Assessing the impact of different water policy options on agriculture

Sapiano M.

in

Karam F. (ed.), Karaa K. (ed.), Lamaddalena N. (ed.), Bogliotti C. (ed.).
Harmonization and integration of water saving options. Convention and promotion of water saving policies and guidelines

Bari : CIHEAM / EU DG Research
Options Méditerranéennes : Série B. Etudes et Recherches; n. 59

2007
pages 149-160

ASSESSING THE IMPACT OF DIFFERENT WATER POLICY OPTIONS ON AGRICULTURE

M. Sapiano
Directorate for Water Resources Regulation, Malta Resources Authority, Millenia, Aldo Moro Road, Marsa – Malta, E-mail; manuel.sapiano@mra.org.mt

INTRODUCTION

A 'Review of Water Resources' for the Maltese Islands was carried out by the Malta Resources Authority (MRA) with the collaboration of the Food and Agriculture Organization of the United Nations (FAO) during 2002/03. This study, amongst others, included a holistic assessment of the sectorial water demand in the islands which, in contrast to previous demand estimates, took into consideration both public and private water production sources. The results obtained showed that the arable agricultural sector, annually consumed an estimated 32% (app. 18 million m^3) of the total water produced (collected, abstracted and/or treated) in the Maltese islands. These results thus placed arable agriculture, together with the domestic sector (at 33%) as the two highest water consumers in Malta.

Agricultural water use for irrigation was also identified as the sector with the largest share of groundwater utilisation. In fact, use of groundwater accounted for around 81% of the sector's total water demand. The estimated utilisation of other water resources such as harvested rainwater and treated sewage effluent for irrigation was rather limited.

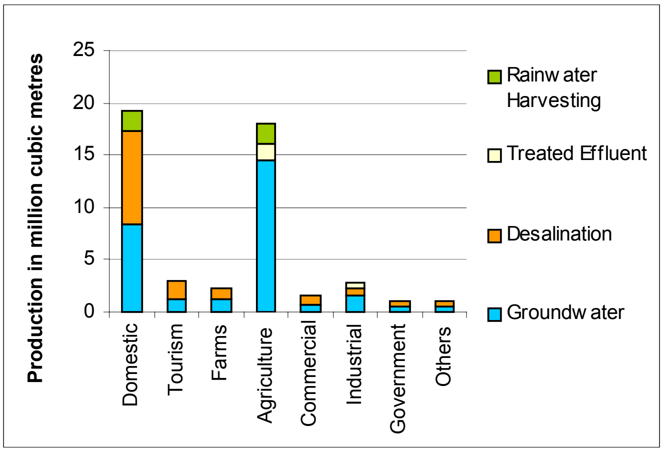

Fig. 1 Water consumption by sector (2003)

These water demand estimates were based on deficit irrigation requirements; that is the water required by the crops in excess to that supplied by the average annual rainfall. Should, however one consider the utilization of direct rain-water by agriculture, then, the sector would by far have the largest water demand in the islands; estimated in excess of 45 million m^3 annually; and thus solely almost accounting for Malta's estimated total current water demand.

A secure supply of good quality water for agriculture is therefore recognized as an essential area for this sector's development. This implies that agriculture must continue to use available water to best effect and aim to cost-effectively develop other non-conventional sources of water in order to diversify from its existing dependence on groundwater.

Malta's Article 5 Report, prepared as part of the implementation process of the EU Water Framework Directive (WFD), identified a number of major groundwater bodies as being under threat of failing to achieve the Environmental Objectives of the Directive. One of the major reasons for this classification is the over-abstraction of groundwater. Notably, all the major groundwater bodies on the islands are at risk of not attaining good 'groundwater quantitative status'[11], since currently estimated abstraction from these groundwater bodies closely approaches or exceeds their mean an nual recharge. These are the same roundwater bodies which by far, till today, have sustained Malta's agriculture.

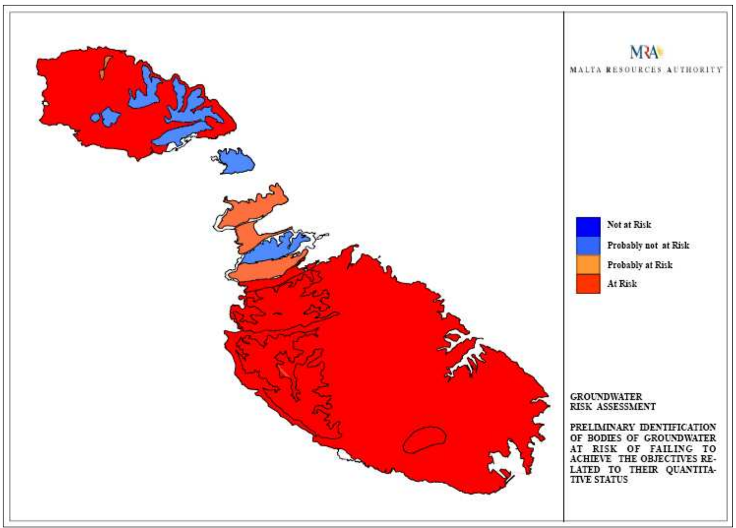

Fig. 2. Preliminary identification of groundwater bodies at risk of failing to achieve 'good groundwater quantitative status'.

The current groundwater demand situation is therefore not sustainable in the long-term and thus policies to address this issue and restore groundwater status are warranted. Being a major user of the water resource, any proposed policy and subsequent implementation measures will inevitably have an impact on the agricultural sector. It is clear that the sector should thus aim for increased productivity and efficiency through the utilisation of smart cropping and irrigation techniques in order to enhance its sustainability. In simple terms, agricultural research should aim to "*obtain more from less water*".

Long term policies also need to consider and address the expected effects of climate change; where in the Mediterranean region annual rainfall is anticipated to fall by 10 to 40% by 2100 and changes in the rainfall pattern are predicted to lead to a shorter rainy season with shorter but higher intensity storms. The expected consequences of these changes will be a greater generation of runoff in lieu of groundwater recharge. These changes will be expected to have a profound impact on the agricultural sector which is particularly heavily dependent on direct rainwater irrigation during the wet season.

WATER USE FOR IRRIGATION

The major constraints facing agricultural activity in Malta are the opportunity costs of land, the scarcity of water resources and the high labour costs. Official Statistics, however, have shown a constant increasing trend in agricultural productivity over the last years, which has also been reflected in an increase in irrigated land. In fact official figures from the Agricultural Census of 2001, show that declared irrigated land[12] has increased from 816ha in 1955 to 1508ha in 2000. The major driver behind this increase in irrigated land area was revenue increase backed by increased water

[11] Good 'Groundwater Quantitative Status' is introduced in Article 4.1(b)(ii) of the WFD which states that "*Member States shall protect, enhance and restore all bodies of groundwater, ensure a balance between abstraction and recharge of groundwater, with the aim of achieving good groundwater status at the latest 15 years after the date of entry into force of this Directive*….."

[12] Irrigated Land is defined by the National Statistics Office as "*land which has a continuous supply of water all year round irrespective of whether it has a natural spring, is served by second class water or water supplied by other sources*".

availability through declining costs of borehole construction and improvements in irrigation technology.

Further impacts on agricultural land use were expected, and in fact in part happened, as a result of land-based subsidies on agricultural investment from the EU, which subsidies became available in 2003. The outcome of the negotiations preceding Malta's accession to the EU can be considered as a viable starting point for projecting these possible changes in the agricultural sector. The main points of interest from these negotiations are:

i. the base area applicable to Malta for arable crops was set at 4565ha;

ii. Malta was granted new planting rights for the production of quality wine up to a total planted area of 1000ha;

iii. the national guaranteed quantity of olive oil for Malta was set provisionally at 150 tonnes which requires between 50 and 75ha of olive plantations; and

iv. an area of 1800ha was indicated for the cultivation of potatoes.

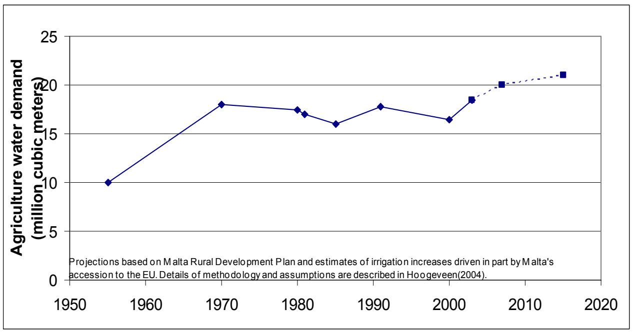

Fig. 3: Projections on Agricultural water demand.

Assuming that the utilized agricultural land area remains constant, attaining these thresholds would result in the net irrigated land increasing to about 2,250ha. Consequently, an increase in the demand for irrigated water in response to these changes in land utilisation and cropping patterns is expected. These indicators clearly show that currently the sector is going through what can be called a 'boom' period.

The major concern for the sector is that if the water supply scenarios remain the same, the projected increases in agricultural water demand will not be achievable without further deterioration in groundwater status.

It is therefore clear that the demand of the sector cannot be met by groundwater alone. Other sources must be brought into play – treated sewage effluent and rainwater harvesting in particular. More efficient methods of groundwater management such as supply augmentation measures involving aquifer recharge with excess treated effluent and rainwater runoff should also be considered.

Therefore immediate improvements in water resource planning in the agricultural sector are needed to avert an ensuing 'bust' period; which albeit has happened in many parts of the world whenever irrigated expansion was solely based on unsustainable groundwater abstraction.

Maintaining the sector's achievements will depend on various factors such as:

i. the extent to which unconventional water sources can substitute for the demand of groundwater;

ii. whether or not the cost of unconventional water sources will enable irrigated agriculture to remain profitable; and

iii. the extent to which improved water resource planning can impact very rapidly on water use of the sector.

In the long-term, unless the demand generated by the agricultural sector is met through the involvement of unconventional sources, the current levels of agricultural activity cannot be maintained.

GENERAL POLICY PRINCIPLES

This situation clearly calls for a review of existing policies. Such an initiative should embrace a holistic and integrated view with respect to the management of water resources, and therefore consider both demand management and supply augmentation aspects in an equitable and just framework. Only by taking such a holistic view can the crucial changes in attitude and behavior required, be acceptable to all stakeholders.

Implementation measures based on 'Demand Management' principles will require the formulation of regulatory instruments in order to adjust, limit or stop water uses or users who are utilising the resource inefficiently and thus contributing to the degradation of the natural resource base. The underlying aim should be to give priority to the environment and to water uses that have the highest social and economic value.

On the other hand 'Supply Augmentation' policies will require the development of a programme of measures which should, wherever possible aim to encourage incentives for the augmentation of the existing and the identification of new water resources both at a local and a regional level.

Many different options exist for augmenting supply and managing demand. A problem-focused approach is therefore needed to ensure that the options selected are the most suitable in the local context.

DEMAND MANAGEMENT

Measures implementing demand management policies (water savings) are generally associated with municipal water use; such as encouraging domestic users to practice water conservation and utilities to reduce leakages in their supply systems.

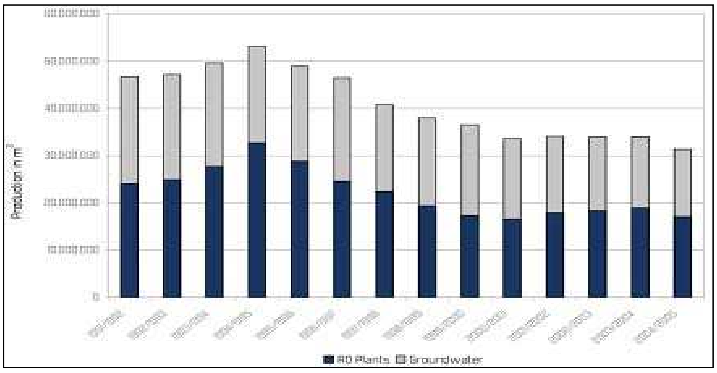

Fig. 4. Reduction in municipal water production (Source: WSC Annual Report 2005)

In fact, municipal water production in Malta has decreased significantly since 1994/95, largely as a result of demand management actions adopted by the Water Services Corporation (WSC). These actions included intensive leakage control, improved management practices and water conservation programmes.

The real question is: Can similar demand management actions be applied with the same success to the agricultural sector?

Clearly, initially, existing water losses and system inefficiencies must be identified and appropriate management actions need to be formulated in order to address these issues. In the agricultural sector, these include:

Fig. 5. Typical uncovered reservoir in the Maltese countryside

i. open reservoirs and distribution channels which are vulnerable to water losses due to evaporation;
ii. the use of inefficient irrigation techniques such as furrow irrigation whenever other forms of hi-tech and more efficient irrigation methods can be used;
iii. improperly managed and un-maintained irrigation systems which result in excessive leakages or in the spilling of water in non-cultivated areas such as roads; and
iv. the cultivation of water inefficient crops and crop varieties which leads to decreased productivity for the water used.

POLICY OPTIONS

A national policy statement reflecting the water demand objectives described above would read: *"Water demand management objectives in water planning processes will be supported and promoted as an alternative to supply augmentation; and to ensure that demand requirements are attained."*

For the agricultural sector this policy statement implies that synergies will need to be developed between Malta's water and agricultural policies. In this scenario, water utilisation by the agricultural sector will be assessed and its efficient use promoted.

Initial measures have already been taken by the Ministry of Rural Affairs and the Environment (MRAE) through a number of 'Voluntary Codes' in Malta's Code of Good Agricultural Practice. Further measures however are needed in the short term to provide incentives for the application of the measures outlined in these codes. Economic instruments would also gradually have to be introduced, in the long term, in order to disincentivise wasteful practices.

The Code of Good Agricultural Practice addresses several important aspects and provides guidelines to farmers to help them make good decisions aimed at amongst others, to protecting the status of the water resource-base. These guidelines address issues such as efficient irrigation techniques, the correct timing of irrigation in order to reduce evaporative losses and the scheduling of irrigation in order to ensure the application of the right amount of water at the right time, thus ensuring that the water is available when the crop needs it.

The most important codes in the field of irrigation are presented below:

Code 55*: The quantity of irrigation water applied to the field should be based on the requirements of the crop and the amount of available water in the root zone.*

Code 56*: Water losses by evaporation can be reduced by good cultivation practices.*

Code 57*: Irrigation should be scheduled by use of actual agro meteorological data and the soil water content.*

Code 58*: The irrigation system with the highest water use efficiency should be used.*

Code 60*: The irrigation system should be maintained regularly to ensure even distribution of water.*

Synergies will need also to be created with rural development policies in order to address infrastructural issues such as those relating to uncovered reservoirs. In a typical Mediterranean climate with a long, hot and dry summer season, these structures are effectively prone to major water losses from evaporation. Development policies should guide farmers towards the construction of covered reservoirs. Furthermore, wholly underground reservoirs should be encouraged since these, apart from being significantly lagged and thus less prone to losses, do not encroach on the arable land footprint.

The maximisation of crop-yield efficiency through the use of hi-tech irrigation systems should also be promoted. The possibilities of introducing fiscal incentives within existing Rural Development Programmes for the installation of such irrigation systems should also be considered.

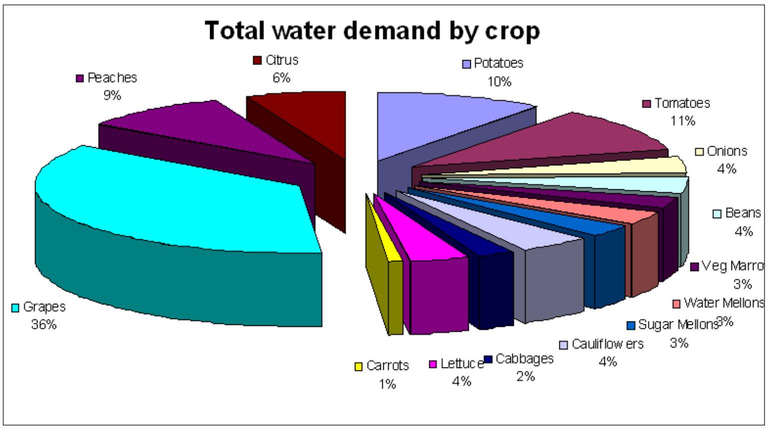

Fig. 6. Total percentage water demand per crop.

Studies on 'alternative cropping' to determine the viability of current agricultural practices and their impact on water resources management should be initiated. These studies should take full account of aspects concerning productivity, water demand and economic benefits in order to identify the most suitable crops in the local situation.

SUPPLY AUGMENTATION

Current estimates place the arable agricultural sector as the major user of groundwater in the islands. In fact, around 81% of the sector's supply is derived from groundwater. In a scenario, where the major groundwater bodies in the islands have been identified as being under threat due to over-exploitation, changes to this situation are warranted.

Policies aimed at the augmentation of water supplies need therefore to be developed. These polices have to address two major issues:

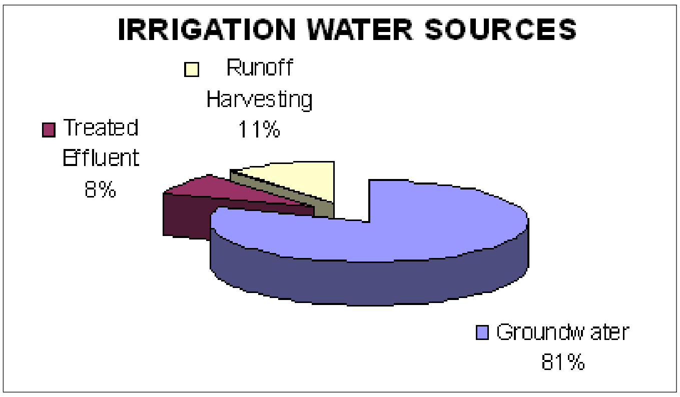

Fig. 7. Sources of irrigation water for the agricultural sector.

(i) Increasing the availability of groundwater through strategies aimed at artificially increasing its recharge;

(ii) Increasing the availability and utilisation of other water sources such as through increased harvesting of rainwater-runoff and increased production and utilisation of treated sewage effluent.

It should be noted that although the contribution from both fields can result, through a targeted development programme, in significant increases to the current water supply scenario; the success of such programmes will eventually depend on their cost-effectiveness for the end-user.

The development of a water supply plan aimed at maximising the use of all water resources available should however take into consideration a number of constraints. Issues relating to:

Water availability - since groundwater and treated effluent are the only water sources available all year round in significant quantities;

Water quality – since groundwater from certain regions of the mean sea level aquifer is saline; and treated sewage effluent, unless further treated over the secondary stage, is saline and could contain pollutants (mainly of industrial/pharmaceutical origin) which cannot be removed by conventional treatment;

Need for investments – sufficient storage space is needed to store rainwater and unutilised TSE from the rainy to the dry season, both on a local and national scale; whilst since a highly centralised approach has been adopted in waste water treatment new infrastructures are required to store and distribute this water; and

Health issues - potential threats to human health, such as viruses and bio-accumulating pollutants, arising from the utilisation of treated sewage effluent;

will all need to be considered in formulating management actions for the implementation of supply augmentation policies.

GROUNDWATER

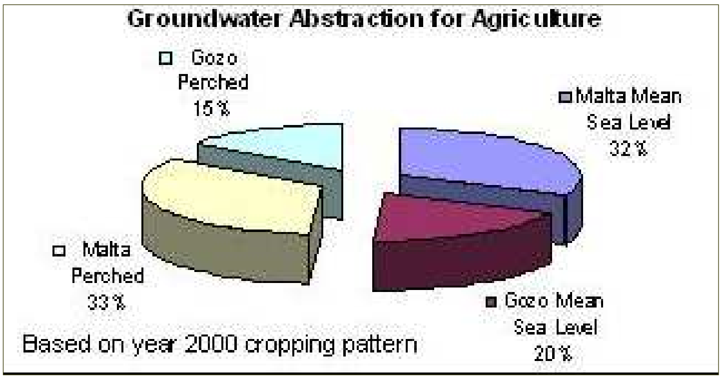

Fig. 8. Breakdown of groundwater abstraction from different aquifer systems.

Groundwater is abstracted for irrigation through a number of private boreholes conveniently located at the point of use. These sources are currently estimated as serving around 81% of the sector's demand.

Most of the irrigated lands are located in the north-western areas of Malta and the northern areas of Gozo, primarily overlying or in the vicinity of the perched aquifers, where historically groundwater was more available. During the early 1980's the commissioning of the Sant'Antnin Sewage Treatment Plant saw the establishment of a number of irrigated areas in the south-eastern region of the island of Malta. However, during the late 1990's the advent of more advanced drilling technology and the subsequent lowering of drilling costs, resulted in the gradual spreading of groundwater-irrigation sources all over the islands.

Mal-practice in abstraction and abstraction source construction is however substantially damaging the resource and consequently the ability of the resource to sustain the agricultural and other sectors. In fact, such mal-abstraction practice has led to the abandonment of wells in several areas due to salinization – this has been the case in the island of Gozo in particular; where the sea-level groundwater body due to its smaller size is more responsive to changes.

Restoration of the resource does not depend exclusively on cut-backs in abstraction but should also consider ways and means of increasing the potential groundwater yield through increasing the annual aquifer recharge, even where feasible by artificial methods.

The main policy objective for ensuring sustainable groundwater use in the islands could plausibly state that: "*Malta should seek the long-term sustainable management and exploitation of groundwater resources, meeting the needs of existing users and without compromising the ability of future generations to meet their own needs*."

Basically, for the agricultural sector such a policy statement will require the adoption and enforcement of a code of 'good abstraction practice'. This code will regulate according to scientific best-practice, functions such as well-location, well-depth, construction of the well-head and pumpingrates, to ensure that both the quality of the groundwater resource and that of the abstracted groundwater is ensured and sustained.

The use of other sources in lieu of groundwater will have to be promoted – so as to reduce the pressure on the resource and aim at the full utilisation of all available resources. Incentives related to the harvesting of rainwater and the use of treated effluent are considered in the subsequent sections.

Incentives will have to be devised for users who use available resources efficiently and development programmes initiated for other users to upgrade their irrigation systems. It is of paramount importance that the necessary technical information and expertise is made available to all involved stakeholders. In the long term wasteful practices will have to be disincentivised even through fiscal measures, if necessary. Such fiscal measures may include the setting up of a graded abstraction licensing regime and targeting of the major water users through rising-block abstraction charges.

RAINWATER HARVESTING

The climate of the Maltese islands is typically semi-arid Mediterranean, characterised by hot, dry summers and mild, wet winters. The mean annual rainfall[13] is around 550mm but with high seasonal and interannual variability, with some years being excessively wet and other being extremely dry. The highest precipitation rates generally occur between October and February. Rainfall is characterised by storms of high intensity but of relatively short duration.

Figure 9 presents the deviation from the mean annual rainfall for the Luqa meteorological station for the period 1974-2004. The average rainfall at this site for this period was 569mm. The figure shows that annual rainfall of 300mm more or 250mm less than the average is common. Although there is no indication of systematic variability, consecutive years of above- or below-average annual rainfall are common.

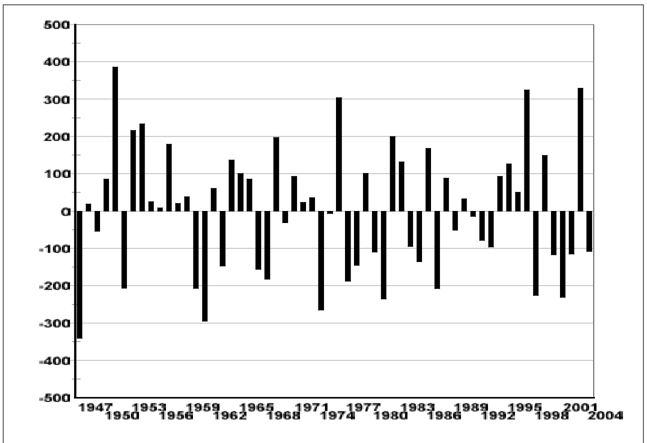

Fig. 9. Deviation form the mean annual rainfall for Luqa meteorological station, 1947-2004.

Rainwater for agricultural use is generally stored in open reservoirs, whence runoff is channelled from adjoining streets or upstream catchment areas. The average reservoir size is generally small and reservoirs more often than not are utilised to store abstracted groundwater instead of rain-water. This situation leads to a limited rain-water storage capacity compared to its potential availability.

It should also be noted that the last survey on the agricultural sector carried out by the National Statistics Office (NSO) during 2000 registered a reduction in investments in reservoir construction for the post 1996/7 period compared to the previous 20 year period. This, whilst the expansion in irrigated land was under-way. This data possibly indicates that users consider investments in the development of groundwater abstraction sources (boreholes) as offering more security in terms of a

[13] Mean for the years 1900 to 2000.

more reliable and constant water supply; compared to rainwater harvesting which apart from being highly dependent on a nature's variability is solely available during the winter months.

Fig. 10. Uncollected rainwater runoff on a field surface after a storm.

A policy statement addressing the main issues in the field of rainwater harvesting might read: *"Exploitation of opportunities for the capturing and utilisation of rainwater as a means of increasing the use of renewable water resources whilst reducing the reliance on groundwater should be encouraged."*

Possible measures implementing such a policy statement will include actions both on a national and local scale, such as:

i. the formulation of appropriate incentives for the construction of reservoirs of sufficient capacity for the irrigation of a whole cropping cycle;

ii. the alignment of national development policies to permit reservoir construction solely when it can be demonstrated that the reservoir will be effectively utilized for the harvesting of rainwater runoff;

iii. the rehabilitation of dams in the major valley lines (and construction of new ones) in order to enhance groundwater storage and recharge; and

iv. the creation of runoff storage facilities (such as major roadside reservoirs) within new flood management or infrastructural projects which can be utilised by the agricultural sector.

TREATED SEWAGE EFFLUENT

Fig. 11. Sant'Antnin Wastewater Treatment Plant

Currently, in Malta there is only one Waste Water Treatment Plant which produces around 2 million m^3 of treated effluent annually. Approximately 75% of this volume is provided to the agricultural sector and utilised for the irrigation of land in the Zabbar area.

The relatively high Electrical Conductivity of the raw wastewater (influent) creates a number of operational problems and also deteriorates the quality of the resulting effluent. These high conductivity values arise due to a number of factors such as infiltration of sea-water in certain segments of the sewerage network, dumping of RO-reject from upstream private installations and the utilisation of sea-water for flushing purposes in a number of hotels.

Apart from salinity, there are other considerations which limit the utilisability of treated sewage effluent (TSE). In principle, any type of application involving the infiltration of TSE in the ground, as in the case of irrigation, is constrained by hydrogeological conditions, the quality of the effluent and the cost of the treatment. The degradation and/or elimination of microbiological pollutants from surface recharge is directly related to travel time in the unsaturated zone besides retention in the aquifer before abstraction. The Maltese aquifers are geologically composed of fractured and weathered limestones having a high permeability and thus prone to rapid infiltrations from the surface.

Viruses and the presence of emerging industrially derived bio-accumulating pollutants which cannot be removed with traditional treatments are the main points of concern in relation to public health issues. In view of these considerations, and with the available knowledge to date, it is desirable to utilize, for the time being, TSE (bacteriologically purified) exclusively in those areas, where flow gradients in the aquifers are directed towards the shoreline and away from public abstraction points, and/or where groundwater is known to be poor in quality and not exploited for potable purposes.

A highly centralised wastewater management plan has been adopted for the country, wherein three main new waste-water treatment plants have been planned which when commissioned are expected to produce an annual volume of treated effluent in the region of 14 million m^3. Two of these plants are located at Cumnija and Wied Ghammieq, respectively in the northern and south-eastern regions of the island of Malta, whilst the other treatment plant is located at Ras il-Hobz in the island of Gozo. The Wied Ghammieq plant is by far the largest of the three and will treat an estimated 85% of the total sewage generated.

The application of TSE is thus further constrained by the location of the plants and the varying seasonal demand.[14] Production is expected to be fairly constant throughout the year, peaking slightly during the summer months due to the increased water consumption registered by the tourism sector.

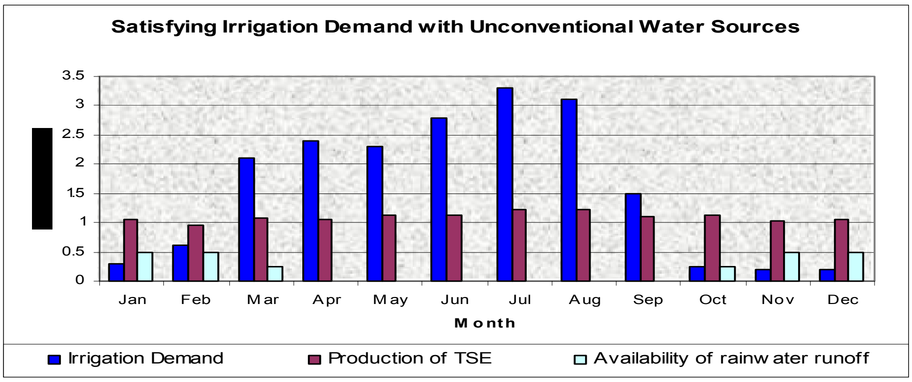

Fig. 12. Satisfying irrigation demand with unconventional water sources. TSE production is modelled on monthly water consumption for the years 2001-03.

TSE production is thus expected to outstrip the national irrigation demand during the rainy seasons (when better quality harvested rainwater runoff is available). During these months the demand for TSE is therefore expected to be minimal. The demand for TSE is expected to materialize mainly in the period from March till September, which basically means that around half of the total production will not be utilized. The effluent produced in this period is estimated to be far below the irrigation demand. This is shown in figure 12, where the irrigation demand for the period October to January can be satisfied by the existing rainwater runoff collecting facilities; whilst during the remaining part of the year, there is a good potential for TSE utilization since the irrigation demand exceeds the volume of TSE produced.

The location of the plants poses further problems. It is expected that the TSE produced in the Malta-north and Gozo plants can be fully utilised within the agricultural regions neighbouring the plants and thus requiring only localized distribution networks. However, the production from the Malta-south plant is expected to exceed the demand in the southern region. A correlation of TSE production

[14] This correlation assumes that TSE will be utilised exclusively by the agricultural sector and does not take into consideration other potential users such as the industrial sector and landscaping consortia.

in the latter plant with the irrigation demand in the neighbouring agricultural regions (Zabbar, M'Scala, Zejtun, Xghajra and Kalkara local council areas) is presented in figure 13. The plot shows that supply is expected to exceed demand throughout the whole year. This scenario risks the global non-usage of around 6.4 million m^3 of treated effluent produced in the Malta-south plant annually, unless efficient distribution methods can be found. Of these, 2.7million m^3 will be produced during the summer period.

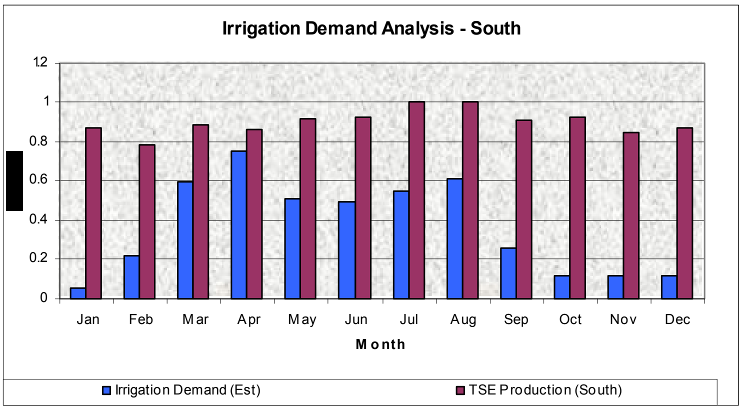

Fig. 13. Irrigation demand analysis in the southern region of Malta.

A policy statement aimed at encouraging the utilisation of unconventional water resources would read: *"Malta should seek to promote the cost effective utilisation of non-conventional water resources, particularly treated sewage effluent for secondary uses including agriculture."*

The eventual use of TSE in the agricultural sector has to be effectively regulated with due account of health considerations and protection of groundwater resources being taken. This needs the identification of areas where treated sewage effluent can be safely and effectively utilised by the agriculture sector or for groundwater recharge purposes.

The principal problems to address involve the eventual distribution of the treated effluent produced and its cost. Obviously the cost will depend on the amount of further treatment above statutory requirements[15] which will be needed to make the effluent usable and as such can be significantly reduced through regulatory measures (mainly discharge control and sewer maintenance). For TSE to be utilised as an alternative to existing sources, the final cost of the effluent should be such that agriculture would still remain profitable.

Distribution on the other hand will most likely require the development of a separate second class water distribution network. The management of such a system should also be considered, since it will have a direct bearing on the cost of the effluent to the end-user. Existing infrastructure such as unutilised sections of the municipal distribution system and reservoirs should were possible be employed. Various management scenarios ranging from placing the onus of distribution on the producer (WSC) to setting up separate distribution co-operatives should be considered.

Facilities for diverting un-utilised treated effluent for artificial recharge purposes should also be considered, subject to the provisions of existing national and European legislation; particularly in the light of the fact that a considerable volume of treated effluent is not expected to be utilised during the winter months. Such actions should form part of the river basin management plan currently being developed by the MRA under the Water Framework Directive.

ROLE OF POLICY, INSTITUTIONS AND INCENTIVES

An effective implementation of the water policy objectives stated above will require alignment of other policies that have the potential to impact on water supply and demand. The implementation of

[15] Malta in line with the requirements of the Urban Waste Water Treatment Directive is required to process all wastewaters up to secondary treatment prior to discharge into the marine environment. In this paper it is therefore being assumed that the costs for treating wastewaters up to these statutory requirements will be borne by the polluter and not any eventual user of the treated effluent.

such a holistic water policy will almost certainly lead to changes in patterns of water availability and use that may result in distinct winners and losers and reduced equity. If there is a risk of this happening, conflicts should be managed by ensuring that losers are compensated.

This, since in order to be effective, proposed policies must have an impact on the water demand of the water-using sectors. While there is scope for many users to make more efficient and productive use of water, and thereby to reduce their overall demand, there is a risk that there will be negative impacts on some commercial operations and the livelihoods of some users. In such cases, policy measures should be accompanied by the necessary safeguards in order to ensure minimal impacts on poorer social groups.

Finally, even a perfectly spelled out water policy is doomed to fail if the measures proposed are not effectively implemented and enforced. Therefore any proposed policy options in the agricultural sector (and not only) must be backed up with sufficient resources aimed initially at introducing and incentivising; and progressively at enforcing the proposed measures.

REFERENCES

Cubasch U. et al (2001): Projections of Future Climate Change, in Climate Change 2001 – the scientific basis. Intergovernmental Panel on Climate Change, United Nations.

Food and Agriculture Organisation (1997): AQUASTAT – Information system on water in agriculture. Food and Agriculture Organisation, Rome.

Food and Agriculture Organisation (1998): CROPWAT for Windows. Food and Agriculture Organisation, Rome.

Hoogeveen, J. (2004): Rapid assessment of irrigation water use on Malta. FAO/MRA Consultancy Report.

International Water Management Institute (2003): Water Policy Briefing – Improving Water Productivity: How do we get more from every drop? International Water Management Institute, Sri Lanka.

Malta Environment and Planning Authority (2006): The State of the Environment Report. Malta Environment and Planning Authority, Malta.

Malta Information Centre (2003): L-Aggornat (January 2003). Malta Information Centre, Malta.

Malta Resources Authority (2003): Review of Water Resources (internal report). Malta Resources Authority, Malta.

Malta Resources Authority (2005): Initial Characterisation of the Maltese Water Catchment District. Malta Resources Authority. Malta.

Ministry for Rural Affairs and the Environment (2003): The Maltese Code of Good Agricultural Practice. Government of Malta.

National Statistics Office (2001): Census of Agriculture 2000. National Statistics Office, Malta.

Water Services Corporation (1997): Future application of secondary waters in the Maltese Islands (internal report). Water Services Corporation, Malta.

Water Services Corporation (1998): Use of Treated Sewage Effluent (internal report). Water Services Corporation, Malta.

Water Services Corporation (2005): Annual Report 2004-2005. Water Services Corporation, Malta.