MedWater Policy - Policy Initiative to Overcome Water Competition between Agriculture and Tourism – Case Study Naxos

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ABSTRACT

"MedWater Policy" is a research project co-financed by the European commission in the frame of the INCO-MED Programme. "MedWater Policy" elaborates strategies to overcome the water competition between the vital economic sectors of agriculture and tourism in the countries of the Eastern Mediterranean Basin. The consortium based its investigation on an analysis of the water situation in five target regions e.g. the Greek Island Naxos. In a further working step the technical, economic and political aspects of sustainable water supply were scrutinised. Focus was put on the option of renewable energy (RE) based desalination systems. Different combinations of RE technologies and desalination techniques were assessed for their technical suitability and economic performance. The project findings are compiled in the ***MedWater Model for Integrated Water Planning****. This computer tool is based in MS Excel and therefore widely usable for water planning on local and regional levels. The tool allows the analysis of the water situation on local and regional level and assists in formulating concrete action plans to accomplish sustainable water supply.*

I. INTRODUCTION

In the countries of the Eastern Mediterranean Basin, agricultural irrigation consumes 85% of the total water resources. Concurrently, the water demand of tourism sites is growing rapidly. Both economic sectors are of vital importance for the region: while agriculture provides the living basis for most of the rural population, tourism carries hopes for significantly increasing wealth and employment in the region. Therefore, the water competition between the two sectors damages the social and economic foundations of the region. It forces farmers to abandon agricultural land and raises the investment costs for new tourism projects.

„MedWater Policy%is a research project co-financed by the European Commission in the framework of the INCO-MED programme. The MedWater consortium constitutes a network of water institutes from from Europe and the Mediterranean. „MedWater Policy%elaborates strategies to overcome water conflicts between tourism and agriculture for the countries of the Eastern Mediterranean Basin. The major outcome is a working tool that supports decision makers in creating water management plans for their regions. This tool was elaborated on the basis of an exemplary analysis of the water situation in selected target regions and an evaluation of the technical and political options of sustainable water planning. One target region was Naxos in Greece, an island, which at the same time has important agricul-

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tural activities and a quickly expanding tourism. Other target regions for MedWater research with similar preconditions were: Cap Bon Region in Tunisia, Dead Sea Region in Jordan, Fethiye Region in Turkey, Jericho District in the West Bank (Palestine).

I.1 Water supply on Naxos Island

With an average precipitation of 373 mm/y Naxos island is a semi- arid region which strongly depends on groundwater supply. Naxos has many springs and wells which supply more than 12 MCM (millions of cubic metres) per year. The earth dam of Eggares supplies 0.75 MCM/y for irrigation and drinking water. A second dam · Faneromeni · with a capacity of 1.5 MCM/y started its operation during 2002. A third reservoir with a capacity of 3 MCM (reservoir of Tsikalario) is under study. There are two wastewater treatment plants with a capacity of 0.08 MCM/y and 1.75 MCM/y. Of the first plant the amount of treated wastewater peaks up to 300 · 350 m^3/day from June till September and then drops down to 150 · 175 m^3/day during the rest of the year. The second waste water treatment plant · which serves the city of Naxos · started operation recently.
The quality of the water supply is continuously deteriorated by human pollution and sea water intrusion. Mainly in the area of Livadi the water is contaminated by NO_3^- and Cl^- due to human activities (fertilizers, cattle breeding etc) and the intrusion of the sea due to over pumping. Currently only 20 % of the island water resources are of drinking water quality.

I. 2 Water demand in agriculture

The total agricultural land of Naxos is 10 400 ha, according to the data of the National Statistic Service of Greece. Only the 2 500 ha of this area are cultivated due to the fact that a lot of fields cannot produce crops competitively due to steep slopes, lack of irrigation water, low fertility and lack of workers in the agricultural sector. The irrigated surface of the island is approximately 1 300 ha. The low quality of irrigation water and the particularities of the climatic conditions (high temperatures, low rainfalls and strong winds) do not favour the increase of irrigation. The main cultivated crops are potato for food and seed production (820 ha) and the olive trees (1 000 ha). A significant growth of cattle raising (cows, lambs and goats) can be observed recently.

Crops	Cultivated area (ha)	Irrigated Area (ha)	Consumption per ha (m^3/ha)	Total consumption (m^3 / y)
Vegetables				
Potatoes for seeds	490	490	3 700	1 813 000
Potatoes for food	330	330	2 500	825 000
Vegetables open field	200	200	6 520	1 304 000
Forage crops				
Sorghum for animal feed	70	70	2 300	161 000
Other forage crops	30	30	10 250	307 500
Orchards				
Olive trees	1.000	70	3 330	233 100
Other trees	100	80	4 570	365 600
Greenhouses				
Greenhouses	3		16 000	48 000
Grapevine	300	**-**	**-**	**-**
TOTAL	**2500**	**1 270**		**5 057 100**

Table 1: Water demand of different agricultural products on Naxos.

The figures in the above table do not include losses in the distribution and irrigation system. Systems losses of approximately 50 % result from the predominant technique of sprinkler irrigation (application efficiency 60-80%), the small sizes of farm fields and the windy climate of the island. So the water consumed for the irrigated crops is approximately double the quantities presented in the previous table.

I.3 Water demand in tourist sector

Before 1980, tourism in Naxos was very limited. Then tourist numbers increased significantly. The annual number of arrivals by boat grew from 190 000 passengers in 1981, to 416 000 passengers in 2000. Today, Naxos has 75 hotels with 3 000 beds. There are also 12 000 rooms to let and 1 000 beds in small hotels providing agro tourism. The water consumption per person in the hotels and the other rooms to let was estimated at $0.15 m^3$/person/day.

A special group of tourist are the emigrants originating from the island and staying for one month in their family houses in summer. They have the same water demand as the average inhabitants of Naxos which is approximately 0.18 · 0.19 m^3/person/day. For the total water consumption in this sector losses in the distribution system of 30 % have to be added. This sums up the total water consumption for the tourist sector to 0.45 MCM /year.

I.4 Water conflicts between agriculture and tourism

Severe water competition between agriculture and tourism was analysed in detail. This hampers economic development in both sectors. This competition stems from the sharp water scarcity in the region. The demand peaks of both tourism and agriculture are found in the summer months and so correspond unfavourably with the reduced supply of natural water at this time of the year.

Agricultural and tourism projects compete for the same insufficient water sources, particularly from the storage dams. Political initiatives often resolve the water conflict by allocating water sources from the agricultural towards the tourist sector. The dam of Faneromeni, for example, which was originally dedicated to agricultural irrigation, today is used for domestic and tourist water supply. So in spite of its much smaller quantities, tourism water demand creates crucial competition for the agricultural water supply.

II. COMPUTER MODEL FOR SUSTAINABLE WATER PLANNING

II.1 Need for Integrated Water Planning

Sustainable water systems can only be accomplished through comprehensive planning in which all individual supply and demand contributors are taken into consideration. The water situation on Naxos Island gives an idea for the complexity of water management systems, thus highlighting the need to support integrated water planning by information materials and computer based analysis tools. These support tools must be able to simulate water supply scenarios with sufficient accuracy, whilst remaining of restricted calculation complexity.

II.2 Features of the MedWater Model for Integrated Water Planning

The MedWater consortium decided to base the MedWater Model for Integrated Water Planning on MS Excel which is available as standard software on many computers. The main objective of the proposed model is to allow users to analyse the water situation through an integrated approach and visualize the results of own decisions in a quantitative and qualitative way by numerical outputs and graphics. The model determines the water balance of a region in both present and future years: present year is used as a base year for testing the available data and then for calculating the water balance in future year. The model gives the user ample opportunity to modify assumptions to the regional context and to test different future scenarios. The model does not aspire to give precise and difficult predictions but rather analyses „what-if%questions. For instance, it helps analysing & answering questions such as:

- If municipal demand increases to 50 litres per day per capita in the future, what does this mean in terms of the overall balance and what will be the consequences for other sectors such as tourism?
- Is it possible to compensate for the increase water demand with treated wastewater and desalination?

The consortium strived to create an user friendly tool. This intention can be found in the design of the central site of the model which introduces the user to the different calculation features.

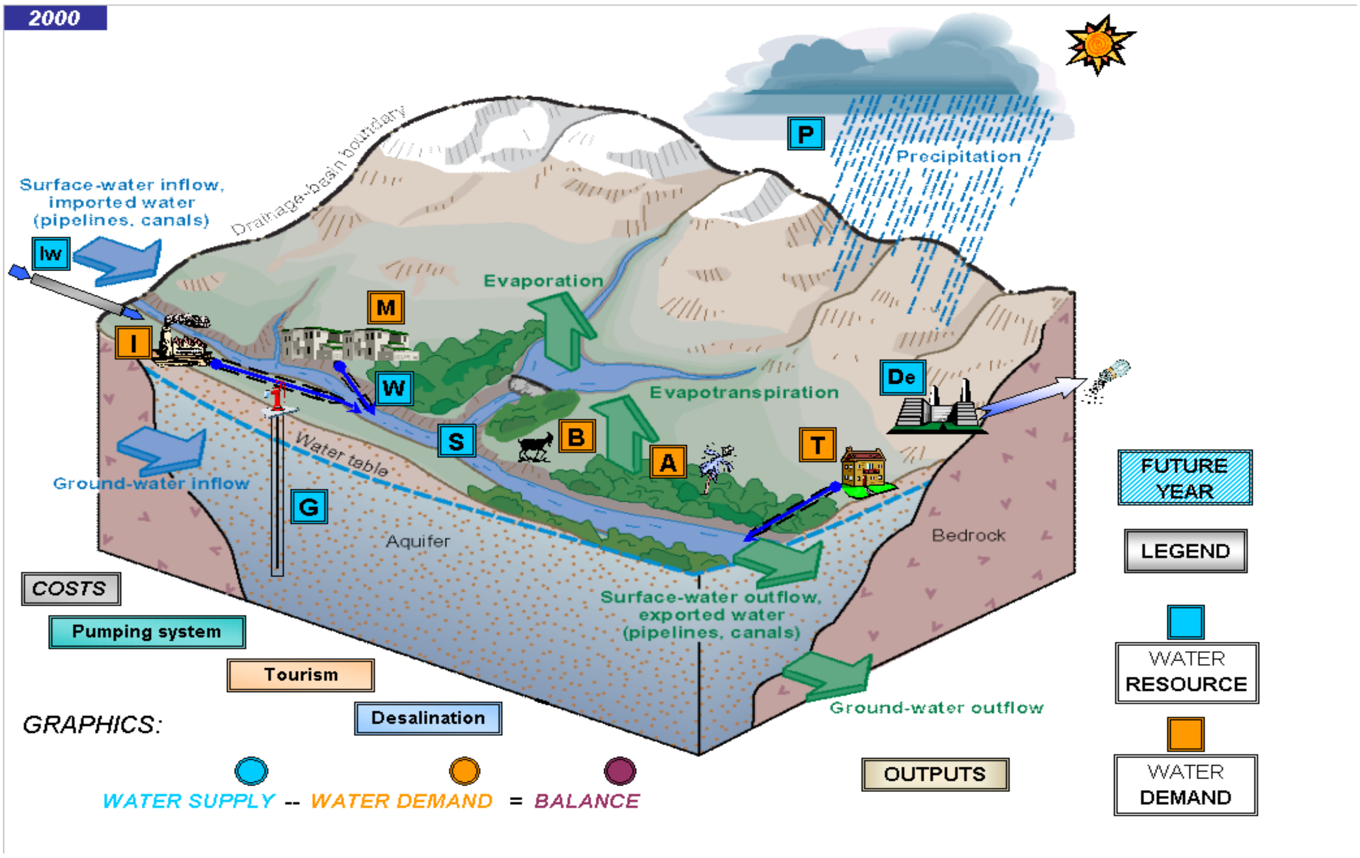

Figure 1: Screen shot of the MedWater Model entrance site.

In the MedWater Model the user can insert the required data and can modify all major variables and directly monitor the effects of these changes on water demand and on water supply. This feature makes the program a very suitable tool for scenarios testing and sensitivity analysis. The analysis carried out by the model strongly depends on the quality of inserted data; the MedWater consortium adopted the input requirements to the expected data availability in the target regions. Thus, the model itself incorporates assumptions for the water related effects of certain economic activities which the user can overtake or ignore. E.g. the model suggests a water efficiency of sprinkler irrigation of 65 %. For the two most complex water calculation issues · the assessment of groundwater and surface water resources of the selected region - the model makes reference for external analytical instruments. The Integrated Model was elaborated in close linkage to the existing literature and similar instruments which can be found in the internet. Important addresses are: www.fao.org; www.iwmi.cgiar.org; http://water.usgs.gov/. The final version of the MedWater Model will be available in summer 2003.

II.3 Model Structure

Two main modules (each one composed by sub-modules) were identified: the **water supply module** for the estimation of the available resources and the water supplied to the distribution system; and the **water demand module** used for the calculation of the water needs of the economic and domestic sectors (tourism, agriculture, municipal and industry) in the region. In the following figure, the structure of the model is shown. Also, a specific sub-module for assessing the reclaimed flow (RF) is included.

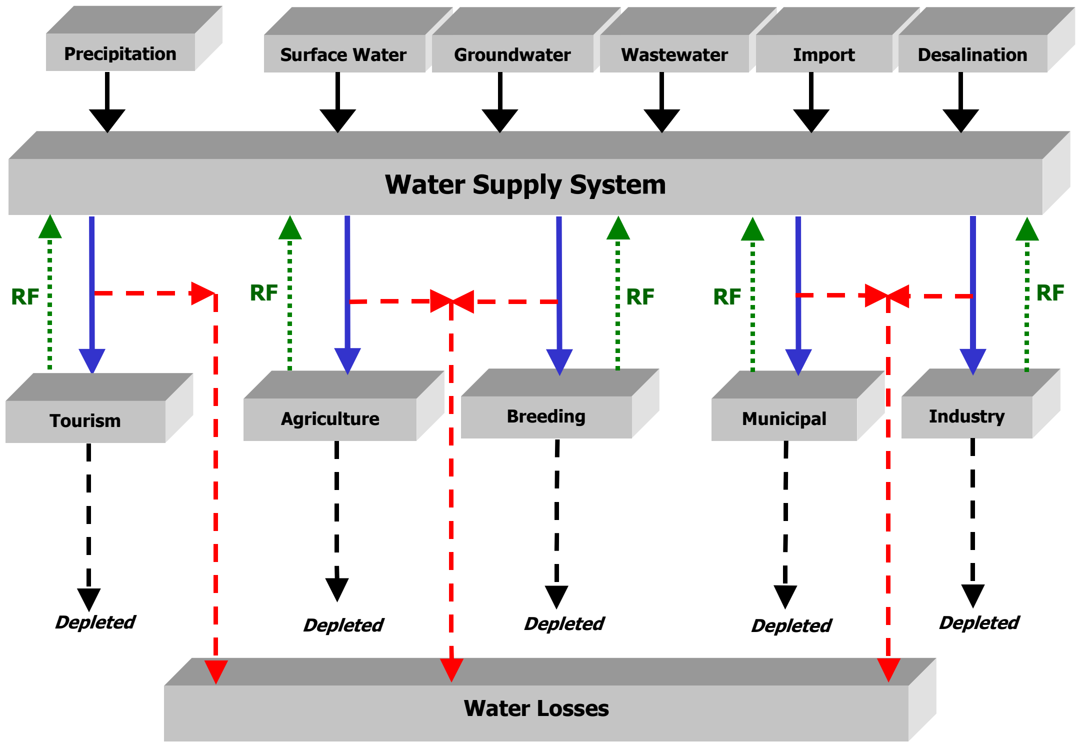

Figure 2: Layout of the MedWater Model.

II.3.1 Water Supply module

The water supply module is constituted by sub-modules: surface water (like rivers, dams, etc.), renewable groundwater, imported water, desalination systems, wastewater treatment and precipitation. Precipitation is used only for the calculation of the water demand in agriculture. The definitions used in the model are in accordance to the IWMI report „World Water Demand and Supply, 1990 to 2025: Scenarios and Issues‰The main output of this module is the calculation of the water amount which does enter into the supply system- and then can be used for all the purposes of the region. This amount includes also the Reclaimed Flow (RF), i.e. the drainage water from a withdrawal that flows back into the water system where it can be recycled for other uses. The Effective Water Supply is a gross value, including distribution losses, and is used for all the purposes of the selected region: agriculture, tourism, industry and urban/municipal sector. It is the water used to produce an intended „good‰for instance the water used for producing an industrial product, or the water used for an irrigation system; a part of this water is definitely depleted and cannot be reused; the remainder is recycled and returned to the water distribution network.

II.3.2 Water Demand

The second module is named „water demand‰The following sub-modules compose this module: (1) Agriculture; (2) Livestock breeding; (3) Tourism; (4) Municipal; (5) Industry. Input data for agriculture sector demand are: start period for planting the crop (month and decade), number of irrigated hectares per crop, irrigation system, geographical and meteorological data of the considered region for calculating different kinds of evapotranspiration. Harvesting period of the crops and Kc coefficients adopted for the different periods of each crop are default data. These data are elaborated for the calculation of total monthly irrigation requirements, including distribution losses.

III. FUTURE WATER SUPPLY SCENARIOS ON NAXOS

An analysis of the future water supply of Naxos with the MedWater Model is based on the following assumptions in the two main competing water intensive sectors, **agriculture** and **tourism**.

Growth of tourism: In the last decades an average increase of 5% of tourists was observed on the island. Taking into consideration that the number of visitors during the year 2001 was 2 200 000 and adopting the above-mentioned annual increase rate, the visitors for 2015 are estimated to be around 4 800 000.Water consumption per tourist (0.195m^3/day) is not expected to increase considerably, due to the growing awareness environmental issues and the expected implementation of water saving techniques (particularly a better maintenance of the distribution system).

Change in the agricultural situation: The evolution of agriculture on Naxos is expected to follow the general trend of the agricultural sector in Greece, i.e. a stagnation or a progressive decrease which will lead to the abandonment of low fertility fields and a shift to more attractive activities which guarantee a higher income and less work e.g. tourism. Therefore, we can estimate that the size of irrigated land will not change radically. It can be assumed that all fields which will be abandoned in the next years are today without irrigation. The farmers who will remain in the agricultural sector will try to improve the competitiveness of their farms. For this reason we can expect that improved irrigation systems will be adopted (drip irrigation instead of sprinkler irrigation) and that in some dry cultivated fields (especially the olive trees or vineyards fields) drip irrigation systems will be introduced.
We can adopt two scenarios: in the first, a realistic scenario, the total irrigation area stays stable (1 270 ha) but there is an improvement of the drip irrigation usage, from the actual 9% to 25-30%. In the second one, a hypothetical scenario, we can presume that a high proportion of all the cultivated fields are irrigated (2 200 ha, 49.5% drip, 0.5% surface irrigation and 50% sprinkler).

Simulation results of the Integrated Model: The simulations of the future water supply situation (2015) considers an expected increase of the permanent inhabitants from 17 500 to 22 000. Moreover, annual water supply is increased of 1.5 MCM through the Faneromeni dam. In the following table we can observe that, in the first scenario, annual water supply can satisfy annual water demand, while in the second scenario we have an annual water deficit of 5.3 MCM.

	2001	**2015** first scenario	**2015** second scenario	
DEMAND				
Agriculture	11 310 000	10 450 000	16 764 000	CM
Municipal	1 445 000	1 925 000	1 925 000	CM
Cattle-Breeding	120 000	320 000	320 000	CM
Industry	2 600	3 000	3 000	CM
Tourism	472 000	1 214 000	1 214 000	CM
SUPPLY				
Surface water	750 000	2 250 000	2 250 000	CM
Groundwater	12 600 000	12 600 000	12 600 000	CM
Treated wastewater	80 000	100 000	100 000	CM
WATER BALANCE	-	+ 1 040 000	- 5 275 000	CM

Table 2: Main Model Outputs.

The following output figure of the MedWater Model for Integrated Water Planning illustrates the monthly water demand of the second scenario in 2015.

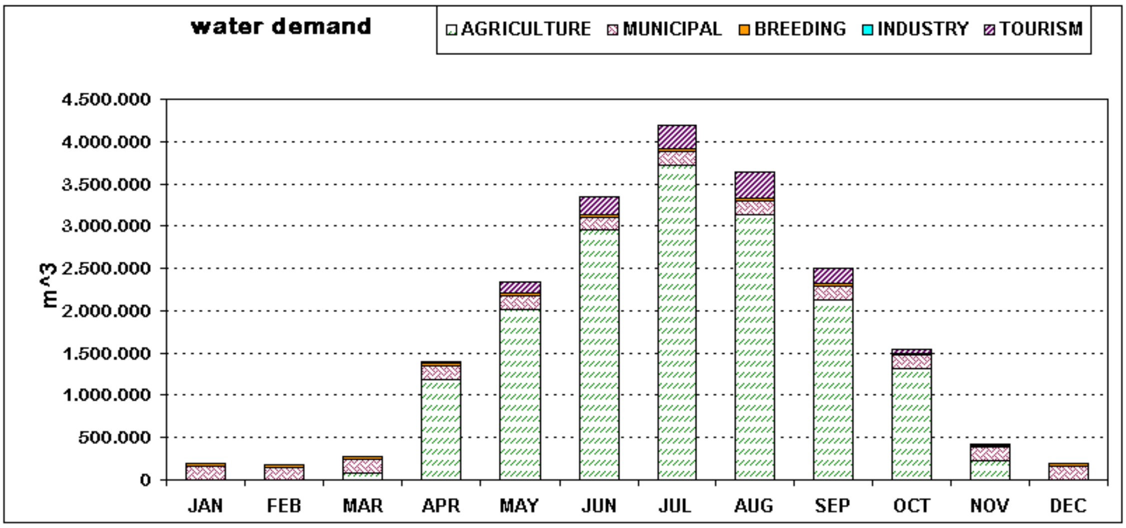

Figure 3: Monthly water demand of each sub-module.

IV. RES BASED DESALINATION SYSTEMS ON NAXOS

The model simulation work has shown that in the near future the water demand on Naxos cannot be met by natural resources only. One important option is the implementation of desalination units. The required energy for these systems could be generated from renewable resources. Renewable energy technologies are particularly relevant for the Island of Naxos, which is dependent on expensive energy imports. The MedWater Model provides basic features for assessing the requirements and effects of renewable energy based desalination units. For more detailed information the model makes reference to the MedWater Report on Water Saving, Reuse, Desalination and RES Options which explains the technical conditions of the most promising options for renewable energy based desalination and waste water treatment. The type of RES to be used with a particular desalination process depends on RES availability, plant capacity and the specific energy consumption of the desalination process.

The climate conditions on the Island Naxos make Wind Energy Converters (WEC) and PV Systems the obvious choices for supplying the energy for small autonomous desalination units. Concerning the coupled desalination system, Reverse Osmosis (RO) is the most versatile desalination technology and can deal with fluctuations in the energy supply, having also the smallest specific consumption. Two technology recommendations can be made for Naxos Island:

1) PV-RO is a promising solution especially for small-scale desalination and for stand alone operation. PV-RO could offer solutions for single home or hotel units.
2) WEC-RO offers larger scale production of desalinated water than PV-desalination. A WEC-RO system could therefore be designed to serve a number of farming units or a combination of hotels, homes and farming units.

Economic viability for both systems can be reached when the conventional water supply requires long-distance transport e.g. by ships.

The main challenge of RES-Desalination is in interfacing the two technologies. RE sources are by their nature characterised by intermittent and variable intensity. Desalination processes are designed for continuous steady state operation. Two approaches to solving this problem have been identified. These are modulating the process to cope with variable energy input, or by including an energy buffer to even out the energy supply.

To-date, battery storage has always been used in order to maintain a stable power source. However, battery storage is expensive. For seasonal energy storage purposes therefore consideration may also be given to storing energy as drinking water in a tank, rather than as electricity in a large battery.

V. CONCLUSIONS

1) The MedWater research on Naxos Island has shown severe water competition between agricultural and tourist activities. Both sectors have their consumption peaks in the summer months. The insufficient water supply leads to overexploitation of the natural resource and endangers development and prosperity in both agriculture and tourist sector. The agricultural sector suffers from the reallocation of their water sources to tourist projects. The development of tourism has to cope with the declining quality of water resources, requiring expensive water transport and treatment infrastructure.
2) A prerequisite for the sustainable water supply which is urgently needed in the arid regions of the world is integrated water planning, paying attention to all parts of the water chain. Decision makers require computer based support tools for being able to cope with the complexity of integrated water planning. The computer tools have to provide simulation features for analysing the current and future water situation of a specific region with sufficient accuracy. At the same time the complexity and size of these computer models must suit the financial and knowledge resources of domestic decision makers.
3) The project MedWater Policy elaborated the MedWater Model for Integrated Water Planning. With this MS Excel based tool the water demand of specific economic activity can be assessed e.g. one tourist accommodation in a certain tourist facility or the irrigation demand for one hectare of a particular crop. The modelÊs main feature is to analyse „what-if‰questions that will raise the sensitivity for the water related aspects of regional and local planning and the understanding of the current and future water balance of the region. The MedWater Model is a user-friendly tool, which pays attention to the restricted availability of water data in many regions. Thus, the model itself has programmed assumptions for the water related effects of certain economic activities that the user can accept or ignore. These assumptions are based on the research results of the MedWater consortium, which analysed the water situation in five target regions in the Eastern Mediterranean Basin.
4) The Integrated Model simulation for Naxos Island pointed out that both tourism and agriculture sectors will increase their needs in the future, thus worsening the water scarcity in the region
5) The additional future water demand on Naxos can be partly covered by renewable energy based desalination units. The analysis performed within the MedWater project pointed out that for Naxos Island PV-RO units for smaller applications and WEC-RO units for middle size applications are suitable options. These options then are to be scrutinised in a detailed feasibility studies.

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