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Measures for facing Water Scarcity and Drought in Malta

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Abstract: The Maltese Islands are densely populated but poorly endowed with freshwater resources. Since the 1980's, the drinking water supply has been heavily dependent on saltwater desalination. The population and the tourist sector are served with good quality drinking-water, but certain trends such as the depletion of groundwater in terms of both quantity and quality and a growing dependence on oil imports for water desalination give rise to concern. The management of water resources in Malta must be viewed in the perspective of a scenario where demand vastly exceeds the sustainably achievable supply from naturally renewable resources. Moreover, this situation is further compounded by the current climatic trends observed in the Mediterranean region which tend towards a reduction of the potential yield of the island's renewable water resources. This paper presents the 'water' situation on the island and explores possible pathways which could be taken to ensure a sustainable water supply which is essential for a continued social, economic and environmental development.

Key words: Water Demand Management, Water Framework Directive, Programme of Measures, Supply Augmentation.

1. BACKGROUND

Historically, Malta has had a lack of natural resources in relation to demand, and water resources have always been considered of strategic importance. Archeological evidence of structures for the harvesting and storing of water goes back to the Neolithic Period, with the discovery of a number of rock-cut cisterns in the immediate vicinity of the Megalithic Temples of 'Hagar-Qim' and 'Mnajdra' (Zammit, 1931).

The first reported 'hydrological' survey of the islands dates back to 1512, when a fact-finding mission of the Knights of St John reported that "*The water is salty and putrid but there are good springs which are probably due to rain fallen in winter time. The origin of these springs is not very deep, they often disappear in summer but they always diminish in volume. One generally drinks rainwater collected in tanks and ditches*".

Figure 1: Illustration showing rock-hewn cisterns under the new capital city of Valletta (Spiteri,2007)

The Knights of St John also introduced the first legislation requiring the construction of rainwater harvesting cisterns with every new urban development (Figure 1). In particular, heavy fines were set for buildings within the fortified cities which lacked adequate water harvesting facilities. This was to ensure the sustainability of these cities in case of prolonged siege. Regular surveys of the storage capacity and upkeep of these cisterns were carried out by special commissions, with reports being submitted to the Gran Council of the Order (Spiteri, 2007).

Living with water scarcity has inevitably left an indelible mark on the lifestyle of the island, where even today one can find a relatively low per capita water demand (140l/cap/day) when compared to that registered in other European countries. However, it must also be noted that current trends show an increasing demand, mainly as a result of the ever increasing standard of living commanding an increased water use for recreational activities (Micallef et al., 2000).

2. CLIMATOLOGICAL ASPECTS

The climate of the Maltese Islands is typically semi-arid Mediterranean, characterized by hot, dry summers and mild, wet winters. During the summer season, the islands are dominated by high pressure conditions. The mean annual rainfall was about 550mm for the period 1900-2000, but with high seasonal and interannual variability (variation coefficient: 27%), with some years being excessively wet and other years being extremely dry. The highest precipitation rates generally occur between October and February. Rainfall is characterized by storms of high intensity but relatively short duration.

The potential evapotranspiration calculated by the Penmann formula using 1947-1989 climatological data for the Maltese Islands is 1,390mm (albedo=0.2) with an interannual variability of 3%. Based on models developed by the Bureau de Rechereche Geologique et Miniere (BRGM, 1991) preliminary estimates of actual evapotranspiration rates have been calculated on the basis of daily rainfall values recorded at the Luqa Meteorological Office (1948-1998). These estimates show that in this period the actual annual evapotranspiration varied between 197 and 402mm, or 36-89% of the measured annual rainfall. Runoff coefficients are low, characteristic of the carbonate environment of the outcropping geological formations. In fact, runoff from rural areas is estimated to be in the region of 1-3% of the total rainfall. High runoff coefficients are only registered in the urban areas, where runoff can reach as much as 80% of the total rainfall (NSO, 2002, 2006).

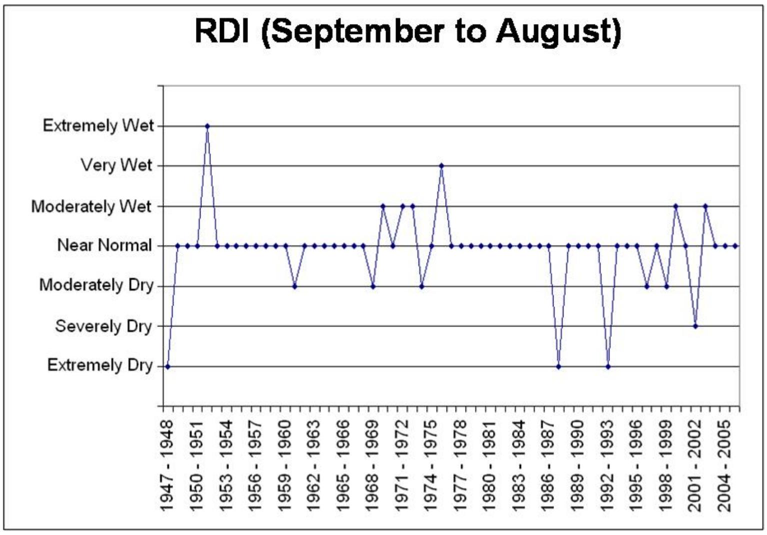

Figure 2: Classification of Hydrological Years as per RDI categories

Recent studies with the aim of classifying the local hydrological data according to an established index, called the 'Reconnaissance Drought Index' which takes into consideration both the rainfall depth as well as the evapotranspiration losses when classifying drought conditions, has shown a trend towards an increase in the number of dry years and therefore towards less water availability (Figure 2). The ensuing scenario of reduced water availability is expected to have two main effects:

i. an increased water demand in response to a reduced natural water availability, particularly by those sectors which are heavily dependent on the natural water supply; and
ii. reduced recharge to groundwater arising from the decreased availability of superficial waters.

Both these two effects will therefore result in an increase on the pressure on groundwater, which is the only naturally renewable water resource of the islands.

3. WATER AVAILABILITY

The geology and topography of the islands do not permit the development of any economically exploitable surface waters. In fact, the only time when surface water flows (for a few days at most) along the beds of the major valleys is after heavy torrential rains. Perennial surface waters are only limited to a small number of streams, with an extremely low flow; whose importance is limited to the sustainment of endemic eco-systems.

The potentially exploitable rainwater runoff on the islands amounts to around 24 million m^3; however occurring over an extremely short period of time. To retain this storm discharge, a number of small dams have been constructed across the major drainage lines in the valleys. The storage capacity of these dams is however quite small, primarily constrained by the relatively small dimensions of the valleys. The estimated storage capacity is around 250,000m^3, and the stored water is primarily used by the agricultural sector for irrigation (MRA, 2004).

These storage facilities are supplemented by a large number of small cisterns and tanks which have been constructed by the individual users both in fields and also in houses, in particular those located in rural areas. The estimated storage capacity of these facilities is around 2 million m^3.

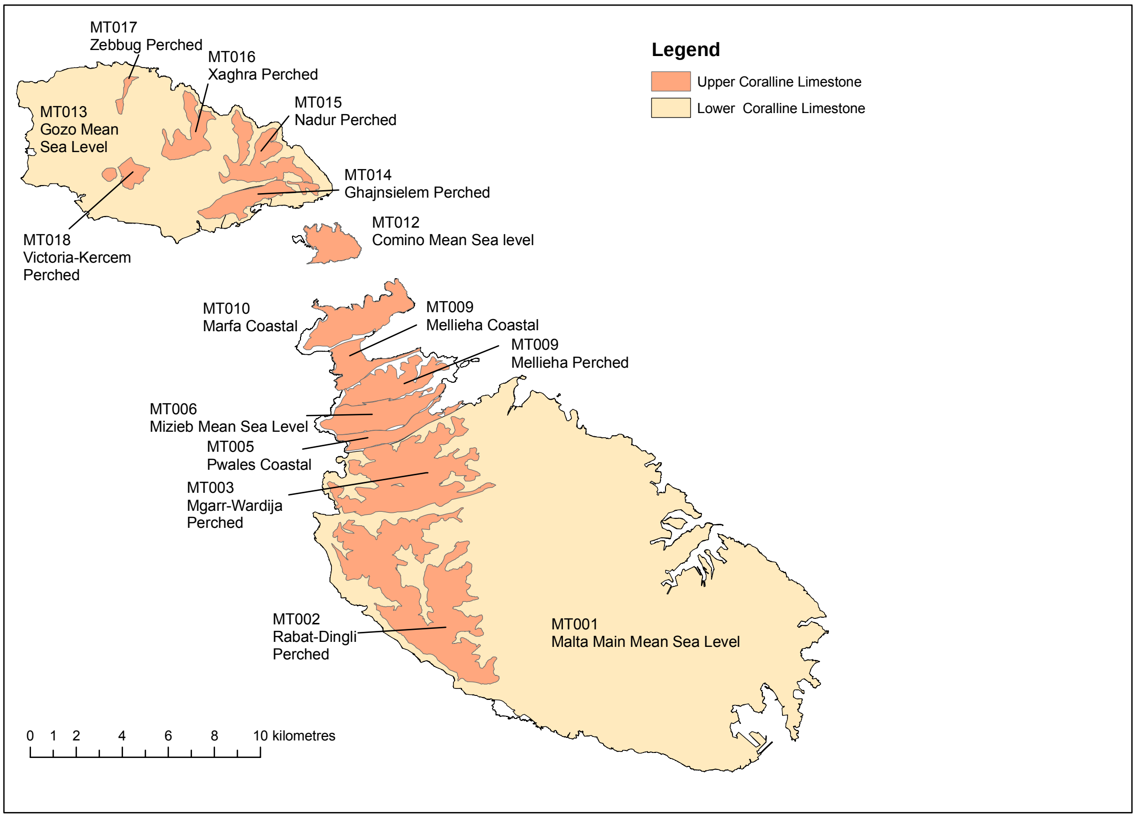

Figure 3: Natural groundwater resources in the Maltese Islands: Perched(Upper Coralline) and sea-level (Lower Coralline) aquifer systems

The main renewable natural water resources of the island (Figure 3) are therefore its aquifer systems, sustained in the Upper and Lower Corallaine Limestone formations. The geological structure of the islands permits the development of two aquifer types:

i. perched aquifers, sustained in the Upper Coralline Limestone by the underlying impermeable Blue Clay formation; and
ii. sea level aquifers, fresh-water lenses floating on the denser sea-water sustained in the Lower Coralline Limestone formation.

The perched aquifers have a relatively low abstraction potential, mainly constrained by their small size and low storage capacities. On the other hand, the sea-level aquifers have a relatively high abstraction and storage potential and are the main renewable resource of the island. Their high storage capability also enables these aquifer systems to act as a buffer between dry and wet years since the water taken from storage in a low recharge year can be effectively replaced by the unabstracted volume during a wet year.

4. STATUS

The high population density of the island is inevitably reflected by a high overall water demand, and along the years economic development and an increased standard of living have exacerbated this problem. In fact, since the 1960's potable water supply in Malta has been supplemented to a varying degree by desalinated water, first by the introduction of Multi-Stage Flash Distillators and subsequently by Reverse Osmosis Desalination. Today, desalinated water accounts for around 50% of the municipal water supply, and its use is essential for the attainment of the potability standards of the EU Drinking Water Directive. This is due to the degrading quality of the sea level aquifer system as a result of years of over-abstraction.

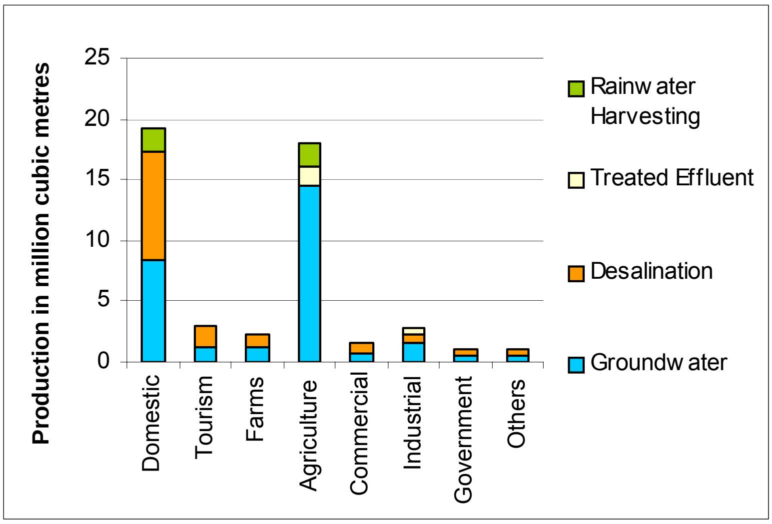

Figure 4: Breakdown of the water demand of the main economic sectors

Water balance calculations estimate the island-wide sustainably abstractable groundwater resources at around 25 million m^3; whilst on the other hand water demand models set the current rate of abstraction at around 33 million m^3. These estimates (Figure 4) identify the domestic and the agricultural sectors as having the highest relative demands for water, with the agricultural sector being more dependent on groundwater, most of which is abstracted through a number of private sources located at the point of use (FAO, 2006). Whilst, having the advantage of reducing distribution losses and the resulting added pressures on the aquifers; this system due to the large number of distributed users presents a significant regulatory challenge. It should also be noted that the 'economic' sectors (industry, tourism, commercial concerns) have a relatively limited water demand.

An assessment of the risk of not achieving good quantitative status carried out by the Malta Resources Authority (Figure 5) as part of the implementation process of the Water Framework Directive in 2005; confirmed the available evidence that the major groundwater bodies of the island are being overabstracted and thus at risk of not achieving the Directive's quantitative environmental objectives, which require abstraction to be lower than the mean annual recharge (MRA, 2005).

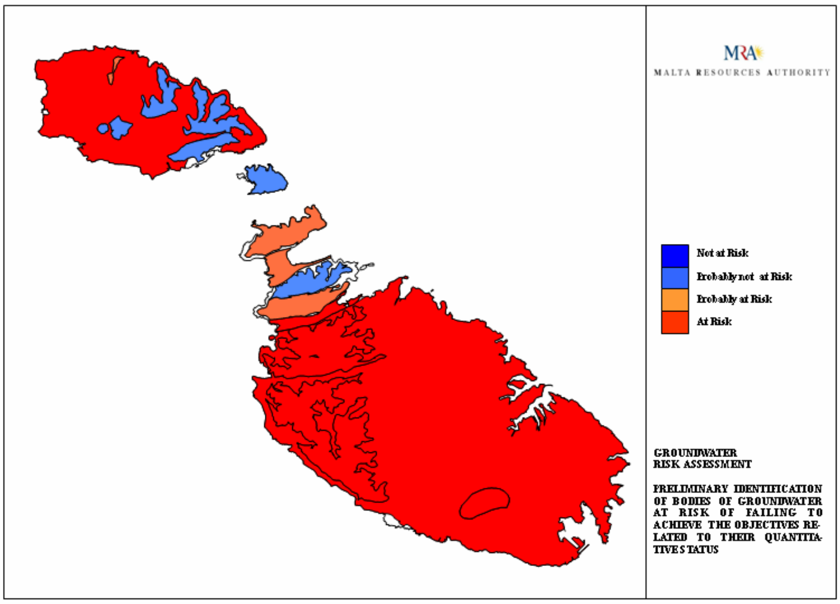

Figure 5: Results of the risk assessment carried out as part of the implementation process of the Water Framework Directive. The illustration shows the risk of achieving 'Good Groundwater Quantitative Status'.

5. RESPONSE

Definitely this situation calls for a reduction in groundwater abstraction; in order to sustain the wholesomeness of this renewable water supply into the foreseeable future. However, this reduction in abstraction must be accompanied with a targeted action plan with the aim of balancing water supply and demand in order to ensure the continued economic development of the country. The approach towards solving the 'water problem' of the island must therefore consider both supply augmentation and demand management measures; with due importance being given to the newly developing scenarios as a result of the changing climate.

Looking to the island's 'water history' one can identify several instances where new water sources were harnessed to address scarcity. The most recent example is the introduction of desalination technology to supplement groundwater abstraction; but even the development of deep abstraction wells to tap the sea level aquifers in the 19^{th} century was driven by the need to supplement the freshwater supply from the perched aquifers following years of drought. However, today, further alternatives need to be investigated.

Compliance with the Urban Waste Water Directive has seen the development of three new wastewater treatment plants with a combined treatment capacity of around 14million m^3 each year. This development invariably presents a new potential source of water supply, which is available in consistent quantities even during the dry season. However its utilisation is constrained by qualitative issues arising from the high salinity of sewage in Malta - arising from discharges and infiltrations of saline waters into the sewerage network; as well as by distribution aspects since the treatment plants are located at the point of discharge. Also, the further harnessing of rainwater runoff with the construction of new storage facilities both at a local and regional level is another possibility which cannot be overlooked; given the relatively large unharnessed potential of this resource. However the high costs required for the construction of the large infrastructural facilities needed for the storage of runoff to enable its availability during the dry season is definitely a major constraint.

However, supply augmentation measures alone will definitely not solve the island's water problem. The introduction of parallel water demand management measures aimed at increasing the efficiency of water use is important in order to contain the ever increasing demand. The possibilities for demand management measures can vary from measures which target the water production, distribution and use infrastructure to fiscal measures which target the waste of water.

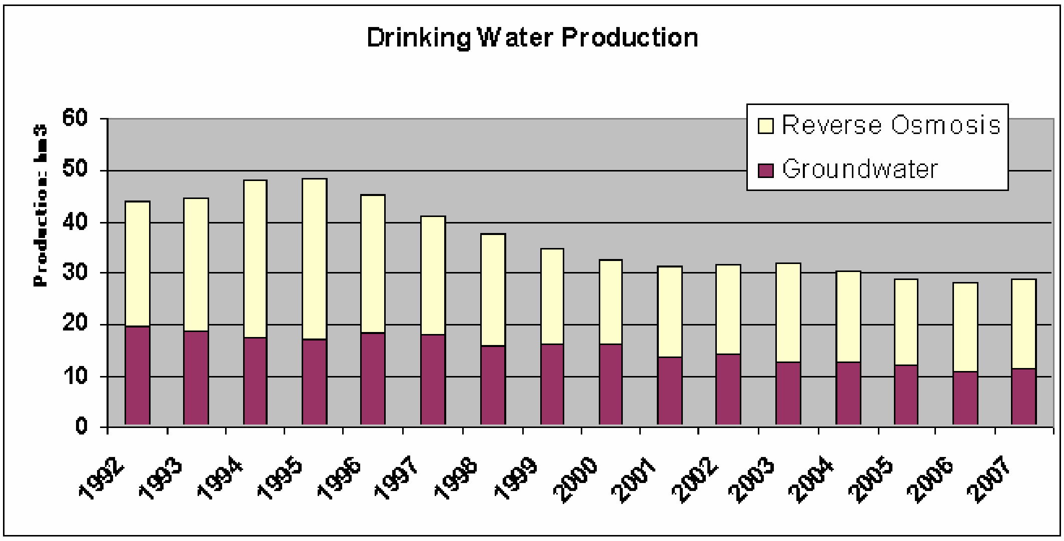

Figure 6: Production of waterin Malta for Municipal Use.

On a national scale, significant progress has been achieved in the control of water losses in municipal distribution system, and today leakage control plays a vital role in the operations of the water utility (Water Services Corporation), particularly as these represent a substantial loss of revenue in real terms. The leakage control programme introduced by the utility in the mid-1990's (comprising active leakage localization, leakage repair, pressure control and network infrastructure management) is considered to be a major contributor towards a reduced national system demand (Rizzo, 2000). It has been estimated that leakages have been reduced over the whole distribution system from 2,692m^3/hr in 1995 to about 650m^3/hr in 2007. The unavoidable annual loss of the distribution system is estimated to be 300m^3/hr, and the WSC plans to reach this target by 2010 (WSC, 1997-2007).

However, to be effective water demand management programmes should not only be tackled on the national and/or regional scale; but also should go down to the user-level. Malta is currently in the process of preparing its first River Basin Management Plan under the implementation process of the EU Water Framework Directive. Under this process a number of significant water management issues have been identified and a programme of measures is being developed to address these issues; with the final aim being the achievement of the Environmental Objectives of the Directive. Definitely, achieving sustainable groundwater utilisation levels is one of the most important water management issues for Malta; and therefore 'quantitative' measures are being considered for all the water using sectors (domestic, agriculture and economic) with the aim of increasing the efficiency of water use in each sector (MRA, 2001-2007).

In fact, the analysis undertaken for the identification of potential measures for the domestic sector indicated that there is still scope for further reducing the water demand, through a series of measures aimed at the local household. The main identified actions relate to:

i. increasing the efficiency of water use in the home through the installation of water efficient devices (such as aerators, plastic replacement volumes for flushings, …..) and appliances (double button flushings, adjustable shower roses …..)

ii. increasing the storage and production of water from other sources through incentives aimed at encouraging the construction of rainwater harvesting cisterns and the introduction of grey water recycling facilities in households.

On the other hand, the analysis carried out for the agricultural sector indicated that whilst there is still scope for increasing water-use efficiency in irrigation, given the high percentage of land already under improved irrigation techniques the margin for improvement is quite low (MRRA, 2004). Efforts however should be made to ensure that the best use is being made of these new techniques; and that the expected reduction in water demand is being achieved. This is mainly possible through the provision of technical help to farmers at the field level.

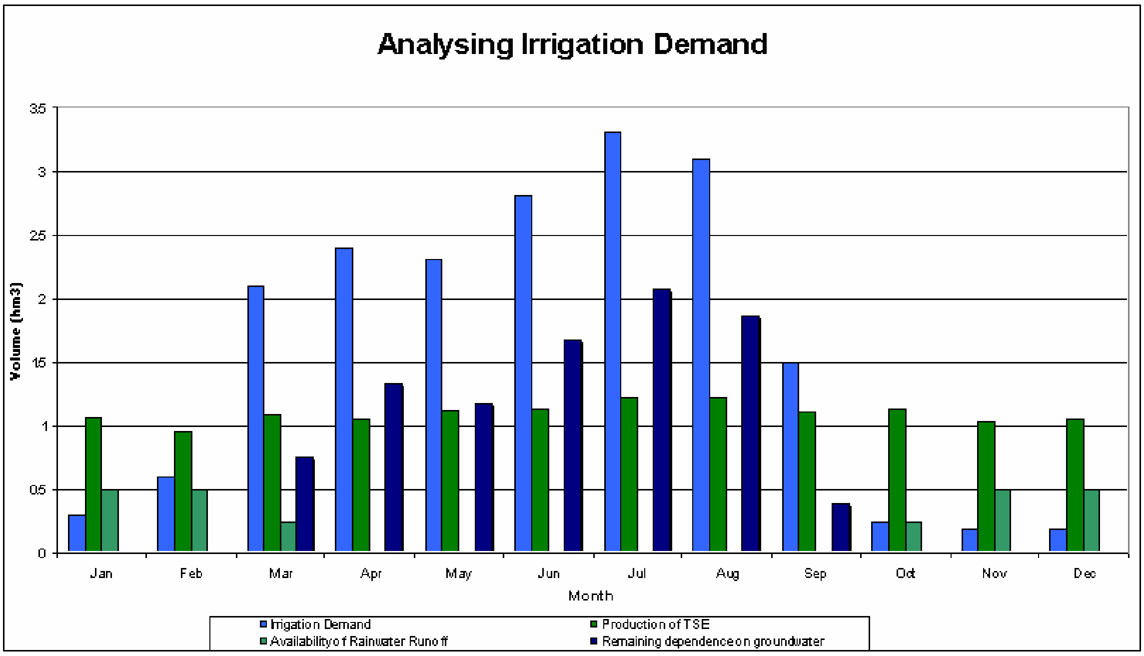

Figure 7:The monthly irrigation demand compared with the availability of alternative water resources (rainwater runoff and treated sewage effluent (TSE)) so as to highlight the potential residual dependence of the agricultural sector on groundwater.

On the other hand, the same analysis (Figure 7) indicated that the major benefits in the agricultural sector could be obtained through shifting part of the demand from groundwater to other sources - mainly through the increased collection of rainwater harvesting in on-field reservoirs and the increased use of recycled water from the municipal wastewater treatment plants. If issues related to the quality and the distribution of the effluent can be solved, the current studies indicated that it offers the potential to provide around 7million m^3 of water per year, for irrigation.

Further to this, the alignment of national agricultural and water policies is highly recommended; such that these two policies will have the common aim of managing the sector's water demand; whilst ensuring the financial feasibility of the sector. Moreover, research by the agricultural sector aimed at testing the effects on yield of new irrigation techniques such as 'deficit irrigation' should be encouraged with the aim of eventually introducing these techniques as a further tool in the management of the sector's water demand.

The main measures being considered for implementation in the commercial and industrial sectors relate to incentives aimed at facilitating the introduction of water recycling facilities in these concerns. Given the relatively small size of industrial concerns in Malta, possibilities for the construction of decentralised treatment plants in the main industrial areas should also be considered. However, where locally introduced water recycling has made a significant impact on the industrial concern's water demand with reductions in demand of the order of 70% being registered in specific cases.

6. CONCLUSIONS

Throughout its history, Malta has always had to tackle problems related to water supply and demand management. The applied solutions have however tended to be more problem specific, aiming to solve a particular problem through the implementation of a particular action. The adoption of the Water Framework Directive presents a more holistic vision towards the solution of these problems. In fact, the Environmental Objectives of the Directive aim at improving both the quantitative and the qualitative status of water bodies, with due importance also being given to the various water uses and natural ecosystems which depend on these waters. Good status must therefore be achieved through the implementation of a number of measures located within a more holistic ‘River Basin Management Plan’. A comprehensive ‘Programme of Measures’ is currently being developed for the Maltese River Basin District, which programme will be made operational by 2012 with the aim of achieving good status in all water bodies by 2015.

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