MEDITERRANEAN EUWI/WFD JOINT PROCESS

State of the art on Drought & Water Scarcity in the Mediterranean:

Monitoring water scarcity and drought in the Mediterranean Synthesis note

Produced by the
MEDITERRANEAN WATER SCARCITY AND DROUGHT WORKING GROUP

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1. INTRODUCTION

The objective of the present synthesis is to give a state of the art of water scarcity & drought magnitude in the Mediterranean region, as well as to analyse the results of the activities been carried out last years under the framework of the Mediterranean Working Group (WG) on Water Scarcity and Drought (WS&D). This synthesis will also analyse the common outputs (e.g. data collected, maps, indicators, etc.) produced in the pilot basins and in the countries, and also to highlight the existing gaps in data items necessary to produce the identified aggregated indicators, which are very essential for water scarcity and drought monitoring and management.

This synthesis includes some recommendations to improve the provision of the necessary data items. Moreover, it identifies the gaps for data provision and recommendation for improvements.

The Mediterranean EUWI/WFD Joint Process was first presented during the EU Water Directors Meeting in Dublin, on 23 June 2004. Two phases have been achieved (Phase I: 2004-2006 & Phase II: 2007-2009).

The Med Joint Process encourages the establishment of a network of water experts, volunteers for sharing their own difficulties/solutions and ready to get experiences from other basins or countries.

The Joint Water Framework Directive / EU Water Initiative process (JP) aims specifically at developing synergies between the two mechanisms to facilitate the implementation of sound water policies. This process included since its launch six working groups:

- Groundwater management: leaders: Greece and the European Commission;
- Water Scarcity and Drought: leaders: Morocco, MENBO, EMWIS
- Linking rural development with water management: leader: the European Commission;
- Waste water re-use: leaders: Malta, the European Commission; supported by EMWIS
- Shared water resources management: GWP-Med
- Water monitoring: leader: EMWIS

Complementary to these working groups and the EU Pilot River Basins exercise, pilot activities have been developed in the southern rim of the Mediterranean. The exercise consisted in testing the existing EU guidance as well as recommendations produced by the Med Thematic WGs covering different aspects of the WFD. Concrete testing would allow identification of activities / measures to be implemented for achieving the targeted objectives.
The two pilot river basins (Sebou in Morocco and Litani in Lebanon) conducted such exercises for basins characterisations and water quantity reporting. The reports produced are instrumental in matching major water management problems and needs of the river basins with solutions from the EU experiences while helping the river basin authorities in developing their own action plan.

The mandates, progress and results of the thematic Working Groups have been presented, discussed and agreed at the Conferences of the Water Directors of the Euro-Mediterranean and South-eastern European Countries.

On the other hand, those WG activities are closely linked with the recent elaborated "Strategy for Water in the Mediterranean" prepared under the framework of the Union for the Mediterranean –UfM-, a process formerly launched at the Paris summit in July 2008, bringing

together 43 states (27 EU countries, Balkan countries, North Africa countries and countries of Middle East), the European Commission, the League of Arab States and Libya as observer.
This Mediterranean Water Strategy (SWM) aims to tackle challenges and opportunities facing water resources in the region:

- Ensure the integration of policies.
- Enhance and facilitate the participation of all stakeholders. Promote the establishment of active user associations.
- Increase citizens' awareness on the value of water and its culture
- Ensure the capacity building of all competent stakeholders of water management and environmental protection and facilitate knowledge and expertise exchange.
- Secure comparable water data collection and monitoring also employing appropriate indicators.
- Support research in all water aspects as a way to achieve the necessary development and address challenges.
- Establish and support fair and socially sensitive valuation and cost recovery.
- Ensure optimal use of available instruments and tools (EIA, SEA).

The strategy contains four priority themes, each one described with objectives, approaches/instruments and recommendations for action:

- Enhancing effective governance for integrated water resources management.
- Adapting to climate change and enhancing drought and flood management.
- Promoting water demand management, efficiency and non-conventional water resources, and protecting quality of water and biodiversity
- Optimizing water financing, water valuation and appropriate instruments, with emphasis on innovative mechanisms

To translate the recommendations into action, short-term (2012-2015), medium term (2016-2020) and long terms targets (2021-2025) have been defined for the SWM operational objectives.

The implementation of the current SWM will need to be translated into an action plan with:
a set of indicators allowing to follow its progress, achievements and impact and financing opportunities for well-targeted and sustainable projects to be selected according to a set of general UfM criteria and technical criteria already defined in the SWM.

In this process as suggested by the European Commission at the last ministerial conference in Barcelona in April 2010, the experiences gained through programmes like MEDA Water, the EU research programmes, the WFD implementation and the Mediterranean Joint Process could be very valuable for the development and implementation of water policies in the Mediterranean region.

Hence, the activities of the Med Joint Process, notably those implemented by the Med WG on WS&D should support the implementation of Mediterranean water strategy (SWM) by providing expertise to the Water Expert Group (WEG) for the preparation of the Action Plan and the definition of indicators. Therefore, the WG on WS&D should support the action on adapting to climate change and enhancing drought management.

The Mediterranean Water scarcity and drought WG is strongly interfaced with the Drafting Group set up by the EU Water Directors in the Framework of the Common Implementation Strategy (CIS). The overall objective of the Med WG is to share information on definitions and possible actions in order to react on scarcity issues. Linkages with working groups –WGs- of the EU Common Implementation Strategy of the Water Framework Directive (WFD CIS) have been ensured thanks to EU experts involved in EU WGs dealing with similar issues.

A first Mediterranean report on Water Scarcity and Drought has been published in June 2008. It provided an overview of the information available so far in the Mediterranean Region. The

conclusions of the report pointed out issues to be further addressed in order to progress towards a Mediterranean system of information on water scarcity and droughts.
To prepare this report a data collection survey exercise was carried out o have an overview of the magnitude of the problem of water scarcity and droughts in the Mediterranean, particularly an assessment of their impacts, and exchange information on possible alternatives of water use that contribute to its saving and could be applied by different types of users.

2. MEDITERRANEAN CONTEXT

The most severe water scarcity in the world is in the Middle East, and critical water shortages in the Eastern Mediterranean region as a whole affect the region's social and economic potential, increase land vulnerability to salinisation and desertification and raise the risk of political conflict around this limited resource (Brooks & Mehmet 2000, Jagerskog 2003, Tropp & Jagerskog 2006). According to Allan (2002), the region "ran out of water in the 70s" and is currently surviving on virtual water and in cases on over exploiting its own renewable water resources. Per capita water consumption in the study region is variable and generally low, reflecting equity issues which relate to access and rights to water, as well as availability. In the Gaza Strip and West Bank, Palestinian water consumption is well below World Health Organization standards of 100 litres per day (UNEP 2003). The World Water Development Report (2003) classifies Jordan as facing an extreme situation of water scarcity. Jordan is overexploiting its water resources by between 10 and 20 percent at the expense of natural ecological systems (Tropp & Jagerskog 2006). Similarly in Israel the coastal plain aquifer has been overexploited since the 1960s, although this has stopped in recent years (Benoit & Comeau 2005, Ministry of National Infrastructure 2006). Consequentially, water levels are dropping and salinization and salt water intrusion are taking place. Lebanon, with an abundance of water resources relative to the region, is predicted to face water shortages and be unable to meet its local demands by 2025, purely as a result of demand increases, not taking climate change into account (Bou-Zeid & El-Fadel 2002). Combined with water scarcity, poor water efficiency exacerbates water shortages. Most countries in the Mediterranean region already find it increasingly difficult to cope with increasing water demands from their growing and urbanizing populations and those of adjacent countries with which they share water resources (Bou-Zeid & El-Fadel 2002, Bucknall 2007).

The term drought is used to define a temporary decrease in water availability due for instance to rainfall deficiency. Drought is an indistinct event, of water deficiency, that results from the combination of many complex factors and neither the beginning nor the end can be precisely defined, (COM (2007) 414). The term is relative, since droughts differ in extent, duration, and intensity, and definitions differentiate based on the analysed effects, meteorological, agricultural, hydrological and socioeconomic (CEDEX, 2004).

Water scarcity refers to the relative shortage of water in a water supply system that may lead to restrictions on consumption. Scarcity is the extent to which demand exceeds the available resources and can be caused either by a reduction of the natural water availability or by human activities which increase the freshwater abstraction, such as population growth, increased economic activity (industry, agriculture, tourism etc.), water misuse etc.

In the Mediterranean, most of the countries are facing water scarcity and the high risk of water shortage is generally ascribable to increasing demand despite the limited renewable water resources (which are often of high spatiotemporal variability and affected by climate change). In some places it is exacerbated by poor water quality. To analyse in depth the drought and water scarcity occurrence and its extended impacts, one needs to look at the Drivers, Pressures, State, Impacts, and Response –DPSIR- associated with these phenomena.

The figure below provides a schematic representation of the DPSIR framework depicting their cause-effect relations.

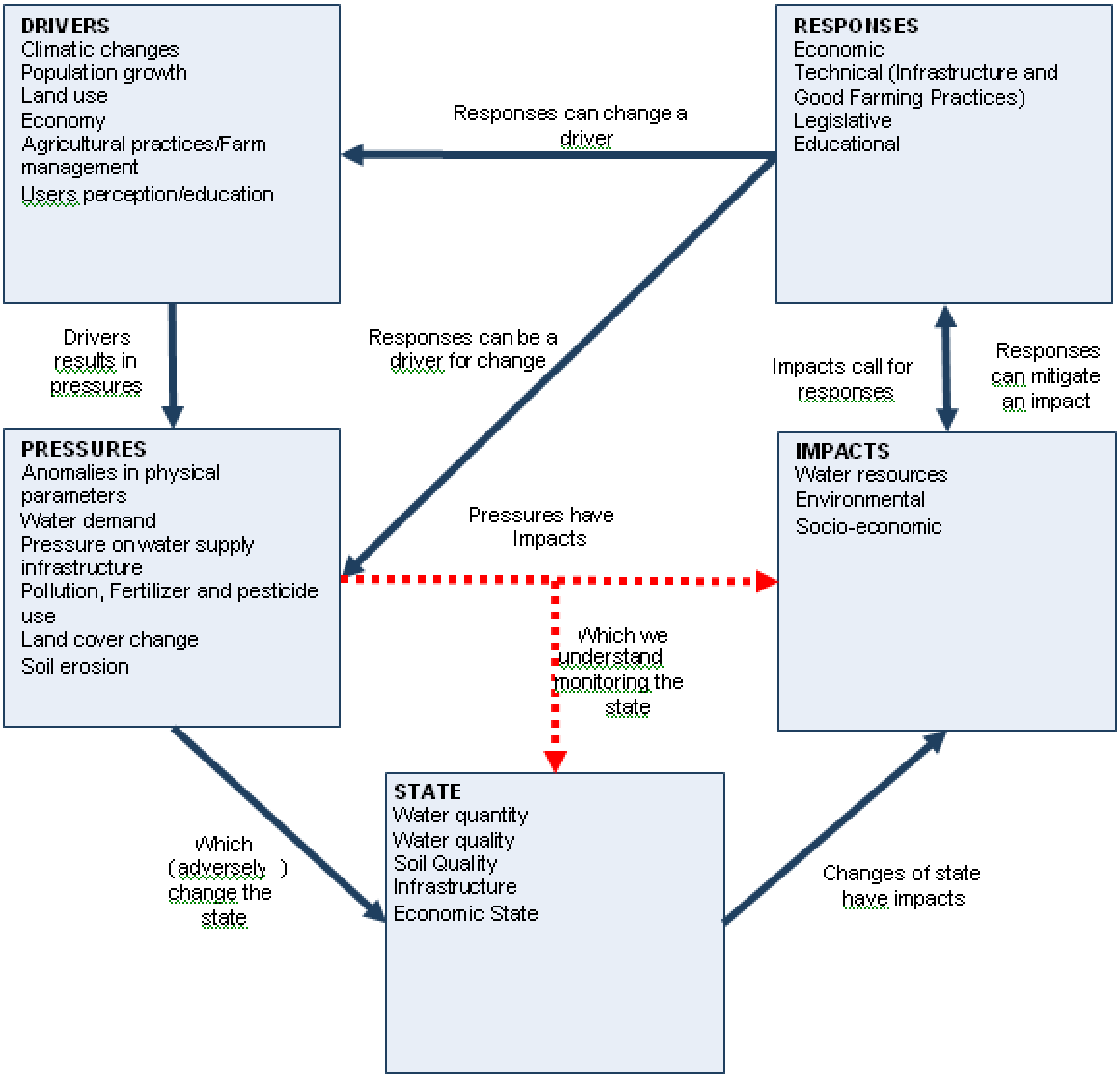


Figure 2.1: DPSIR framework for Water Scarcity and Drought

Water Scarcity and Drought produce a complex mix of economic, social and environmental impacts that are very difficult to assess in quantitative and monetary terms (data may exist in a number of countries, decentralised in different agencies, thus making it difficult to collected and assess). While it may be easy to obtain figures on impacts for drought events (because they are limited in time and impacting specific sectors), the impacts and the costs associated with scarcity are largely more difficult to obtain. In the previous report of the WG, a certain number of examples from different countries in the Mediterranean were given, including the impact on water quality. In summary, the environmental impacts affect directly the plant and animal species (loss of biodiversity), the wildlife habitat, the air and water quality, while increase the risk of forest fires, soil erosion and the degradation of landscape quality. Some of the effects are only short-term and normal conditions are quickly re-established. Other environmental effects linger for some time or may even become permanent. For example, the degradation of landscape quality, including increased soil erosion, may lead to a permanent loss of biological productivity of the area. The socio-economical impacts (either direct or indirect) occur in agriculture and related sectors (industry, tourism etc.) which depend on the surface and groundwater supplies. In addition to obvious losses in yields in crop, livestock and industrial production, associated work loss, migration of drought-hit rural people in urban areas, conflicts between users etc. cause additional chained effects e.g. on water pricing, credibility and reliability of country's exports, political stability especially for transboundary water resources (WS&D could be a source of both conflict and cooperation in the Middle East). Finally, adverse impacts occur on domestic hygiene, public health (e.g. increase in insect infestation) and safety.

BOX 1

Impacts of the 2010 drought in the West Bank (Palestine)

- Economic: High prices of tanker water
- Social: Limited supplies of water for drinking, domestic consumption, inadequate supplies of water and fodder for livestock
- Environmental: Lower water table, dried spring, drying of grazing shrubs and grasses

Impacts of the 1999 drought in Jordan, Israel & Palestine

- Economic: Severe agricultural water use restrictions, collapse of rain-fed farming in the West Bank, purchase of water on the black market
- Social: Water rationing in Jordan and the Palestinian Territories, with resulting health implications
- Environmental: Degradation of stream water quality, sharp water depletion and increased salinity of groundwater systems, increased salinity of soils
- Other: Political ramifications

Tunisia faced more historical droughts in 1937, 1947 and 1960; they resulted in famine, rural depopulation, epidemic and even some rural revolts, unfortunately informationis very scarce. Impacts of the 1987-89 and 1993-95 very severe droughts in Tunisia:

- Economic: Restrictions of water use in agriculture, and reduction of agricultural production (olives and cereals). Budget allocated to mitigation measures in 87/89: 26 M€; in 93/95: 34 M€. The GDP decrease of 1994
- Social: Decrease in farmers' revenue
- Environmental: Sharp increase in salinity of surface water and soils, drying up of lakes

3. INDICATORS AS TOOL TO ASSESS AND MANAGE SCARCE WATER RESOURCES

3.1. Why collecting data and using common indicators

The main objective of collecting data and formulating common indicators is to ultimately provide a basis for the harmonized assessment of Drought and Water Scarcity conditions taking into account both demand, supply and availability issues (i.e. both socioeconomic and environmental dimensions). It is important to include the socio-economic dimension Water Scarcity is a socio-environmental problem par excellence. The process of using common data and indicators reinforces exchange of experiences between the Mediterranean countries, allows clear understanding at operational level and thus facilitates the communication between stakeholders (indicators simplify a complex reality), provides a basis for integrated water management at river basin scale, and furthermore allows assessing mitigation strategies in those countries. Moreover, Common indicators (or Benchmark indicators) could help efficiently in monitoring the impact of the Med Water Strategy and related projects and in setting priorities by identifying the key influencing factors, as well as in raising public awareness on the specific problem.

Based on the EEA Typology for Indicators (Smeets, E., Weterings, R., EEA, 1999), indicators can be classified into 4 simple groups, which are related to key underlying policy questions, as shown in the following table:

Type of Indicator	Key policy question	Functionality
Descriptive Indicators (Type A)	What is happening to the environment and to humans?	They describe the actual situation with regard to the main specific issue
Performance Indicators (Type B)	Does it matter?	They compare the actual conditions with a specific set of reference Conditions, allowing thus a "distance to target" assessment
Efficiency Indicators (Type C)	Are we improving?	They provide insight in the efficiency of products and processes. Most relevant for policy-making are the ones that relate environmental pressures to human activities
Total Welfare Indicators (Type D)	Are we on the whole better off?	They measure the total sustainability

BOX 2

Collective Approach for scarcity Response in Palestine (Water Scarcity Task Force):

The following indicators have been in order to respond to water scarcity situation related to the domestic sector. The thresholds proposed range from 3- High to 1-Low.

Indicator	Description	Measurement Unit	Humanitarian Scarcity baseline (unit)	Risk Threshold		
				H (3)	M (2)	L (1)
Availability / Consumption	Availability of water for drinking and domestic consumption	Liters per capita per day	30 lpcpd	<30	30-50	50-60
Affordability	Price of water purchased including transportation	NIS / cu.m	20 NIS/cu.m	>20	20-10	<10
Resilience	Household level coping capacity, connectivity to a functioning network and / or having adequate storage capacity[1] for water	% of households connected to network or having storage capacity	Households (community) with neither networks nor storage capacities	>80% unconnected or without storages	>80% unconnected but with storages	>80% partially connected but with out storages
Water Quality	Safety of water for drinking and domestic consumption	Qualitative	Unsafe source	Unsecure source	Mixed source	Secure source
Protection	Risk of displacement	Qualitative	Area C Communities	Sensitive Area C	Other Area C	Area B & A

These indicators define the process of targeting the communities for scarcity response and do not underline the minimum service delivery figures for response. For the agricultural sector indicators proposed are: 1) animal water consumption, 2) Dependency, on herding, 3) Viability (number of months that herders rely on purchased fodder).

3.2. Water scarcity & Droughts Indicators

Several hydro-meteorological indicators and indices have been developed and it is always necessary to select a combination of the most suitable ones in order to describe in a synthetic and efficient manner the evolution of drought in time and space over the affected socio-economical-environmental systems, taking in account the different drought characteristics (meteorological, agricultural, hydrological, socio-economic) and basing the selection on specific criteria (e.g. robustness, data availability, reproducibility, capacity of integration of the indicators etc.). For water scarcity, it is also necessary to monitor the water availability per sources, the water abstraction, and the water uses & demands for the different economic sectors involved, in order to evaluate and individuate the reasons of the imbalances and activate proper measures. In both cases, characterization of the events should include preliminary analysis of the sources of information, including data reliability, and selection of the appropriate spatial and temporal time scale. Achieving a solid proactive management highly depends on the selected indices for the events identification and the adopted thresholds for preventing and mitigating impacts.

The Mediterranean WG on WS&D has worked in the second phase on identifying the most widely used indicators for Water Scarcity and Drought, with the aim to get an agreement on the most useful ones for decision making process. Dozens of drought indicators are actually used in the region and in the world: Percent of Normal; Deciles; Palmer Drought Severity Index (PDSI); Palmer Hydrological Drought Severity Index (PHDI); Palmer Moisture Anomaly Index (Z-Index); Surface Water Supply Index (SWSI); Standardized Precipitation Index (SPI); Rainfall Anomaly Index (RAI); Reconnaissance Drought Index (RDI); Run Analysis; Crop Moisture Index; Soil Moisture Anomaly Index; Normalized Difference Vegetation Index (NDVI); water deficit index, 'Socio-economic vulnerability to drought' Index; Water scarcity Index, etc. Drought indices assimilate long time-series of data on rainfall, snowpack, streamflow etc. into a comprehensible and easy to communicate output. A drought index value is typically a single number, far more useful than raw data for decision making. Although none of the major indices is inherently superior to the rest in all circumstances, some indices are better suited than others for certain uses. The current trend in the monitoring and early warning centres is to utilise a range of different drought indices in the context of a public information system on the hydro-meteorological variables and on the state of the water resources.

Few indicators are today available to correctly illustrate the extent of water scarcity at river basin or national level and its characteristics. Used indicators include a combination of simple indicators such as water use per economic sector, water balance, reservoir storage etc., while some complex indices exist in literature such as the Water Availability Index (WAI), the Integrated Sectoral Water Stress Index (ISWSI), the Aquastress Water Stress Index (AWSI) etc. One of the mostly used ones in the Mediterranean region is the Water Exploitation Index (WEI), defined as the total annual freshwater abstraction of a country divided by its long term annual freshwater availability (LTAA) (ref. Figure 3.1.). It illustrates to which extent the total water use puts pressure on the water resource.

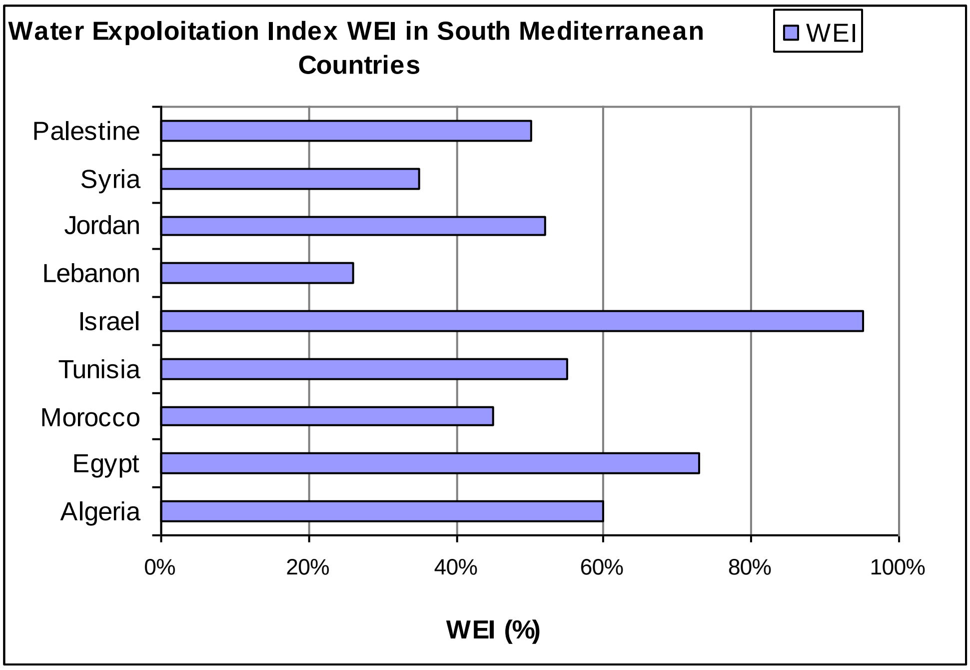


Figure 3.1. Water Exploitation Index (WEI %) in South Mediterranean countries
Data Sources / ref. year of abstraction data: Algeria: Eurostat/2008, Egypt: Eurostat - 2008, Morocco: Eurostat – 2003, Tunisia: Eurostat – 2007, Israel : Eurostat – 2007, Lebanon: Eurostat – 2005, Jordan: Eurostat – 2007, Syria: Eurostat – 2007, Palestine: Aquastat - 2007

The warning threshold for WEI which distinguishes a non-stressed from a stressed country is around 20 %. Severe water stress can occur where the WEI exceeds 40 %, indicating unsustainable water use. Yet, since WEI is calculated at country level, a water rich area may leverage a water stressed area biasing the national output and covering the regional problem. By using this index at river basin scale (disaggregated level), water saving efforts can be focussed in areas of water stress and take account of the success of existing measures and resource developments. The WEI although it does not allow for the identification of the drivers of the problem or of the main users, it has the advantage of using for its calculation consistent information which is collected periodically by the statistical services (and reported to Eurostat and Aquastat) across the Mediterranean.

It should be noted that in the context of the DPSIR framework and for the in-depth assessment of the water scarcity and drought aspects, indicators which take into account the socio-economic dimension are also very important (Iglesias et al., 2009). These indicators can depict the main drivers (helping to understand the underlying causes of risks) and assess the effectiveness of the adopted response, evaluation thus the societal vulnerability to drought and water scarcity and its ability to anticipate, cope and respond to such phenomena.

3.3. Pilot testing of WS&D indicators in the Mediterranean

With the overall vision to develop a coherent concept for water scarcity and drought observation and information in the Mediterranean, a pilot exercise was launched in order to investigate the data collection capabilities and the possibilities of developing common indicators, and to provide a first argumentation for the further needs in streamlining this process for supporting policy and assessing mitigation strategies.

The specific objective of the exercise is to test the application of WS&D indicators in selected pilot river basins in the Mediterranean, in order to draw conclusions on the applicability, clarity and validity of this approach, while at the same time enhance the selection (screening) of the most relevant indicators based on specific criteria (i.e. robustness, capacity of integration/combination, data availability, consistency, diagnostic ability etc.). The pilot areas which participated in the exercise include 2 pilot River basins in South Mediterranean, the Litani RB in Lebanon and the Sebou RB in Morocco, and in 1 pilot River Basin District in North Mediterranean, the Cyprus RBD. The EEA "WQ Reporting Tool v1.1." (Kossida, 2009) has been used for a harmonised data collection. This tool has been developed by the European Topic Centre on Water for the purpose of collecting data under the WISE-SoE data flow on the "State and Quantity of water Resources" (SoE reporting sheet#3). The requested data cover in general water availability (water balance, groundwater level, streamflow, reservoir inflow/outflow etc.), water abstraction per source and water use per sector.

Following a quality assurance process, the data have been used to develop relevant indicators, using the DPSIR methodological division to provide a thinking framework for their development and categorisation. The selected indicators are scientifically sound and representative, allowing common understanding of what the information shows, yet are subject to the current data availability limitations.

4. EXPERIENCES WITH PILOT BASINS

4.1. Litani Basin, Lebanon

4.1.1. Description

Litani River Basin with a total area of 2,088 km^2 covers approximately 20% of Lebanese territories. Water flowing in the river accommodates for 30% of the water running in all Lebanese rivers. The average discharge of the river, being the largest river in Lebanon, is 360 MCM per year. While the river system serves for irrigating 77,000 ha of current, ongoing and proposed schemes, the Litani produces 10% of national needs of clean hydroelectric power.

The Litani River system includes considerable number of tributaries and watercourses. Litani main river bed stretch along 172 km added to 60 km of tributaries. The biggest portion of Litani river (132 km or 80%) drains firstly southward, and then diverts at "Deir Mimas" village to the west yielding in the sea. Drainage density is higher in the coastal part of the river (1.2 km/km2) than in the Bekaa area (0.9 km/km2). The average discharge of the river, being the largest river in Lebanon, is 360 MCM per year. Water flowing in the Litani system amounts to 30% of the water running in all the Lebanese rivers. A remarkable number of springs issue in the Litani river basin, with different magnitudes and hydrological regimes. The spring's

Figure 4.1.1: Hydrological sub catchments of the Litani RB

magnitude ranges mainly from 6.31 to 28.3 l/sec and they are located at elevations ranging between 900 and 1200 m. However, some springs have higher discharge volumes like (31 to 77.63 Mm3/year). Elaborate and reliable data related to underground water in the Litani watershed is yet unavailable. The number of drilled wells in the basin is unknown precisely, since most of them are private; however, recent studies indicate that 4000 wells are drilled in the plain in deep levels, and 3000 wells are affecting the coastal part of the basin.

The Litani RB can be subdivided into four major sub-catchments depending on physical and hydrological properties (i.e. the upper sub-catchment (USC), the middle (MSC), the lower (LSC) and the coastal one (CSC). Their characteristics are presented in the following table and their location is depicted in Figure 4.1.1.

Sub-catchments characteristics	Upper (USC)	Middle (MSC)	Lower (LSC)	Coastal (CSC)
Coverage (% of the basin)	50 %	20%	10%	19%
Width (km)	30 km		10 km	
Area extent (km2)	1016	442	212	418
Slope gradient (m/km)	10	20	25	65 (especially in mountainous areas)
Prevailing flow direction	NNE - SSW	NNE – SSW	NNE – SSW	E - W
Volume of discharge water	295	441	641	130
Discharge density (km/km2)	0.84	0.72	0.71	1.12
Characteristics	Hosts the major springs yielding in the basin	Imbeds Quaroun Lake (5.6 km2)		Smallest coverage (10%)

Table 4.1.1:Sub-catchments of the Litani River Basin

4.1.2. Assessment of Water Scarcity & Drought based on selected indicators

Based on the reported data which presented limitations, an attempt to assess the prevailing drought and water scarcity conditions was made using relevant indicators, as analysed in this section. Additional data have been collected through literature review. The selected indicators are briefly presented in the following table 4.1.1, while the availability of data resources and their credibility to support drought indicators for Lebanon at large is presented in table 4.1.2.

Indicator	Hydrological years	Comments
Precipitation	1967-2005	Calculation of average annual precipitation per decade in Lebanon to detect trends Comparison of the monthly long-term average precipitation 1975-2006 (LTA) in the 4 eco-climatic zones of Litani RB to assess the spatiotemporal variability
Stream flow	1965-1999	Comparison of annual discharges (hm^3) from 1965-1999
Abstractions from surface water for irrigation	2007-08	Monthly irrigation water abstraction from surface water from the Upper and Lower Litani subcatchments in order to assess the spatiotemporal variability.
Change in Reservoir area Reservoir water balance	1939-2008 1973-2005 (incomplete time series)	Evolution of Qaraoun Lake area (km^2) from 1973-2005
Population	1994-2010 and 2015, 2020 projections	Evaluation of the population growth trends
Desertificated prone areas	Map	Evaluation of the areal extend and intensity of desertification risk

Table 4.1.1: Indicators used in the Litani RB analysis

Indicator	Elements	Tool	Available output	Date	Creditability
Precipitation	Volume Intensity	Gauge stations Gauge stations & TRMM*	Records & graphs Records & maps	1967-2008 1998- to date	Reliable
Rivers	Discharge	Flow meters	Records & graphs	1965-2006	Reliable
Spring	Number of springs Discharge	Topographic maps Flow meters	Desk study Records & graphs	1963-2005 1963-2005	reliable
Lakes and Reservoirs	Number of lakes Areal extend	Topographic maps & aerial photos Satellite images	Desk study Non-continuous measurements	1963-2005 1963-2005	Partially reliable Partially reliable
Snow cover	Areal coverage	Satellite images	Maps	1973-2007	Partially reliable
Groundwater	Pumping Water table Water quality Submarine springs	Well testing and measure records Airborne survey	Discharge, depth and steady state flow Radiometric images	No regular and non-continuous measurements 1973 & 1997	Partially reliable Reliable

* TRMM: Tropical Rainfall Mapping Mission extended by NASA

Table 4.1.2: Tools and data availability of drought indicators in Lebanon

Source: Amin Shaban, Impact of Climate Change on Water Resources of Lebanon: Indications of Hydrological Droughts, National Council for Scientific Research, Remote Sensing Center, Chapter in: Climatic Changes and Water Resources in the Middle East and North Africa

To assess precipitation trend over the years data from Lebanon were obtained for the years 1967-2005 and the average annual precipitation per decade has been calculated. This indicators clearly shows a decreasing trend over the last 4 decaded pointing out increased meteorlogical drought conditions (figure 4.1.2). The increased drought conditions are also depicted by the hydrological variables as the streamflow in Litani from 1965-2006 is contantly diclining, while the surface area of the Qaraoun Lake (which is the major reservoir) is deminishing (figures 4.1.4 and 4.1.3 respectively).

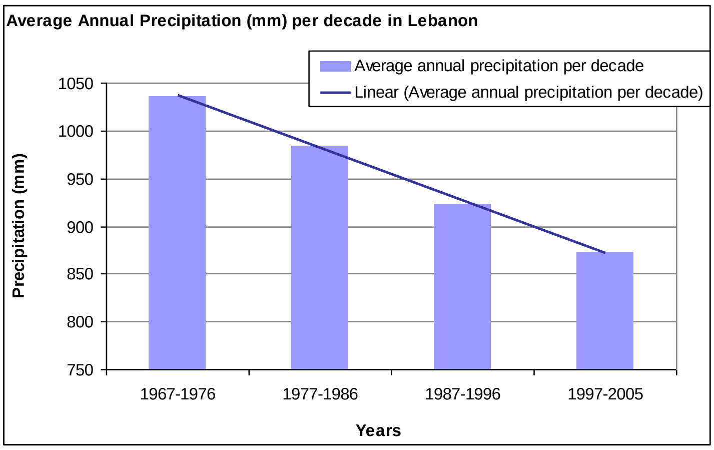


Figure 4.1.2: Precipitation trends per decade from 1967-2005 in Lebanon
(Data retrieved from Shaban, 2009)

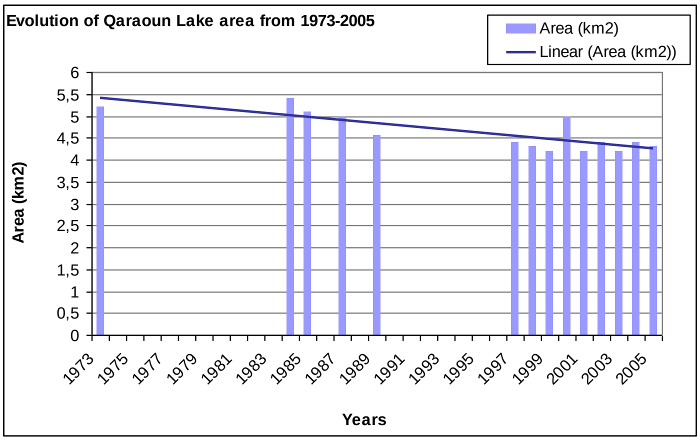


Figure 4.1.3: Evolution of the Qaraoun Lake area from 1973-2005
(Data retrieved from Shaban, 2009)

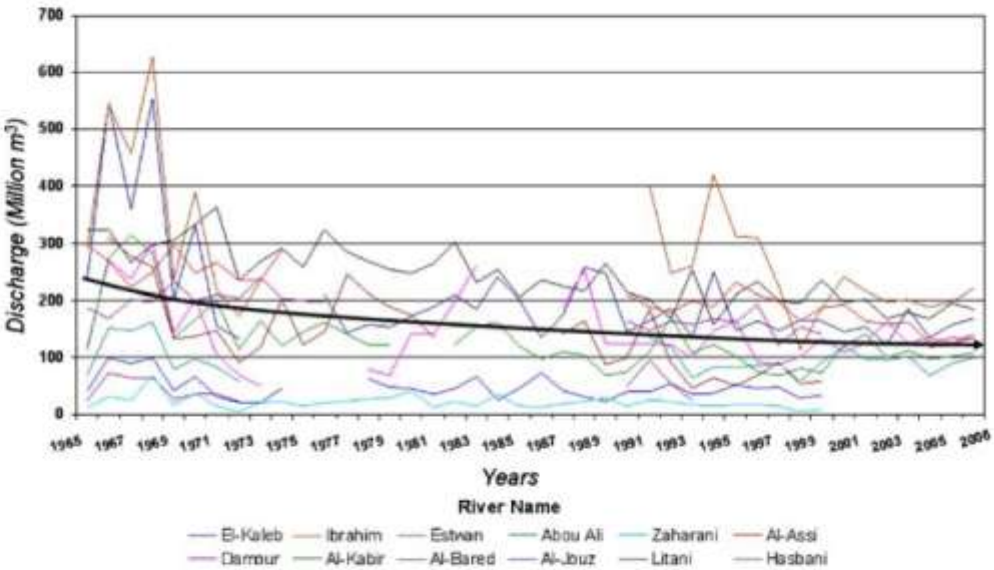
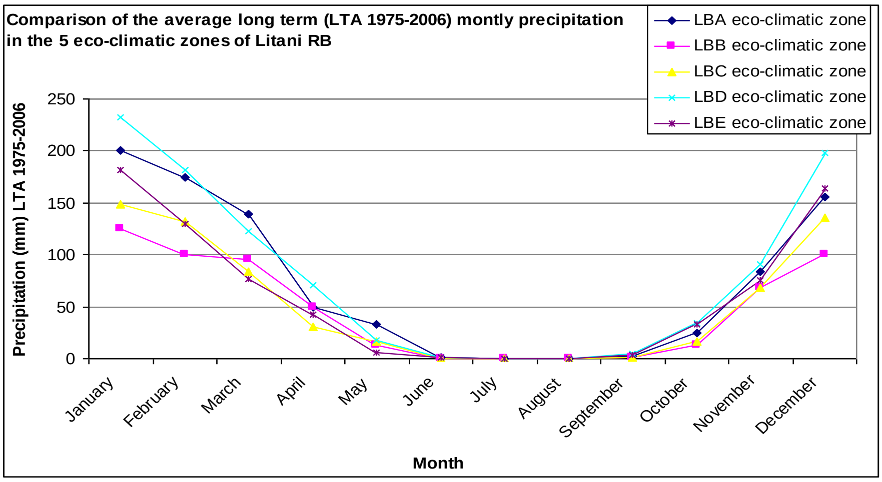


Figure 4.1.4: Discharge trends in Lebanese rivers, including Litani, from 1965-2006 (Source: Shaban, 2009)

The distribution of precipitation is highly variable in Litani (figures 4.1.5 and 4.1.6) both in terms of space (the east and north-eastern parts are much drier) and time (May-September precipitation is practically absent). If we overly this indicator with the similarly high variabilty of the surface water abstractions for irrigation (figure 4.1.7) in the Upper and Lower Litani subcatchments (figure 4.1.6) we can observe similar trends (higher abstractions in winter months), yet as these irrigation abstractions are significant and projections for future urban water demand are also increasing based on the population growth (figure 4.1.7), a well thought management plan of the available water resources needs to be in place to eliminate water stress and related impacts.



Memo: LBA: Northern part of the basin (Baalbeck and Aarsal)
LBB: Central zone (Zahle and Rayak)
LBC: Southern zone (Rachaya and Hermon)
LBD: Central mountainous part (Mount Lebanon)
LBE: Coastal southern strip of the basin

Figure 4.1.5: Comparison of the monthly long-term average precipitation 1975-2006 (LTA) in the 5 eco-climatic zones of Litani RB.

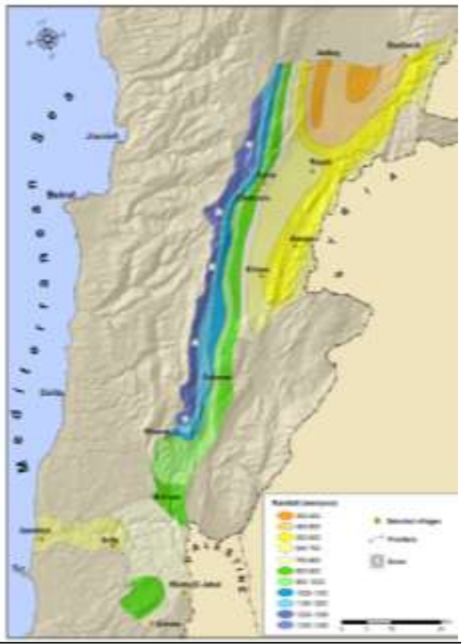


Figure 4.1.6: Spatial distribution of rainfall in Litani RB

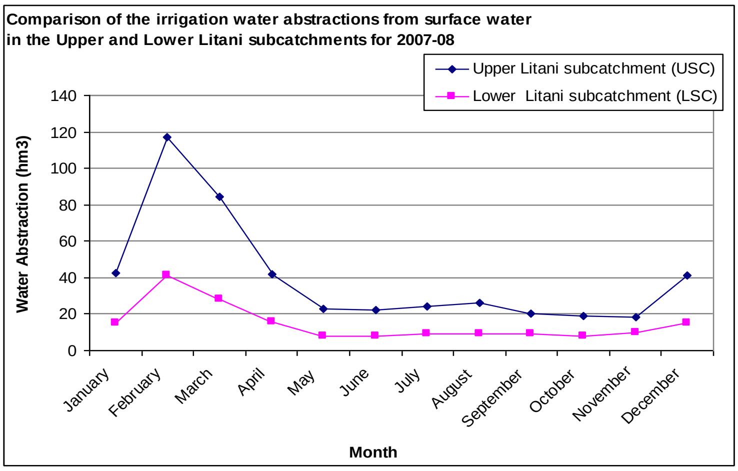


Figure 4.1.6: Monthly variability of irrigation water abstraction from surface water in Upper and Lower Litani subcatchments for the year 2007-08.

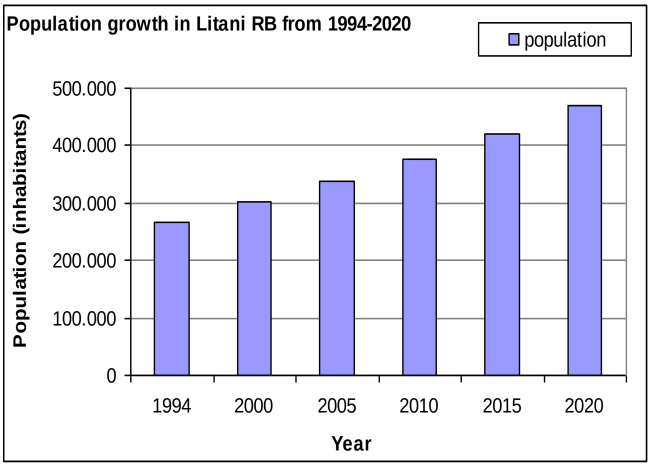


Figure 4.1.7: Population growth and future projections in Litani RB from 1994-2020

The water balance for the Qaraoun Reservoir is presented in the following table:

Storage capacity	Abstractions	Actual remaining storage
220 Mm^3	- 60 mm^3 for irrigation to Bekaa valley - 130 mm^3 for hydropower generation (10% of total national need), which is then released to Lower Litani for irrigation	60 mm3 (according to the Litani River Authority)

Table 4.1.3: Water balance of the Qaraoun Reservoir

An additional indicator available in the Litani RB relates to the risk of desertification. The areas prone to (and related degree of) are presented in the figure 4.1.8.

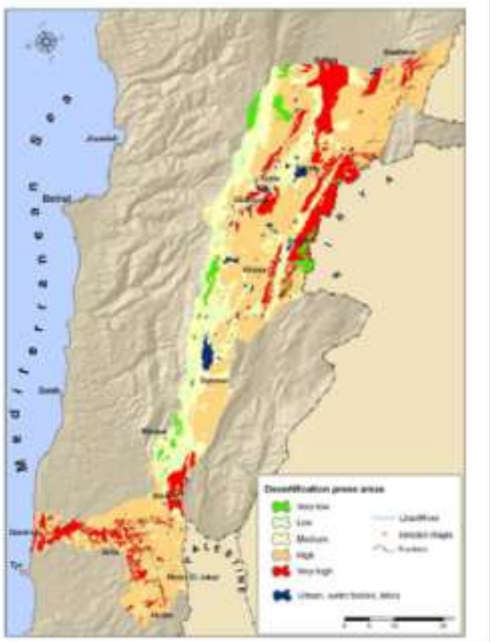


Figure 4.1.8: Areas prone to desertification in Litani RB

4.1.3. Conclusions and recommendation for improvement

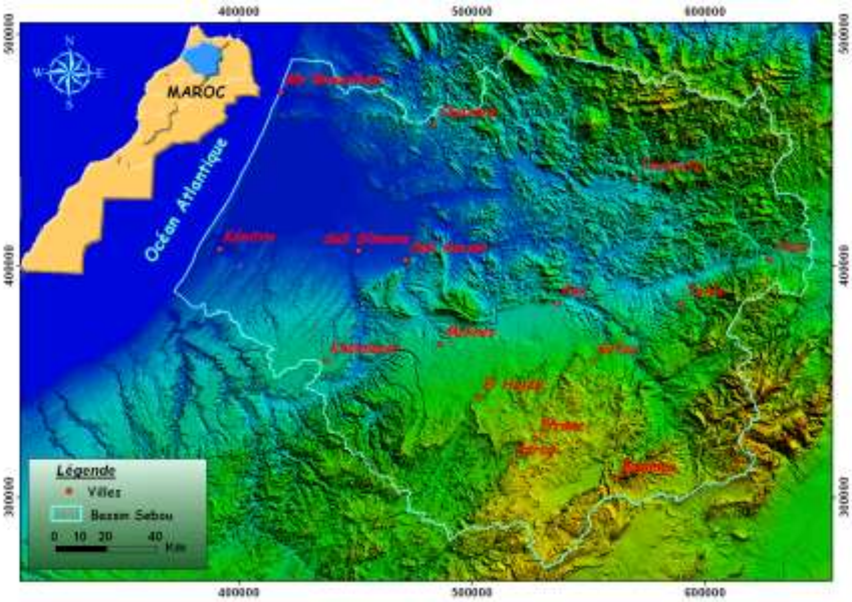
Collecting data is considered the most challenging part in every project. In Lebanon, this task is even more difficult when dealing with governmental institutions. While implementing this pilot exercise, the following obstacles faced the team during data collection:

- The Litani River Authority and the Ministry of Energy and Water were considered to be the two main sources of data; however needed data were not release due to bureaucratic obstacles.
- Some data were not available as they were related to private properties (private wells) and there were no official measurements taken.
- Some measurements were conducted by private universities or research institutes. However, they are considered as private data and are not released.
- Most measurements were done only during research periods and not continued later on, thus there is no continuity of measurements taken.

This exercise is very useful for strategic planning and drought forecasting, that can be adopted by the Litani River Authority. Some of the constraints are that most of the data required to fill in the EEA tool might be available at the LRA offices, and they were not released on time in order to fill the requirements of this tool. Another constraint is that the LRA should be made aware of the importance for decision making of the data that is not available or not collected. If this report is conveyed to the LRA and the LRA personnel are trained to fill in the data, better analysis, planning and improvement can be done on the management of this scarce amount of water available.

4.2. Sebou Basin, Morocco

4.2.1. Description



The Sebou River with a total drainage area of 40.000 km^2, running from its Wadi Guigou source in the Middle Atlas mountains into the Atlantic Ocean, is the second largest river and one of the most important river basins of Morocco, providing water to the country's most fertile region, the Gharb (107.000 ha irrigated). The basin holds about 1/3 of the country’s surface water and represents one of the most active agricultural areas as well as a main industrial area heavily contributing thus in the country’s economy. The main characteristics of the Sebou RB are summarized in the table below:

Mean annual Precipitation	600 mm (high spatiotemporal variability from 300-1.000 mm)
Mean annual Evapotransporation	1400 mm
Total Population	6.235.880 inhab. (2004)
Total volume of Surface Water	5.600 hm^3/ year (LTAA 1939-2002)
Total discharge to the sea	1.500 hm^3
Total Reservoir Storage capacity	5.836 hm^3 (of witch 46% are regulated)
Main Catchments and sub-catchments	- Sebou du Moyen Atlas (Haut Sebou, Inaouene, Moyen Sebou), drains 615 hm^3/ year - Ouergha, drains 2.877 hm^3/ year - Beht, drains 363 hm^3/ year - Bas Sebou
Main Groundwater Aquifers (out of 12 in total) Total Renewable Groundwater Resources	Saiss, Maamora-Gharb, Causses Moyens Atlantiques, Bou Agba, Fes-Taza, Moyen Atlas, Taza 1.000 hm^3
Total Water Use - from Surface Water (53%) - from Groundwater (47%)	2.330 hm^3/year (2005) 1.200 hm^3/year for irrigation 30 hm^3/year for domestic and industrial water supply 900 hm^3/year for irrigation 200 hm^3/year for domestic and industrial water supply

Total Irrigation Water Use	2.100 hm3/year (or 90% of total water use)
Total Irrigated area	357.000 ha (2005) Of which: 114.000 ha irrigated Great Hydraulic (GH), 247.000 ha irrigated in Small & Medium Hydraulic (PMH) and Private Irrigation (IP).
Total Utilised Agricultural Area	1,8 millions ha (about 20% of the national UAA)
Irrigation method	Gravity (in 90% of the area), low efficiency
Main problems and constraints	Spatiotemporal irregularity of water resources Groundwater overexploitation (resulting in dropping groundwater levels, seawater intrusion, irrigation water shortage, increased pumping cost, water quality deterioration) Low efficiency irrigation networks (and method) Reservoir silting, erosion Water losses in the sea Pollution, deterioration of water quality, increased vulnerability of coastal zone Water demand projection show increasing trends in all sectors

Table 4.2.1: Main characteristics of the Sebou RB

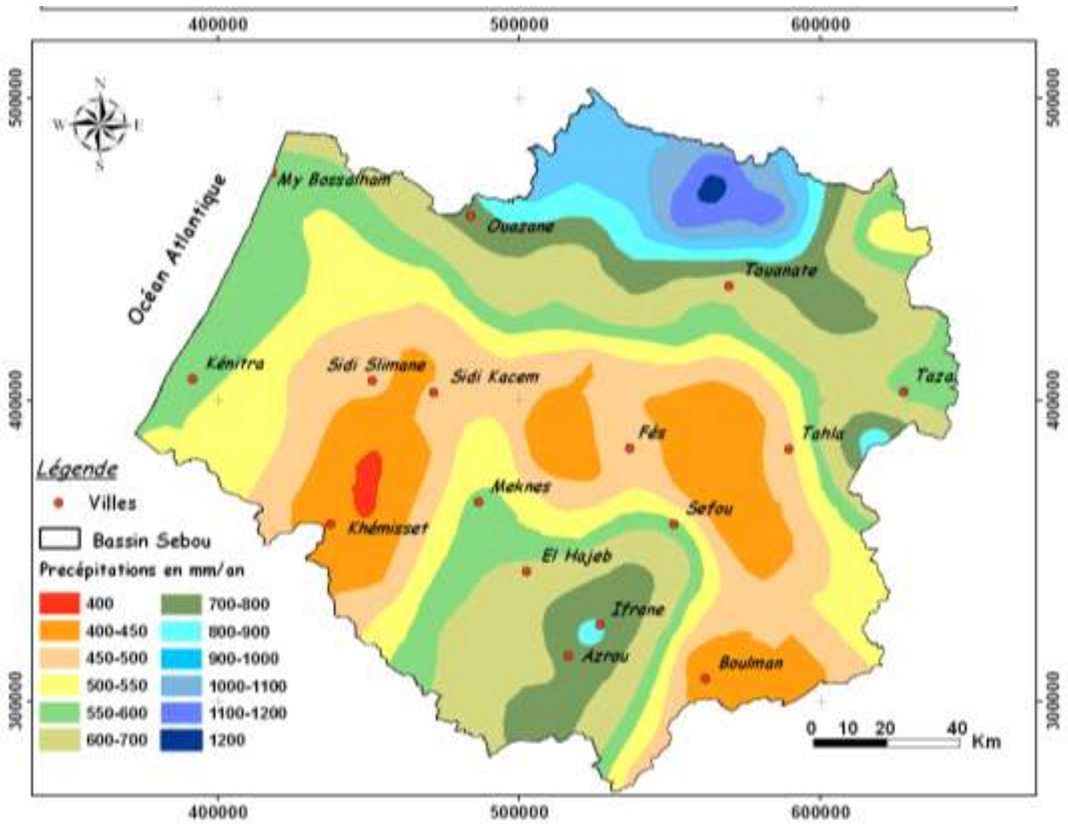


Figure 4.2.1 Average annual rainfall 1973-2002

4.2.2. Assessment of Water Scarcity & Drought based on selected indicators

Based on the reported data an assessment of the prevailing drought and water scarcity conditions was made based on relevant indicators, as analysed in this section. The selected indicators are briefly presented in the following table:

Indicator	Hydrological years	Comments
Standard Precipitation Index (SPI)	1939-2006	Calculation of SPI-1 year for the hydrological years 1939-2006
Reservoir Inflow	1939-2008	Comparison of average annual inflow per decade in A.Fassi and Al Wahda reservoirs for the hydrological years 1939-2008
Streamflow	2008	Comparison of 2008 mean monthly discharges (m^3/sec) to the long term averages (LTA) of the respective months from 15 representative streamflow stations.
Groundwater levels	2008	Comparison of 2008 mean annual groundwater levels to the long term annual average (LTAA 1970-2008) from 8 monitoring wells
Abstractions from Reservoirs Water Abstraction for Hydropower	1999-2008	Comparison of annual inflows and outflows for A.Fassi and Al Wahda reservoirs for the hydrological years 1999-2008 Comparison of abstraction for Hydropower from A.Fassi and Al Wahda reservoirs for the hydrological years 1999-2008
Water demand (urban and rural)	2004, 2025	Comparison of 2004 water demand (urban and rural) with 2025 projections
Population (urban and rural)	2004, 2025	Comparison of 2004 population (urban and rural) with 2025 projections

Table 4.2.2: Indicators used in the Sebou RB analysis

Based on the SPI-1year (figure 4.2.1) it is noticeable that precipitation shows a decreasing trend after the 1980. In the pre-1980 period wet episodes were prevailing (with 11 dry episodes), while after 1980 only 7 normal-wet years have been observed while major and extreme drought events are present. Similarly if we compare the average annual inflows per decade in A.Fassi and Al Wahda reservoirs from the hydrological year 1939 to the year 2008 (figure 4.2.2), the inflows are significantly higher in the pre-1980 period as compared with the post-1980 years (almost half) and there is a clearly declining trend. This trend is also depicted in the stream flows (figure 4.2.3) measured in different locations in the Sebou RB sub-catchments, were we can observe significant low values in e.g. 2008 (as compared with the LTAs), especially during the winter months. Looking at the groundwater levels in 8 monitoring wells though (figure 4.2.4), we observe that groundwater was not similarly affected in 2008 since when compared to the LTAA (1970-2008) the observed table is at a higher level.

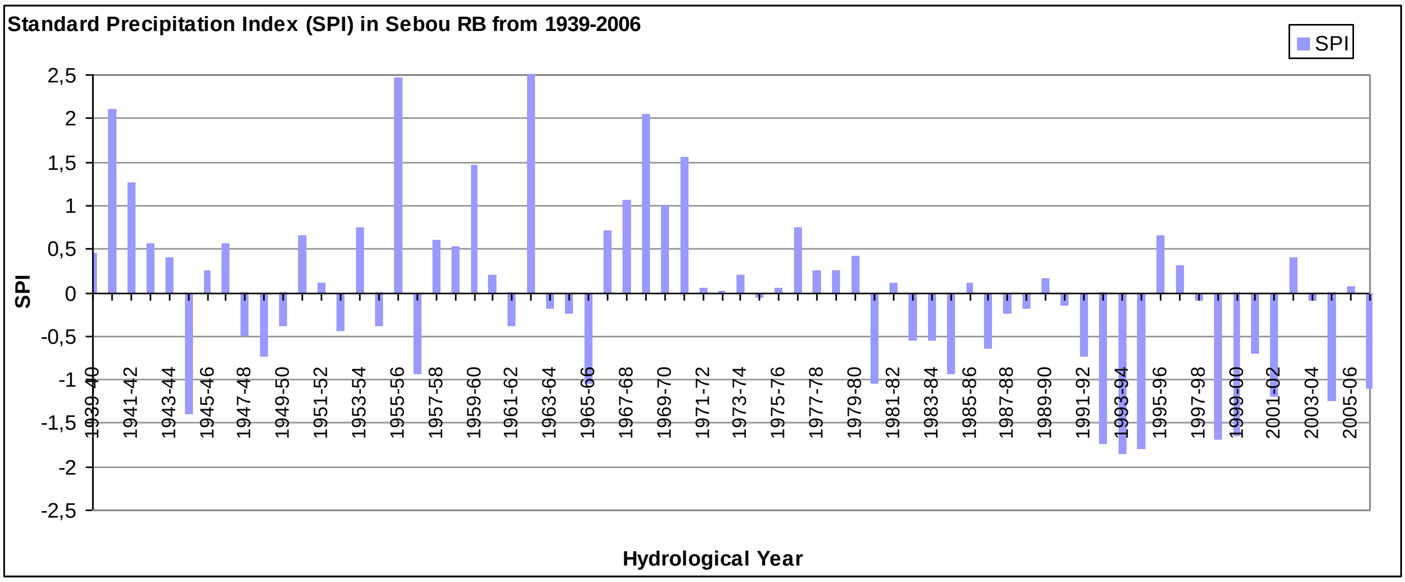
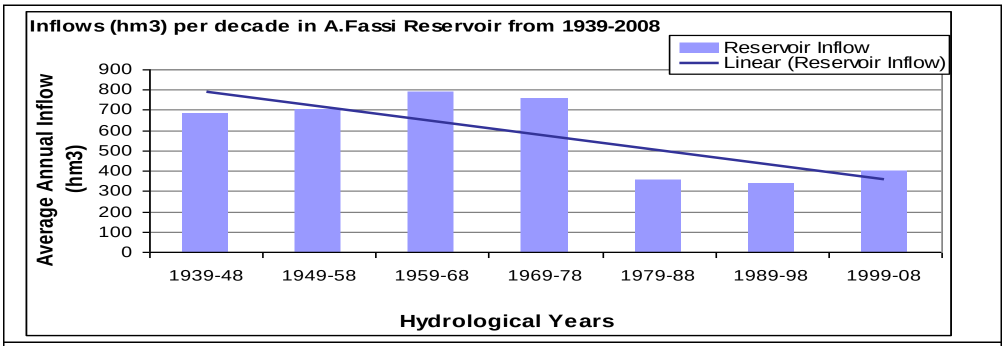


Figure 4.2.1: The 1-year SPI in Sebou RB for the hydrological years 1339-2006 (68 years record).



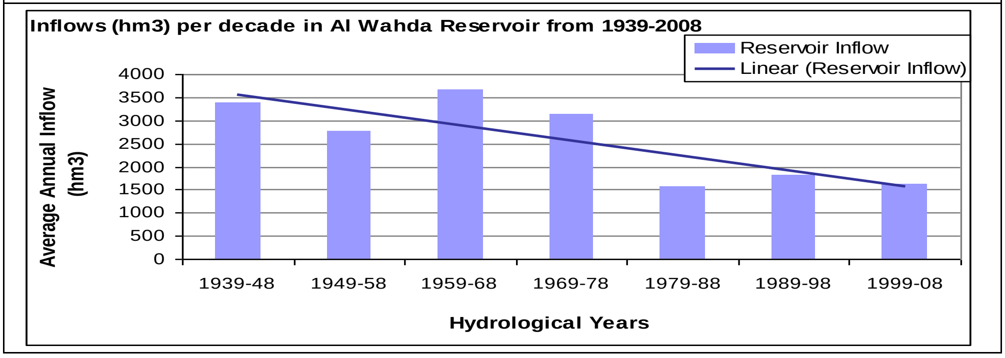
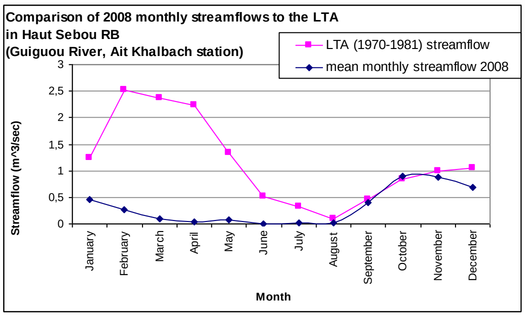
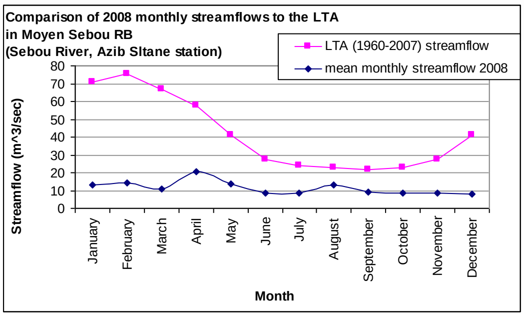


Figure 4.2.2: Comparison of average annual inflow per decade in A.Fassi and Al Wahda reservoirs for the hydrological years 1939-2008





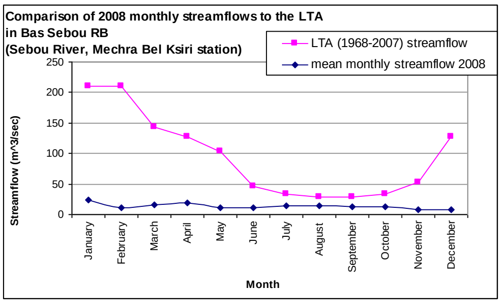


Figure 4.2.3: Mean monthly 2008 streamflows from 3 station (left: Haut Sebou, middle: Moyen Sebou, right: Bas Sebou) compared with the respective long term average (LTA)

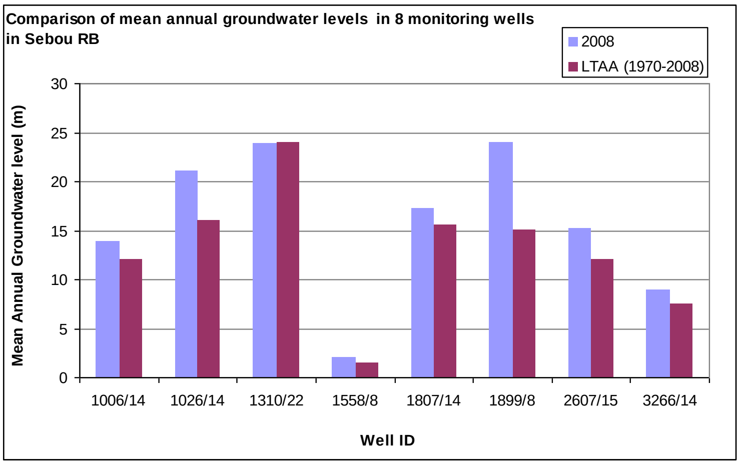


Figure 4.2.4: Comparison of 2008 mean annual groundwater levels to the long term annual average (LTAA 1970-2008) from 8 monitoring wells.

Regarding the management of the available water resources, looking at data from A.Fassi and Al Wahda reservoirs for the hydrological years 1999-2008, we can observe that the total abstraction (outflow to users) from the reservoirs (especially for A.Fassi) almost equals the inflow (which is highly variable this last decade) and in some cases in even larger which means that part of the water stored in the previous period is used up (figure 4.2.5) . If we overlay an additional indicator on hydropower water use, we can notice that most of this water is abstracted for hydropower generation which is a non-consumptive use (and thus not actually "lost" from the system), yet we can observe that the potential for energy production highly varies from year to year (especially in Al Wahda) and as its dependability on this water resource is major it bears a high socio-economic impact in the area (figure 4.2.5). Based on projections for future water demand, both urban and rural populations will increase and thus demand will increase as well, with rural demand through increasing at a much higher rate (147%) and disproportionally to the population (20% increase) (figure 4.2.6). This is due to the fact that rural population has not good access to the water (70% has access varying e.g. from 40% in Taza to 95% in Sefrou provinces). These indicators, if we also consider the foreseen increase in industrial water demand and irrigated area (up to 418.000 ha) underline that water scarcity conditions may become more severe in Sebou and appropriate proactive actions and concrete planning need to be taken.

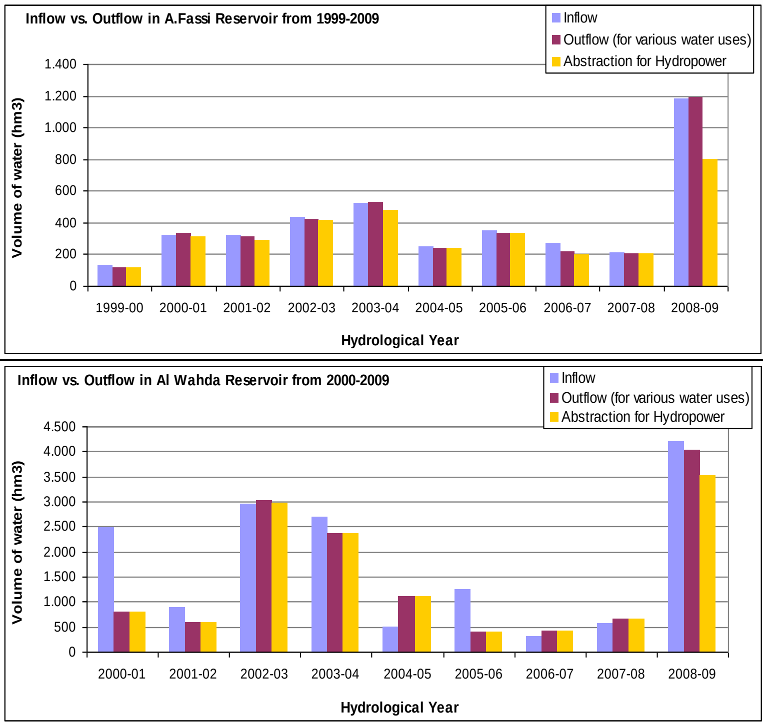


Figure 4.2.5: Comparison of annual inflows, outflows and hydropower water abstraction in A.Fassi and Al Wahda reservoirs for the hydrological years 1999-2008

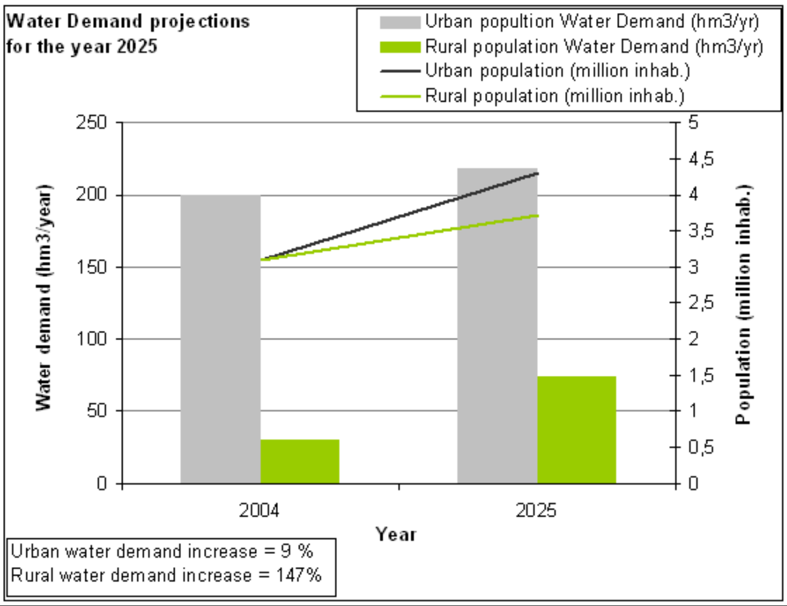


Figure 4.2.6: Comparison of 2004 population and water demand (urban and rural) with 2025 projections

4.2.3. Conclusions and recommendation for improvement

The selected indicators for the analysis were subject to data limitations. Hydro-meteorological parameters were easily available for Sebou RB and for a long historical record which allowed a clear overview of the drought evolution in the area. Socio-economic data such as water use were more difficult to obtain (although do exist), yet based on the limited analysis in this section (reservoir abstractions, hydropower abstraction, water demand projections) it is clear that they are essential for the assessment of water scarcity, since they can allow the identification of the main drivers and pressures of the system which call for proper response measures and facilitate adequate planning.

4.3. Cyprus River Basin District

4.3.1. Description

Cyprus is situated at the Northeastern part of the Mediterranean basin and is the third largest island in the Mediterranean with an area of 9,251 km2 out of which 47% is arable land, 19% is forest land and the remaining 34% is uncultivated land. In 2008 the population of Cyprus was 796,900 inhabitants. Its topography is dominated by two mountain ranges, while between them lies the Morphou and Messaoria plains, which together with the narrow alluvial plains along the coast make up the bulk of the agricultural land of the island. Most of the rivers flow only in winter. Cyprus has a typical Mediterranean climate with mild winters, long hot, dry summers and short autumn and spring seasons. The average annual rainfall is about 500 mm and ranges from 300 mm in the central plain and the south-eastern parts of the island up to 1,100 mm at the top of the mountains. The variation in rainfall is not only regional but annual and often two and even three-year consecutive droughts are observed. The average maximum temperature in July and August ranges between 36^{o}C on the central plain and 27^{o}C on the mountains, while in January the average minimum temperature is 5^{o}C and 0^{o}C respectively. Due to the aridity of the climate evapotranspiration is high, which, on an annual basis, corresponds to 80% of the rainfall.

Water Resources
Until 1997 the main source of water in Cyprus was rainfall. According to a long series of observations, the mean annual precipitation, including snowfall was estimated at 503 mm, and from 2000 until now has been reduced to 463 mm. The quantity of water falling over the total surface area of the free part of Cyprus (5,800 km^2) is estimated at 2.750 million cubic meters (hm^3), but only 10% (275 hm^3) is available for exploitation, since the remaining 90% returns to the atmosphere as direct evaporation and transpiration. The rainfall is unevenly distributed geographically and there is great variation of rainfall with frequent droughts spanning two to four years. The average annual net rainfall of 275 hm^3 is distributed between surface and groundwater storage with a ratio 1:3 respectively. From the underground storage approximately 1/3 flows into the sea. Cyprus has experienced many drought episodes and water scarcity situations, with its groundwater resources being over-exploited and its water stress conditions reaching critical levels.

4.3.2. Assessment of Water Scarcity & Drought based on selected indicators

Based on the reported data an assessment of the prevailing drought and water scarcity conditions was made based on relevant indicators, as analysed in this section. The selected indicators are briefly presented in the following table:

Indicator	Hydrological years	Comments
Precipitation Deciles	1970-2009	Calculation of annual precipitation for the hydrological years 1970-2009
Total Annual Water Abstraction	1998-2008	Comparison of annual water abstraction for the years 1998-2008
Annual Groundwater Abstraction Mean Annual Aquifer Recharge	2000-2008	Cross-comparison for the years 2000-2008 to assess groundwater exploitation
Annual Surface Water Abstraction	2000-2008	Cross-comparison for the years 2000-2008 to

Annual Volume of Surface Water Annual Inflow to Reservoirs Changes in Reservoir Storage		surface water exploitation
Sources of domestic water provided by the public water supply system Annual Domestic water use Population Domestic water use increase per capita GNI increase per capita	1999-2009	Comparison of the share of natural vs. additional water sources (e.g. desalinates, imported) in domestic water supply, in order to evaluate the dependency from external water resources Cross-comparison of domestic water use, population, domestic water use increase per capita, GNI increase per capita to evaluate the main driver of the domestic water use and be able to make future demand projections
Nights spent in hotels and similar establishments Number of collective tourist accommodation establishments		Cross-comparison of domestic water use (which includes tourism facilities connected to the PWSS), nights spent in hotels, number of new tourist accommodations to evaluate the drivers of tourism water use and be able to make future demand projections

Table 4.3.1: Indicators used in the Cyprus RB analysis

Cyprus has experienced many drought episodes varying from below Normal precipitation (81-90% normal) to severe drought (≤ 70% normal). The long term annual average (LTAA) precipitation from 1901-1970 is 541 mm, while the LTAA from 1971-2009 has fallen to 463 mm. From 1970-2009 (40 year record) the wet and dry years are classified as shown in the table 4.3.2. Examining the Areal Precipitation trend of the last 11-yr period 1998-2008 (figure 4.3.1) we can observe that 5 out of the 11 years had precipitation below the 30 years LTAA (1979-2008) and 6/11 above it. Although the precipitation was above normal in the years 2000-2003, the area experienced water scarcity conditions. The causes of this situation can not be depicted by looking at precipitation indicators solely. Thus, to assess Water Scarcity conditions and evolution, different indicators have been used to cover water availability versus water abstraction and use, as well as additional socio-economic parameters as presented in the following section.

Precipitation state	# years	Corresponding years
Extreme wet (> 130% normal)	0	
Wet (121-130% normal)	3	1975, 1988, 1992
Above normal (111-120% normal)	5	1976, 1980, 1981, 2002, 2003
Around normal (91-110% normal)	13	1971, 1977, 1978, 1985, 1987, 1989, 1993, 1995, 1999, 2001, 2004, 2007, 2009
Below normal (81-90% normal)	8	1972, 1979, 1982, 1983, 1984, 1986, 1994, 2005
Drought (71-80% normal)	8	1970, 1974, 1990, 1996, 1997, 1998, 2000, 2006
Severe drought (≤ 70% normal)	3	1973, 2001, 2008

Table 4.3.2: Classification of wet and dry years

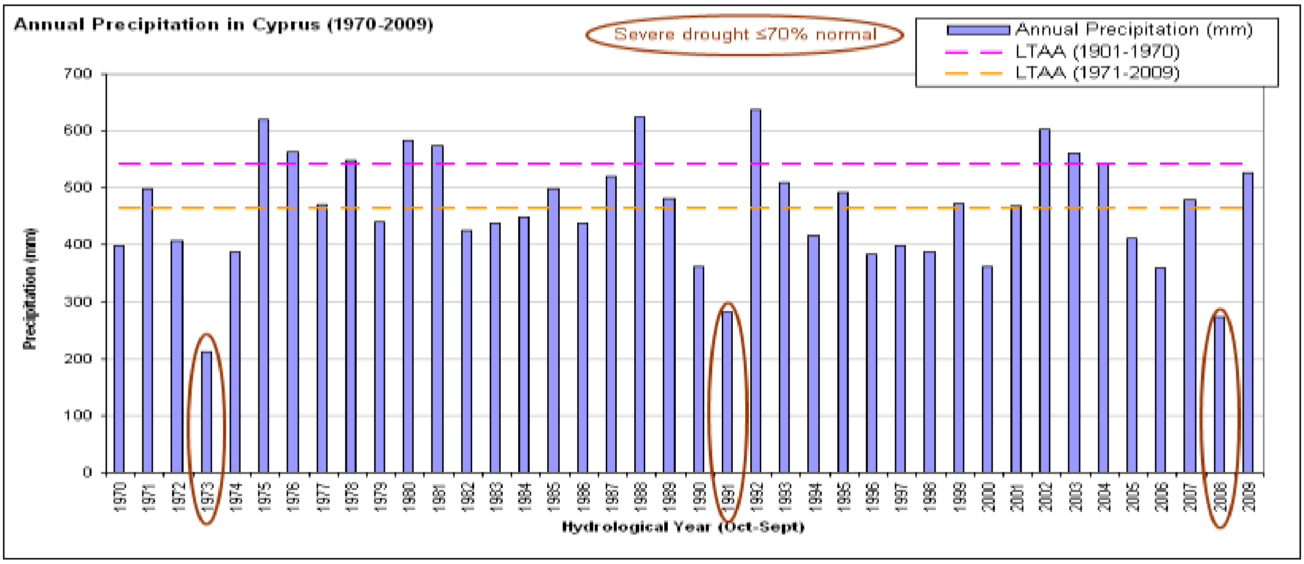
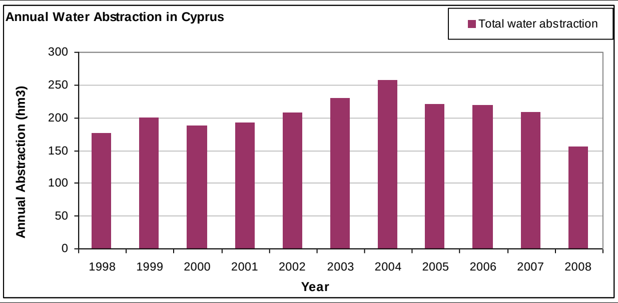


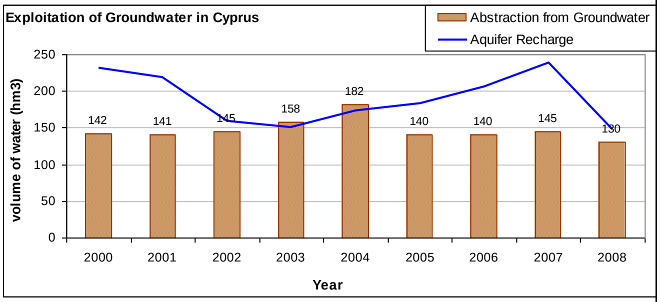
Figure 4.3.1: Annual Precipitation (mm) in Cyprus for the hydrological years 1970-2009

Exploitation of Water Resources

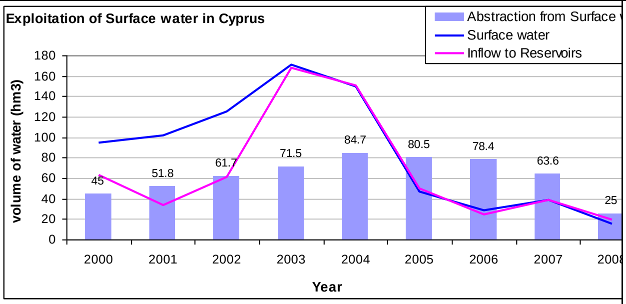
A first investigation was carried out using the Water Exploitation Index (WEI). Even during the years 2000-2004 which, as demonstrated previously, had a precipitation above normal and thus the water availability was high, water stress conditions were still experienced, with the WEI increasing progressively from 50% in 2000 to 65% in 2004. To investigate further this situation (is it due to decreased availability or to increased water use?) one has to look at the partitioning of the abstractions per source and sector along with the changes in groundwater and reservoir storage. By comparing water abstractions to the evolution of the areal precipitation it looks that until the year 2004 wet conditions prevail, yet abstraction is gradually increasing and this is what causes the increase in water stress conditions (Figure 4.3.2.a). After 2004 the abstraction follows a decreasing trend, yet precipitation is now low (dry years) and thus water stress conditions are exacerbated. In order to draw a more comprehensive picture of the groundwater and surface water exploitation in Cyprus the following indicators have been combined (Figure 4.3.2.b-d): abstraction from groundwater, aquifer recharge, abstraction from surface water, surface water (volume of), inflow to reservoirs. From this comparative analysis it is evident that groundwater abstractions have been increasing from 2000-2004 by 26% (from 142-182 hm^3) while the aquifer recharge has been declining causing the system to be at risk. From 2005 onwards the groundwater abstractions have decreased and stabilized around 140 hm^3 while aquifer recharge has increased. Similarly, surface water abstractions have dramatically increased from 2000-2004 by 89% (from 45-85 hm^3). Surface water availability has also been increasing until 2003 (wet years) but starts decreasing after this. Inflow to reservoirs follows the same trend, it is though remarkable that in 2003 and onwards the reservoirs capacity has drastically increased, and inflow to reservoirs equals the total amount of available surface water. After 2004 surface water abstraction starts decreasing, remaining though at high levels until 2007, the surface water availability (and respectively the inflow to the reservoirs) keeps decreasing and is not able to meet the abstraction needs. Thus the created deficit is reducing the water stored in the reservoirs leading in unsustainable conditions. The reservoir storage dropped as much as 67hm^3 in 2006, and roughly all the water that was accumulated until 2004 was used up the following years (figure 4.3.2.d).



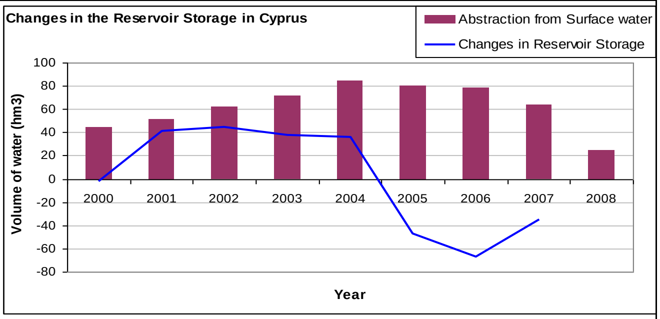
(a) Annual water abstraction in Cyprus for the years 1998-2008



(b) Exploitation of groundwater in Cyprus from 2000-2009



(c) Exploitation of surface water in Cyprus from 2000-2009



(d) Changes in the reservoir storage in Cyprus from 2000-2009

Figure 4.3.2: Exploitation of surface and groundwater resources in Cyprus for the years 2000-2009.

Analysis of Domestic Water Use:

The domestic water use (including tourism) has been analyzed based on different indicators (share of natural vs. additional water resources, domestic water use vs. population, domestic water use increase per capita vs. GNI increase per capita, domestic water use vs. nights spent in hotels and similar establishments, domestic water use vs. number of collective tourist accommodation establishments) in order to evaluate the different drivers and pressures, and possibly the implemented response measures. The different indicators are presented below (Figures 4.3.3-4.3.5). Looking comparatively at all the above mentioned it can be inferred that: Domestic water is highly dependent on additional (not natural) water resources (i.e. desalination) in order to meet the demand. This may have both environmental (e.g. disposal of the desalinated water residuals) and financial impacts, however the Cyprus experience has shown that desalination remains the only means of achieving water security and independence of the domestic water supply from the climatic behavior. The driving forces for the increase of domestic water consumption are the increase of urban population, mainly due to immigration, in-country and from abroad, the development of tourism and holiday homes as well as changing household habits.

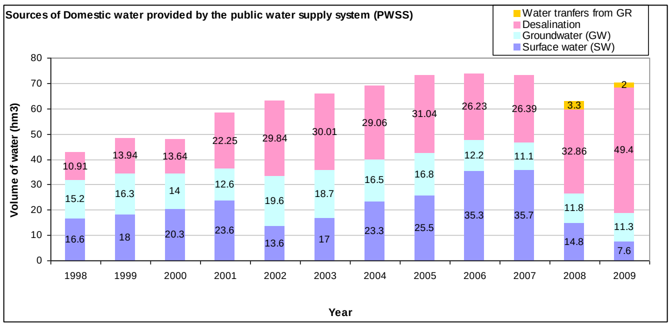
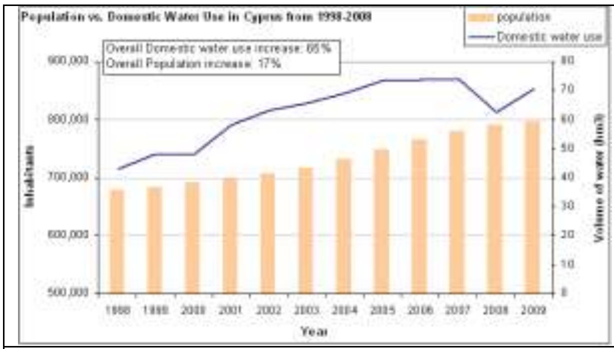


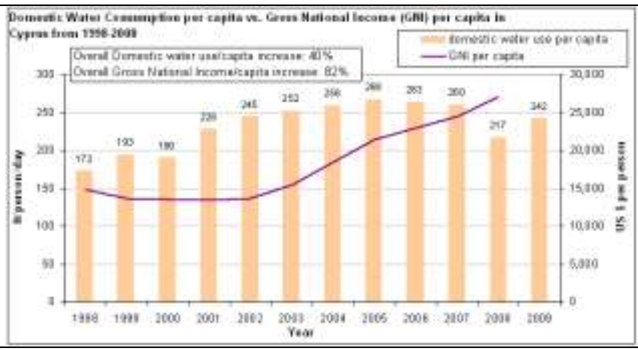
Figure 4.3.3: Sources of domestic water provided by the public water supply system (pwss).

Note: Desalinated water (which was first introduced in 1997) increases rapidly by 121%, and in 2008 and

2009 it constitutes the major sources of domestic water



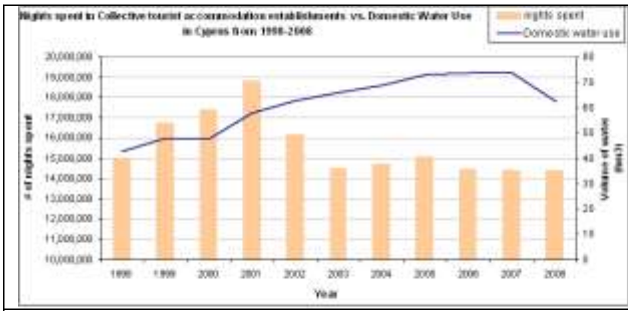
(a) Population vs. of domestic water use trends



(b) Domestic water use per capita vs. Gross National Income (GNI) per capita

Figure 4.3.4:Domestic water use trends vs. socio-economic indicators

Note: The domestic water use increases at a much higher rate of 65% (non-linear to demographic increase), which clearly show that the average per capita consumption is increasing. It is observed that the GNI, which can be considered as an indicator of the living conditions of the population, has increased by 82% from 1998-2009, especially after 2002. This trend follows the increasing trend of the per capita domestic water use (overall 40% from 1998-2009), depicting that the improvement of the living conditions has a stronger effect on the water consumption than the increase in the population.



(a) Number of nights spent in collective tourist accommodation establishments vs. domestic water use

(b) Number of collective tourist accommodation establishments vs. domestic water use

Figure 4.3.5:Domestic water use trends vs. socio-economic indicators

Note: Tourism water use (for establishments connected to the WPPS) is included in the domestic water use.

It is illustrated that the total number of nights spent in hotels and other collective accommodation establishments has a decreasing trend (overall 9%), as opposed to the increasing trend of the domestic water use. The number of collective tourist accommodation establishments (hotels etc.) has highly increased in 2001 (by 50% comparing to 2000), and has certainly caused the increase in domestic water consumption.

4.2.3. Conclusions and recommendation for improvement

Cyprus RBD has large data availability. Additional data (not included in this report) on agricultural and industrial water uses and respective yields and income generated from these activities, allow for a comprehensive assessment of all the water users, making possible the identification of the drivers and causes of failure of the system, and thus allowing adequate proactive planning and management to mitigate drought and water scarcity impacts.

The Cyprus case study shows the importance of using indicators related to water abstraction together with indicators on water availability in order take the right decisions during drought periods.

It is clearly demonstrated that for holistic and rounded assessments of drought and water scarcity a combination of indicators is needed rather than a couple. Additionally, socio-economic indicators are proven very important from a water management and policy aspect as they allow for clear identification of drivers and pressures, they demonstrate strong links between socio-economic trends and water abstraction behavior, they are valuable in the evaluation of the efficiency and performance of the system as well as in assessing vulnerability and future trends.

5. CONCLUSIONS & RECOMMENDATIONS

Water scarcity and drought monitoring is an essential element in the decision making process for planning proper measures of prevention and mitigation of the impacts, giving the information about the possible duration, intensity and extension of the events. The distinction between water scarcity and drought events is not an easy task due to the difficulties in differentiating the natural impact of drought from the anthropogenic pressure and the sometime improper level of abstraction for the different water uses.

There is a gap of knowledge and tools at the EU level on the demand side of the Water Scarcity and a **lack of reliable information** [COM(2007)414], thus the formulation of an adequate indicators' framework could provide a powerful tool for building a common basis for policy and decision making. The same statement is true for the South Mediterranean countries as well, where data collection may be challenging. Yet, it is essential not only to fortify the process of data collections, but the **validation and quality assurance** as well, since reliable information is the basis for all assessments.

Water quantity monitoring is often undertaken on a project approach with external implementing agencies financed by Technical and Financial Partners. It is necessary to move from a project approach to a sector approach for more efficient investments and water management. Data collection, analysis and dissemination are necessary not only for water master planning, identification of programme of measures and their monitoring; but also for mitigation and emergency responses.

Drought definitions differentiate based on the analysed effects, meteorological, agricultural and socioeconomic and therefore there is a need to combine indicators and indices used up till now to observe and monitor drought with socio economic indicators that will identify drivers, pressures and impacts of the phenomenon. Furthermore, the common indicators help in the benchmarking exercises and monitoring those phenomena.

The selection of the indicators is subject to data availability limitations. They should require data that can be retrieved from stakeholders and used to support decision making. Indicators are a dynamic system that can represent the evolution of Drought & Water Scarcity conditions over time and at the appropriate temporal and spatial resolution, thus their reproduction needs to be easily feasible.

It is still too early to reach an agreement on common indicators between all the countries, as further exploration is necessary through pilot exercises. But the necessity to use indicators is recognised, as well as the fact that different types of indicators are necessary to respond to the needs of stakeholders' categories, e.g. politicians, managers, famers. Based on the various end users and purposes we need simple descriptive indicators that relate to monitoring and assessment of drought and water scarcity conditions and can easily communicate a message, but we also need more elaborated operational indicators that can trigger response and mitigation actions. Indices which relate to vulnerability may be more difficult to result with, since they may require data not readily available in the South Mediterranean countries.

Today, most of South and East Mediterranean countries use indicators such as rainfall (compared to long term average), water levels in reservoirs and groundwater, associated with thresholds to assess the level of drought and the application of mitigation measures.

The Med WG on WS&D members are aware of the importance of associating indicators with simulation tools (real-time models) and Decision Support System to improve user participation in planning or during scarcity periods. Indeed, end users and farmers are the real actors that can contribute directly to the improvement of water use efficiency. The members of the WG believe also in the necessity of taking into account climate change impact at long term, as well as considering water quality and political issues especially in the Middle East countries.

Recommended actions for a new phase of this working group under the framework of the Joint Process should focus on:

- Additional testing of data collection and indicators at local level (e.g. pilot river basins), and demonstrating the usefulness in decision making process, mitigation and preparation plans and participatory approaches
- Based on the results of pilot tests draw some common indicators that could be used for benchmarking at local or national levels
- Enhancing the knowledge-base regarding climate change impacts and the vulnerability to them so that appropriate policy responses can be developed based on reliable data and information on the likely effects of the phenomenon and the costs and benefits of different adaptation options.
- Developing methods, models, data sets and prediction, and acquire early-warning tools to enhance monitoring of hydrological cycles and of impacts, risk mapping, identification of 'hot-spots' considering the impacts of global changes
- Developing vulnerability indicators taking into account socio-economic aspects
- Facilitating the creation of an experience-sharing regional platform.
- Identifying and monitoring the environmental, social and impacts of water demand management measures
- Increasing regional and transboundary cooperation and assistance to cope with emergency situations arising from droughts

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