Techneau,
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Case Study Report Cyprus

Flexibility in coping with water stress and integration of different measures

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Title

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This report is:
PU = Public

Executive Summary

Introduction
As Cyprus suffers from the highest water stress in Europe, it was selected as case study to investigate adaptive strategies to cope with water stress especially where impacts from climate change aggravate the status of the existing water resources regarding water quantity and quality.
During the last decade the water demand of users supplied by governmental water utilities has been persistently exceeding the water supply and existing water resources particularly the aquifers have been continuously overexploited. To increase the water supply two desalination plants have been commissioned in 1997 and 2001. A third one is in operation since December 2008. Also water reuse has been introduced in agricultural irrigation to reduce the freshwater demand. Still other measures identified as adaptive strategies could contribute to improve the current situation and make the water resources management more sustainable.
Based upon existing data and results from previous studies (e.g. AQUASTRESS) the water management in Cyprus will be analysed. Envisaged alternative water resources management measures such as desalination and aquifer recharge with reclaimed water will be described and an integrated WRM approach will be developed. Furthermore the decision and implementation process will be evaluated. The work will be accomplished in cooperation with the local stakeholders (e.g. the Water Development Department).

Importance
On the water policy agenda, the issue of water scarcity and drought has been gaining increasing attention. It has been recognised that this phenomenon needs to be addressed both as an essential environmental issue and also as a precondition for sustainable economic growth in Europe.
An in-depth assessment of water scarcity and drought describing the magnitude of the problem in Europe was elaborated by DG Environment in 2007 The same year, the Commission's Communication addressing the challenge of water scarcity and droughts in the European Union has identified the challenges to be addressed, and has defined some priority actions in developing water efficiency across Europe.
A major way of achieving this will be the through the proper implementation of the Water Framework Directive. Therefore, drought management is being tackled as part of the Common Implementation Strategy (CIS) for the Water Framework Directive. In addition, a dedicated activity within the CIS is dealing with Climate Change and Water, exchanging best practices and providing guidance on how to take climate change into account in the first river basin management plans. In consequence, strategies for coping with water stress will constitute both a tool to manage scarce resources and to comply with European water legislation.

Approach

The information contained in this report is based on various sources and was derived in stakeholder consultation and dialogue in 2008, as well as from accessible documents published by the Water Development Department.
It also builds on work carried out in other research projects, as e.g. AQUASTRESS and Water Strategy Man.
Comments on data availability and data robustness:
Most information used in this report is taken from resources, i.e. reports prepared in the early 2000s, conference presentations etc.
Data often represent estimation (of demand, abstraction from groundwater, recharge rates etc.) as many of the required parameters are not measured or monitored regularly and consistently.
The data situation is even more dispersed as regards future water supply project, planned demand measures. Therefore non-scientific and non-official sources have been accessed and are quoted as well.
It has to be noted, that possibly some information was not retrievable due to language barriers.

Results
The water management structure in Cyprus is quite complex with various entities involved at different organisational and administrative levels.
Following up the recent drought management in 2008, it was found that adaptive strategies were limited. Dealing with the shortfall of water resources rather consisted of corrective and emergency measures. On the demand side, water cuts and water use restrictions in agriculture and domestic applications (hose pipe bans) were imposed. At the same time water supply was backed-up by water imports and the commissioning of a mobile desalination unit.
The measures were accompanied by awareness raising campaigns to promote more rational and efficient domestic water use.
To circumvent a comparably drastic water shortage in future, the water availability and supply will be increased through desalination and water reuse to make up for constantly declining yields of reservoirs. In parallel the water consumption shall be reduced. Yet, the concept seems not fully developed with saving targets not having been defined and the envisaged secure water supply not being quantified.

Contents

1 Case study background

1.1 Water stress in Europe

Water stress occurs when the demand for water exceeds the available amount during a certain period or in a particular area or when poor quality restricts its use. Water stress is often related to the deterioration of fresh water resources in terms of both quantity and quality. Overexploited aquifers, dry rivers, are typical indicators and at the same time promoters for water stress. The situation is often aggravated by quality problems such as eutrophication, organic matter pollution or saline intrusion (EEA, 1999). Water stress leads to sectoral competition and thus necessitates to better allocate water between users. This may also include the need to expand water supply and to tap new or alternative resources as the conventional ones become exhausted.
The water stress index (WSI) is one indicator to quantify water stress in a region or country. It relates water availability and water use and is defined as the ratio of annual water withdrawal from ground and surface water to the total renewable freshwater resources. Hence high water stress indices can either be caused by low availability or excessive high water demand.
The OECD (2003) defines a water stress index of more than 40% as high water stress, 20% to 40% classifies as medium-high, whilst 10% to 20% is defined as moderate water stress. Figure 1 reveals that Cyprus is the most affected country of the European Union.

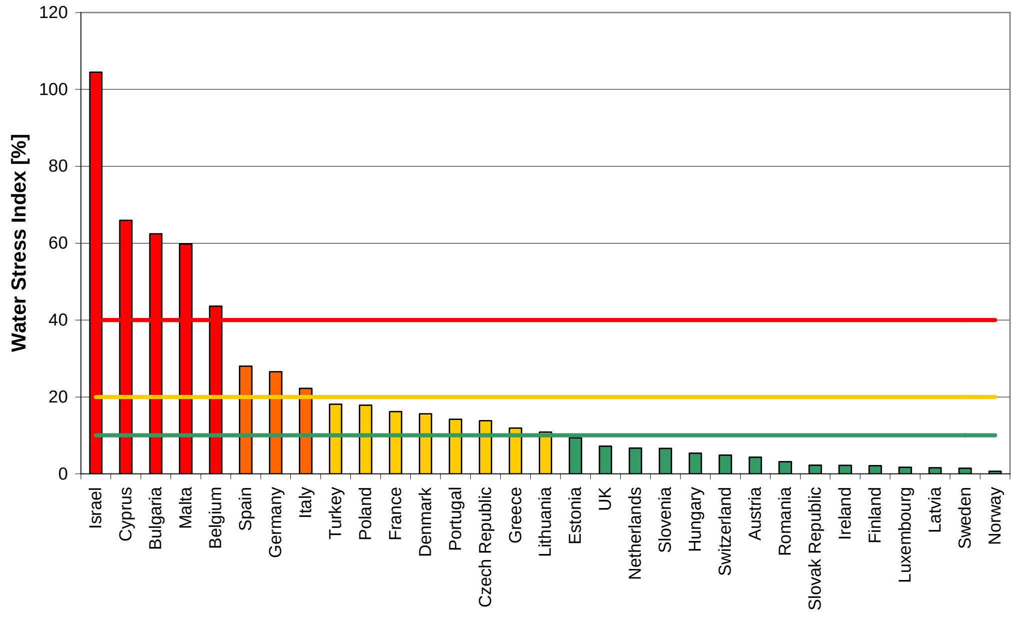


Figure 1: Water stress index for European countries, Israel and Turkey (AQUAREC, 2006)

In the last years, the growing importance and impact of water scarcity and drought have been recognised at the European level. An in-depth assessment of these issues reported that the total population concerned is 130 million inhabitants mainly in Mediterranean EU Member States (Cyprus, Malta, Italy, Spain, Portugal, Greece) (EC, 2007). Additionally, climate change is expected to aggravate the availability of water, particularly in the Mediterranean basin and adaptation measures like more efficient use of water and water reuse are increasingly being considered as mitigation options (EEA, 2007).

Water management and drought planning in particular is moving from a mere crisis management to a more risk management based approach. Appropriate plans should provide a dynamic framework for actions to prepare for, and effectively respond to the challenges. Adaptation measures and achievements will be periodically reviewed to allow for readjustment of goals, means and resources (EC, 2008).

Stored volume: 115 Mm^3 Stored volume: 1 Mm^3

Figure 2 Aerial vies of the Kouris dam April 2004 (left) and December 2008 (right)

For the Cypriot case, the depletion of reservoirs over a period of 4.5 years as depicted in Figure 2 is an alarming signal and raises the question of how this could happen and how this can be prevented in future. It has been stated that the water crisis is as much the result of shortcomings in human rules and regulations as much as nature's resources (Iacovides, 2005). The report at hand will try to throw light on these assumptions and to point out strategies to overcome these shortcomings.

1.2 Characteristics of Cyprus

1.2.1 Geography and climate

Cyprus is situated at the north-eastern end of the East Mediterranean basin. With an area of 9,251 sq. kilometres it is the third largest island in the Mediterranean. (GoC, 2008)
The climate is Mediterranean with a typical seasonal rhythm strongly marked in respect of temperature and rainfall. About 60% of the average annual total precipitation for the island falls from December to February and is the main

source for replenishment of water resources. Summer rains do not contribute significantly to recharge of aquifers or run-off.
Moreover precipitation is distributed unevenly across the country, increasing from 450 millimetres at the south-western windward slopes to nearly 1.100 millimetres at the top of the Troodos massif. There is a steady decrease of amounts on the leeward slopes towards the north and the east. The central plain and the flat south-eastern parts of the island receive only between 300 and 400 mm of rain (see Figure 3).

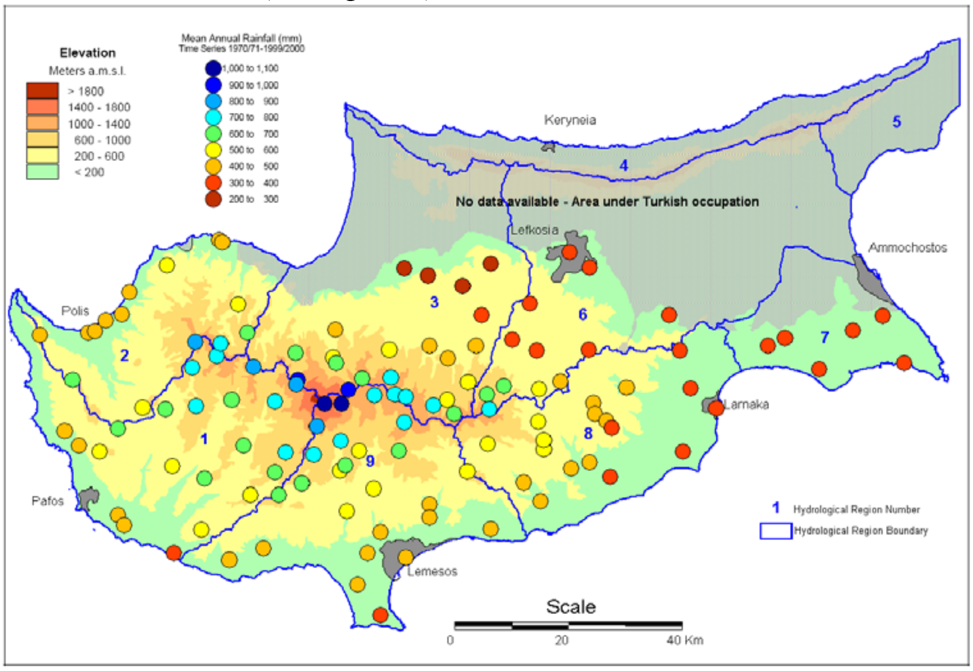


Figure 3: Mean annual rainfall in Cyprus (from WDD-FAO, 2002, Chapter 1.4.1-Surface Water Resources)

Temperatures are high in summer and the mean daily temperature in July and August ranges between 29°C on the central plain to 22°C on the Troodos Mountains, while the average maximum temperature for these months ranges between 36°C and 27°C respectively. Winters are mild with a mean January temperature of 10°C on the central plain and 3°C on the higher parts of the Troodos Mountains and with an average minimum temperature of 5°C and 0°C respectively. (GoC, 2008)

1.2.2 *Water availability*

Climate and geography of the island determine the renewable freshwater resources and its availability. The re-assessment of Cyprus water resources (WDD-FAO, 2002) found that the mean annual surface runoff amounts to 190 Mm^3 whilst the natural annual recharge rate of all aquifers amounts to 282 Mm^3/yr of which only 90 Mm^3/yr are retained by the aquifers, the remaining is outflow to springs and to sea (Demetriou and Georgiou, 2004). Various mathematical models suggest that 5-15% of annual rainfall contributes to replenishing the aquifer systems (WDD-FAO, 2002; Boronina et al., 2003).
In view of these geographical conditions and the uneven distribution of precipitation, the actual water availability highly depends on storage, which is naturally performed by aquifers. Sufficient storage capacity is even more

essential to serve peak demands that occur at times of lowest rainfall, in the summer months. Accordingly, more than 100 dams have been constructed on almost all rivers of the country. To date, all reservoirs provide a storage capacity of 327.5 Mm^3.

1.2.3 *Water demand structure*

Water demand is characterised by a pronounced seasonal peak in summer related to agricultural irrigation and tourist activities. The total annual water demand in Cyprus is ca. 275 Mm^3/yr. Sectoral water use is dominated by agriculture, which accounts for 67% of the water demand. Domestic water supply to households and urban users including tourism, consumes around 30% (of which 5% is for tourism/hotels). Landscape irrigation (public parks, gardens etc.) and ecological flow is included under environmental demand and make ups 1%, as do industrial self-suppliers (cf. Figure 4).

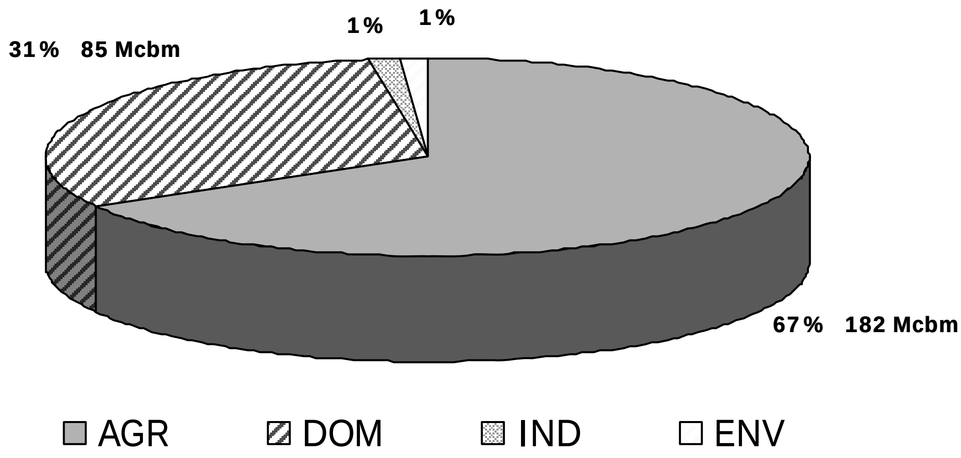


Figure 4: Water demand pattern by sector where AGR: agriculture, DOM: domestic; IND: industrial and ENV: environmental demand; Mcbm = million cubic meter

Actual water allocation to agriculture through governmentally managed schemes is dependent on availability and based on a quota system. Farmers apply for required volumes for the irrigation season in February of the year. Depending on water storage in dams, the WDD grants a certain proportion of it, divided in allocations to permanent and seasonal crops. Deficits of supply during droughts can be as high as 70% (Tsiouris, 2005), causing considerable loss in agricultural production and income.

Domestic water supply

Two thirds of the population is served by Town Water Boards which primarily function as water distributors. They purchase bulk water from the Water Development Department's treatment works.

The standard treatment technology comprises removal of solids, pre-chlorination, aeration, flocculation and sedimentation with subsequent sand filtration. Liming and post-chlorination complete the treatment (WDD, 1999).

Municipalities and communities often operate their own boreholes for drinking water production and distribution. The specific domestic water demand is:

- 215 L/cap.d for town residents,
- 180 L/cap.d for rural residents and
- 465 L/cap.d for hotel guests (WDD-FAO, 2002 - Chapter 1.5.1 - Asssessment of Water Demand)

Network losses vary greatly between suppliers. Water Boards manage to keep them in the range of 17-28% equalling a total of 7.6 Mm^3. Leaky pipes and theft in the municipalities and community networks generate losses between 35-40% (Audit Office of the Republic, 2007).

The relevance of the different sectors for the Cypriot economy is illustrated in Figure *6*. The tertiary sector (services) contributes almost 80% of the gross domestic product. The secondary sector covering manufacturing, energy production and construction produces roughly 19% of the gross domestic product, whereas the primary sector generates hardly 3%, which almost entirely stems from agriculture (CYSTAT, 2009).

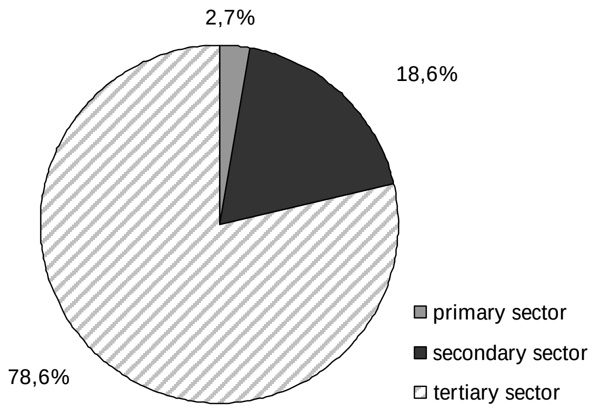


Figure 5: GDP per sector for year 2006 (based on data by CYSTAT, 2009)

In the national accounts tourism is not identified as a distinct sector. As a cross-cutting activity over construction, 'wholesales and retail', hotel and restaurants and 'Real Estate, renting and business activities' it contributes to several items of the secondary and tertiary sector.
Yet the 2006 revenues of tourism amounted to 1,755.3 million euro which represents 14% of the 2006 GDP (CYSTAT, 2009 and 2009a). Latest estimates are less bright and estimate the contribution of tourism to GDP with 8-9% (WTTC, 2009).
Relating these numbers to the water use of the relevant sectors reveals a striking imbalance of economic return on water input (see *Figure 6*). This ratio must be kept in mind when reconsidering water allocation and rationing measures. Agriculture only contributes a minor share to the countries economy, while accounting for two third of the annual water demand. Tourism produces 14% of the GDP for around 8% of the total water demand. It is to be noted, that this is a simplified comparison, as for the

tertiary sector it is not so easy to properly relate water consumption of "tourism" to its contribution to GDP. In this case the numbers refer to hotels and tourism resorts and facilities only.

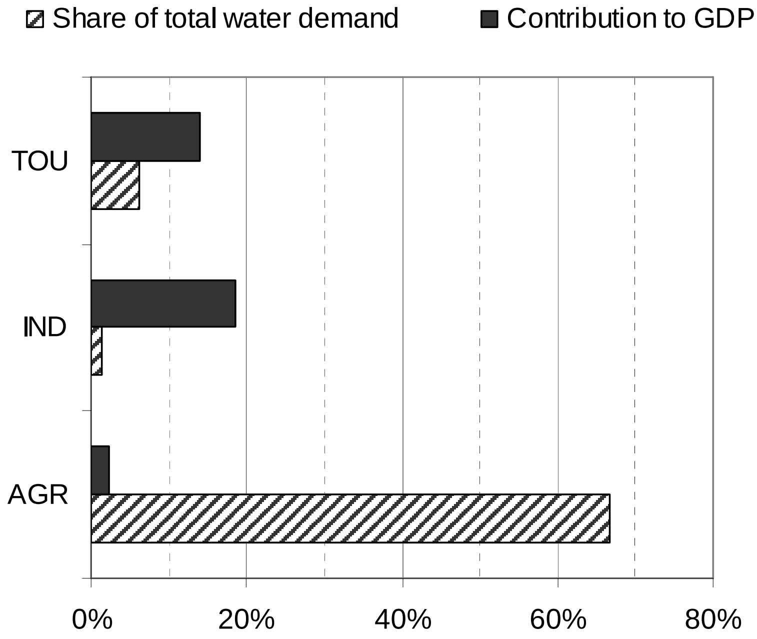


Figure 6: Sectoral water demand and contribution to GDP for year 2006 (based on data by CYSTAT, 2009 and WDD, 2007)

1.2.3.1 *Use per water source*

The different sectors satisfy their demand from different water sources to various extents as depicted in Figure 7. Agriculture, when supplied by Governmental Irrigation Schemes receives mostly dam water but private boreholes are supposed to be exploited to approximately the same extent. The domestic water supply is mainly served by surface water (50%) with desalination contributing another 30%. In 2008 the share of desalinated water made up 52% of the distributed water while contributions from surface reservoirs were halved (24%). Pumped groundwater accounts for ca. 20% of drinking water supply. Self supplying industry abstracts from licensed boreholes, though most industrial enterprises are connected to the public water supply. Environmental demand is equally dependent on groundwater and surface water.

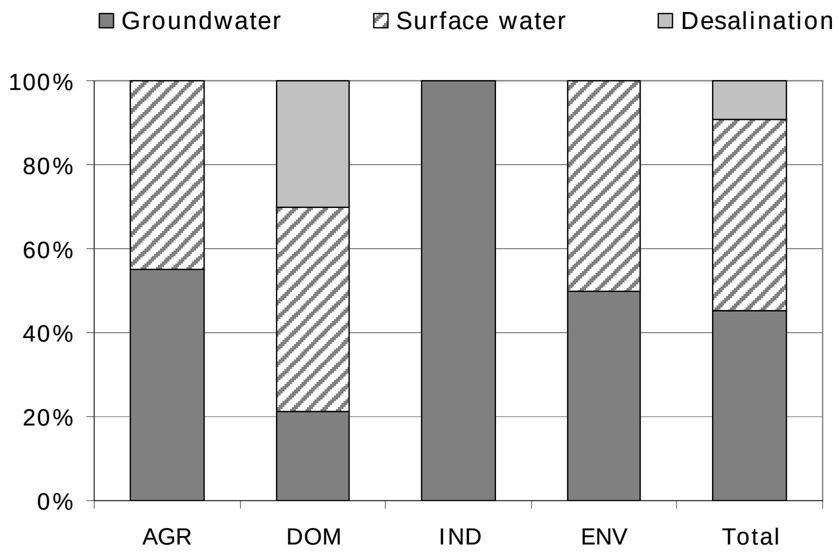


Figure 7: Water demand by source and sector, where AGR: agriculture, DOM: domestic; IND: industrial and ENV: environmental demand.

In total, the water demand pattern is made up by equal shares of groundwater and surface water (45% each). Desalination satisfies roughly 10% of the total demand.
The countries key figures on the water balance are summarised in Table 1.

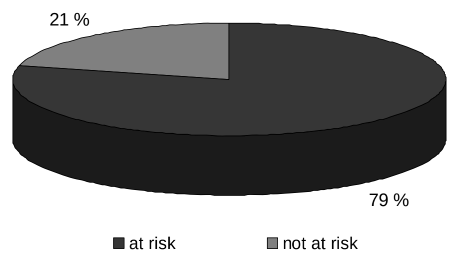
*Table 1: Key figures for the Cyprus water balance (WDD-FAO, 2002; number are rather based on estimates than on measurement; *of which 190 Mm³ flow out to sea and springs)*

Process	Yield unit	Yield amount	Remark
Aquifer recharge	Mm^3/yr	282 (90)	Of which 165 Mm^3/yr is outflow to springs and to sea (25 Mm^3/yr)
Surface run-off	Mm^3/yr	190	Measured and estimated as river flows
Dam storage capacity	Mm^3	327	
Average inflow to dams	Mm^3/yr	76	(years 1987-2008)
Annual water demand	Mm^3/yr	275	

1.2.4 Pressure on water resources

As described in the previous paragraphs, both surface water and groundwater resources are intensively used for water withdrawal. Whilst the use of surface water resources is managed by the Water Development Department, the abstraction of groundwater is less well administered. The number of boreholes is estimated to exceed 50,000 a considerable number of which is illegal with uncontrolled abstraction.
Characterising water bodies according to requirements of the Water Framework Directive, around 80% of the groundwater bodies have been

assessed as being at risk of failing to achieve a "good status"[1] by 2015. This is mainly due to over-pumping, saltwater intrusion, high nitrate concentrations and pesticide pollution (Figure 8) caused by agricultural activities (MANRE, 2005)



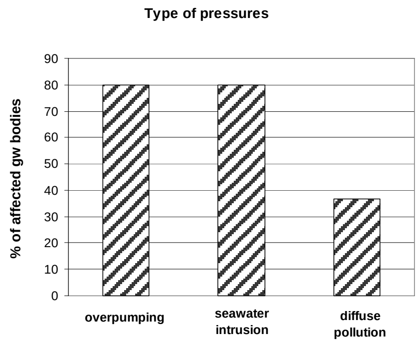


Figure 8: Status of groundwater resources in Cyprus (based on Art.5 Report by MANRE, 2005)

Additionally, many surface waters have been categorised as heavily modified water bodies and 21% have been classified as being at risk to be not in "good status" by 2015. Elevated loads of nutrients and oxygen demanding substances are major causes for this assessment (MANRE, 2005). Sometimes the poor quality of the resources inevitably makes them unsuitable for any uses, which further reduces water availability and thus exacerbates the water stress situation.

1.2.5 *Organisation of water management*

The water management in Cyprus involves a great number of organisations and authorities, as illustrated in Figure 9. On the national policy level competence in water management is divided between the Ministry of Interior (MoI), the Ministry of Agriculture, Natural Resources and Environment (MANRE) as well as the Ministry of Health (MoH). While the latter controls the drinking and bathing water quality, the MoI is responsible for the authorisation of most water use such as water abstraction from boreholes and wastewater discharge.

At the MANRE the Water Development Department is concerned with the development of water resources, resources planning and related infrastructure. Groundwater reserves are monitored and developed by the Geological Survey Department. Aspect concerning best practice in agriculture, education of farmers including the use of reclaimed water falls into the responsibility of the Department of Agriculture. Whilst the technical expertise is within the WDD the legal and administrative power is associated with the MoI and its District Offices. Although consultation is foreseen it does not always take place (WDD-FAO, 2002 – Chapter 2.1). The responsibilities for various water sources are assigned to different institutions as follows:

[1] good status is a term of the Water Framework Directive and is defined along various parameters assessing the chemical and ecological quality of water bodies and its quantitative status

- Surface water & dam management: MANRE, Water Development Department
- Groundwater monitoring: MANRE, Geological Survey Department
- Drinking water quality: MoH, Medical and Public Health Services

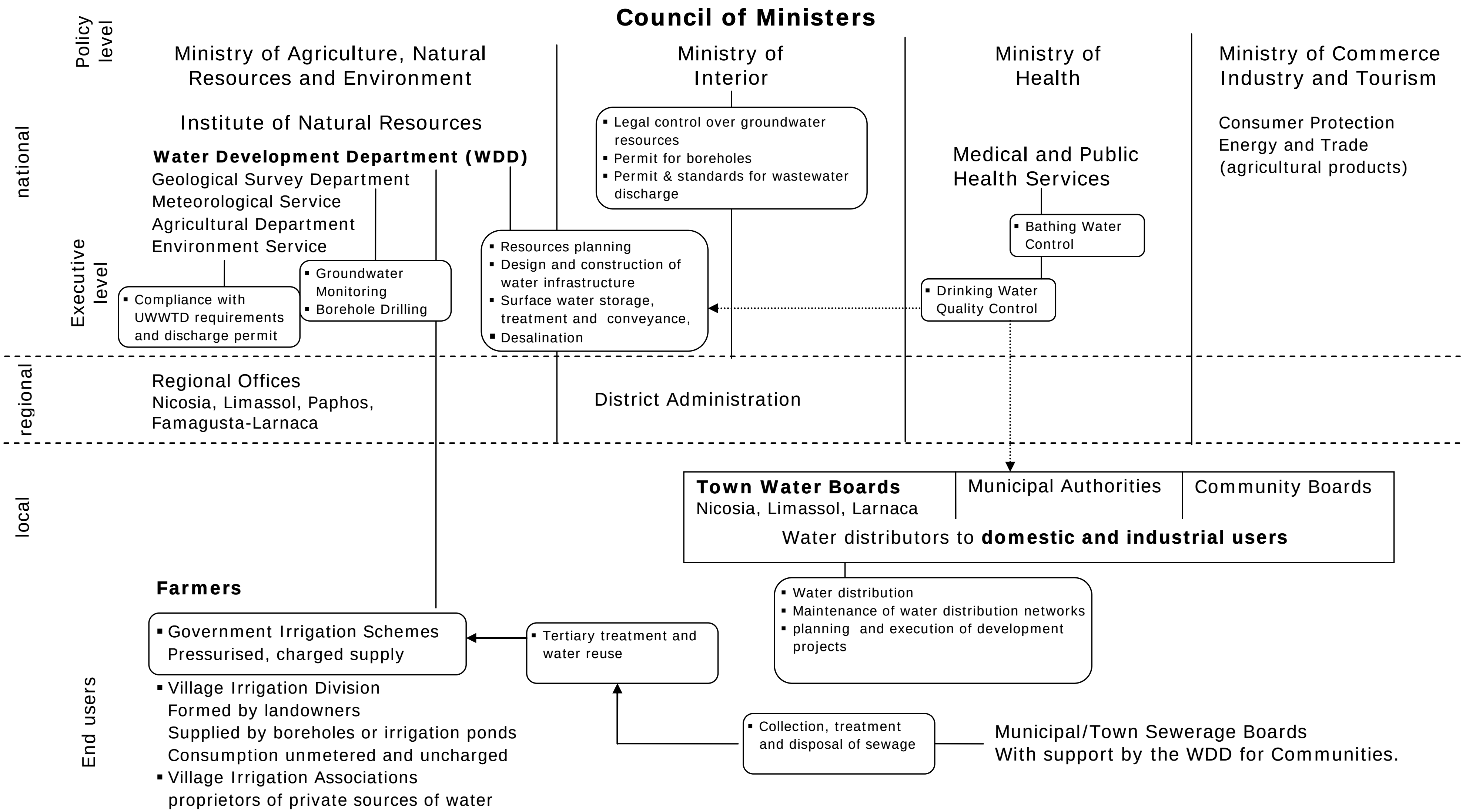
Provision of most water services takes place at a local level. The **water distribution** to domestic and industrial end-users is provided by three Town Water Boards (Nicosia, Limassol and Larnaca), Municipal Boards and Village Boards. The Town Water Boards serve 66% of the population, mainly with bulk water purchased from the WDD, but they also operate their own boreholes. They are financially independent entities, yet their prices to consumers are subject to approval by the Houses of Parliament.
On the other hand the user group with the highest demand, the farmers, are directly served by the Water Development Department through their governmental irrigation schemes. Additionally, irrigation divisions and associations develop and operate their own schemes often with financial aid and technical support by the WDD.

Wastewater collection and treatment falls into the responsibility of the Sewage Boards, while discharge of effluents of the big municipalities is task of the WDD. For many years there has been an appeal for and also legislative changes proposing to empower a single Water Entity for the country. This re-organisation of the water management would establish this entity at the MANRE without affecting the water users–supplier relationship. Nonetheless it would transfer competences from the MoI to the WDD/Water Entity and by that concentrate administrative and authorisation procedures.

On top of this, not only is water management parcelled out into various authorities, also manifold legislation indirectly affects water issues through decisions in other sectors. Politics related to the major water users such as agriculture and the specific demands of tourism are covered by different ministries, e.g. the Ministry of Commerce, Industry and Tourism

It is in this framework that the various competent authorities and organisations are facing a number of challenges for the water sector. It should be able to allow for the consideration of local solutions and involve the different levels in future implementation of measures.

Figure 9 Scheme of water management in Cyprus - based on information in WDD-FAO, 2002 (cf. to p. 61 flow charts, Kambanellas (2004)) and Sogesid 2005



2 Challenges for the water sector in Cyprus

The original task of any water supply is to produce drinking water of a defined or desired quality from a source of given quality and quantity.
As described in the previous chapter, water resources in Cyprus are exploited and partly of deteriorated quality. These aspects are supposed to aggravate and complicate the water supply under the expected impact of the most relevant trends, which are

- climate change
- population development (be it permanent or seasonal)
- increasing energy demand under full dependency on fuel imports (oil and natural gas)

The associated impacts and challenges are outlined in the following sections.

2.1 Climate change and impacts on water availability

Regional climate change projections for the Eastern Mediterranean expect a 20-30% decrease in winter precipitation in 2080-2099 period compared to the 1980-99 average (Christensen et al., 2007). This is supported by Giorgi and Lionello (2008) whose regional climate modelling arrives to a reduction in precipitation between -10 and -30% compared to the reference period 1961-90. Summer temperatures will possibly increase by between 3-4°C with an annual mean of + 3°C (Christensen et al., 2007).

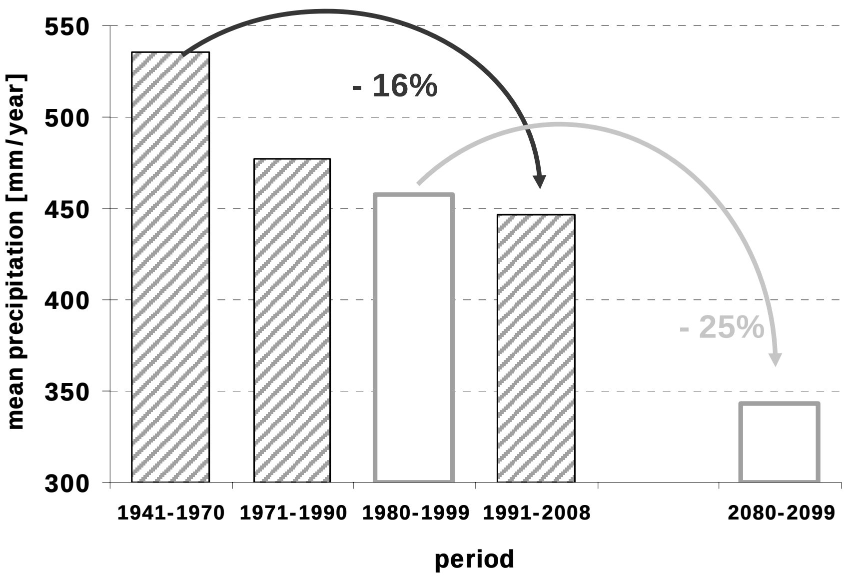


Figure 10: Observed (shaded bars) and projected (open bars) changes in mean annual precipitation (prepared from WDD statistics and Christensen, 2007)

Analysis by the WDD-FAO (2002) revealed that the observed step-change in precipitation around the year 1970 resulted in a decrease in stream flows varying between 20% and 60%. The 16% decline in precipitation as documented by standard meteorological reporting and the problems encountered in the last year give a foretaste of the difficulties to be handled under climate change predictions. The above mentioned projections of 25% decrease in precipitation would cause a drop to 342 mm/yr (Figure 10, open bars).

2.2 Population growth

The current population of Cyprus is 789,300 inhabitants in the area under governmental control of which 70% live in urban areas (CYSTAT, 2008). This population growth was accompanied by an increasing number of households which at the same time became smaller. From 1997 to 2006 the number of persons per household declined from 3.19 to 2.94.

There are various projections for the future development, which all assume a further increase based on positive birth rates and particularly migration but the total numbers differ, depending on source. The Cyprus Statistical Services calculate a population of 851,500 for 2032 (CYSTAT, 2004) while the EUROPOP2004[2] estimate expects 921,000 inhabitants for 2030 in a baseline scenario (Eurostat, 2006). In the Cypriot projections population will decline from then on and reach 822,069 in 2052. On the contrary, the Eurostat calculations arrive at a further population growth with 975,000 inhabitants in 2050. As the numbers of the CYSTAT projections for early years have already been exceeded by the actual numbers, the Eurostat estimates seem more reliable.

There are no official documents available quantifying the consequences for future water demand. The only assessment dating back to 2001 is the WDD-FAO report assumes quite low population numbers but very high and even increasing specific water demands for both domestic and tourist supply. According to those estimates (see Table 2), the public water supply sector will reach a volume of roughly 100 Mm^3. By 2020 the tourist demand will have more than doubled and request 31 Mm^3/yr while the residential population would demand 70 Mm^3/yr.

Table 2: Water consumption (including losses)(WDD-FAO, 2002)

	Domestic	Tourism	Total	Total
	Estimated demand [Mm^3]			Actual supply
2000	50.6	14.1	64.7	52.7
2005	55.1	18.0	73.1	
2006	70	15	85	
2010	59.6	22.9	82.5	
2020	69.5	30.8	100.3	

It has to be admitted that these estimates are based on figures for water consumption in 1997-2000 and are likely to be outdated. Especially they may not be suitable to define future water demand limits, which should fully take into account the effects of further implementation of water saving technology

[2] EUROPOP2004: EUROstat POpulation Projections 2004-based

In summary, the water demand of the public supply sector will increase considerably if no measures for demand management are realised which bring down the consumption to a reasonable European average of 150 -200 L/inhabitant/day.

2.3 Tourism

Tourism contributes to temporary and seasonal increase in population. Around 2.4 million tourists visited Cyprus per year in 2005-2008. With a total 14.4 million overnight stays they equal additional 39,400 residents, which is a 5% increase in the permanent population.
Tourism has traditionally been a major source of income and a driver of economic growth in Cyprus. However, this has changed in the last few years when this economic activity slowed down (Clerides and Pashourtidou, 2007). Revenue gained amounts to 1,800 million EUR and contributes around 13% to the country's gross domestic product (CYSTAT, 2009). Projections of the economic development of this sector are not at hand but it is evident that Cyprus will rely on growth of tourism but at the same time needs to develop more diversified, higher quality products and services than just the 'sun and sea' nature tourist product to attract financially strong tourists (Clerides and Pashourtidou, 2007). Among those are two marinas being planned in Limassol and Paphos able to accommodate 1,000 boats each[3],[4].
A highly disputed subject in view of the recent water crisis is the issuing of licences for the construction of 14 new golf courses on the island. Though the permits have been granted under the provision '*that the irrigation and water supply of the project must be carried out by desalination plants that will use electric power from renewable sources of energy*' they provoked considerable opposition.

2.4 Agriculture

As described in section 1.2.3, agriculture is the main water user in Cyprus - and this is likely to continue. The future agricultural water demand is supposed to stay constant at around 182 Mm^3/year (WDD-FAO, 2001). On the other hand it is expected that in view of ever declining resources the actual water supply to agriculture will be reduced, as it used to be during times of drought.
The future development of agriculture will be greatly dependent on climate change effects. Reduced availability of irrigation water and less nutrient uptake may cause reductions in yields. Further factors with negative impacts are an expected shorter growing season, extreme events during development stages, higher risk of heat stress, higher risk of rainy days during sowing dates, higher rainfall intensity and longer dry spells (AEA, 2007).
Irrigation efficiency in the government irrigation schemes is high as they are equipped with modern irrigation systems that have been tested by the Agricultural Research Institute. The use of drippers, mini sprinklers and low capacity sprinklers is applied to greenhouse cultures, citrus and other trees as well as field vegetables. Subsidies on the installation costs, resulted in a rapid expansion of the new irrigation systems (Papadopoulos and Chimonidou,

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[3] www.marina-limassol.com
[4] Press release of 12 February 2008, available at http://www.free-press-release.com/news/200802/1202818165.html

2004). It is estimated that currently over 95% of the total irrigated land of the country is being served by modern irrigation methods. The on-farm irrigation systems comprise 90% micro-irrigation, 5% sprinkler irrigation and 5% surface irrigation (Tsiourtis, 2004).
Whilst the irrigation technology is reasonably advanced, the irrigation schedule leaves room for optimising the water application (depending on soil moisture etc.). Also changes in cropping pattern may offer potential for water saving in the agricultural sector.

2.5 Increasing energy demands and costs

Cyprus' energy sector is almost fully dependent on imported fossil fuels. Consequently, rises in international oil prices put considerable pressure on the national economy. Cyprus' energy policy aims at decoupling economic growth from energy use through efficient use of energy and energy conservation. Further key aspects are the diversification of conventional energy sources (oil and LNG) as well as the promotion and development of renewable energy sources. (MCIT, 2008). In 2007 the primary energy consumption was 2,660 ktoe (kilo tonnes oil equivalent) comprising 2,580 ktoe from oil products, 44.8 ktoe from renewable energy sources and 36.2 ktoe from solid fuels. The final energy consumption amounted to 1,881 ktoe (MCIT, 2008).
The same year, the per capita electricity consumption was approaching 5,500kWh/cap.yr after having grown steadily over the last years, on an average rate of 2% annually. As illustrated in Figure 11 projections expect a constant increase in electricity generation of 7.4% per year for the period 2008-2017 ultimately reaching 8,500 GWh. At the same time prices have gone up by 22% throughout all sectors (TSO, 2006; CYSTAT, 2008).

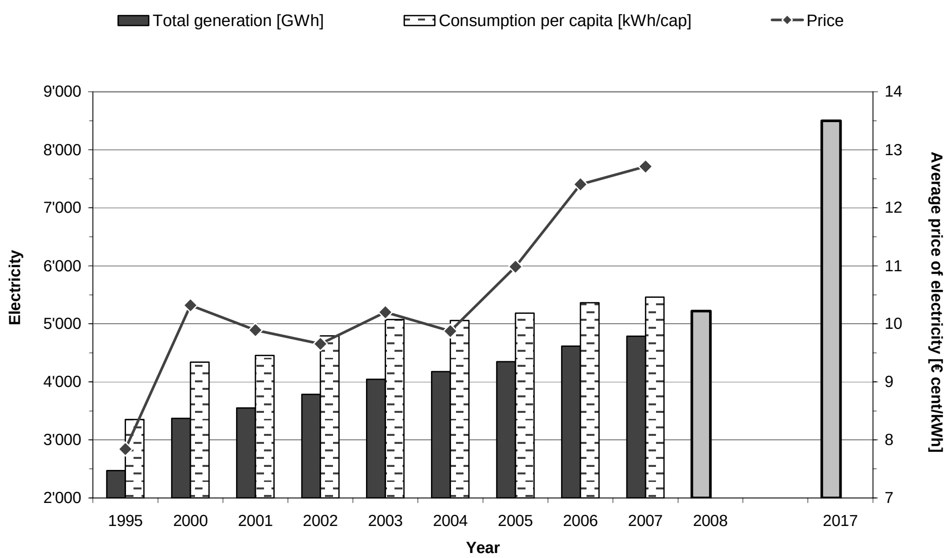

Figure 11: Development of total electricity generation, per capita consumption and consumer electricity prices (based on data by CYSTAT, 2008 and TSO, 2006)

The objective is to increase the share of electricity generation from renewable energy sources (RES), which should contribute 6% to the total electricity

consumption in 2010. Two thirds of this will be derived from wind energy.. Further, the longer-term strategy is also to develop solar-thermal power plants of 10-50 MW installed capacity (MCIT, 2008).
On the other hand, Cyprus is world leader in solar water heating with 90% of households, and 53% of hotels having installed solar water heaters.
Cyprus has the highest installed solar collector per capita with about 0.8 m^2 of solar collector per person (ESTIF, 2008)

3 Adaptive strategies

Facing various challenges and constraints from future trends and developments, adaptive strategies will enable water supplier to effectively perform their business. It should be kept in mind, that water management measures should not primarily be aimed at increasing the availability of water for itself. It is rather a key objective to guarantee the services water provides to the end-user (Boerema, 2008). Depending on sectors, these include domestic cleanliness, personal hygiene or income from agricultural produce and industrial production. This will be an important aspect in the assessment of, and decision making for, water management measures. Drawing up adaptive strategies will have to take into account that challenges occur at different levels in the water (supply) sector and therefore have to be equally diverse in their responses and the components they use.

3.1 A historic perspective

Cyprus has been suffering from recurring droughts for decades and has been repeatedly facing the problems of insufficient supply of water to domestic and agricultural users. The principle issues and possible policy measures have been summarised as follows in 1997 (FAO, 1997) and seem to be valid ever since.

Principal issues:	**Policy measures:**
• supply-demand imbalance; • groundwater pollution from agrochemicals; • high cost of new supplies; • conflict and competition between users; and • inefficient water use, which is inappropriate for the extreme, water scarce situation in municipal supplies, with over-application even with improved irrigation systems.	• water pricing; • re-use of municipal wastewater; • desalination of sea water; • improved water efficiency and reduced losses; • modification of cropping patterns; • protection of water quality; • control and restriction of reclamation of new irrigation area.

A major effort has been undertaken to match supply to demand by developing sufficient water resources. In adapting to upcoming changes, managing demand according to water availability will be as important. Particularly, intervention has to be tailored to the relevant problems and be specified in various scales:

- Time: when are measures applied and how enduring are their effects?
- Level and location: to whom are the measures applied, who applies the measure?
- Mode: how the measures are applied: which kind of steering instrument is used - imposed, prescriptive, mandatory, incentivised?

3.2 Adaptive strategies put into practice

A first overview on options for adaptive measures applied in Europe has been compiled by the European Environment Agency as a stock-take of existing practices (EEA, 2007). Those are listed in Table 3 which also categorises them along their status of implementation and application in Cyprus can be applied as centralised or decentralised solutions.

Table 3 List of possible measure to adapt Cyprus' water management to climate change impacts (adopted from EEA, 2007) further elaborated

	Adaptation measure	Implemented	Planned	Local / decentral	National	Prescriptive / legally binding	incentive	Examples & remarks
A	Supply management - addressed to water utilities and managers							
A1	Technical measures to increase supply	X	X					
	Reservoirs	X	X					
	Water transfer							
	Water import	X						
A2	Diversification of water resources utilisation	X	X					
	Use of alternative resources							
	Water reuse							
	Desalination	X	X					upgrade and new plants
	Grey water reuse	X		X				Subsidy provided
	Stormwater harvesting		X					
B	Demand management - enduser oriented							
	Increasing efficiency of water use	X	X			X	X	
	Restriction of water uses	X				X		
	Standards for building development (water saving fixings, greywater reuse)					X	X	back up by subsidies
	Water cuts	X	X					
	Awareness raising or information campaigns	X	X				X	
C	Economic instruments	X	X				X	Steering function
D	Other instruments							
	Landscape planning measures to improve water balance	X	X					
	Improving forecasting, monitoring, information - alert system	X	X					

A closer characterisation of the most relevant measures in the Cypriot context is given in the following sections

3.2.1 Technical and other measures to increase supply

3.2.1.1 Dams and reservoirs

In Cyprus, water management has been characterised by impressive infrastructure projects to capture rainwater. Under the theme *Not a Drop of Water to the Sea* - the policy since the 1960s was directed towards a maximising capture of run-off. Dam storage capacity was increased by a factor of 50, from 6 Mm^3 to 300 Mm^3. This concept disconnected many of the downstream users from their commonly used surface water resources. In addition, recharge of the coastal aquifer by river bed infiltration no longer took place.

In parallel an extensive distribution network was constructed to transport water from the dams to the big towns and to connect irrigation districts. The dilemma now is that given the decline in precipitation these reservoirs seem oversized and do not yield sufficient water. Ironically the boost in storage capacity during the 1980s coincided with a drop in average annual precipitation, as illustrated in Figure 12. Overall the actual yields are 30-35% less than originally calculated (Tsourtis, 2001).

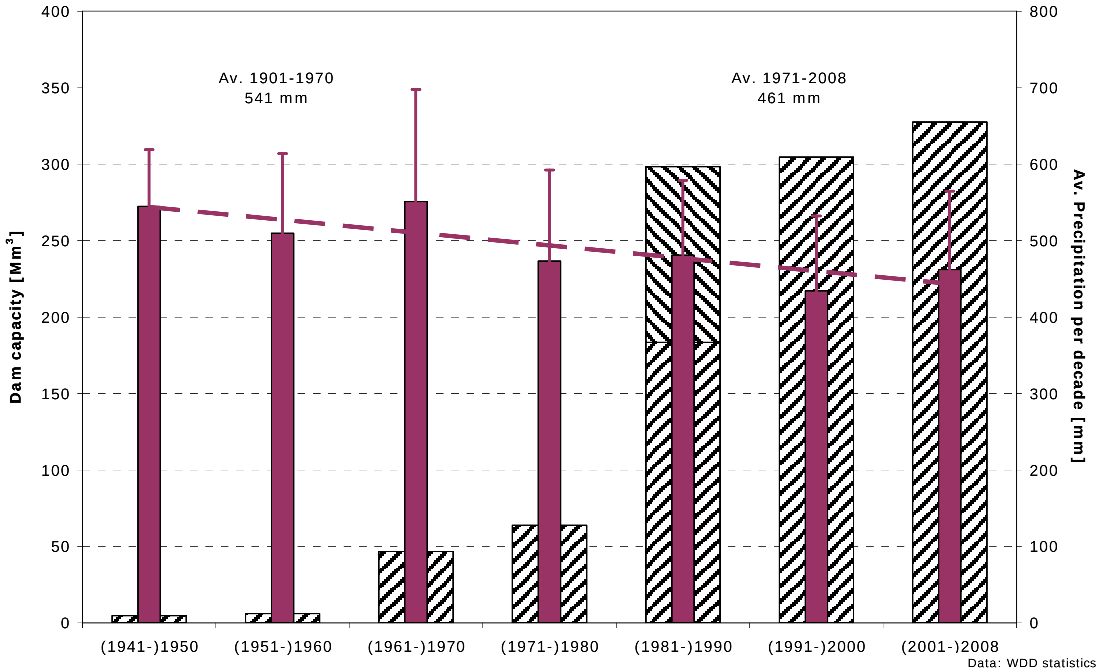

Figure 12: Installed dam capacity and corresponding average precipitation per decade (prepared from WDD statistics)

3.2.1.2 Water import

Emergency water was shipped into the island from Greece during summer 2008. This unprecedented action was vital to supply Limassol with drinking water and earmarked the extraordinary severity of the drought.

A total of 8 Mm^3 was to be delivered from June to November for a total expenditure of around 40 million EUR. In fact the daily delivery was only 35,000 m^3. According to the Water Development statistics[5], the imported amount in 2008 was 3.3 Mm^3.

3.2.2 Water reuse

Water reuse provides additional drought-proof water supply, favours a more local sourcing of water and avoids the use of drinking water quality sources where such high quality is not needed. The potential for water reuse depends on the availability and accessibility of wastewater, hence the wastewater infrastructure, and the acceptability by potential end-users and consumers. Though the policy claim *Not a Drop of Water to the Sea* was coined for maximum capture of run-off by dam construction, it is equally applicable to the handling of wastewater, which should not be disposed to the sea.

3.2.2.1 Wastewater treatment

The total amount of treated wastewater in Cyprus in 2007 was approximately 15 Mm^3/yr. Most of the sewage - 90% - is treated in municipal wastewater treatment plants (CYSTAT 2007, WDD, 2008[6]), while a number of smaller communities and decentralised plants for military camps, hotels and hospitals contribute a minor share. Treatment mostly consists of secondary treatment aiming at reduction of organic loads. Nutrient removal is only applied to one third of wastewater treatment facilities (CYSTAT, 2007). Effluent undergoes sand filtration and chlorination before being reused.

3.2.2.2 Reuse applications

In general, all treated wastewater is reused, primarily for the irrigation of agricultural land, parks, gardens and public greens. Most crops irrigated are trees such as citrus and olive or fodder crops and cow grass. A small proportion is used for groundwater recharge (see Figure 13). At Paphos the Ezousa aquifer is recharged artificially with 2-3 Mm^3 reclaimed effluent per year, which is re-abstracted for irrigation. Investigations by Christodoulou (2007) showed that the aquifer would be able to store more water, once available.

According to the Water Development Department's statistics the contribution of recycled water to all irrigation water supplied by the Government Water Works makes up about 7-10% which equals 3-5 Mm^3. Only in exceptional cases, mostly during winter, when there is no irrigation water demand, treated effluent is discharged into the sea. This amount can be as high as 3-4 Mm^3 but recently only made up 1 Mm^3 as irrigation of crops had to start earlier.

[5] http://www.moa.gov.cy/moa/wdd/Wdd.nsf/f8ca32f24081da0ac22573e000406fff/0ac7d6e86ef8422ac2256e7e004404a7/$FILE/17KB.pdf

[6] numbers presented cannot be reproduced by addition of single items

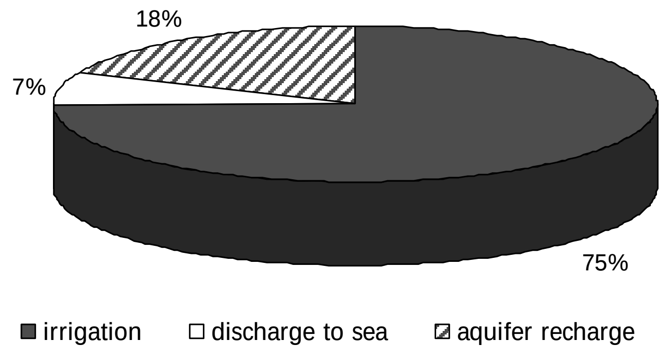

Figure 13: Re-Use of treated effluent in 2007 (WDD, 2008)

3.2.2.3 *Future perspectives*

There is an immense potential for growth of water reuse practice driven by both the demand for water and the increasing volumes of treated effluent. Aiming for compliance with the Urban Wastewater Treatment Directive (91/271/EEC) requirements, the wastewater collection and treatment infrastructure is being significantly expanded and upgraded.

The pollution load to be treated is set to 675,000 population equivalent (p.e.) of which 80% is generated in urban agglomerations, which are the greater areas of Nicosia, Larnaca, Limassol and Paphos, and the municipalities of Ayia Napa and Paralimini. In rural areas the pollution load rarely exceeds 5,000 p.e. per individual agglomeration. Therefore, several communities are supposed to set up central, combined schemes. This will reduce the number of plants and produce some economies of scale (WDD, 2005).

Existing sewage treatment plants have been extended recently. The Limassol-Amathus sewage treatment work has been enlarged from a treatment capacity of 70,000 p.e. to 272,000 p.e. and is now able to handle 40,000 m^3 per day). Such upgrades correct the overload under which some plants have been working for years and will eventually improve the effluent quality. A projected plant in the greater Nicosia area for a population of about 150,000 will use membrane technology to treat part of the 55,000 m^3 effluent per day. The plans foresee the use of one third of the water for local irrigation. The remaining 66% will be treated with reverse osmosis and get fed into the irrigation networks of the Southern Conveyor Project (WDD, 2006, Artemis)

After full implementation of planned schemes the treated wastewater flow will amount to 59 Mm^3/yr in 2012 and increase further till 2025, as summarised in Table 4 (WDD, 2008). The annual water recycling is expected to use 52 Mm^3 by 2012 which equals 28.5% of today's agricultural water demand (WDD, 2008a).

Table 4: Estimated volumes of treated wastewater (WDD, 2008 and 2008a)

	2012	2015	2025
	Mm^3/yr		
Municipal wastewater treatment plants	46	51	69
Rural wastewater treatment plants	13	14	16
Total	**59**	**65**	**85**
Annual water recycling	52		

3.2.3 *Greywater reuse*

In Cyprus this decentralised form of water reuse is propagated is also used. The Government of Cyprus has set up a subsidising programme for greywater reuse at household level. Recycled water will be used for purposes not necessarily requiring drinking water quality, such as toilet flushing and domestic irrigation. Currently the subsidy is 3000 EUR per plant and covers almost half the cost[7] (2009 subsidy scheme). Greywater reuse can yield a true saving of drinking water in residential areas (35% - 40%) and enable the service of more inhabitants with the same amount of drinking water. (Kambanellas, 2007).

Yet retrofitting of existing installations bears some difficulties. Information on acceptance and utilisation of this subsidy scheme is lacking as it is for the total budget for this programme. According to Kambanellas (2006) the government paid €1.275 million to consumers in the period from 1999 up to September 2005 but no scheme numbers or achieved savings are presented.

It is striking that on the website there is virtually no material for interested customers to help them take an informed decision of whether to apply for this grant or not. Neither the technology, nor the operating costs or final water quality are mentioned.

3.2.4 *Desalination*

Compared to water capturing in dams, desalination is a highly engineered and energy intensive process. Relying on this technology to produce drinking water exchanges concrete infrastructure and reliance on rainfall for stainless steel and a dependable energy supply. The associated high cost and environmental impacts cause a considerable reluctance and opposition to implementation. Nevertheless Cyprus embarked on desalination technology in the late 1990s after a series of drought years.

3.2.4.1 *State of implementation and future prospects*

Currently Cyprus has an installed desalination capacity of 112,000 m^3/d. The plant in Dhekelia was put into operation in 1997 with a nominal capacity of 40,000 m^3/d. Since 2001 a plant in Larnaca supplies 52,000 m^3/d.

In Moni, a mobile unit was installed and then commissioned in December 2008 providing another 20,000 m^3/d. Desalination already makes up for

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7 http://www.cyprus.gov.cy/moa/WDD/WDD.nsf/applications_en/applications_en?OpenDocument

almost 40% of domestic water supply with a clear upward trend. Future plans encompass the construction of another desalination plant near Limassol (in the Episkopi area) and to invite tenders for real mobile desalination units that are installed on ships that cruise the Cypriot coastline and supply freshwater to municipalities where needed (WDD tender, Cyprus Mail). A full list of plants and projects is given in Table 5 below.

Table 5: Installed and planned desalination capacity in Cyprus

Plant Location		Commission date Year	Nominal capacity m^3/d	Mm^3/yr
Dhekelia	Permanent	1997	40,000	14.60
Larnaca	Permanent	2001	52,000	18.98
		Planned upgrade 2009	10,000	3.65
Moni[8]	Mobile	December 2008	20,000	7.30
Paphos (Kouklia)	Mobile	Planned June 2009	30,000	10.95
Episkopi	Permanent	Planned for 2013	40-60,000	21.90
Limassol	Floating plant	Summer 2009 (for 5 years) to replace imports	20-50,000	
			Total	77.38

The annual production capacity of 77 Mm^3 could easily satisfy ¾ of the project demand of the year 2020 (100 Mm^3/yr). With a projected permanent capacity of 70 Mm^3 desalination will become a cornerstone in the public water supply sector while leaving less reliable source of dam water for other uses.

The existing plants have been constructed and operated under BOOT (build, own, operate, transfer) contracts and will become the property of the Cypriot Government at the end of the contract (2011 for the Larnaca plant). Nevertheless there are also trends for private installations that may directly supply hotels or single users. Further small-scale desalination units (1,500 m^3/d) to serve hotels in the Pegeia district are under discussion[9] and companies are trying to develop this business (Dutch Water Group, 2007). Desalination is also an option to satisfy new demand, though this is highly controversial. Recently the licences for 14 new golf courses and the accompanying housings (requiring an estimated 30 Mm^3/yr), have been issued under the precondition that they have their own desalination unit, which must be powered from renewable energy sources (AFP, 2009)

3.2.4.2 *Technology*

All plants are based on membrane technology, applying the reverse osmosis process. Energy requirements of the Larnaca and Dhekelia plant is around 4.5 kWh per 1,000 L permeate (Koutsakos and Moxey, 2008).

[8] http://www.thebluesource.com/news.php / Newsletter
[9] http://cyprusgreenparty.blogspot.com/2008/11/peyia-case-study-in-unsustainability.html

3.2.5 Water demand management

Measures to manage users' demand play a key role in adaptive strategies. The amount of water required, the time and season it is requested will essentially influence the design of all technological measure, as plant capacities, network dimension, and consequently the energy consumption. Water demand management is a proven tool to defer capacity expansion and to reduce capacity requirement thus delaying and downsizing investment needs (see Figure 14). Moreover it can be the most effective in the short-run, cause it deals with already available water.

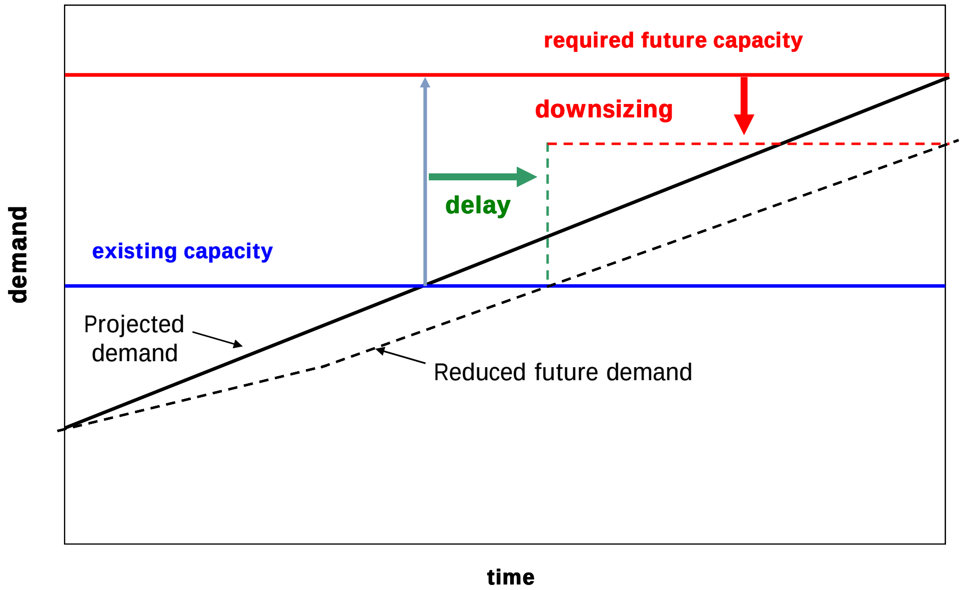

Figure 14: Effect of water demand measures on required infrastructure capacity and invest)

3.2.5.1 Domestic sector

A search for water demand management measures delivered only limited information about the situation in Cyprus. Measures listed on the website of the Water Development Department mainly focus on behavioural changes in households which are additionally illustrated in a short movie.

> *By following a number of water saving measures, which require little time and money to implement, not just during drought conditions but year-round, significant amounts of water can be saved.*
>
> - *Check the plumbing installation for leaks.*
> - *Check taps for drips and make repairs promptly.*
> - *Install plastic water bags in the toilet flush tanks.*
> - *Take a shower instead of a bath and avoid having to run the water until it's hot. Turn off shower water while you apply soap to body*
> - *Encourage and advise children not to mess around with water in the bath, garden or anywhere else.*
> - *Turn off water while you shave and/or brush teeth*
> - *Wash only full loads in the washing and dish washing machines.*
> - *Water the garden with a watering can early in the morning or in the evening when evaporation is limited.*

- *Wash the car with a sponge and a bucket, instead of a hosepipe, which is prohibited by Law.*
- *Use a broom, not a hose, to clean verandas and pavements. The use of a hosepipe is prohibited by Law*

Furthermore it offers subsidies for certain technical installations such as hot water recirculators or the installation of greywater treatment plants. Remarkably, the drilling of and connection to boreholes is also promoted, though this measure only reduces the amount of drinking water to be delivered by the water supplier, but not the overall water consumption of the household.

3.2.5.2 Tourism

During the 2008 drought the Cyprus Sustainable Tourism Initiative in collaboration with the Cyprus Tourism Organisation launched a water and energy saving pilot project with the aim to reduce the consumption of water and energy in the hotel industry. They report having achieved a 10% reduction in water consumption (CSTI, 2009). Detailed information of absolute figure of consumption and applied saving measures are not published.[10]

3.2.5.3 Water cuts

A drastic tool to reduce water consumption is the restriction of the water supply. Facing drought and extreme water shortage, the Water Development Department is urged to impose water cuts which forces Water Boards to interrupt supply periodically. Also water for agriculture is rationed below the agreed amounts. This was repeatedly the case in 2000 and also in 2008. Those measures impact heavily on all sectors, which have different capabilities to cope with reduced or irregular supply. Water users will exhibit a reactive adaptation to the repercussions related to the management options chosen by the water managers in the frame of their adaptive strategy.
Drastic cuts in irrigation water may be compensated for by abstraction from groundwater resources, if accessible, though this might be illegal.
For the domestic sector it has been shown that people can get along with less water however at the price of increased inconvenience. Water rationing has prompted behavioural changes so that domestic water users have changed the timing of their activity to fit them into hours of supply. This of course is a loss of independence and freedom (Kelay et al., 2009)
Put simply, water cuts proved that water consumption can be reduced if the pressure is sufficiently high. In 2008 the domestic supply declined to 62 Mm^3 compared to 74 Mm^3 in previous years (-15 %). In a more positive way, however, people should be motivated to use water rationally always. Instead of having when to use water dictated to them, they want to take informed decisions on smart water saving options – and be rewarded for water-wise behaviour. For that a rational, clear and sufficiently attractive incentive scheme of subsidies and water pricing is required.

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[10] Remark: In none of the 4 hotels in Limassol the author stayed in during 2008 was a towel-reuse programme established - common for hotels of comparable standard in Western Europe

3.2.6 *Economic instruments*

Economic instruments are applied to make politically preferable and environmentally beneficial actions and behaviour more attractive, compared to their alternatives. They are steering instruments to direct the decisions of consumers.

3.2.6.1 *Water price*

The price of water is the most visible signal for its valuation and an appropriate means to manage demand. At least the price should reflect the scarcity of the good and prevent from wasteful use. The established increasing block-tariff reflects this approach. Recent price increase in Paphos charges rates as high as 8 EUR/m^3 for excessive use. A summary of water prices is listed in Table 1Table 6.

Table 6: Water prices in Cyprus

		Prices EUR/m^3
Drinking Water		
Purchase of bulk water from WDD		0.77
	Consumption per quarter	
Limassol	from $1m^3$ - $40m^3$	0.23
(Water Board of Limassol website)[11]	from $41m^3$ - $80m^3$	0.41
	from $81m^3$ - $120m^3$	0.79
	from $121m^3$	4.55
Paphos		
	from 21 - 30 m^3	2
	from $30m^3$	8
Irrigation water		
From Government water works		
(WDD, 2008, personal communication)	Within quota	0.19
	Exceeding quota	0.57
Reclaimed water (WDD, 2008)	agricultural production - irrigation division	0.05
	agricultural production - private person	0.07
	sportsgrounds	0.15
	hotel greens & gardens	0.15
	golf courses	0.21
	pumping of reclaimed water from GWR	0.08

3.2.7 *Improving monitoring and forecast*

As most problems in the water supply are related to the scarcity of the resource, a close monitoring of the relevant meteorological parameters and the inflow to the dams has been established. Yet in urban areas the rainfall

[11] http://www.wbl.com.cy/english/index.php?article_id=9&subject=standalone&parent_id=7

stations should be more numerous to better follow especially heavy rainfall events (WDD-FAO, 2002). The observation of groundwater resources has been less well attended to in the past, which has led to excessive over-pumping of aquifers. Improved monitoring networks are required to collect sufficient and robust data to base an indicator system for the state of the resources on it.

Aiming for more water use efficiency requires the reduction of losses in water distribution works. The application of leak detection, real time tele-monitoring and tele-control to optimize operation and maintenance of networks is among the envisaged measures (Iacovides, 2008).

4 Evaluation and assessment of measures and adaptive strategy options

In its efforts to cope with water scarcity and recurring droughts Cyprus has implemented various water management adaptation measures that form a good basis for further improvements.

– **Dam capacities** have been maximised to store as much water as possible. This practice has reached physical limits as favourable sites are not available and even more because there will be ever decreasing precipitation and natural run-off to capture.
– **Interconnection** of reservoirs and conveyor systems allow distribution of water across the island and offer some flexibility in operation.
– **Metered supply** of domestic users is established. This allows users to observe their consumption and to follow up effects of water saving measures.
– **Network losses** in municipalities partly < 20%.
– **Micro-irrigation schemes** are wide-spread for agriculture uses.

As outlined in the previous chapter these crucial elements of the list of measures are being applied already, yet dramatic supply problems have occurred repeatedly. This raises the question of how the efforts should be enforced and which aspects have to be taken into account to achieve sustainable water resource management to assure safe water supply.

4.1 Improve the data basis

Essentially, you can only manage what you measure. It is hence crucial for any water planning (e.g. River Basin Management or Drought Management Plans)

– to provide key figures on status and objectives,
– to detail the measures to be implemented (type, expected impact) and
– to define budgets including a proposed distribution of cost (over users and over time).

In that respect the Cypriot case evidently has some shortcomings. The data situation is scanty and partly outdated. On the other hand it can be recognised that the implementation of the Water Framework Directive is bringing forward considerable efforts to improve the data availability. Remarkably there is no **annual report on water** summarising all relevant data on water availability, water use, water prices, wastewater treatment and reuse and so forth. This has been critically highlighted by local stakeholders on the 2008 Global Water Efficiency Conference in Limassol. Though the scene is set and the challenges for the water supply are properly acknowledged, they are not sufficiently described quantitatively.

The same applies for any planned measures addressing the challenge of water scarcity in Cyprus. The future strategy of a more diverse resource mix is clearly addressed but the exact contributions of each source for the different sectoral demands are pending. In an integrated approach there will always be the need to weigh different measures against each other and to assess the effects of various options with regard to a defined objective, which in turn requires a sort of quantification.
Instead, there is a lack of comprehensive, clearly visible and concise information. Measures to be implemented remain vague, with no numbers given for water saving objectives, targets for resources development, no budget and no timeline. This has also been admitted by Iocovides (2008) stating the there 'is no explicit National Strategy for improving water use efficiency (sectoral and total) and there are no deadlines for achieving improved efficiency'.

This makes success control almost impossible and gives a signal of weak commitment only. Aiming for cost-effectiveness it is important to assess the effect of the investment by determining e.g. the water saving realised for each euro spent (cf. greywater subsidising scheme 3.2.3). With sufficient knowledge about various options, they can be grouped along priority parameters such as cost, energy demand, ease of implementation etc … and then be prioritised for implementation.

4.2 Drought planning vs crisis management

Cyprus has a drought management plan in operation but in its current form and application it is rather a tool for trouble shooting. These shortcomings have been critically addressed by Tsiouris (2005) and the European Commission (2008), who found that decision makers have reacted to drought episodes mainly through a crisis-management approach by declaring a national or regional drought emergency programme to **alleviate drought impacts**, rather than on developing comprehensive, long-term drought preparedness policies and plans of actions that may significantly reduce the risks and vulnerabilities to extreme weather events. Such a strategic approach deploys different levels of intervention and action which assure flexibility, instead of starting intervention once the crisis is there, unavoidable or inescapable.
Various concepts have been developed for drought management planning that can be transferred or extended to water management in general. Figure 15 illustrates the systematic approach developed in Spain (Estrela and Vargas, 2008). The main elements are

- an early warning system based on hydrological indicators
- a correlation of indicators with thresholds for different drought stages to trigger action
- a set of phase-specific measures to achieve objectives (programme of measures PoM)

Types of management / mitigation measures				
Indicator value				
States	Normal	Pre-alert	Alert	Emergency
Objective	Planning	Information-control	Conservation	Restriction,
Type of measure	Strategic, preventive		Tactics	Emergency
	– sustainable water management policy – prioritised water resources management – public awareness and continuous education – demand management, including water efficiency measures – develop hydraulic infrastructure and strategic reserves (protected groundwater resources		– groundwater recharge, grey-water reuse in hotels – use restrictions changes in water allocation matrix	– water cuts – water imports – mobile desalination units – compensation for those affected

Figure 15 Elements of drought or water management planning as suggested in Spanish Drought Management Plans (Estrela and Vargas, 2008), complemented by a number of measures

4.3 Need to take the lead

The spread and impacts of water shortages are extensively represented and discussed in newspaper articles and other media. The contributions are often a mere expression of critical attitudes and discontent with the current water management and often convey a call for change. Public opposition usually blames the water management organisation for the lack of integration in approaching water scarcity and water security issues, which is often attributed to the lack of a unified, single water entity.

This need for organisational changes had been acknowledged by politicians years ago when calling for a new Directorate for Integrated Water Management, which was proposed to '*manage the island's water resources within the framework of the national water policy in a holistic way. The Directory will deal with the provision of water for domestic purposes and agriculture, will control water extraction from surface and underground water systems, will supervise the safety of dams and reservoirs through the formulation of an appropriate legal framework, and will promote the conservation and management of water-related ecosystems. An advisory committee will be set up, comprised of key stakeholders in the water management sector, who will have an active role in the formulation and implementation of water related policies. The Directory for Integrated Water Management will be based on the existing Water Development Department within the Ministry of Agriculture, Natural Resources and Environment.*' (WDD, 2004)

This entity could also communicate in a comprehensive and illustrative manner on planned and ongoing water management measures.

Even more importantly, leadership has to become visible through appropriate policy measures and programmes. Envisaging a saving or efficiency aim for water use has to be combined with the definition of relevant standards. This could include enforcing fixed standards for water appliances or even go beyond this to develop a building performance standard that new buildings must not exceed a certain anticipated consumption per capita. In the United Kingdom this approach aims to reduce the per capita demand from 150 L/day to 125 L/day for new developments in the water scarce south-east of the country. There the government aspires to water neutrality in the Thames Gateway development, i.e. that water for new customers will be freed from savings by existing customers (Dunn, 2008).

4.4 Integration of measures

The success of measures will be influenced by the choice of the right implementation strategy featuring the appropriate policy measures and incentives. Success includes the effectiveness of the measure, its acceptance by users and society, as well as the technical and economic feasibility of the action. Obviously, some actions may necessitate new organisational structures for implementation and follow-up as well as legal frameworks to be effective.

4.4.1 Desalination and sustainability

Desalination is a prominent example for the necessity to reconcile and integrate adaptive measures on various levels and across various sector-based policies. In this case, additional energy requirements at the local scale are possibly in conflict with supranational agreements on CO_2 emission reductions. This would require an additional effort to overcome these contradictions in thinking even beyond, for example, to encourage the search for technologies based on renewable energy sources. Additionally, people may be concerned about the link between the rush for more desalination plants and even more unsustainable development. This may refer to town planning as well as to hotly debated golf course projects

Basing public water supply on energy intensive desalination technology clearly requires and justifies strict water demand management to bring down the per capita consumption to lower levels than current 215 L/capita/day (WDD-FAO, 2002, Chapter 1.5.1). Even if only considering the projected permanent plants, the envisaged production capacity of around 70 Mm^3/yr would be sufficient to serve a population of 921,000 in the year 2030 (cf. section 2.2) with a specific water demand of 208 L/cap/d.

The risk of unsustainable growth of water consuming activities is an intrinsic problem when tapping additional resources and augmenting water supply which has to be controlled by complementary water demand measures.

4.4.2 *Water reuse and water demand*

Water reuse is another example for the importance of integration of measures, as any demand measure will impact on the domestic water consumption and hence the available amount of wastewater. Secondly, the capacity of the sewerage network and the degree of connection will determine the amount of wastewater collected. During the 2008 water cuts in Limassol, the average daily inflow to the Limassol-Amathus wastewater treatment plant dropped from 17,000 m^3 to 13,000 m^3. Additionally, the degree of grey-water reuse will further influence the reliably available amount of reusable wastewater in centralised plants. The location of newly built wastewater treatment plants has to consider the envisaged use of reclaimed effluent and seek for optimised supply of potential users in order to keep transportation cost and piping network dimensions low.

4.4.3 *Water reuse and public acceptance*

Reclaimed water not used for irrigation in the winter period, is discharged to the sea. Depending on the climatic conditions these amounts sum up to 2-3 Mm^3/year. Aquifer recharge offers an opportunity to store this water and make it available in times of increased demand. The WDD had planned accordingly and even constructed the pipes and recharge basins, but has never gained the required agreement of the municipality on which grounds this scheme was to be implemented.

Despite its potential benefits, there is persistent stakeholder opposition to groundwater recharge due to water quality concerns related to the risk of drinking water resources pollution. In this specific case, no societal consensus on the urgency of the water scarcity issue and the need to compromise could be achieved. There was a surprisingly and most probably unjustified optimistic belief in 'a few good years of rainfall' in near future, which would make such actions unnecessary. This is a striking neglect of scientific views on development of water resources in the climate change context as well as of the state-of-the-art in groundwater recharge with reclaimed water.

Additional pitfalls were intrinsic to the system: The organisation of the water sector and the distribution of decision competences have also contributed to the development of such a 'locked-in' situation. A late involvement of stakeholders in plans for aquifer recharge combined with previous bad experiences eroded the confidence in the Water Development Department to be able to properly operate such a scheme. Belief in the competence and credibility of the acting institutions are obviously missing, which weighs even more as it has been characterised as paramount success factor when implementing reuse schemes (Hartley, 2006; Nancarrow et al., 2007). This was underpinned by work performed in WP6 of the TECHNEAU project, which showed, that there is a perceived low competence of authorities among consumers.

Quality of reclaimed water has always been an issue, but to date, the problem of micro-pollutants has not been considered yet. Though reclaimed water has to be analysed for bulk parameters and selected metals, no organic micro-pollutants are being monitored thus far.

In developing a diversified water reuse practice and making it an important contribution to the water balance, this issue should be anticipated.
Regions with comparably severe water scarcity problems have already considered or implemented even indirect potable reuse by augmenting drinking water sources.

4.5 Centralised versus decentralised concepts

4.5.1 Alternative sanitation concepts.

Most of the rural population and many newly built settlements are not connected to a sewerage system. They use septic tanks, which often leak into the ground and pose the risk of pollution to groundwater resources. This problem could be tackled by semi-decentralized water and wastewater management concepts which integrate wastewater treatment, water reuse, recovery of nutrients and energy. The advantages of decentralized concepts over centralised systems are foremost related to savings in construction costs. They allow for reducing the sewer pipe diameter and their installation depths as well as central sewage plants and sewage storage reservoirs. Nevertheless, those concepts will have to be fitted into the overall town planning.

4.6 Learning from good examples in other regions

Cyprus is not the only dry spot on earth. California and Australia are suffering from similar limited water availability but also in Europe, Spain, Greece and Italy are drought-hit. These regions may share valuable experiences in drawing up and performing adaptive strategies - and even expertise in how to approach and overcome specific obstacles for implementation. It will yield beneficial effects to utilise available knowledge and experience, as well as to dare to contribute to the generation of new knowledge and own experiences.

4.6.1 Catalan Water Management Plan

The region of Catalonia in Spain has been in a comparably bad situation as Cyprus with dramatic water shortage and water being shipped to Barcelona in May 2008. The Catalan Water Agency's planning pursues an integrated approach to assure sufficient water supply to both customers and the environment. Water reuse, desalination and aquifer restoration are key activities to produce additional water. Both investments are aimed at assuring sufficient water supply for future years (2015 and 2013 respectively), yet a water augmentation objective is only defined for Catalonia (300 Mm^3) whilst lacking for Cyprus.

Table 7 gives a rough overview of the planned investment in Catalonia and in Cyprus.

Table 7 Comparison of foreseen water management investment in Cyprus and Catalonia, Spain (WDD, 2008a; Gencat[12]; Borras, 2008)

Population	Type of measures or programme	Total cost / invest	specific expenditure		additional water supply
million]		[million €]	[€/per capita]	[€/per capita/yr	Mm³/yr]
Catalonia	period:	2007-2015			
	Urban wastewater treatment programme	3,226	454,37		
7.1	Reuse programme	319	44,93		75
	Environmental recovery	750	105,63		25
	Water supply (desalination, networks etc)	2,091	294,51		200
	Total	**6,386**	**899,44**	**100**	**300**
Cyprus	period:	2007 – 2013			
	short-term and emergency measures	447	566.32		
0.7893	medium term measures	624	790.57		
	sub total	1,071	1,356.90		
	Implementation of UWWTD	438	554.92		
	Total	**1,509**	**1,911.82**	**467**	

4.6.2 *Zaragoza (Spain)– a best practice example for water demand management*

The project was realised with by the EU Life Programme from 1997-2003. It realised remarkable saving through changes in people's habits and new technologies.

The project focused on domestic uses and aimed to achieve a saving of 1 Mm3 Introducing 50 efficiency water use best practices in the city the per capita consumption dropped to 96 litres per day, the lowest in Spain[13]. The project was particularly successful as it managed to simultaneously promote the demand for water saving technology among consumers, while stimulating the market of these products and train and inform professionals from the water field.

4.6.3 *The Western Corridor Recycled Water Project (Queensland, Australia)*

The Western Corridor Recycled Water Project is an example of particularly fast and timely implementation of a water reclamation scheme to integrate

[12] http://www.gencat.cat/hidro/eng/inversions.html

[13] Website of the European Commission – Spanish Case Study on Urban Water Savings http://ec.europa.eu/environment/water/quantity/pdf/2007_01_09_forum_meeting/spain_case_study_urban_water_savings.pdf

alternative water resources into the water cycle. Several advanced water treatment plants upgrade municipal effluent and distribute it as cooling water to power stations. Most of the remaining water is intended to be used to recharge Brisbane's main drinking water reservoir. This indirect potable reuse aspect is expected to be initiated once the storage levels drop below 40% of capacity.

Here, the storage level triggers the resource augmentation by alternative water resources in order to allow for continuous water use and drinking water supply. Such a practical application of flexibility in managing the water resources mix could be an example for other regions.

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