecosystem this was supported UNDP-project. This four-year project resulted in two key areas being declared nationally protected parks, including the Jabal Bura'a National Park, covering an area of 4,287 hectares, and the Aden Wetlands Protected Area, covering an additional 2,580 hectares and encompassing five crucial wetland areas(Fig.10).



**Figure 11:** Yemen protected area

The project, in partnership with the Government, has transformed an area that was nothing more than an open dump and stagnant pools of water back into a living, breathing marshland that is once again attracting a number of species of birds, including flamingos, crab plovers and ospreys. The land was previously earmarked for development but through advocacy and education, the interests of a sustainable future won out. Perhaps more importantly, the transformation has occurred through the participation of local villagers, who depend upon the marshland for their livelihoods. For example, many of them have received training as tour guides for the wetlands, which have become a destination thanks to the creation of walking trails, picnic sites and the construction of a two-storey bird observatory. And while the Aden Wetlands does not yet have a management board, the local community has created, and largely manages, their own community nature reserve with support from Yemen's Environmental Protection Authority.

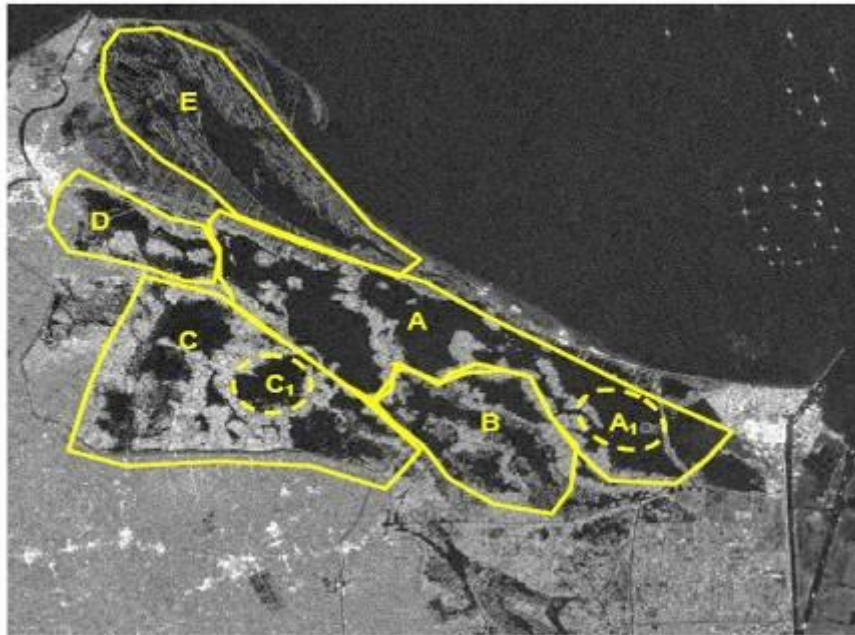
#### **2.4.4 Water Management Project in Manzala Lake, Egypt**

Emerging water management technology has seen only limited use worldwide, and even less use in the context of trans-boundary water governance. One location where the integrated use of different emerging water monitoring technologies has been piloted is in the Nile Basin in Egypt in two recent programs were applied, namely:

1. "An Environmental Security and Water Resources Management System Using Real Time Water Quality Warning and Communication" implemented in 2007 under the Science for Peace initiative of NATO
2. "Satellite Monitoring of Lake Water Quality in Egypt" implemented in 2005 and funded under the

TIGER initiative of the European Space Agency (ESA)

In recent years, Egypt has become increasingly vulnerable to the loss of Nile waters through a combination of withdrawals by upper riparian countries, water pollution, climate change, and increasing water demand / in Egypt and throughout the Nile basin. Egypt depends on the Nile River for 97% of its surface water. Real time water monitoring involves continuous measurement of water related parameters in-situ with results provided in real time or near real time. The water monitoring system implemented under the NATO Science for Peace initiative comprised of four real-time water monitoring stations (quantity and quality), one automated weather station, and set-up of a data collection and reporting command centre (Khan *et al.*, 2006). Water station to measure the water quality was established in Manzala Lake as shown in Fig. (11).



**Figure 12:** Sites in which the IWRM project was implemented in Manzala Lake

#### **2.4.5 District Decision Support Systems (DSS) for Irrigation and Drainage Water Management in Beni Sueif and Minia Governorates/Egypt (IUCN 2007)**

In **Egypt**, the REWARD project will work on developing a practical DSS at the district level for the irrigation/drainage system in the Nile Valley. DSS project will much focus on cropping pattern forecasts and calibration of water availability and demand. At the same time, farmer organizations are encouraged to participate in the design of such a district DSS to better adapt environmental cropping requirements to availability of water.



**Figure 13:** District Decision Support Systems (DSS) for irrigation and Drainage Water

The project is strongly supported by the Ministry of Water Resources and Irrigation, as it fits very well in developing models for decentralized management of irrigation and drainage systems at the district level. The project will be implemented by The Center for Environment and Development for the Arab Region and Europe (CEDARE), in cooperation with CEOSS and CARE Egypt. All REWARD projects build strongly on the methodologies for participatory planning and stakeholder dialogue in the water sector developed by EMPOWERS project that was funded by the European Commission and implemented by CARE International with local and international partners. Water resources management is becoming an increasingly important issue for policy makers. However, without changes in the way consumers use water, sustainable water resources management is impossible. Raising awareness should be seen as an interactive process in which different parties are engaged, each with their own roles, responsibilities and ways, to make their voices heard and create social change.

In this context, two training courses on “How to design & Implement Public Awareness Campaigns” were held in both Morocco and Syria. The outcome of the workshop showed not only high level of cooperation between the different participants, but also intensive knowledge sharing through learning by doing. This exercise enables the participants to explore some of the conceptual notions behind raising of awareness and its relation with knowledge, attitudes and behavior that are useful to understand how communication influences behavior. This is based on a wide spreading recognition on how to mainstream gender issues and the need for community involvement in government or NGO initiated programs to ensure that their needs are addressed in all policy, procedures and practice. This has to be reflected also in all areas of public awareness campaigns so as to improve use and management of water resources. To this end, the training methodology used the EMPOWERS participatory planning cycle for Integrated Water Resource Management (IWRM). This cycle builds on the identification of water-related problems and the development of area specific long-term visions and strategies for water resource development to support

stakeholders at different levels in making the technical and political decisions to develop and manage their water resources.

This integrated water monitoring, warning and reporting system will allow the management of Egypt's water resources using a real-time pro-active approach, providing decision makers with information about the present status of water quality. It will allow senior water managers to protect the integrity of Egypt's vital water resources against any natural or anthropogenic threats, take immediate corrective and mitigation measures, and report the suitability of water for designated beneficial water uses. Such a real time water monitoring network will lay the foundation for greater environmental security and water resources management in the country.

#### **2.4.6 Water desalination at Omayed Biosphere Reserve, Egypt**

Omayed (El Omayed) Biosphere Reserve lies about 80 km west of Alexandria. Part of Egypt's Western Coastal Desert, it is located on the Mediterranean coast. Water is scarce and variable. Groundwater in the Omayed Biosphere Reserve comes from the Moghra and Wadi El Natrun Aquifers. Unfortunately, due to over-extraction and infiltration, both are now saline.

At that first meeting with the local community (villagers) in this biosphere, the challenge was the scarce of the clean water. The Biosphere authority decides to involve the villagers in dryland conservation projects, they had to propose a solution to their shortage of clean water. The desalination of well water seemed the most option. Although large-scale desalination technologies have been used in Egypt for many years, these have not yet become widely available in a form that would suit the needs of the Bedouins especially in protected areas.



**Figure 14:** Small Scale Solar Unit at Omayed Biosphere

The small scale solar powered desalination system meeting all the above criteria was invented by a German scientist on the basis of technology that goes back two thousand years to the Roman Empire in Europe. For the process to be sustainable, water would need to be pumped in amounts permitting its natural replenishment. The technique would have to be

simple, clean, environmentally friendly and compatible with the local culture. It would have to use a minimum of energy, adapt to the natural conditions and require little maintenance.



**Figure 15:** Delivery of water to households in Omayed Biosphere Reserve

Salty water was pumped from the well in the protected area and traveled to water tank, heated by solar panels. Water evaporates in the form of water vapor leaving salt residues. The water vapor then condenses on a gently sloping ceiling, water drops formed and later collected. About 100-120 liter of water was produced per day depending on the amount of sunlight. The Bedouin community has shown a great appreciation. This is an example of the best management of water resources even of it is salty (Boshra 2006).

#### **2.4.7 Water Management in Elba protectorate, Egypt**

Rainfall shortage during the last decades reflected on the water quality in these wells. The management team in the Elba protectorate, try to manage water resources based on two following issues: (Osama El Gazaly, manager of the protected area, report on water management by personal communication).

- (a) A drip irrigation methodology was used for farming area within the protected area. This protocol was achieved by using controlled well mouth and directs the pumped water in the irrigation lines as outlined in Figure (15).



**Figure 16:** Controlled water extraction from a well in Abu Saafa, Elba protectorate, adjusted for drip irrigation.

- (b) At Abu Saafa, the newly established sandy dam (Figure 16), was to secure the watershed during rainy season and to collect water to be used by the local Bedouins in dry season.



**Figure 17:** Water dam in Abu Saafa, Elba protectorate

#### **2.4.8 A successful WM: the PREM project in Morocco (after d'Ostiani 2004)**

The ongoing Pérennité des Ressources en Eau du Maroc (PREM) project focuses on conserving water resources. Co-funded by the Ministry of Environment (25 percent) and the United States Agency for International Development (USAID), the project started in 1996 with a total budget of US\$16 million. It included several initiatives for water saving, recycling and water management, such as:

- Waste water treatment and recycling in Agadir Province;
- Water resource conservation in the irrigation, urban and industrial sectors;
- Experimentation of pollution-prevention systems in Oued Sebou Province.

The PREM project aims to reinforce the Ministry of Environment's capacity to implement its agenda and develop a more effective role in the coordination of sectoral policies. The project also worked on water management in the Oued Nakhla river basin, which was identified as a priority area because of the serious soil erosion that affects the Rif Mountains in northern Morocco.

This started with an in-depth analysis of soil erosion factors based on statistical data and participatory local surveys, which identified two types of action for project implementation: direct actions to prevent soil erosion (planting of fruit trees, rehabilitation of irrigation networks, stabilization of soil, etc.); and indirect actions for mitigating human pressures on natural and forest resources and for diversifying local communities' sources of income. Farmers' associations and village committees were established to carry out project activities, which also involve the

Environmental Department of the Ministry of Agriculture, local administrations and the Northern Provinces Development Agency.

The role of each partner is formally defined in a convention. The Agricultural Directorate of Tetouan District is responsible for carrying out field activities, and four different operational zones have been defined, covering a total area of 500 ha, 20 percent of which is degraded forest ("matorral" or scrub). By the end of 2002, five village committees were coordinating local farmers' activities. More than 70 000 olive trees have been planted on sloping lands, and laurels have been planted in the valleys. Several workshops have been held in order to include local farmers in the dissemination of good technical practices and local women in income-generating activities related to forest wood and non-wood products. Future activities include the sowing of local fodder species in the area to improve its biodiversity.

- **Assessment of WM approaches in Morocco (after: d'Ostiani 2004)**

Most of Morocco's national territory suffers various forms of soil erosion, and 25 percent of the total watershed land area is at high risk of erosion. Upstream soil fertility is decreasing rapidly, while downstream reservoirs are losing much of their stocking capacity (65 000 m<sup>3</sup>/year - i.e. 0.5 percent of their overall stocking capacity - which could supply enough water to irrigate 5 000 to 6 000 ha of land). Operation and maintenance (O&M) costs for various infrastructures are increasing. Drinking-water availability per capita, which was 1 151 m<sup>3</sup>/year in 1990, is expected to drop to 689 m<sup>3</sup>/year by 2025. In the meantime, Morocco has evolved through the following steps:

- 1917-1951: preventive measures for forest resource conservation and the fight against slash-and-burn techniques.
- 1952-1969: special legislation and public action to combat soil erosion through contracts with communities and landholders or within the framework of National Interest Perimeters;
- 1970: reconnaissance study of erosion status, covering water mobilization policies, watersheds that are upstream from major irrigation schemes, and the drafting of a general plan of action.
- 1997: adoption of a National Watershed Management Plan (PNABV) as the strategic framework for integrating small-scale, local-level planning and long-term integrated participatory WM.
- Establishing a National Council on Water and Climate (Conseil superieur de l'eau et du climat), November 1996.
- Establishing the Hydraulic Basin Authority of Oum Er-Rbia, November 1996;
- Reviewing master schemes for water resources and their integrated management (Plans directeurs d'aménagement integre des ressources en eau) and for the PNABV, October 1997;

- Establishing fixed regulations for the collection of water in dams, 1997.
- A system of authorizations for the use of public water resources, 1998.
- New rules and limitations regarding changes to river beds' morphology and the extraction of material, February 1998.
- Creating District Water Commissions, February 1998.
- Defining water quality standards and carrying out an inventory of water pollution levels, February 1998.
- Defining standards for waste water recycling, February 1998.
- Delimiting areas for the protection of water aquifers, February 1998.

On the one hand the new PNABV approach involves major costs and a long-term horizon for extension services, training and capacity building, on the other hand it ensures users' ownership of soil and water conservation works and significant improvements in cost/efficiency ratios. As well as a need for a new funding mechanism with extra-budgetary resources, management flexibility and a system for setting priorities (Omeranai 2002).

#### **2.4.9 Marj Sanour Watershed Development in Jenin/ Palestine (IUCN 2007)**

In Palestine, the Regional Water Resources & Drylands Programme (REWARD); work on a simple model for watershed development planning, supported by a user-friendly Decision Support System (DSS) that can be applied in the mountainous zones of the Middle East. This will be tested and applied in Marj Sanour, a closed watershed in Jenin Governorate. The project will give important emphasis to sustainable livelihoods, agricultural development of rain-fed crops, as well as olive and fruit orchards, in addition to conjunctive use of ground and surface (run-off) water. This is an example to manage water in watershed area in a the most troubled area in the world.

The project is supported by the Palestinian Water Authority, Ministry of Agriculture, Ministry of Local Government and the Environmental Quality Authority. It will be implemented with newly identified IUCN members, such as the Palestine Hydrology Group and the Union of Agricultural Work Committees (IUCN 2007).

#### **2.4.10 IWRM in Saudi Arabia (IUCN 2007)**

No available data concerning IWRM in Saudi Arabia protected areas. However, the Bedouins' ethics and traditions in such type of dry deserts have a very good experience in water management along the time. The National Commission for Wildlife Conservation and Development (NCWCD) has a strong partnership with IUCIM, which extended over 20 years of technical collaboration in protected areas management in Saudi Arabia. A workshop on The Participation of Local Communities in Establishing and Managing Protected Areas was held in July 2007 by the Protected

Areas Programme and NCWCD in Saudi Arabia. As an outcome of the technical workshop, a Strategy for Protected Areas Management was developed for NCWCD.

#### **2.4.11 Al Zaranik wetland, Egypt (El-Shinnawy 2002):**

The Physical Settings of the Al Zaranik wetland (Fig.17) is represented by most eastern region of Al-Bardaweel Lake that is situated along the Mediterranean coast in North Sinai. It's a shallow hyper-saline lake, connected with the sea by two small outlets (Boughaz). The depth of the lake ranges between 0.4 and 1.85 m. The eastern sector of the lake is the shallowest, showing an average depth of 0.5 m. The present area of the wetland is about 250 km<sup>2</sup>, of which 68% (170 km<sup>2</sup>) is open water and 32% (80 km<sup>2</sup>) is sand dunes. The Wetland is separated from the sea by a strip of land covered with sandbars and dunes of varying widths and heights. Recently, the international road that would connect North Africa States has been constructed to the south of the wetland. The bottom of the lake is sandy material. The wetland is one of most well known areas for birds' migration.

Currently, the Government of Egypt represented by the Ministry of Water Resources and Irrigation (MWRI) is implementing Al-Salam Canal that will divert the Nile water to Sinai. Unfortunately, Al-Salam waters is mixed from Damietta Nile Branch and agricultural drainage water (Bahr Hadoos drain and Al-Serw drain) that contains many pollution sources. The agriculture practices that will be activated in the near future will affect the pollution-free environment of Sinai. Also, it will affect the environment of Al-Bardaweel Lake through groundwater seepage to the Lake. As a result, it would be of high importance to consider the agricultural practices to the south of the Lake as an urgent issue.

- **Hydrological Evolution of the Wetland**

Many factors have contributed to the hydrological evolution of the lake. The more important of which is the development of the Arabic chief that took place about ten thousand years ago. It has been developed as a result of tectonic actions that resulted in initiating the Suez Gulf and Al-Aqaba Gulf. It has been developed as a low-level depression to the north of Sinai where water seeps to that depression from the groundwater after rainfall season and from the sea all over the year. Moving forward with poor water movement, accumulation of salts resulted in a hyper-saline environment. Al-Bardaweel Lake was developed more with the increase of its importance for fish catching. The area was more developed as it receives many types of birds all over the year.



**Figure 18:** Showing Zaranik protectorate area

The national and international authorities have paid more attention to the area after it was used extensively by Israelis for fish production during the occupation of Sinai (1967-1979). After the liberation of Sinai, Al-Bardaweel Lake has become one of the most important lakes for its role in fish production and birds migration.

Rainfall data recorded at Al-Arish (70 year) and Port Said for a period of 100 year has been collected and examined. According to the World Meteorological Organization recommendations, data collected from these two stations has been considered as a representative for the whole lake as the area of Al-Bardaweel Lake is less than 1200 Km<sup>2</sup>.

Rainfall data recorded at Al-Arish and Port Said were collected and estimation for rainfall depths at Al-Zaranik has been produced and examined. Monthly records of rainfall data have been treated and statistically analyzed. Mean monthly values have been estimated and presented in Table (21).

Analysis indicates that the mean annual rainfall over the area is 92.52 mm. This depth of water provides the wetland with mean annual volume of about 15.73 million cubic meters. Analysis also demonstrates that most rainfall takes place during the winter season (October - March). The area does not receive any rainfall in the summer months. The maximum depth of rainfall is received in December and January.

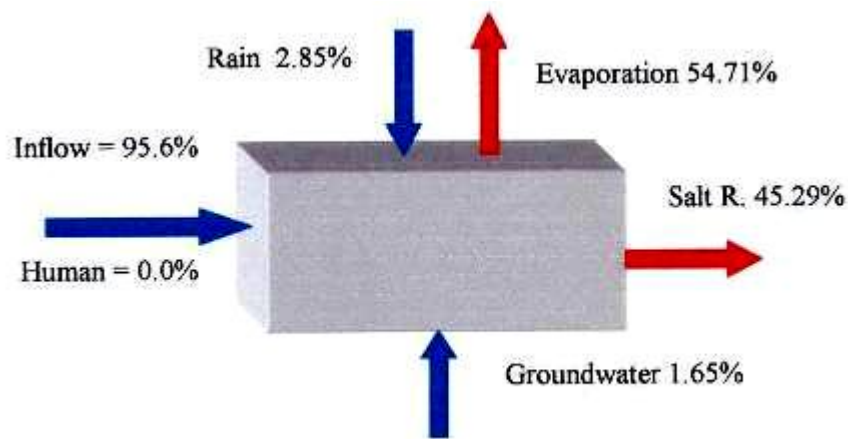
**Table - 21: Monthly Rainfall Depth and Volume over the Wetland**

Month	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Depth	18.8	16.0	11.9	5.81	2.4	0	0	0	0.5	4.4	13.8	18.7	92.5
Volume (in Million m <sup>3</sup> )	109	113	138	147	161	167	179	176	165	157	138	127	15.7

- **Groundwater Inflow/Outflow**

The behavior of the aquifer in the dune system provides an idea about the discharge and recharge process. The recharge was estimated at 38000 m<sup>3</sup>/day and the discharge from the aquifer was estimated at 14000m<sup>3</sup>/day. As a result, the net recharge is about 24000 m<sup>3</sup>/day. This volume represents the life body of water that result in water flow to Al-Bardaweel Lake.

Catchment area studies revealed that water moves northward from the quaternary aquifer to Al-Bardaweel Lake. The permeability coefficient of an average value of about 425 m/d was considered in groundwater modeling. Using an average slope of the ground surface of about 0.0025 m/m and an interface length of about 22.5-Km, the groundwater aquifer contributes to the wetland an average daily volume of about 24000 m<sup>3</sup> by utilizing Darcy's equation and Poisson's assumptions. This rate contributes an amount equal 720000 m<sup>3</sup>/month. This volume will be considered as a constant rate of groundwater contribution each month. Figure (18) represents a mathematical Model for the groundwater flow system at Al-Zaranik Wetland; North Sinai. It illustrates the relation between the groundwater aquifer and the Sea including the wetland (El-Shinnawy 2002).



**Figure 19 :** Water Balance of Al-Zaranik Wetland  
(after : (El-Shinnawy 2002).

- **Evaporation**

Evaporation measurements by Al-Nasr Salt Production Company in the wetland have been collected. To calculate the monthly evaporation, the daily value for a certain month was multiplied by the number of the days in that month. The monthly values of evaporation have been transformed to volumes of water losses from the wetland by considering the surface area of the water body in the wetland (68% of 250 km<sup>2</sup>). To involve evaporation losses in the water balance equation, time interval was introduced and considered. The total volume was estimated to be as much as 302.09 million cubic meters per year (Table 22).

**Table - 22: Average Daily, Monthly, and Volume of Evaporation**

Month	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<b>Daily</b>	3.52	3.04	4.35	4.9	5.2	5.67	5.77	1.68	5.5	5.06	4.6	4.1
<b>Month (mm)</b>	109	113	138	47	161	167	179	176	165	17	138	127
<b>Vol. million</b>	18.3	19.2	23.4	24.9	27.3	28.3	30.4	29.9	28.0	26.6	23.4	*
<b>Daily</b>	3.52	3.04	4.35	4.9	5.2	5.67	5.77	1.68	5.5	5.06	4.6	4.1
<b>Month (mm)</b>	109	113	138	47	161	167	179	176	165	17	138	127
<b>Vol. million</b>	18.3	19.2	23.4	24.9	27.3	28.3	30.4	29.9	28.0	26.6	23.4	*

\* No available data

- **Interaction between the Wetland, the Lake, and the Sea.**

To estimate the interaction between the wetland and the adjacent water bodies represented by Al-Bardaweel Lake and the Mediterranean Sea, a water balance procedure was implemented.

A water balance is a systematic method for quantifying the hydrologic components that are important within a specified drainage system. A water balance includes all of the major sources and sinks of water with the hydrologic boundaries of the wetland system. A water balance is often used to estimate the magnitudes of unknown hydrologic components such as outflow and the change in storage within the wetland. To evaluate the change in the storage for Al-Zaranik Wetland, the water budget was estimated as follows:

$$\frac{dt}{ds} = Inflow - Outflow$$

Where:  $dS/dt$  = change of storage within the wetland over a specified time interval, Inflow represents water bodies contribution to the wetland, Outflow represents water losses and water interaction with the sea.

Inflow terms are the rainfall volumes and groundwater distribution, and water intrusion while, the outflow term is represented by evaporation and water released from the wetland for salt production requirement. The process was made on monthly basis. Results of the water balance are presented in Table (23).

**Table - 23: Water Balance of Al-Zaranik Wetland**

<b>Month</b>	<b>Rainfall (10<sup>6</sup> m<sup>3</sup>)</b>	<b>G Water (10<sup>6</sup> m<sup>3</sup>)</b>	<b>Salt Req. (10<sup>6</sup> m<sup>3</sup>)</b>	<b>Evaporation (10<sup>6</sup> m<sup>3</sup>)</b>	<b>Inflow (10<sup>6</sup> m<sup>3</sup>)</b>	<b>Water depth (cm)</b>
<b>Jan</b>	3.2	0.72	1.33	18.53	-29.945	-17.6
<b>Feb</b>	2.73	0.72	15.90	19.21	-31.66	-18.6
<b>Mar</b>	2.02	0.72	19.415	23.46	-40.13	-23.6
<b>April</b>	0.99	0.72	20.68	24.94	-43.91	-25.8
<b>May</b>	0.418	0.72	22.65	27.37	-48.88	28.75
<b>June</b>	0	0.72	23.49	28.39	-51.16	-30.1
<b>July</b>	0	0.72	25.18	30.43	-54.89	-32.3
<b>Aug</b>	0	0.72	24.76	29.92	-53.96	-31.7
<b>Sep</b>	0.086	0.72	23.21	28.05	-50.46	-29.7
<b>Oct</b>	0.755	0.72	22.09	26.69	-47.303	-27.8
<b>Nov</b>	2.345	0.72	19.415	23.46	-39.809	-23.4
<b>Dec</b>	3.182	0.72	17.87	21.59	-35.555	-20.9
<b>Total</b>	15.726	8.64	250	302.04	527.678	
<b>% WR</b>	2.85	1.65	45.29	54.71	95.6	

% WR = Percentage of item related to total water volume within the system

**The water balance outlined in Figure (18) indicating the following:**

- Rainfall represents less than 3% of the total inflow to the system.
- Groundwater contribution represents less than 2% of the total inflow to the system
- Total water inflow to the wetland represented by rainfall and groundwater contribution is about 24.37 million cubic meters annually.
- Evaporation losses represent about 54.7% of the total outflow of the system
- Salt water requirement represents about 45.3% of the water outflow of the system

- Water moves always from the sea towards the wetland
- Water in the wetland goes below sea level with depths range from -17.93 to -32.3 cm.
- The water movement below sea level is not observable, as the rate is less than 1 cm per day. Wave movement recovers this daily draw down.
- Results indicate and provide the main process of water movement in the system that takes place continuously from the adjacent water body to the wetland.

## **CHAPTER III**

### **IDENTIFICATION OF THE STRENGTHS AND WEAKNESSES OF THE IWRM CURRENT PRACTICES IN PROTECTED AREAS (PAs)**

#### **3.1 The basic elements and challenges to the application of IWRM in Arab World**

A wide range of issues associated with the relationship between protected areas and application of the integrated water resources plans. Among these issues challengers are mostly related to the shortage in available knowledge for beneficiaries and decision makers at the same time particularly from the following points:

##### **(a) Environmental, biophysical and hydrological functions of the IWRM plans in PAs.**

- Protection of the water catchment's area within the protected area and the related area outside.
- Smoothing of peak flows and reduction of downstream flooding to save soil.
- Climate and moisture regulation are influenced by flows during dry seasons;
- Prevention of soil erosion through reduction in the velocity of precipitation
- Protection/improvement of water quality for downstream processes.
- Improve the environment for ecotourism
- Presence fish species, enhanced by presence of sustainable water body.
- Sustainability of natural and anthropogenic vegetation; to maintain the stakeholder's benefits.

##### **(b) Possible economic contribution of the IWRM plans in PAs.**

- Source of commercial fish species, or others e.g. crab, shrimp.
- Avoided costs of flood damage
- Water available for additional cropping; both of wild or cultivated origin
- Less arid microclimates for crop production and sustaining soil fertility through keeping its moisture.
- Retention of soil fertility, savings from reduced need to apply artificial fertilizers as replacements
- Low cost/free input of goods and services for recreation experiences
- Supply and maintenance of suitable water quality and other conditions as free input into growth and reproduction of commercially valuable species and raw material in local and national level
- Improved life performance of the local inhabitants.
- Commercial value of maintaining food sources for harvested species all-over the year.

### **3.2 Difficulties encountered the application of IWRM in PAs:**

#### **3.2.1 Difficulties related to the valuing of water resources in PAs:**

Protected areas (PAs) safeguard the hydrological and biophysical functions provided by the natural environment. These functions protect water volume, quality and regulate its flow. In this way, PAs help to maintain the economic benefits that local and national communities derive from sustainable water use. However, the poor planning, inadequate protection and ineffective management of PAs in Arab World reduce the ability of the PAs managers to apply the IWRM. Water resources are fundamental to human livelihood, regional and national economic development. Each year billions of dollars are spent in trying to manage water resources to meet human needs: to prevent flooding, to provide a source of clean energy; and to provide water supplies for domestic and industrial consumption and sanitation.

Protected areas are a key component in protecting and enhancing the availability, quality and quantity of water resources, and thus in providing economic benefits to local, provincial, and national economies. The achievement of water valuing is facing a wide range of difficulties among of them:

- Local communities in the PAs are mostly poor people.
- The problem of pricing: The pricing can be regulated by the price mechanism, between the supply of the resource and the levels consumed.
- Who will pay the costs of freshwater treatment, infrastructure for WRM, and the waste water treatment.
- Allocation of the indirect costs (and benefits) arising from the consumption of the reused by third parties.
- There is no financial pressure on users to consume water resources efficiently.
- The term of the economic costs of environmental degradation associated with water over use is not applicable in Arab World.
- Rainfall low, climate extreme, higher means temperatures, lower stream density, water scarcity an emerging constraints.
- Who pays for IWRM? When (water is publicly owned in most countries?)

#### **3.2.2 Difficulties related to information management in PAs:**

- No, or loose indicators and reduced management data with low significant information.
- No, Arabic or typical Arid land model for IWR, especially in the Protected Areas.
- No available data for water resources: duration, quality, quantity, recharge duration and amount.
- Lack of knowledge about the impact of the applied IWRM on microclimate and the on surroundings (fauna and flora).
- Decision makers and beneficiaries must be informed that: World Bank move to a more coordinated approach to at least some areas of water resource management which will "...integrate lake and reservoir management policy into its training programs for integrated river basin management and

integrated coastal zone management; support preventative and restorative measures and support a Lakes Management initiative...". The increasingly important role of PAs in water resource management must also be taken into account (Ayres *et al.* 1997).

### **3.2.3 Difficulties related to legislations addressed to the PAs:**

- Appropriate legislations to determine the water supply functions (e.g. irrigation, drinking water, industrial, recreation, waterfalls, ...) for each water source.
- Establishing guidelines for water use and ecological protection for sensitive systems, including protected areas.
- Legal pressure must be directed to enhance users to consume water resources efficiently.
- Most water users get their water directly from rain and from private or community storage without any significant mediation from public agencies or organized service providers because the bulk of water provision takes place in the informal sector, it is difficult to pass enforceable water legislation.

### **3.2.4 Difficulties related to institutional issues"organization management-Capacity Building and Research needed:**

- Water resource managers and economic planners must better understand the contribution of PAs to water resource development.
- Awareness programme must be directed to the role of PAs water resource management and the need to develop an integrated approach to water resource planning.
- The need to carry out robust studies to value the economic benefits of the hydrological and ecological services provided by PAs for water resource-based development.
- Decision makers must incorporate PA establishment and water management into an integrated approach to river basin management and national economic development.
- Economists and PA managers to encourage national planners and donor agencies to appreciate the role of protected areas in creating economic benefits, especially with regard to water resource management.
- Water management initiatives, are encouraged to incorporate protection of natural water services in an integrated planning framework.
- In addition to the value of species protection, biodiversity conservation and landscape protection in these PAs. Also the protected area managers, local community and decision makers have to be confident with the economic contribution of the water-based sectors to the national economies.
- Water resource planners, engineers and beneficiaries invited to become conscious during selection of the best technological/engineering approaches for IWRM.
- Protected areas managers need to demonstrate to water resource agencies and national development economists that PAs can play a major role in water resource management, and thereby provide eco-

conomic benefits to local and national communities.

- Foundational water institutions (formal water governance structures in a nation) appear to drive good governance from the top down. What are the basic organizational and functional requirements of water policy, water law, water pricing, and funding national water initiatives?

### **3.3 Topic for assessment of the current (or future) application of IWRM in protected areas:**

1. Which implementation factors of IWRM make the difference?
2. How can the implementation of these factors be accelerated? And who can monitor this process.
3. Nomination of a generic template of "best IWRM practices"; must be nominated and approved from environmental and scientific views.
4. Are evidence-based solutions rather than experts' opinions of what is the best IWRM?
5. Who and how we can assess the IWRM and identify the terms of the best practices?
6. What indicators should we use to assess the best IWRM?
7. Do we have enough knowledge to already adaptively manage?
8. How much further governance research is required?
9. How much further awareness programmes are required? In what topic, time, and beneficiaries?.
10. How can we separate IWRM practice in PAs from overall national economic development plan and practices?
11. How we can tell that IWRM has made a difference or save environmental change?
12. Who pays for IWRM? Should there always be a private sector partner when the common resource (water) is publicly owned in most countries?
13. How is IWRM best taught for a coming generation of water resources managers? Workshops, masters-level programs, in-service training, or combinations of these?
14. What is the appropriate time frame for integrated adaptive management? Can we see results in generational time frames?
15. How do the contextual dynamics of integrated watershed management and the broader approach, IWRM, influence outcomes?

Finally, the above topic has provided new insights into the widespread experience of IWRM (Hooper 2005).

## **CHAPTER IV**

### **THE BEST PRACTICES AND MODELS OF IWRM:**

#### **TUNISIA'S EXPERIENCE IN WATER RESOURCE MOBILIZATION AND MANAGEMENT**

#### **4.1. Introduction**

As far as the authors know, the Integrated Water Resources Management (IWRM) in Arab biosphere reserves is still not quite obvious. The Tunisian's example for IWRM is the most successful one in the Arab Drylands. Tunisian civilizations have developed management systems extended time ago to cope with the risks of floods and droughts (Louati & Bucknall 2009). Recently, the government has invested heavily in measuring, mobilizing, and managing resources and practical steps in managing water, showing the evolution from traditional practices to large government-led investments to store and transfer water. However, the Tunisia's experience could be further improved, it still representing a good example of planning and management among the Arab countries.

#### **4.2. Water problem in Tunisia**

Tunisia is a Mediterranean country in which rainfall is the main water source. Nowadays, the available water 4836 Mm<sup>3</sup> /year, this volume is less than 500 m<sup>3</sup> / Capita/ year. This volume will decline to 360 m<sup>3</sup> by 2030. In addition, Tunisia shares international surface water in some rivers along the western border with Algeria, where an agreement for water mobilization and use was developed. Water transfers along the country from North to South, in Ancient time through Zaghouan (built in 72 AD) the Roman aqueduct, similarly, Mejerda-Cap Bon Canal (constructed in 1982). The irregular supply and amount variability highly affect the country in the form of floods and shortages of varying seriousness. However, the infrastructure available and the applied practices in recent decades have enabled Tunisia to store and transfer water, thus reducing the impacts of both flood and drought.

Tunisia has also water quality problems. Less than half of the country's water resources containing a reasonable salinity (< 1.5 g/l). Consequently, surface water is used both for direct consumption and to improve the quality of other water resources.

### **4.3. Water management in Tunisia**

Different scenarios were developed in Tunisia to overcome this water shortage. The most characteristic practices are the dams and groundwater reserves; where surplus water in wet years stored, these stocks used in dry years. For surface water resources, Mejerda River is an international river between Algeria and Tunisia. Tunisia and Algeria have reached an agreement on sharing the annual volume available in the relevant basins. Monitoring system also has been established to track pollution and water volumes from Mejerda River.

The international groundwater, located in the Djeffara coastal basin is shared between Libya and Tunisia and, most importantly, in the North-west Saharan Aquifer System, shared between Algeria, Libya, and Tunisia. This aquifer has more than one Mkm<sup>3</sup> of water with very limited recharge, of which some 80,000 km<sup>3</sup> are in Tunisia. The three countries have established a commission to monitor this aquifer and have agreed to cooperate on its management to minimize cross-border impacts. This is one of only two such agreements in the world (Louati & Bucknall 2009). Particularly, the Tunisia's water policy aims to contribute to sustainable socioeconomic development. This water policy reflected on the balancing between the two conflicting facts, namely limited water supplies and increasing cost to generate, store and transfer and the growing demand for water.

Tunisia has also water quality problems. Less than half of the country's water resources is of a reasonable salinity (< 1.5 g/l). Consequently, surface water is used both for direct consumption and to improve the quality of other categories of water.

#### **4.3.1. Policy and models for Water management in Tunisia**

For the past three decades, policy has been based on mobilizing water resources. The Tunisia strategies for water management have been drawn up for agricultural water, rural and urban drinking water, urban sanitation, and the reuse of treated wastewater for agricultural purposes.

The Tunisian Ministry of Agriculture and Water Resources (MARH) has developed a model to help in operating the country's water systems and managing the risks. The models compares available resources with the expected needs under various planning scenarios. The MARH's model consists of a number of separate information systems: **1)** the first system is for water, all the country's water resources (conventional and non-conventional), were identified at both the regional and national

levels. 2) This system is for agriculture, agricultural database was compiled into a GIS, comprising close to 50 layers of geographic data. This map gives an overview of the agricultural area of each governorate, its resources, development potential, strengths, and weaknesses. The third information systems the National Water Information System, it combines three different water information systems: one on ground and surface water, one on water pollution, and one on soil quality. Respond to different usage priorities and to enable flexible management (Louati & Bucknall 2009)

Tunisian case study did not only develop model systems for water management, supporting steps were presented as potentially useful for improving the system's performance by several activities among of them: dam construction, re-construction and raise the height. In the system, 13 linked dams already are in place, and additional 14 dams should be online by 2015. Tunisia has an experience of generating nonconventional water and of innovative investments namely: reuse of treated wastewater, desalination of salt and brackish water, and artificial recharge of aquifers. Reverse osmosis technology was used to convert brackish groundwater into drinking water. Tunisia has been formally reusing treated wastewater in agriculture and now has one of the world's highest rates of reuse (Louati & Bucknall 2009). Tunisian government subsidizes the private sector to invest in desalination and considers this technology a key part of the long-term water management strategy for the country. The government plans to increase the volumes of artificial aquifer recharge to more than 200 Mm<sup>3</sup>/ year in 2030.

#### **4.3.2. Projects for water management**

Initiatives to improve the efficiency of communal irrigation and drinking water networks have been set in motion. The main results of these initiatives are: the Water conservation project restore and modernize public networks, promote on-farm water-saving equipment, and transfer the management of these operations to farmer groups. Irrigation efficiency was improved by enhancing the irrigation canals. The government's strategy to measure the water volume produced and distributed; this will play a key role in water management. The government intends to equip all drinking water supply systems with appropriate regulation equipment.

#### **4.3.3. Participation of the beneficiaries in water management**

Self-managed mutual water systems goes back to early 1900s when user-owner associations were created. In 1987 these associations were converted into communal interest groups. Their function was to develop public water resources; construct, maintain, and use public water works; irrigate and

decontaminate farmland; and develop drinking water supply systems. On the other hand, regional committees to assess and ensure the implementation of the water conservation program were set up in March 1992 .

#### **4.3.4. Application of IWRM to Biosphere Reserve in Tunisia**

However, Tunisia is a best example for IWRM among the Arab Arid land, the term was not applicable to the Biosphere Reserves. The typical example to clear this point is the Ichkeul Nation Park (World Heritage Site, northern Tunisia). Lake Ichkeul is the last of a chain of shallow freshwater lakes which once extended all along the northern African seaboard. The lake and its surrounding marshes are extremely important for the high numbers of wintering Palaearctic waterfowl: ducks, geese, storks and pink flamingos among others which feed and nest there.

The lake badly deteriorated as the result of the construction of three dams on rivers cut off almost all inflow of fresh water; causing a destructive increase in the salinity of the lake. A management plan developed to the National Park in 1977. The most important objectives were to control the water level and salinity of the lake and to maintain and develop the pondweed *Potamogeton*, the major food source for wintering and migrating waterfowl. In 1996 the Tunisian Ministry of the Environment commissioned a report on measures to reverse the degradation; some have been taken. Three smaller proposed dams have been canceled for the time being, water from existing dams is to be released to the lake and a pumped supply from Sidi EI-Barrak dam (127 km west) may be made available but the necessary pumping station had not been built by 2002.

Monitoring practices were also conducted namely: monitoring of the water, lake siltation, flora and bird species were to be continued and the analyzed information made available to decision-makers. In addition an international request by the Tunisian government in 2003 to the IUCN and the Centre for Mediterranean Cooperation for help in restoring the lake with funding from UNESCO. Unfortunately, in 2005 the lake appears red due to the presence of aquatic plants. Nowadays; commercial fishing, logging, poaching, agricultural expansion, and pollution by pesticides, fertilizers and tourism comprise the major threats. After heavy winter rain, the ecosystem partially recovers and the number of birds wintering in the west end of the lake increases, but numbers are still low (<http://www.eoearth.org/article>).

#### **4.4. Best practices and models for IWM in Arab Biosphere Reserves**

The current water practices carried out in the biosphere reserves in Arab Aridlands cannot continue on the present trend, where the management of water resource is not observable. In addition; the term sustainability is not applicable from different perspective: economic, social or environmental. The problem becomes more and more complicated with the refusal of treated water as an economic good. Participation and lack of coordination of different sectors and institutions in the field of water management was leading to unsustainable water management efforts. We must adopt a new approach to water resource management in the region to overcome the failures, reduce poverty and conserve the environment. Investments are required to improve the PAs infrastructure; the ability of the established system to operate and maintain sustainable is another fundamental issue. The earlier mentioned requirements must be carried out parallel to the increase in public awareness; and strengthen the related institutions.

#### **4.5. Water management in Drava River Basin, a trans-boundary project**

The Drava River Basin Project (<http://www.drava-river-basin.net>), has elaborated the comprehensive strategy concept and concrete waste and waste water management pilot projects .The Drava River Basin Project has achieved the following results: - Systematic Guideline for the Implementation of Environmental Infrastructure Measures in Water and Waste Management Sector for the European Union as well as other Eastern and South-Eastern European Countries, - Integrated Regional Environmental Strategy Concept (master plan for the Drava River Basin project area, consisting of the waste management and water management components), - Successful development of pilot projects and preparation of concrete large-scale investments: one waste management pilot project (regional waste management solution for north-western Croatia) and two wastewater management pilot projects (wastewater management solution for the selected pilot project municipalities of Lepoglava and Varaždinske Toplice, both in north-western Croatia), - Integration of the DRBP waste management pilot project in north-western Croatia into the Croatian National ISPA Strategy, - Wastewater management concepts (technical, economic, ecological, legal, organizational and financial) for the pilot project municipalities of Lepoglava and Varaždinske Toplice, - Establishment of a co-operation network of public and private sector experts from Austria, Croatia, Hungary and other countries and institutions, - Enhancement of the environmental situation in the Drava River Basin and in the Danube regions downriver, - Increase in the living standard of the local populations- Improvements to the

environmental infrastructure in the regions, - Optimization of administrative structures, - Raising public awareness of environmental issues .

## **CHAPTER V**

### **RECOMMENDATIONS AND PROPOSALS**

#### **5.1 Legislative and Executive Actions by Governments**

- Adoption of decentralization issues and privatization on water conservation interventions.
- Direct links between PAs beneficiaries and decision makers in government.
- The PAs organization has to improve the staff quality for water management skills, leadership and communication Information and Monitoring.
- The PAs organization has its own, or joint access to, a well developed, accurate, up-to-date, information and water monitoring systems.
- Linkages among research institutes, technical line agencies and land users are encouraged.
- Sharing experiences and techniques at the local, national and sub-regional levels helps improve professional skills, attitudes and working methods for IWRM.
- IWRM in PAs must be included in water polices and its application guidelines in different ecosystems.
- Existence of local political/institutional systems that are capable of responding to and satisfying the needs identified during IWRM activities.

#### **5.2 The Role of Environmental Education in Achieving Integrated Water Management for PAs**

- Integrate concepts of water management for PAs in the curriculums of deferent discipline in pre and post university stage.
- Training supervisors and teachers in this field.
- Preparing supplementary books and awareness material in this domain.
- Preparing self-learning units for training teachers and supervisors.

#### **5.3 The Role of Private Sector in Partnership to Achieve the Integrated Management**

- Financed through cost-sharing; is a target to apply water management programmes.
- Water pricing and alternative demand management are practiced.
- Political and administrative organizations are encouraged to identify national focal point institutions/agencies to deal with water management in protected areas; in each Arab country.
- Incentives must be directed to the society, or local communities, and beneficiaries of a protected area to manage water resources.
- Public services are expected to withdraw from the rural territory in favor of local users' associations, NGOs and private enterprises.

#### **5.4 Demands and Initiatives for the International Organization**

- Regional conventions required to enhance the best water practices especially in the trans-boundary water.
- Establishment of network to collect and assess the ongoing laws exist to enact natural resources management relevant to water management, in Arab world.
- IWRM would necessitate strong networking, exchange and collaboration among all the Arab countries and the related countries in Arid region.
- Applying for multi-donor partnership programme; especially with the European countries.
- More systematic information exchange will facilitate effective networking, inter-country collaboration and policy harmonization
- Sub-regional experience exchange between Arab countries.

#### **5.5 Community Participation and Actions**

- Local beneficiaries participate in selecting technical measures and implementation methods.
- Awareness programmes for the local community is of urgent need to improve water harvesting, conservation and recycling techniques.
- Public involvement processes are encouraged to be effective, providing for joint decision-making and conflict resolution
- The roles and responsibilities of stakeholders must be pointed and specified and understood.
- Attention is paid to traditional expertise, despite its value and adaptability to the environment including the local community.
- Community payments for IWRM (through taxes, for instance) must be feasible and the controlled by local community representatives.
- Involvement of marginal groups (i.e. women, young people, ethnic minorities, etc.), showing consideration for their cultural and traditional backgrounds.
- UNESCO can supervise 3 case studies about IWRM in PAs in three Arab countries, for example, Tunisia, Jordan, and Egypt after that a regional workshop will be held to achieve a regional program for conservation IWRM in PAs.

## **Concluding Remarks**

The numbers of the protected areas recorded in this paper including 22 Arab countries are 668 Protected Area, among this number, 381 were already established protected areas (PAs). Most of these PAs with known area, borders, date of establishment as well as its classification categories (UNESCO, Ramsar or MAB- Reserves; Tables (2- 20). While the other 283 PAs are recommended or proposed (♣; Tables 2-20) protected areas.

In addition these protected areas are listed in the World Database on Protected Areas (WDPA); Feb. 2010- <http://www.wdpa.org/>). As far as the authors know during preparation stages of this paper the practices even the concept, of the IWM in these PAs is still obscure. The most obvious outcome of this paper is the clear vision about the current status and the future needs to implement the IWRM.

Accordingly the following pressing issues must be addressed to the Biosphere Reserves for Arab Drylands:1) Decision makers in Arab Drylands are urgently invited to assess the current water practices in their countries.2) Water (surface and underground) management plans; should be applied to minimize the predicted negative impacts of the climatic change facilitated by the by overpopulation in Arab Drylands. 3) Water practices and its related activities still far to reach the concept and the principles of the Integrated Water Resources Management (IWRM). Accordingly awareness programmes must be conducted and implemented in all levels. 4) Water pollution related to health problems are notably observed in different sites belonging to the Arab Drylands (Egypt among of them).

The concept of water quality must be addressed to the governmental (GOs) and non-governmental (NGOs) institutions. The traditional ethics for utilization of the treated waste water must be reformed. NGOs are invited to participate in benefit, loss and practices related to integrated water management.

This paper was conducted to explore the current water practices and the possibility to implement the IWRM approach and its available methodology in protected areas. Now, conventional drainage methodology is the dominant philosophy, accordingly the best drainage practices are invited to be applied. Additionally, the management of rainwater is also a complicated issue in different river basin, especially in Arab Biosphere Reserves.

The economy of water management still needs to be explored in and out the Biosphere Reserves. Also benefit sharing between the NGOs, GOs, stakeholders and local inhabitants' are also among the hot issues. New strategies for IWRM should emphasize the concept of high water production efficiencies. Reduction of water consumption by the Biosphere reserve inhabitants and reduction or stabilization of their family size will enhance the best achievements in the field of IWRM strategies.

## REFERENCES

- Abdel Mageed, Y. (1995). Planning Water Resources Development in Arid Zones. An Agenda for action in the Arab Region. The Sultanate of Oman. International Conference on Water resource management in Arid Countries. Muscat, 12–16 March 1995. Vol.3, pp. 47–54.
- Abu-Zeid. M. & Hamdy, A. eds. (2002) Water vision for the twenty forth Century in the Arab world. World Water Council 3<sup>rd</sup> World Water Forum, France, Pp. 90
- Al Hassan, O. (1996), Water Resources in the Middle East in 1996 from G.O. Bamey. The Global 2000 Report to the President: The Technical Report. Vol. 2. Council on Environmental Quality and the State Department, 1980.
- Ayres, W. S.; Busia, A., Dinar, A.; Hirj, R.; Lintner, S. F.; McCalla, A. , A. F. & Robelius, R. (1997). Integrated lake and reservoir management: World Bank Approach and Experience.
- Boshra, S. (2006). Using the sun to quench their thirst. A World Science, Vol. 4 no.3 September 2007.
- Bauer, C. (2004). Results of Chilean water markets; Empirical research since 1990; Water Resources Research, 40: 11 pages.
- CEDARE & Arab Water Council Report (2007). Status of MDGs achievement in the Arab region. CEDARE & Arab Water Council Publication, P. 1-30
- Davis , S. D.; Heywood, V. H. & Hamilton, A. C. (1994). Centers of Plant diversity: A guide and strategy for their conservation. Volume 1: Europe, Africa, South West Asia and Middle East. World Wide Fund (WWF) and IUCN-The World Conservation.
- d'Ostiani L. Fe (2004). Water management Case study: Mediterranean; water-shed management: a key component of rural development in the Mediterranean region. FAO publications Rome, 2004.
- El-Barbary Z. & Sallam G. A. (2004), Optimizing use of rainfall water in desert of Egypt.. Eighth International Water Technology Conference, IWTC8 2004, Alexandria, Egypt. P. 73-81
- El-Shinnawy, I. (2002). Al Zaranik wetland's hydrological study; catchment area studies & water balance; final report. The Natural protectorates Central Administration- Egyptian Environment Affairs Agency (EEAA).
- Engelman, R. & LeRoy, P. (1993). Sustaining Water: Population and The Future of Renewable Water Supplies. Population Action International. P. 65.

- FAO (1997). Food and Agricultural Organization of the United Nations. Aquastat, 1997, [www.fao.org/](http://www.fao.org/).
- Fariz, G. H. & Hatough-Boura, A. (1997). Case study: Jordan population dynamics in Arid Regions: The experience of the Azraq Oasis conservation project. In: Water and population dynamics: case studies and Policy implications. Eds: Alex de Sherbini and Victoria Dompka, Montreal Canada "<http://www.aas.org>"
- Forester, J. (1999). The Deliberate practitioner: Encouraging Participatory Planning Processes. Cambridge MA: MIT Press.
- Hooper, B. P. (2005). Integrated River Basin Governance: Learning From International Experiences. London, IWA Publishing. Technological Paper No. 358, The World bank, Washington DC.
- IUCN (1994). Guidelines for Applying Protected Area Management Categories. Ed. Dudley, N. (2008). 86 PP; Gland, Switzerland: <http://data.iucn.org/dbtw-wpd/edocs/PAPS-016.pdf>
- IUCN (1998). Economic Values of Protected Areas: Guidelines for Protected Area Managers. No. 2. Task Force on Economic Benefits of Protected Areas for the World Commission on Protected Areas (WCPA) IUCN in collaboration with the Economics Service Unit of IUCN, 1998 mission on Protected Areas (WCPA) of IUCN.
- IUCN (2007). Annual Report of West Asia/Middle East (WAME) Regional Office .32 PP
- Khan, H., Khan, A. A., Boals, R. G, Abdel-Gawad, S., El-Sadek, A. & Mostaza, T. M. S, (2006). An Environmental Security and Water Resources Management System Using Real Time Water Quality Warning and Communication, NATO.
- Lemos, M. C. & Oliveira, J. L. F. (2004). Can Water reform survive policies? Institutional change and river Basin Management I Ceara, northeast Brazil. World Development, 32 (12): 212-237.
- Lemos, M. C.; Recharte, J. & Chang, C. T. (2007). Integration of social science in the UNESCO's Ecohydrology Programme. Report submitted by the UNESCO's Ecohydrology Programme Social Science Task Force, April 2007.
- Louati, M. H. & Bucknall, J. (2009). The best practices and models of IWRM: Tunisia's Experience in Water Resource Mobilization and Management. P.157-180. In Water in the Arab World: Management perspectives and Innovations, ed by Jagannathan, N. V. ; Mohamed, A. S. and Kremer, A. Middle east and north Africa Region- the World bank
- Lloyd, J. W. (1990). Groundwater Resources Development in the Eastern Sahara. Journal of Hydrology 119: 71-77.

- Nuttle, W. K.. (2002). Is Ecohydrology one idea or many? *Hydrological Sciences-Journal-des Sciences Hydrologiques*, 47(5) : 805-807.
- Omeranai, A. (2002). Watershed management. In: FAO, Institutional implications of participatory approaches. Decentralization and Rural Development No. 20 Rome.
- Osborne, C. (1981). *An Insight and Guide to Jordan*. UK: Longman Group Limi UNDP, Jordan, 1994. Conservation of the Dana and Azraq Protected Areas: Project Document. Washington DC: Global Environment Facility.
- United Nations. (1982). *Groundwater in the Eastern Mediterranean and Western Asia. Natural Resources/Water Series No.9*. New York: UN Department of Technical Cooperation for Development
- UNESCO (2005). Consultative workshop: towards integrating social & cultureal aspects into Ecohydrology; 7 Paris: International Hydrological Programme (IHP). Man and Biosphere (MAB).
- Wester, P., Merrey, D. J. & deLange (2003) . Boundaries of consent: Stakeholder representation in river basin management in Mexico and South Africa; *World Development*, 31: 797-812.
- World Bank Estimates: World Development Report, World Resources Institute 1991, 1992, 1992–93, 2001; <http://go.worldbank.org>)
- Zaara, M. (2004). "Desalination in Tunisia: Reality and Perspectives." Seminar in Almeria, Spain, November 23.
- Zalewski, M. (Ed) (2002) "Guidelines for the Integrated Management of the Watershed -Phytotechnology & Ecohydrology", United Nations Environment Programme Freshwater Management Series No. 5. 188pp,
- Zalewski, M. Janauer, G.A. & JoIankaL G. (1997). "Ecohydrology. A new paradigm for the sustainable use of aquatic resources", UNESCO IHP Technical Document in Hydrology No. 7. IHP - V Projects 2.3/2.4, UNESCO Paris, 60 PP.

### **Additional Information Sources**

- <http://www.eoearth.org/article>
- <http://en.wikipedia.org/wiki/Ecohydrology>
- <http://www.aaas.org>; Water and Population Dynamics : Case studies and policy implications eds: Alex de Sherbinin and Victoria Dompaka Montreal , Canada ,1996
- NASA/GSFC/METI/ERSDAC/JAROS,
- U.S./Japan ASTER Science Team