

WATER, WETLANDS AND CLIMATE CHANGE
Building Linkages for their Integrated Management

Mediterranean Regional Roundtable
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Climate change and
Water Resources In Tunisia

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Global Water Partnership – Mediterranean

Preface

The Global Water Partnership (GWP), the Dialogue on Water and Climate Change, and IUCN-The World Conservation Union, have joined forces to facilitate an exchange of views on the common challenges faced by Mediterranean societies in enhancing their capacities to adapt to climate change.

Scientific consensus is that climate change would have a pervasive influence on the future demand, supply and quality of fresh water resources in the Mediterranean, and would add pressure to water and environment resources, and coastal systems currently under stress. All sectors of the economy, environment and society may be vulnerable to one degree or another, where steps to increase the capacity to adapt to greater hydrological variability, including more frequent flood and drought extremes are required.

Under Article 4 of the UNFCCC, it was agreed all Parties would develop short, medium, and long-term strategies for climate adaptation in a phased manner, taking into account the different socio-economic contexts. A number of Mediterranean countries are now at the preliminary stages of identifying and formulating specific climate change adaptation strategies and responses, while others have yet to start.

This document is one of twelve country base-line studies and thematic papers prepared as background material for a Roundtable meeting in Athens, Greece in December 2002, to discuss key linkages between climate change, water and wetlands resource and management in the Mediterranean. While the primary aim is to exchange views, perspectives and experience on climate change adaptation planning, the discussion would also explore the opportunities to enhance synergies in responses to the UNFCCC and Ramsar Conventions.

Eight country base-line studies were prepared for:

- | | |
|----------|-----------|
| ✍ Cyprus | ✍ Morocco |
| ✍ France | ✍ Spain |
| ✍ Greece | ✍ Tunisia |
| ✍ Italy | ✍ Turkey |

The four crosscutting thematic papers are:

- ✍ Mediterranean Water Resource Planning and Climate Change Adaptation
- ✍ National Approaches to Drought Preparation in the Mediterranean
- ✍ Adaptation Strategies for Improved Flood Management in the Mediterranean
- ✍ Biophysical and Socio-Economic Impacts of Climate Change on Water and Wetlands in the Mediterranean

Electronic copies of the reports and paper noted above may be downloaded from the web page of The IUCN Centre for Mediterranean Cooperation at www.uicnmed.org

Disclaimer:

The views, conclusions, and recommendations contained herein are those of the authors, and are not necessarily the views of the Governments of the countries concerned, the GWP, the Dialogue on Water and Climate Change, or the IUCN.

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SUMMARY

Tunisia have signed the United Nations Framework Convention on Climate Change (UNFCCC) in Rio de Janeiro in 1992, and then ratified it in July 1993. As non-annex I Party to the UNFCCC and in accordance with article 12, Tunisia have submitted its first national communication in October 2001.

Like most countries affected by aridity and particularly within the Maghreb region, water resources represent in Tunisia the most precious environmental good. The annual average rainfall is estimated to 36 000 Millions cubic (Mm3) / year. Unfortunately, potential water resources (total flow) represent only 4629,6 Mm3/year, of which 550 Mm3 are not renewable. This potential presents a greater regional disparity:

- ? 2801,5 Mm3/year in the North (17 % of total area), or 60%
- ? 766,8 Mm3/year in the Center (22 % of total area), or 16%
- ? 1061,3 Mm3/year in the South (61 % of total area), or 24%

Others aspects of water resources management concern:

- artificial recharge, limited in volume,
- little use of the no conventional water.

Some pollution problems are observed locally (Sfax region layer), but the main concern is probably water salinity.

Mediterranean region is not favoured by climate change and particularly the south shores. Climate change projections indicate changes in mean climate conditions (temperature, rainfall). However, climate change is likely to bring changes in climate variability and extreme events as well. Furthermore, we expect decrease in stream flow and groundwater recharge. Tunisian climate is characterized by its greater variability and aridity. Tunisian water resources sensitivity to climate change concern particularly: Surface water resources variability exacerbated by climate change, Higher evaporation rate amplified by climate change and some infection costal layers by seawater intrusion. Moreover, wetland sensitivity to climate change concerns: Stagnant water subject to more rate evaporation and rise in the water level of some costal wetland area, such Ichkeul lake.

Considering the previous institutional framework, climate change activity was coordinated by the Environment and Land Use Planning Ministry (the Environment State secretary under the Agriculture, environment and hydraulic resources Ministry in the actual organization). The National Committee on Climate Change (NCCC) was created in 1992. It is an inter-ministerial Committee with an advisory capacity. In October 2001, the NCCC have been substituted by the Focal structure on climate change (FSCC). The aim of this initiative is to improve the efficiency activity notably by, best representatively and meeting at regular frequency. The most activities on climate change issue have been implemented in the framework of the two projects; the national project TUN 95 / G31 and the regional project RAB 94 / G31. Network experts activity and NGO's activity are limited. Regarding the end of the two projects and the unofficial character of the advisory structures, the institutional framework should be strengthened, with particular emphasis on sustainability and ability to make arrangements.

Because, near 80 % of water is used by the agricultural sector, water resources policy and strategy is centralized in the Agriculture, Environment and Hydraulic Resources Ministry. This Ministry has a regional institutional network responsible by the implementation of the national strategy. The mobilization and management of water resources is organised by geographical region: the North, the Center and the South. The water Code represents the main legal framework related to water policy. The NGO's field activity is limited to isolated regions. In spite of their number, NGO's activities is very limited because the lack of tradition and knowledge. Furthermore, wetlands haven't a specific strategy. This issue is included in the Tunisian strategy on water resources mobilization and management. Legal provisions related to wetland conservation and management are including in the Forestry Code.

We have a greater discrepancy between climate change issue and water resources and wetland issue. Water resources are a common concern in Tunisia. This issue has large economic and social impacts. Furthermore, climate change is a new issue with no sufficient assessment of impacts and a large part of uncertainty.

Several studies have been conducted to define the outline of the future water resources strategy and propose the basic elements and prospects the water resources strakes. Unfortunately, these studies have taking as assumption the climate stability. The key challenge, therefore, is to incorporate climate change assumption.

Quantitative assessments of sensitivity, adaptive capacity, and Tunisian water resources vulnerability to climate change, with particular emphasis on change in the range of climatic variation and the frequency and severity of extreme climate events, are not available at the national level. In reality, we have too a lack of methodology to assess such information. The regional collaboration is probably the best way to develop this issue. The aim is to make available, pertinent scientific information that can be used to inform responsible and policy maker and alive them, particular by risks.

Balance between operating water resources and demand resources is very close and climate change assumption can upset it. So, the key challenge is to incorporate uncertainty in the range of climate change, in this balance. We can use an approach by climate change scenario and define a balance of each scenario.

When developing adaptive strategy for water resources and wetland in Tunisia we should be consider some key assumptions such:

- ✍ Water quality degradation,
- ✍ Higher cost of new water resources mobilization,
- ✍ Storage and regulation capacities,
- ✍ Irrigated agriculture,
- ✍ Peasant practices,

Currently supply-side approaches (e.g., increasing flood defenses, building weirs, utilizing water storage area, improving infrastructure for water collection and distribution) can be widely used as basic adaptive measures. These options have the advantage to be integrated in the national water resources strategy and don't have a specific cost related to their adaptive aspect. These measures could have multiple benefits, today and in the future, even in the absence of climate change pressure. In the other hand, some institutional arrangements and practices, available to made, can allow to have immediate benefit and probably with low cost.

In practice, it is difficult to change water management practices. The challenge, therefore, is to develop ways to introduce integrated water management practices into specific institutional settings. Moreover, we should improve and strengthen management institutions and market-like processes.

Tunisia have some adaptive capacity, especially ability to implement integrated water resources management witch enhance adaptive potential to climate change. However, the improvement and strengthen of the national water resources strategy is the best way to adapt and response to climate change.

INTRODUCTION

Tunisia have signed the United Nations Framework Convention on Climate Change (UNFCCC) in Rio de Janeiro in 1992, and then ratified it in July 1993. As non-annex I Party to the UNFCCC and in accordance with article 12, Tunisia have submitted their first national communication at October 2001 and presented it in a side event organized during the seven Conference of party (COP7), held in Marrakech in November 2001. To implemented national communication, subsequent studies has been realized in the framework of two projects on climate change, the national project TUN 95 / G31, and the regional project RAB 94 / G31, among witch:

- ? Climate change and water resources in the Maghreb region,
- ? assessment of the Tunisian juridical aspect related to green house gazes (GHG) emissions,
- ? national inventory of GHG emissions,
- ? Examination of policies, institutional aspects and advisory related to climate change in Tunisia,
- ? first assessment of the Tunisian coastline vulnerability to sea level rise,
- ? Identification of mitigation options of GHG emissions related to
 - ✍ the energy sector,
 - ✍ the waste sector,
 - ✍ the agriculture and forestry sector,

Complementary studies concerning climate change issue related to assessment of vulnerability, and abatement strategies and institutional aspects have been realized, among which:

- ? The creation opportunity of CIEDE (Information Centre on climate change and renewable energy),
- ? Development of portfolio projects related to GHG mitigation abatement program (33 options from energy, 6 options from LULUCF, and 4 options from each agriculture and waste),
- ? The creation of sustainable institutional framework related to the management of climate change issue,
- ? Assessment of vulnerability to climate change of water resources agriculture, public maritime domain, agriculture and other natural ecosystem,

Considering their 1300-Km coastline and the socio-economic importance of this region, priority will be done to complementary study related to an adequate assessment to Tunisian vulnerability to Mediterranean Sea level rise.

Furthermore, if Kyoto protocol enters into force, the orientation is to encourage instigation aspects in the framework of Clean Mechanism Development (CDM).

Taking into account all this consideration, second Tunisian Communication will probably focused mainly on mitigation and abatement emission options susceptible to be financed in the framework of CDM. Water resources and agriculture vulnerabilities to climate change will be too developed. This activity will be the first steep to develop adaptive strategies related to these sectors

I) Tunisian context

I.1) Water resources situation

Like most countries affected by aridity and particularly within the Maghreb region, water resource constitute in Tunisia the most precious environmental good. For the year 1995, Tunisian water resources is evaluate to 528 m³ / capita / year. In accordance with the World Meteorological Organization (WMO) definition, Tunisia is classified like in a hydrological stress situation. According to regional climate change projections and taking into account the expected increase of socio-economic pressure, the situation will even be more alarming and can be defined by WMO as a water shortage situation (less then 500 m³ / capita / year). This situation is even more dramatic for Tunisia witch has probably the lowest level of water resources in the Mediterranean region.

The annual average rainfall is estimated to 36 000 Mm³ / year, which is unevenly distributed:

- from 400 to 1000 mm/year, in the North
- from 200 to 400 mm/year, in the Center
- less than 200 mm/year, in the South

Unfortunately, potential water resources (total flow) represent only 4629,6 Mm³/year, of which 550 Mm³ are not renewable. This potential presents a greater regional disparity:

- ? 2801,5 Mm³/year in the North (17 % of total area), or 60%,
- ? 766,8 Mm³/year in the Center (22 % of total area), or 16%,
- ? 1061,3 Mm³/year in the South (61 % of total area), or 24%,

**Tableau (1): Potential water resources allocation (total flow)
by hydrological basin (Year 1996)**

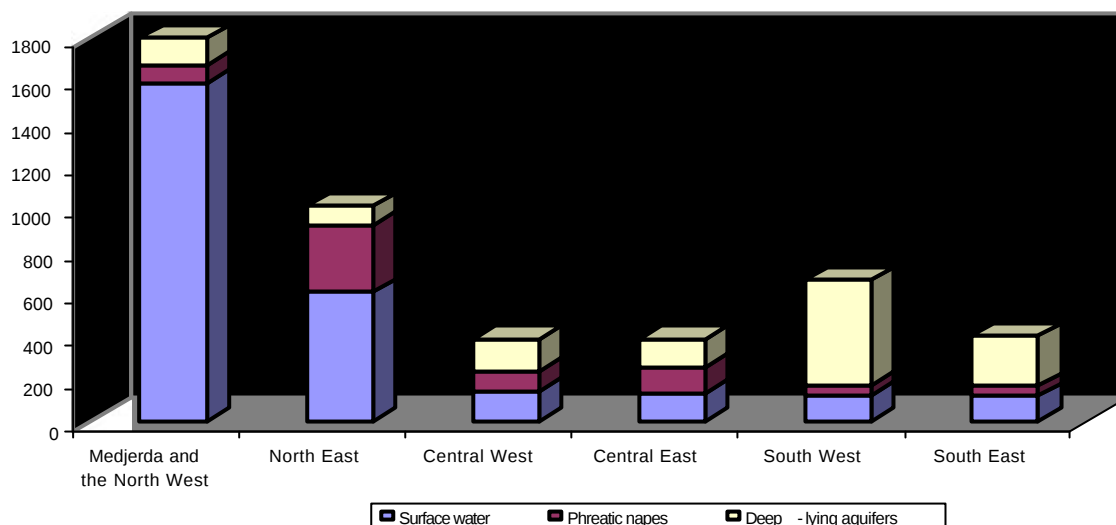
Region	Surface water resources Millions m ³ (%)	Ground water resources	
		Phreatic napes	Deep-lying aquifers
The Medjerda and the North West	1585 (58,7)	84,2 (11,7)	124,2 (10,2)
The North East	605 (22,5)	311 (43,3)	92,1 (7,6)
North of Tunisia	2190 (81,2)	395,2 (55)	216,3 (17,8)
Central West	140 (5,2)	97,2 (13,5)	145,2 (12,0)
Central East	133 (4,9)	124,2 (17,3)	127,2 (10,5)
The Center of Tunisia	273 (10,1)	221,4 (14,2)	272,4 (22,5)
The South West	120 (4,4)	52,3 (7,3)	488,5 (40,4)
The South East	117 (4,3)	49,8 (6,9)	233,7 (19,3)
The South of Tunisia	237 (8,7)	102,1 (102,1)	722,2 (59,7)
All Tunisia	2700 (100)	718,7 (100)	1210,9 (100)

Source : EAU XXI : Strategie du secteur de l'eau en Tunisie (a long terme 2030). Published by Agriculture Ministry

The distribution water resources in the three geographical regions is quite different:

- ? Most surface water resources are localized in the Northern region (81,2%) which represents only 17% of the total Tunisian area,
- ? The biggest part of the ground water resources are in the south, particularly in deep-lying aquifers with fossil water form,
- ? The Center is the poorest region on water resources.

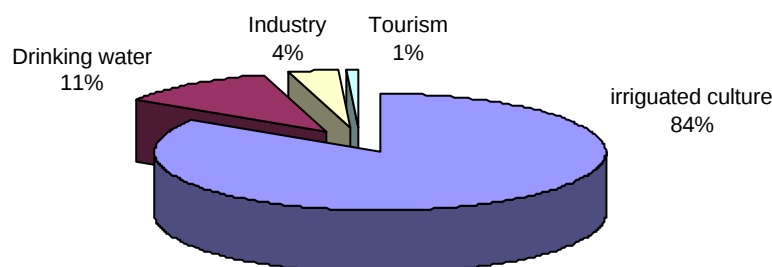
Figure (1): Potential water resources allocation (total flow) by hydrological basin (Year 1996)



Water demand

Global water demand in 1996 is estimate to 2517 Mm3. Water allocation between the main economic sectors is characterized by the large allocation water attributed to irrigated agriculture. The needs irrigated agriculture is estimated at 2115 Mm3, that represent 84 % of total demand. Drinking water demand in urban and rural areas is estimated at 290 Mm3 among witch 256 Mm3 are supply by Specialized Agency (SONEDE) and 34 Mm3 by NGO (Association d'interet collectif). Industry sector demand is estimate to 93 Mm3 that represents 3,7 % of the total demand. Tourism sector demand is near 1 % of total demand

Figure (2) : Allocation water demand



At the horizon 2030, in spite a little decrease in drinking water allocation from 84 to 74 %, we don't observe a real change in the allocation water demand.

Water quality

The main aspects water qualities are:

- ? deep lying aquifers salinity is near 2 g/l and can reach 5 or 7 g/l,
- ? some streams have a salinity between 3 and 5 g/l,
- ? some costal layers are infected by seawater intrusion.

Globally, 72 % of surface water resources have a salinity degree lower than 1.5 g/l. However, we have greater difference between regions and salinity issue is even more problematic in the southern part of the country.

Tableau (2) : Water salinity

	North	Center	South	Total
Surface water resources	2190	320	190	2700
Resources with salinity less than 1,5g/l	1796	153	6	1955
Percentage	82 %	48 %	3 %	72 %

Concerning phreatic napes, only 8% of resources have salinity less than 1.5 g/l, 71% have salinity between 1.5 and 5g/l, and 21% with salinity greater than 5g/l.

Deep laying aquifers water have a better quality. 20% have a salinity degree lower than 1,5 g/l, 57% of resources with salinity between 1,5 and 3 g/l. The remaining part, or 23% have a salinity greater than 3g/l.

Pollution problems are observed:

- On some Medjerda urban affluent,
- Near some urban and industrial regions (Sfax region layer),

Artificial recharge

Recharge aquifers is a new component of the water resources management strategy. So, artificial recharge is offered during raining year, their rate is depending on excess raining. During the period 1992 to 1996, 229 Mm3 have been deducted from water resources and injected in the phreatic napes with the aim of struggling against over operating.

Table (3) : Artificial recharge

year	1992	1993	1994	1995	1996	Total
Volume/million Cubic	23	34	43	62	67	229

Little use of the no conventional water

The no conventional water resources are with little use. So, only:

- 44 refinement stations treat an annual average of 125 Mm3 meters,
- (03) desslage stations (Kerken, Skhira and Gabes) produce an annual average of 12 332 cubic meters.

Furthermore, refinement capacity represents only 60 % of the collected used water.

Main outlines of the Tunisian strategy of water resources

Presently an average potential surface waters resources of 2700 Mm3/year, only 2100 Mm3 or 78% are mobilized. The used infrastructure includes notably:

- ? 19 large weirs with an average capacity of 1369 million cubic,
- ? 12 collinear weirs with an average capacity of 50 Mm3,
- ? 460 collinear lakes with an average capacity of 40 million Cubic.

Taking into account considerations related to mobilization and supply, the strategic management of the Tunisian water resources is based on:

- ? Optimal mobilization of the water resources over the North,
- ? Supply of the need water of the Center and the South of the country by using inter-connected systems.
- ? Control of demand water and valorization of water resources,

I.2) Outlook climate variability and change

The meteorological observations in Tunisia are started in the second part of the 19th century, but systematic observations really began in the 20th century.

Climate observation and monitoring

Created in 1974, the National Meteorological Institute (NMI), who is for budgetary considerations, depending on Communication Technology and Transport Ministry, was assigned by the meteorological observations. In this respect, the national meteorological network observation stations is composed by:

- (26) Synoptical and aeronautic stations
- (34) Agro meteorological stations
- (54) climate stations
- (182) Rainfall stations

This network is in an automating phase. The collected data is included in computer databases managed by a new information system. The first climatic Atlas for Tunisia was published in 1999. Moreover, NMI has been implementing for years studies related to climate evolution and trend.

Main Tunisian climate characteristics

The Tunisian climate is characterized by aridity. The North of the Tunisian Dorsale benefit by a Mediterranean climate presently characterized by:

- A hot and dry summer,
- a mild and relatively rainy winter

The central and Gabes gulf regions have a semi-arid climate, characterized by:

- High temperature,
 - Limited rainfall potential, between 150 and 400 mm / year,
- The South West is a desert and arid region characterized by:
- A very high temperature as well as important amplitude
 - Disparate rainfall rarely exceeding 100 mm / year

Studies related to climatic evolution during the last century concluded on:

- ? The existence of trend in the annual average temperature since 1975 who must be followed
- ? The lack of trend in the annual average rainfall

These conclusions are generally homogeneous with global observation and assessment during the last century. Perhaps, it will be interesting to conduct complementary studies concerning the seasonal level and related to the evolution of extreme daily temperature, raining day and frequency of extreme events likes floods and drought.

Global climate change projection during the 21st century

With reference to the Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change (IPCC), must it be remind that at the global scale and over the period 1990 to 2100:

- The globally averaged surface temperature is projected to increase by 1,4 to 5,8 °C for the full range of 35 scenarios,
- Global average water vapor concentration and precipitation are projected to increase during the 21st century, with a greater regional disparity
- Global mean sea level is projected to rise by 0,09 to 0,88 for the full range scenarios

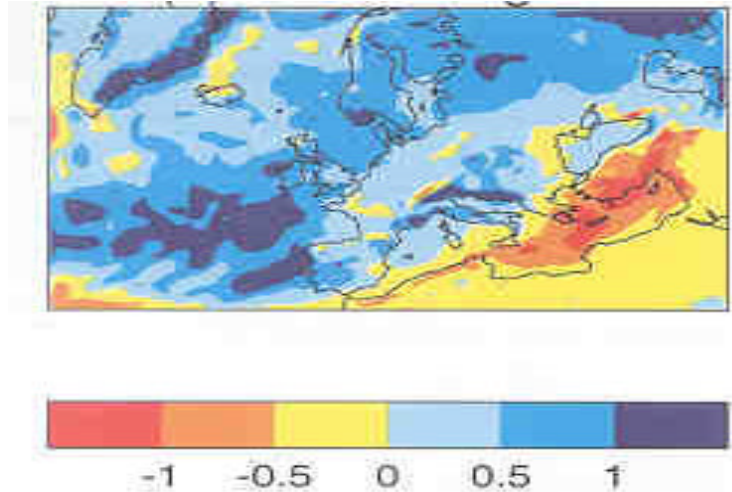
Climate change projection in the Mediterranean region

The regional projection is associated with a greater range of uncertainty. Concerning Mediterranean region, the climate change projections indicate:

- ? Change in temperature, greater than average warming, particularly important during summer (June to august),

- ? No change on precipitation during the winter and a small decrease during summer. This decrease will be probably more important in the South and particularly in the East of the Mediterranean region
- ? Furthermore, we expect more intense precipitation events and more generally, intensification in the main components hydrological cycle.
- ?

Figure (3): Rainfall variation over Mediterranean region due to 2* CO2 concentration



Unit : mm / jour

Source: Climate change 1995, Contribution of Working group I to the second Assessment report of the IPCC

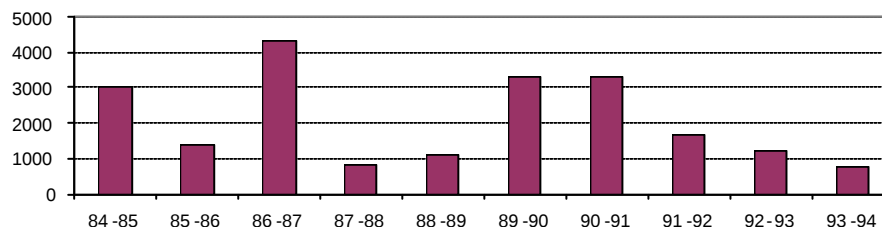
Tunisia is a water-stressed country (using more than 20 % of their renewable water supply). The projected climate change is could further decrease the stream flow and groundwater recharge.

I.3) Sensitivity to climate variability and change

Surface water resources variability exacerbated by climate change

The geographical situation of Tunisia confers to its climate a greater variability. Surface water resources are largely depending on climate variability and particularly on rainfall variability.

**Figure (4) : Surface potential water resources evolution
(in millions cubic)**



Taking into account the reference year 1996, with a potential water resources of 2700 Mm3, we have a minimum of 780 Mm3 during the season 1993-94 and 11 000 Mm3 during the season 1969-70. Previous climate change will probably exacerbate rainfall variability and increase the frequency extreme events likes floods and drought.

A higher evaporation rate amplified by climate change

Maximum temperature during summer exceeds frequently (40 °C). This higher temperature is associated to a higher rate of evaporation. This rate is between 1600 mm / year over coastal regions and can reach 2600 mm / year in some continental regions, particularly in the Southwest. The previous climate change, particularly the increase of temperature, will amplify this important hydrological system component.

Increase in hydrological budget deficit

With the exception of the tellien region in the extreme North which represents around 10 % of the Tunisian area and which have an hydrological surplus budget during rainfall season, the remaining regions have a largely defect hydrological budget over all months.

Damaging of water quality

The demand pressure on water resources is important in some regions. This pressure is the expression of over operating which particularly concerns some phreatic napes from the Northeast, the Cap Bon and the Sahel regions.

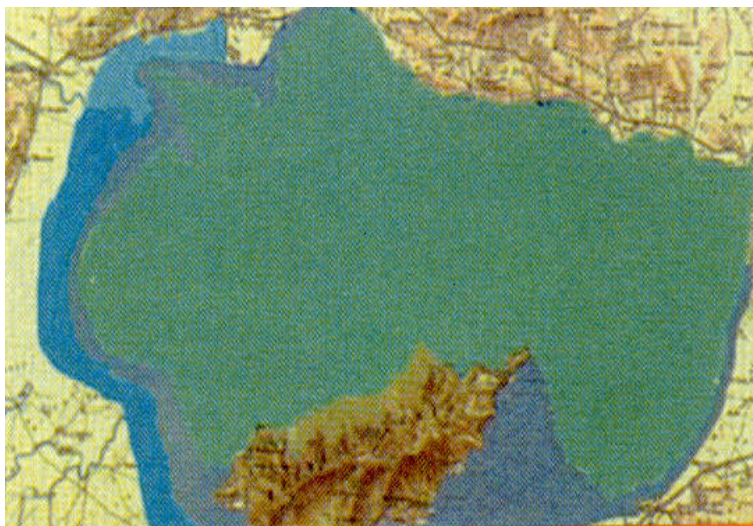
Some of them over the costal region are subject to infection by seawater intrusion due to Mediterranean sea level rise related to projected climate change over this region.

Wetland sensitivity to climate change

Stagnant water from wetland is subject to evaporation. The evaporate rate is expected to increase following global warming due to change in temperature. Such change can induce a decrease in the water level with change in chemical and biological conditions and with also probably affect the fauna and flora situations.

Furthermore, Ichkeul lake, which is probably the most important wetland in Tunisia, is located in the costal region with contact with Mediterranean. This lake is sensitive to rise in the Mediterranean sea level. With an assumption of (1 m) rise in the water level of Ichkeul lake we suspect an increase in water area to the detriment of marshy terrain. Expansion of Ichkeul lake can conduct to the loss of 1160 ha of cultivated area.

Figure (5) : Ichkeul lake: Potential sea level rise impacts
In gray: expansion of water area to detriment of marshy area
In blue: migration of marshy area on cultivated area



II) Institutions / processes and network coordinate water resources, wetland and climate change issues

Institutionally, the Environment and Land Use Planning Ministry is assigned by the national policy in the management and the environment protection matters. But ministerial change occurred on September 2002 have led to the linking of environment issue to agriculture and water resources issue in the same Ministry called “Agriculture, environment and hydraulic resources Ministry”. Furthermore, the environment issue has a specific State secretary.

This part concern climate change activities coordinated by The Environment and Land Use Planning Ministry, during the period 1992 to august 2002. Nevertheless, the proposition, which will follow, must take into account these new institutional arrangements.

II.1) Institutional framework related to climate change

Environment and Land Use Planning Ministry

Created in 1992, This Ministry is being supported in its prerogatives by specialized Institutions:

- ✍ The National Agency of Renewable Energy,
- ✍ The Environment Protection National Agency,
- ✍ The Drainage national Office,
- ✍ The International Center of Environment Technology,
- ✍ The Costs Development and Protection Agency,
- ✍ The Tunisian Observatory of Environment and Development,

With regards to their environmental character, Environment and Land Use Planning Ministry coordinated climate change activities. In order to allow the intervention of institutions concerned by this subject, the Environment and Land Use Planning Ministry created the National Committee on Climate Change.

National Committee on Climate Change

The National Committee on Climate Change (NCCC) was created in 1992 to coordinate the national discussion on the climate change issue and formulate the Tunisian position in the international negotiation related to UNFCCC. It is an inter-ministerial Committee with an advisory capacity. Its activities are being coordinate by the Environment and Land Use Planning Ministry. Unofficially, it is an initiative from Environment Minister who doesn't have a juridical restricting character.

Playing an interested role during the UNFCCC negotiation, it is composed by:

- ✍ Environment and Land Use Planning Ministry,
- ✍ The National Agency of Renewable Agency,
- ✍ Agriculture Ministry,
- ✍ Equipment and habitat Ministry,
- ✍ Transport Ministry,
- ✍ Industries Ministry
- ✍ The Costs Development and Protection Agency,
- ✍ The Electricity and Gas Tunisian Agency,
- ✍ The National Meteorological Institute
- ✍ Women and Environment Alliance and Tunisians Geographers (NGO).

Because of its unofficial character, The NCCC meetings are irregular and sporadic. Its members often change and no real following was performed.

Focal structure on climate change

Having demonstrated its limits and because it had no formal restricting status, the NCCC have been substituted by a Focal structure on climate change (FSCC). The Environment and land use planning Minister (October 2001) have created this Structure. The target of this initiative is to improve the efficiency activity notably by including representatives of all partners concerned by climate change in Tunisia as well as meeting at regular frequency. The Focal structure on climate change secretariat is maintained by the Tunisian focal point with the UNFCCC.

Compared to the NCCC, the Focal structure on climate change composition has been extended to new partners, like:

- ? The foreign Office Ministry
- ? The juridical Department and the international Cooperation Department in the Environment and Land Use Planning Ministry,
- ? The Energy Department in the Industry Ministry
- ? The forestry Department in the Agriculture Ministry
- ? The Environment Protection National Agency,
- ? The Tunisian Observatory of the Environment and the Development,
- ? Research Department from University and High School
- ? Private operator

Climate change projects activities

In the framework on Global Environment Facility / United Nation Environment Program capacitating project, Tunisia was enabled by two projects:

- ✍ **A national project TUN 95 / G31**, entitled "Emissions inventory of greenhouse gases: national strategy and action plans for emissions reduction and fulfillment of national communications under the UNFCCC"
- ✍ **A regional project RAB 94 / G31**, entitled "building capacity of the Maghreb region to response to the UNFCCC "

For the management and implementation activities, two Committees were created:

- ✍ the Executive Committee of the National Project TUN 95 / G31,
- ✍ the Technical and Consultative Committee of the Regional Project RAB 94 / G31,

Regarding, all structures created to deal with climate change; in fact, a group of five persons largely implicated by this question constitute the membership and are active in all fronts. This group represents probably the main valuable asset.

The Sustainable Energy and Environment Information Center

The Sustainable Energy and Environment Information Center (CIEDE in French) is an institutional output from the regional Project RAB 94 / G31. Each country has created its own Center. A first study related to the creation opportunity of this Center was realized in 1996. This study was completed in June 2002 by a second study related to the attributions and administrative status of this Center. Its attributions concern:

- alive and information
- Centralization and coordination of activities and study related to climate change
- Training and capacity building
- Access to financial process like the Clean Mechanism Development (CDM)

Affected with the National Agency of Renewable Energy, this Center has enabled by experience of this Agency. At the end of the RAB 94/ G31 project, its budget will be previous under the mentioned Agency. This is a guarantee concerning the sustainability of this Center.

Technical and Consultative Committee on Climate Change

The Technical and Consultative Committee on Climate Change (CCT-CC) is another institutional output on the regional project RAB 94 / G31 on climate change. It has a scientific status and is composed in majority by scientists from the University and some advisory bureau. Their prerogatives concern the scientific aspects related to climate change and connected fields like vulnerability, mitigation and adaptation to climate change. Since now, their activities are limited to given a scientific expertise and authorized views related to specific subject like water resources vulnerability to climate change, adaptation issue is not yet touched.

Network of maghrebin experts

The RAB 94 / G31 have initiated the creation of four maghrebin (from Algeria, Morocco and Tunisia) network experts:

- ? Climate change and water resources,
- ? Climate change and health
- ? Climate change and transport,
- ? Climate change and atmospheric pollution

The Climate change and water resource maghrebin network has been relatively active during creation period. Two seminars are held and a technical paper related by “climate change and water resources in the Maghreb countries” are coordinated by this network and published by the RAB 94 / G31 project. This technical paper has focused their analysis on water resources management aspects. Authors have only touched on adaptation aspect strategy by using conventional tools. Climate change and health maghrebin network has held a seminar on climate and health with the participation of full experts on the climate and health sectors. Because of its unofficial character, the absence of funds and low level of motivation, this network creation does not seem to be sustainable.

II.2) Institutional framework related to water resources and wetland

Agriculture Ministry

Because, near 80 % of water is used by the agricultural sector, water resources policy has been assigned to the Agriculture Ministry where policy and strategic decisions are centralized. This mainly includes the mobilization of water resources, their management and the definition of new orientations.

Agriculture Ministry is an important administrative department with a wide regional presence. All administrative entities have their regional Agency (Commissariat Régional du Développement Agricole (CRDA)), with Bureau assigned by water resources issue and responsible by the implementation of the national water resources strategy, their decision and their orientation at the regional level. This Ministry has a developed network of Agencies as well as technical and scientific schools at the regional level. The management of water resources is arranged by geographical region: the North, the Center and the South. Each geographical region includes whole catchment basins.

Other operators

At the regional level, water resources management is attributed to:

- Privates, for little irrigated areas located near surface well,
- No Governmental Organization (NGO) or Association with general interest, for medium irrigated areas, near sinking and collinear weir
- regional administration for greater irrigated area on downstream greater weir

The drinking water management is attributed to the Tunisian Agency for operating and distributing water (SONEDE in French). This is a public agency with industrial trading characters. Associations with general interest participated too in this activity

Regarding new institutional arrangements Environment State Secretary is responsible by struggle against pollution. The sanitary monitoring of operating water resources used on drinking water and agriculture are provided by the public health Ministry. Equipment and Housing Ministry maintain protection against floods.

Water Code

Created in 1975 (law n° 75-16, 31 mars 1975), and revised were appropriate, the water code represent the framework of the water policy, regarding to:

- ✍ definition of the hydraulic public domain,
- ✍ preservation and policy water,
- ✍ right water use
- ✍ allocation and concession related to water use,
- ✍ water drinking use and agriculture use
- ✍ water demand and management.

So, between 1987 and 1996, 2033 Associations with general interest (NGO) have been created among which 564 irrigation associations, 1399 drinking water associations and 70 mixed associated. Those associations manage 56 600 ha of irrigated area and supply 175 000 families with drinking water. The field activities of those Associations are generally in the isolated regions. It participates generally to the management of collinear dams and collinear lakes. In spite their number, activity of this Association is very limited on volume water.

Advisory Institutional framework

The water code proposes the creation of an advisory entities among witch:

- the water National Committee (article 4, created by Agriculture Minister decree N ° 78-419, 15 April 1978)
- the hydraulic public domain Commission (article 20, Created by Agriculture Minister decree N ° 78-557, 24 may 1978).

The advisory institutional framework includes several others Commissions and Committee on the fields of water, drought, etc., and others connected fields like meteorology.

Wetland management

The Tunisian strategy on water resources mobilization and management includes in their planning a part related to wetland that doesn't have really specific strategy.

In 1989, a national inventory of all Tunisian wetlands was realized in collaboration with University College of London with a European Community financing (DG II, Contract 158.UK (4) and with additional support from Ramsar and US fish and wildlife Service. The inventory included notably a description of:

- ? Geographical situation,
- ? Climatic condition,
- ? Flora and fauna situation
- ? Risk and threat

Tunisian wetlands map was published. The same, leaflets and others information tools were produced. The Ichkeul Park ecomuseum was open to public since February 1989 and represents the main tool in the education and information sector. With co-financing between Ramsar and the European Community, (project Medwet 2), some part of the technical employees responsible by wetland management received an appropriates training

A study related to the Ichkeul national Park protection has been conducted with the aim of better understanding the main components (chemical, biological, fauna, .) of the dynamic life in the lake. Presently, we have an observation and monitoring system related particularly to salinity and water level.

In Tunisia, wetlands haven't a specific legal framework. Legal provisions related to wetland conservation and management was included in the recasting Forestry code by the law N ° 88-20 from 13 April 1988. In particular,

- the article 224, related to the protection and definition of wetland
- and the article 226, related to all pollution forms (liquid, solid and gazes)
-

Figure (6) : Ichkeul lake



II.3) Coordination between institutions involved in climate change and water resources and wetland policy and management

We must note in the beginning that we have a greater discrepancy between climate change issue and water resources and wetland issue. Water resources are a common concern in Tunisia. This issue has large economic and social impacts. Furthermore, climate change is a new issue with no sufficient assessment of impacts and a large part of uncertainty.

Coordination in the framework of the National Committee on Climate Change

In the institutional point of view, the National Committee on climate Change seems to be the main framework coordination. We have large representatives and Agriculture Ministry is represented. But considering the deficiencies related to the working of this institution, we don't have real coordination.

Coordination in the framework of climate change project activities (TUN 95/G31 and RAB 94/G31)

The management and the execution activities are insured by two Committee composed by a group of five persons largely involved in this question. These projects have allowed implementing several studies related to Tunisian vulnerability to climate change and constituting the memberships who are active in all fronts. Each study constituted a pluridisciplinaries framework discussion. This framework represents probably the main and the best framework to coordinate activities related to assessment of impacts, vulnerability, and adaptation to climate change particularly for the water resources and wet land sectors. Unfortunately, these projects are in their end and this framework is not sustainable

III) Integration of water and wetland resources management policy and practices and climate change

III.1) Water resources development policy and strategy

Water resources development strategy during the period 1991-2000 included four main components:

- ? mobilization of enabling water resources,
- ? prospecting of new water resources, mainly ground water,
- ? investigation of no conventional resources, such sea water desslage,
- ? rational management, with emphasis on agriculture,

The implementation of this strategy has been particularly hinder by:

- Availability financial resources,
- Structural deficiency,
- Environmental problem.

Considering this problem, output has been reprogrammed and period realization has been extended

Outline of future strategy to 2010, 2020 and 2030

Different studies were conducted to define the outline of the future water resources strategy and propose the basic elements and prospect the water resources strakes. Me must note that in 2030, with an efficiency policy that can control water demand to 2800 Mm3/year, the operating resources are estimated to 2700 Mm3/year. Demand and available water resources are so close that a problem has arose with accuracy. Among food for thought:

- ✍ Technical aspect,
- ✍ Economic aspect, including tariff aspect,
- ✍ Institutional aspect,
- ✍ Legal aspect,
- ✍ Risk management.

Integration of climate change issue in risk management

The main risk related to water resources is the natural risk. It includes on first hydrological risk like flood and drought. Meteorological and climate risk such hailstorm and warm episode is too important. Climate change projection related to Mediterranean region suspect an increase in frequency and intensity of climate extreme event like drought and flood. Unfortunately, climate change and possible impacts on water resources have not been considered.

The risk management consists to:

- preventing when possible extreme events
- taking measures to limit their impact.

Introducing climate change in the future water strategy is crucial. Risk management is probably the main sensitive water resources strategy component to climate variability in general and climate change in particularly. We can introduce climate change assumption by using appropriate scenarios

III.2) Climate Change issue: Institutional arrangement

The ministerial change which occurred on September 2002 have conducted to linking environment issue to the “Agriculture, environment and hydraulic resources Ministry”, with a specific State secretary.

Previous institutional framework

The previous climate change discussion framework in Tunisia will be probably based on:

- ✍ The State Secretary of environment who will be responsible for the definition of the Tunisian policy and related decisions
- ✍ The National Agency of Environment Protection who will be responsible of the implementation aspects.

The National Committee on Climate Change

The study related to institutional arrangement concerning the coordination of the process climate change at the national level, realized in the RAB 94 / G31 project framework suggests for the future of the National Committee on Climate Change (NCCC) two alternatives:

- 1- Integrate the NCCC like a sub-Committee under the National Committee on Sustainable Development (NCSD).
- 2- Propose a juridical and legal foundation for the creation of the National Committee on Climate Change

The second alternative will take some times to be implemented. Furthermore, the first alternative allows the NCCC to enabling by the legal foundation of the National Committee on Sustainable Development.

Taking into account that the National Committee on sustainable Development (NCSD) secretary is assured by the National Agency of Environment Protection and the important role that will play this Agency in the future, the second alternative is more practical and effective even it taking account by arising consideration

III.3) Institutional and participation arrangements

Activities between Institutions from different Ministries need generally institutional arrangements that can be sources of problems. For example, better coordination and arrangements between the National Meteorological Institute and The Technical Services from the Agriculture, environment and hydraulic resources Ministry, can largely improve water resources and weirs management at the level of catchment basin. About that, we must take arrangements concerning:

- role of networks observations of each institution and integration data information system,
- operating and best use of a reliable meteorological forecasts,
- use of the prevision outputs of meteorological models to initialize hydrological models.

Concerning flood management, we can enhance intervention capacities of struggle against flood Committee created in each administrative entities by greater flexibility and appropriate arrangements.

III.4) Regional collaboration and cooperation

We can compile a greater number of projects and experiences related to the Mediterranean region, and others related to sub-regional level like the Maghreb. The financial support is provided notably by the European Community.

The Mediterranean Action Plan (MAP) and their PlanBlue initiative report constitute probably the most important regional cooperation example. While the Mediterranean hydrological cycle observing system (Med-Hycos) constitute the most important initiative concerning data and information system.

All countries from the South Mediterranean region have enabling by a national and/or regional project related to climate change, with financial support by the Global Environmental Facility (GEF). These projects have allowed each country to implement their first national communication under UNFCCC, taking into account their priority (e.g. for Morocco, priority is agriculture and water resource vulnerability to climate change, for Tunisia, priority is assessment of coastal vulnerability to Mediterranean sea level rise).

At the national level, Tunisia has enabling by different projects related to all water aspects. As an example, in the framework of Avicenna research program from the European Community, Algeria, Morocco and Tunisia with France like European partners have implemented EL MASIFA project (June 1994-december 1997) related to the monthly and seasonally rainfall prediction.

The main weakness is related to:

- information concerning this experiences and projects,
- the use and application of results and recommendations,
- lack of follow related to this experiences and projects.

The priority is to make an inventory of all these experiences and projects, to make information available, particularly for policy makers and to bear fruit. Concerning actual and future projects and experiences, attaching importance to the sustainability of the outputs.

III.5) Adequacy and availability of research

Climate change is a global issue with an impact at all scales. Climate change, projection related to regional level is associated to a lot of uncertainties and low level of confidence. The Mediterranean region constitutes a climatic entity. Countries from the region, who have important capacities, must initiate, with collaboration by others countries from region, studies related to:

- Projection climate change at the regional level
- Assessment of impacts of climate change on natural system, with emphasis on agriculture and water resources,
- Assessment sensitivities of important natural system, like agriculture and water resources to climate change

The most important issue is probably the lack of information concerning climate change at the national level. In reality, we have also a lack of methodology to assess such information. The regional collaboration is probably the best way to develop such tools. The aim is to make available, a pertinent scientific information that can be used to inform responsables and policy makers and alive them, particular by potential risks

IV) Toward adaptive strategies: discussion points

If we compare climate change to with other pressures, it is likely that over a time horizon less than 20 years, climate change impacts will be small relative to other pressures. Unfortunately, this consideration is not susceptible to prioritizing such adaptive strategy.

IV.1) Issues to prioritizing adaptation response

Quantitative assessment of impacts and risk

Most studies of climate change impacts have focused on changes in mean climate conditions. However, global climate change is likely to bring changes in climate variability and extreme events as well. Furthermore, impact of climate change on water resources depends not only on changes in the volume, timing and quality of stream flow and recharge but also on system characteristics, changing pressures on the system, how the management of the system evolves.

IPCC provides a climate change projection on global scale, associated with information at the regional level. We have a problem of scale and it is difficult to have reliability information at the national level.

It may be important to assess the possible thresholds at which strongly discontinuous responses of water resources to projected climate change would be triggered. It is the main action to assess risk related to climate change. It is important too, to have a quantitative understanding on dynamic response water resources ecosystem to climate change stress. The aim is to bring out the most important climate change impacts and the main potential risks and their disastrous consequences on water resources in Tunisia

Quantitative assessment degree of vulnerability

Degree of vulnerability to climate change is defined by two components:

- Sensitivity to climate change
- Capacity to response

Sensitivity to climate change is determined following the degree of disastrous damage and the potential risk. Furthermore, response capacity depends mainly on institutional capacity and degree of organization.

According to IPCC assessment, the greatest vulnerabilities are likely to be in unmanaged water systems and systems that are currently stressed or poorly and unsustainably managed due to policies that discourage efficient water use and protection of water quality, inadequate watershed management, failure to manage variable water supply and demand, or lack of sound

Concerning Tunisia, we must focus on quantitative assessment of the sensitivity, adaptive capacity, and vulnerability of water resources to climate change, with particular emphasis on change in the range of climatic variation and the frequency and severity of extreme climate events.

Some classic and pessimistic speech related to climate change goes contrary to previous effect. We must implement studies related to the national level in the aim to identify the main vulnerability aspects. It is not important to focus on climate change range because generally level of available data is not sufficient to use a relationship between climate change and impact. Furthermore, it is important to identify:

- ? The most sensitive climate change aspects,
- ? Failure response capacities

Fragile balance: operating water-demand water

The previous evolution of potential water resources and operating water resources is based on scenario with climate stability. It is the same concerning previous evolution of water demand with emphasis on control component.

**Tableau (4) : Balance operating water /demand water
(conventional and no conventional water), unit: Mm3**

	reference year (1996)	2010	2020	2030
Operating water	2767	3300	3106	3121
Demand water	2528	2689	2721	2760

Balance between operating water resources and demand resources is very close and with a business as usual climate change scenario this balance can be upsized. So, the key challenge is to incorporate uncertainty in the range of climate change, in this balance that is on the basis of the water resources Tunisian strategy. We can use an approach by climate change scenario and define a balance of each scenario.

IV.2) Key assumptions for adaptation strategy

This part concerns few relevant points, specific to Tunisian water resources situation and susceptible to be considered when developing adaptive strategy.

Adaptation to hydrological extreme events: drought management

Considering its geographical position, Tunisia climate is characterized by its natural variability. Future climate change related to the Mediterranean region is suspect to exacerbate this variability by increasing frequency and magnitude of extreme events. Flood magnitude and frequency could increase as a consequence of increase frequency of heavy precipitation events, which can increase runoff in most area as well as groundwater recharge in some floodplains. Land use change could exacerbate such events.

The risk of flood or drought inherent to Tunisian climate makes it necessary to manage water resources on both intra-annually and inter-annually range. SO, we must:

- ✍ Store the water surplus during wet years
- ✍ Use water efficiency during drought years

Moreover, country such Tunisia in which water use is more than 20 % of total potential water resources available are expected to experience severe water stress during drought periods.

Adaptive strategy of water resources to climate change should include an important axis related to hydrological extreme events with particular emphasis on drought management.

Water quality

Climate change in the Mediterranean region is expected to increase evaporation rate and little decrease in rainfall associated to increase in the frequency and magnitude of extreme events likes drought and flood.

In this case, we will suspect a drier soil and probably rivers will carry less water. So, climate change would degrade water quality through higher water temperatures and increased pollutant load from runoff and overflows of waste facilities. Quality would be degraded further where flows decrease, but increases in flows may mitigate to a certain extent some degradation in water quality by increase dilution

Some costal phratic napes, particularly in the North East, the Cap Bon and the Sahel regions, subject to an over operating, are vulnerable to a Mediterranean sea level rise and risk infection by sea water intrusion is important.

Higher cost of new water resources mobilization

With an average potential surface water resources of 2700 Mm³ /year, only 2100 Mm³/year are mobilized, witch represent 78%. Regarding the actual capacity and the planning hydraulic infrastructure, we suspect to reach the total mobilization of the identified resources near 2010. The remaining new mobilized water resources have a higher cost and probably a bad effectiveness.

Storage capacity and regulation

The variability of surface water resources in time means that with reference to the average of 2 700 Mm³ / year, the following quantities are actually available:

- ? 2230 Mm³/year, one year over two,
- ? 1500 Mm³/year, one year over five,
- ? 1250 Mm³/year, one year over ten.

The Average annual volume is highly modeled by climate variability. Potential resources water availability is less than 2230 Mm³, one year over two. This is supposing that we must have a minimum annual storage capacity near 470 Mm³. In fact, Tunisian water resources strategy has a main component related to intra and inter-annual storage water resources capacity.

Tunisian adaptive strategy to climate change should include a main component related to storage water resources. The main constraint that can exacerbate this component is water supply during drought season.

Irrigated agriculture

Climate change is unlikely to have a large specific effect domestic demand but may substantially affected irrigation withdrawals. In Tunisia, irrigated culture is developed over 335 000 ha, that is 7 % of the cultivated land, producing on the average of 32 % of the total agricultural production value.

In the horizon 2030, irrigated area will increase to 470 000 ha. Nevertheless, with the use of new technologies, consumption water for irrigation by hectare will decrease from 6230 cubic / ha for the year 1996 to 4355 cubic / ha for the year 2030.

Strategically, this culture is important to supply demand of agglomeration during all seasons. In spite the fact that the proportion of water allocation to irrigated agriculture decrease from 83 % in 1996 to 74 % in 2030, the main challenge is the competitiveness of the irrigated agriculture in Tunisia.

Peasant practices

Regarding a secular empiricism transmitted generation by generation, the rural world have accumulated a peasant practices based on conservation and valorization of water resources and related to:

- ✍ Collection water
- ✍ Management water
- ✍ Use water(drinking water and agriculture)

This peasant practices included notably, little weirs, terrace, water tank, jsour, mrescat, tabia, etc... These peasant practices are different from regions to others. It's depending on regional climate characteristics, soil nature and socio-economic conditions. These peasant practices are homogeneous with environment and have the advantage to be sustainable. It can be considered like an adaptive practice that can be implemented at the local scale.

Specific wetland strategy

The first steep consists to realize a quantitative assessment of climate change impacts on wetland. The second steep is related to a quantitative assessment of vulnerability to climate change. This assessment must be associated by environmental assessment value of Tunisian wetlands. This last assessment is very important to persuade policy makers by opportunity of establishment of a specific strategy on management and preservation wetland.

IV.3) “No regrets” and low cost, no cost measures

Currently supply-side approaches (e.g., increasing flood defenses, building weirs, utilizing water storage area, including natural systems, improving infrastructure for water collection and distribution) can be widely used as a basic adaptive measures. These options have the advantage to be integrated in the national water resources strategy and don't have a

specific cost related to its adaptive aspect. These measures could have multiple benefits, today and in the future, even in the absence of climate change pressure.

In the other hand, some demand-side options (e.g. allocate water between users, efficient technology and institutional arrangement and practices) available to made, can allow to have immediate benefit and probably with low cost.

Some anticipatory and precautionary adaptation options involve numerous no-regrets low cost and no cost is generally more effective and less costly than forced adaptation measures.

Development of approaches to adaptation responses, estimation of the effectiveness and costs of adaptation options, and identification of differences in opportunities for the obstacles to adaptation, are the main steeps to identify “no regrets”, low cost and no cost measures.

IV.4) Integrated water resources management

Taking into accounts their strong tradition and relatively effective management, Tunisia has some adaptive capacities, and especially ability to implement integrated water resources management. Water resource management techniques, particularly those of integrated water resource management, can be applied to adapt to hydrological effects of climate change, and to additional uncertainty, so as to lessen vulnerabilities.

Integrated system using:

- Meteorological and climate information and forecasts
- Hydrological information
- Follow the hydrological by remote sensing technique,

consitute a warning system that can Improve ability to forecast stream flow weeks or months ahead also would significantly enhance water management and its ability to cope with a changing hydrological variability.

In practice it may be very difficult to change water management practices. The challenge, therefore, is to develop ways to introduce integrated water management practices into specific institutional settings. Moreover, management institutions and market-like processes that are not well developed can be largely improved.

Conclusion

In Tunisia, water resources importance sector is not need to be demonstrated. Nevertheless their environmental value, water resources is an important socio-economic development factor. It is urgent to define outlines of adaptive strategy who can building capacity and enhancing ability to adjust to climate change, to moderate potential damages and to cope with the consequences.

When developing adaptive strategy for water resources and wetland in Tunisia we should be consider some key assumptions such:

- ✍ Water quality degradation,
- ✍ Higher cost of new water resources mobilization,
- ✍ Storage and regulation capacities,
- ✍ Irrigated agriculture,
- ✍ Peasant practices,

In practice, it is difficult to change water management practices. The challenge, therefore, is to develop ways to introduce integrated water management practices into specific

institutional settings. Moreover, we should improve and strengthened management institutions and market-like processes.

We have a greater discrepancy between climate change issue and water resources and wetland issue. Water resources are a common concern in Tunisia. This issue has large economic and social impacts. Furthermore, climate change is a new issue with no sufficiently assessment of impacts and a large part of uncertainly.

It is important to include scientific information on impacts, vulnerability, and adaptation, in decision making process, risk management, and sustainable development initiatives.

Tunisia have some adaptive capacity, especially ability to implement integrated water resources management witch enhance adaptive potential to climate change. However, the improvement and strengthened of the national water resources strategy is the best way to adapt and response to climate change.