WaterStrategyMan
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DELIVERABLE 13
WORKSHOP PROCEEDINGS

"TOWARDS COMPREHENSIVE WATER MANAGEMENT STRATEGIES FOR WATER STRESSED REGIONS"

WSM PARIS WORKSHOP
PARIS 8 – 9 OCTOBER 2003

Prepared by

IOW

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The WaterStrategyMan workshop *"Towards comprehensive water management strategies for water stressed regions"* was held in Paris, France, at the Ecole Nationale des Ponts et Chaussées, on the 8th and 9th October 2003. A training workshop, open to the public, was held on the 9th.

All presentations held at the workshop are available for download (for project partners) on the WaterStrategyMan website (http://environ.chemeng.ntua.gr/wsm/)

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1 Introduction

1.1 The Project

The WaterStrategyMan Project - "Developing Strategies for Regulating and Managing Water Resources and Demand in Water Deficient Regions" aims at contributing to the solution of water shortage problems in arid and semi-arid regions of Southern Europe. The goal of the WSM project is the study of the differences between quantity and quality dimensions in water management and the development of alternative options and long-term scenarios, through the establishment of a broad framework on the existing knowledge on IWRM practices, while highlighting of the importance of regionalization and the relevant cultural context.

Methodology, tools, guidelines and protocols of implementation are being be developed that will enable decision makers to select and implement relevant water schemes for full water cost recovery. The project seeks to develop an integrated water resources management that takes into account economic, technical, social, institutional and environmental implications, and to meet the EU requirements concerning preservation and enhancement of the quality of the environment and the availability of natural resources and sustainable development both directly and indirectly.

1.2 The Workshop

The workshop, according to the WSM objectives, aims at presenting and discussing the results of the Analysis Phase, and particularly the GIS Decision Support System developed, to validate the developed methodology and selected tools, to prepare the development of water management scenarios and to train participants on the DSS and methodology application issues.

This was the second Workshop of the WSM Project, undertaken as a joint Project meeting and Public Presentation; it offered the opportunity to present and disseminate for the first time the WSM progress and outcomes to the public in an open session to be attended by all interested parties.

The first WSM Workshop in Syros in July 2002 aimed at presenting the findings of the Diagnostic Phase of the Project to the Partners and invited stakeholders. The **Paris Workshop** marked the initiation of the Strategy Formulation Phase, and the completion of the Analysis Phase in the Project, involving the development of suitable methodologies and the Decision Support System.

The outline of the work flow in the project is portrayed in Figures 1 and 2.

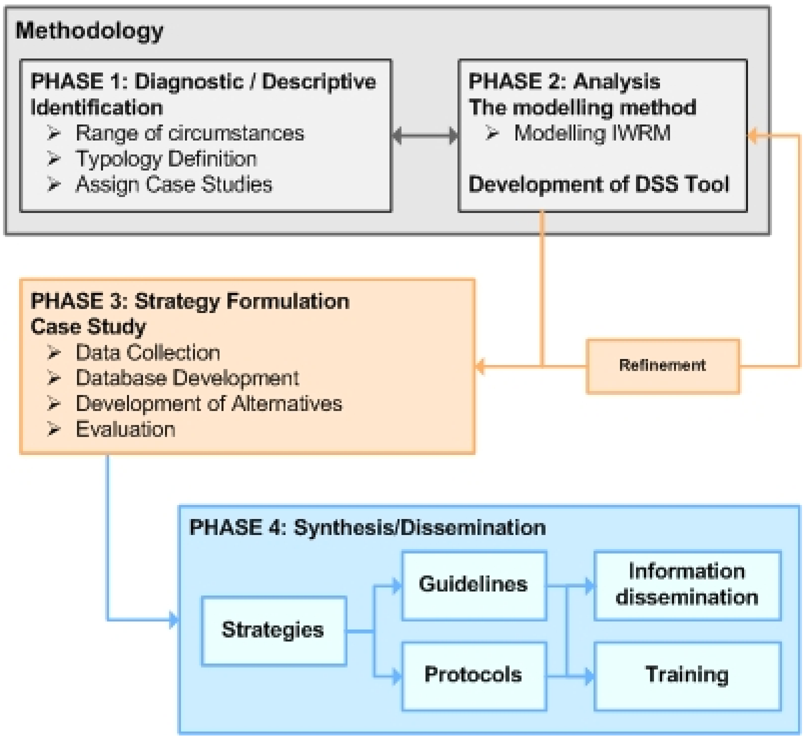

Figure 1. Workflow

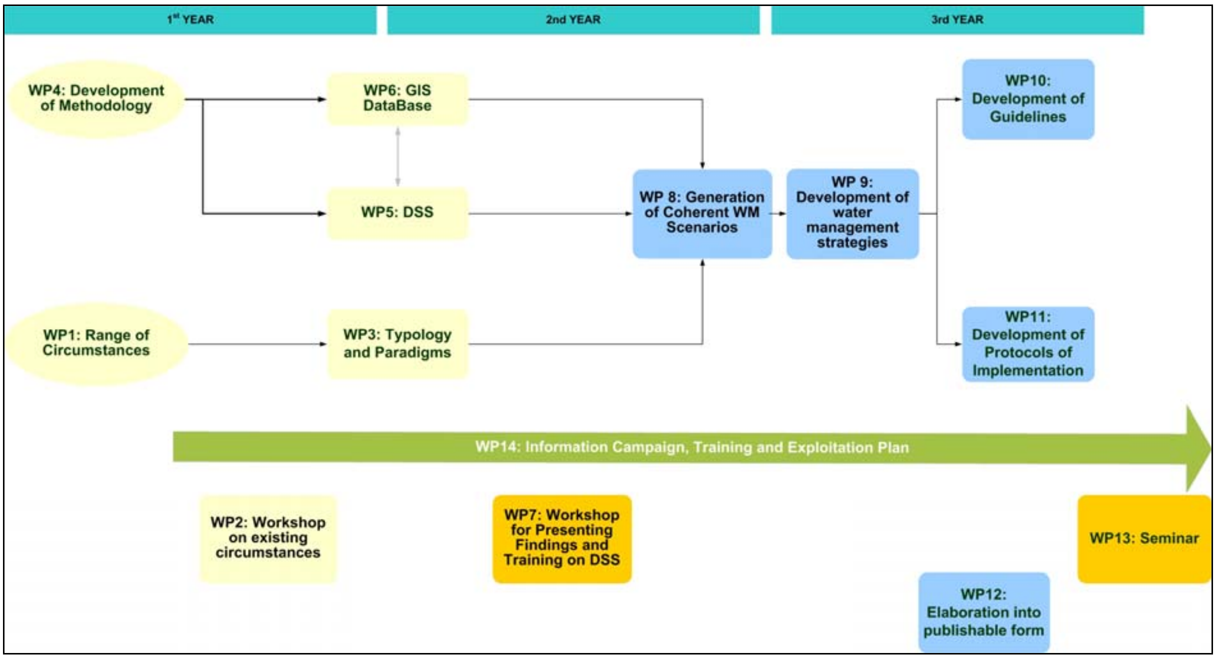

Figure 2. Interrelation of work activities

2 Agenda

Session 1: Introduction to the WSM Project *(Chair and Moderator: C. Karavitis)*

9:00 – 9:30 Registration and introductions

9:30 – 9:50 Integrated Water Resources Management today, and the scope of the WSM Project *(B. Barraque)*

9:50 – 10:20 Supporting decision makers in developing water resources strategies: The WSM approach and methodology *(E. Todini)*

10:20 - 11:00 The WSM Decision Support System *(D. Assimacopoulos)*

11:00 – 11:15 **Coffee Break**

Session 2: Case Studies *(Chair and Moderator: E. Todini)*

11:15 – 11:45 Competing and conflicting water uses: the Cyprus Case Study *(I. Iakovides)*

11:45 – 12:15 Surface and ground water use: trying to achieve a correct balance and protection in Algarve: the Portuguese Case Study *(R. Maia)*

12:15 – 12:30 **Coffee Break**

Session 3: Methodology issues and discussion *(Chair and Moderator: B. Barraque)*

12:30 – 12:50 The search for the "true cost" *(J.-M. Berland)*

12:50 – 13:10 Facing uncertainty in water resources management *(A. Schumann)*

13:10 – 13:30 Challenges and opportunities in comprehensive water management. The WaterStrategyMan example *(E. Vlachos)*

13:30 – 14:00 Open Discussion

14:00 – 15:30 **Lunch Break – End of Workshop**

3 Executive Summary

3.1 Session 1 – Introduction to the WSM Project

After the registration and welcoming of participants by Catherine JUERY and Jean-Marc BERLAND, a first presentation was made by Bernard BARRAQUE on the present state of Integrated Water Resources Management, and the scope of the WSM project. The focal point of the presentation was the difficulty of implementing the 3 E's of the Water Framework Directive, Environmental protection, Economic objectives and Equity. Then the spirit of the WSM project was presented with emphasis on the realization of those objectives in the case studies involved in the project. Finally, B. BARRAQUE presented the three eras of the water industry concluding at the era of environmental engineering and demand management instruments and on how these instruments can be implemented in the WSM Decision Support System.

Supporting decision makers in developing water resources strategies: the WSM approach and methodology

Prof. Ezio TODINI presented the WSM approach and methodology, as an introduction to the WSM Decision Support System. Components currently implemented in the DSS are:

- A basic data management module, to update and retrieve information from the database;
- A case generator, to assist the user of the tool in generating different water availability and demand scenarios and applying a set of water management instruments;
- A water allocation module, to allocate water to the different competing uses;
- Alternative evaluation modules to assist the user in selecting the most appropriate water management strategies on the basis of well-defined indicators covering all aspects of integrated water resources management.

Several computing tools are necessary in the DSS such as a Geographical Information System (GIS), a geo-referenced database and a Graphical User Interface (GUI) in order to provide a user-friendly tool. The tools implemented in the WSM DSS allow for:

- The description of the existing state of the water system;
- The assessment of the state of the system in terms of sources, usage, water cycles, environmental quality;
- The forecasting of the state of the system on the basis of assumed or envisaged scenarios, technical alternatives, management policies and actions;
- The evaluation of the impact of possibly applied actions.

In addition to the modules outlined above the DSS also includes four different models:

- Hydrologic balance estimation performing the calculation of surface water availability (runoff), infiltration and actual evapotranspiration;
- Hydrologic scenario generator, to enable the user to define future possible trends in rainfall, in temperature or evapotranspiration and therefore to simulate different water availability scenarios in the case study area;
- Demand scenario generator to enable the simulation of different assumptions on socio-economic pressures and envisaged development priorities, water quality requirements as well as the effect of different demand management policy options;
- Quality model allowing for the simulation of water quality on a number of receptor bodies and the evaluation of the environmental impact of certain actions.

The WSM Decision Support System and the Case Study of Paros

Prof. Dionysis ASSIMACOPOULOS presented the WSM Decision Support System. The main objectives of work package 5 of the WSM project is to adapt tools and develop a Decision Support System which will be able to:

- Analyse quantitative and qualitative impacts at the regional level;
- Analyse intersectoral competitive water use;
- Describe potential responses, and water policy consequences;
- Suggest appropriate responses and implement alternatives;
- Develop improved management strategies;
- Formulate wide applicable guidelines and protocols for their implementation;
- Help decision-makers to decide upon the best strategy, taking into account regional development priorities, social, economic and environmental constraints, and legal constraints.

In order to evaluate the system, a live presentation of the DSS was made, including a tour of the DSS capabilities, and a test run of the existing situation in the region in order to display the DSS functionalities and the database.

The presentation was concluded with a demonstration of the application of the Decision Support System on the Greek case study of Paros Island, Cyclades, Greece. Instruments applied and evaluated on the case study region were:

- Network unifications,
- Desalination,
- Cisterns,
- Pricing.

The effect of those actions in meeting the domestic demand of the island and groundwater protection was discussed and evaluated against the business as usual scenario. Finally, all policy options were discussed in terms of direct and environmental cost and the rate of cost recovery was estimated according to the current tariff structures.

3.2 Session 2 – Case Studies

During the workshop, different applications of the DSS were proposed and discussed in order to improve them if necessary for the public workshop presentation.

Case studies were selected according to their characteristics and circumstances:

- Peak demand during summer due to tourism : Paros island;
- Competition between tourism and agriculture : Cyprus;
- Salinity problems due to over-abstraction : Ribeiras de Algarve;
- Conflict between urban water supply and agriculture : Tel-Aviv and Arava regions;
- Peak demand during summer due to irrigation demands : Belice basin;
- Year-round high demand caused by tourist influx much larger than the local population : Tenerife.

Several practical applications of the tool were presented through three case studies.

The first one, the case study of Paros was presented by Prof. D. Assimacopoulos after the live demonstration of the WSM Decision Support System. In the second session two representative Case Studies were presented, Cyprus and Algarve, to illustrate the use of the tool for Strategy evaluation.

The second case study, presented by I. IACOVIDES, illustrated competing and conflicting water uses on Cyprus between domestic tourist and agriculture sectors. This case study outlined the DSS use to assess potential schemes to resolve the conflict.

The Portuguese case study dealt with trying to achieve a correct balance between ground and surface water and protection in Algarve. It pointed out the problems arising from overexploitation of the groundwater aquifers. It explored the potential for achieving a new balance between surface and ground water use that will allow the sustainable use of the available resources.

The progress of implementation of the DSS analysis varies in the remaining three Case Studies depending on the available data and the characteristics of each area.

A special training session was performed on the use of the simulation approaches in 10th October.

Conclusions on the case studies and discussion

At the end of the presentation of the case studies, several suggestions were made to improve the DSS:

- an option to introduce a monthly variation of the annual consumption rate for the population could be created in order to simulate the specificities of winter and summer consumption on the different sub-basins;
- an option to introduce a growth rate for each node (in alternative to the entire basin) could be made possible;
- an option to introduce the variation by sub-basin or even settlement (in alternative to the entire basin) could be made possible;
- an improvement of the introduction of river nodes and storage reservoirs in the map editor of the DSS;
- the possibility of loading a new (or changing a) theme without reloading the entire database.

3.3 Session 3 – Methodology issues and discussion

The final session of the Workshop was dedicated to a commentary and discussion on the presented Case Studies and DSS capabilities. The three commentators addressed major issues in Water Management, using the case studies as a reference point. The issues that will be addressed were:

- The search of the 'true cost" the Economic approach,
- Uncertainty in water resource management,
- Challenges and opportunities in comprehensive water management.

The search of the 'true cost" the Economic approach

Dr. Jean-Marc BERLAND explained the economic approach and the importance of integrating this aspect in the DSS, but also the difficulties of defining and modelling the different components of the "true cost" of water. All decisions relating to water resource management and/or regulation should take into account the true cost of water that should include the following:

- Cost of water infrastructures;
- Environmental cost;
- Cost incurred for other possible water uses by the degradation of the resource due to the chosen allocation option (resource cost).

This last component of the water cost is an indicator of the economic impact of a decision on a local society. The conclusion of the presentation was that the economic aspect could be quite complex but the DSS must continue to be user-friendly and deal with low data availability in some case study areas.

Uncertainty in water resource management

Prof. Andreas SCHUMANN exposed problems and options in facing uncertainty in water resource management and the risks involved in forecasting demand and supply. Indicators selected for the evaluation of different water management schemes are outlined in Table 1.

Table 1. Selection of indicators within WSM

Category	Sub-Category	Indicator
Environment/resources	Exploitation	Total water production
		Comsumption index
		Groundwater exploitation index
		Non-sustainable water production index
	Dependencies	Dependence on inter-basin water transfer
		Anthropogenic water produced / total water production
	Water quality	Percentage of treated urban water
		Share of primary treatment
		Share of secondary treatment
		Share of tertiary treatment
Social indicators	Pressures	Agricultural demand per ha
		Tourist per inhabitant
		Water abstractions per capita
	Deficits	Domestic deficit as percentage of demand
		Industrial deficit as percentage of demand
		Environmental deficit as percentage of demand
		Hydropower deficit as percentage of demand
		Irrigation deficit as percentage of demand
Economics		Rate of cost recovery
		Direct costs
		Environmental costs
		revenues

His conclusions were:

- Uncertainty cannot be avoided;
- A comprehensive DSS considers uncertainties explicitly;
- The user should be able to express his opinion about future developments;
- Possibility theory offers a way to consider the personal experience of user.

Challenges and opportunities in comprehensive water management

Prof. Evan VLACHOS described the challenges and opportunities in comprehensive water management through the WaterStrategyMan example. He pointed out the aspects that should be carefully planned when implementing water resources management strategies, focusing on the aspect of public participation and the consultation procedures with local stakeholders.

Discussion – Experts' comments

Three invited experts commented the presentations:

A. MASSARUTO (Dipartimento di scienze economiche - Universita di Udine - Italy) pointed out that every person does not mean the same thing by "Demand Management". It deals with water governance, social demand and availability. He raised the question on which environment functions could be kept and which could be abandoned and how it is possible to compare different values from the different stakeholders and integrate them in the DSS tool. His concluding remark was that we need indicators to give a value to the indicators given by the stakeholders. Their opinions are not explicit values.

Ingo HEINZ (University of Dortmund Institute of Environmental Research - Germany) was impressed by the user interface of the WSM Decision Support System. He mentioned that most of the models of water management are based on hydrologic aspects. The WSM tool integrates for the first time the economic parameters.

Jean-Marie MONGET (Ecole des Mines de Paris - France) was impressed for his part by the complexity of the system. He suggested simplifying the different modules. He proposed to use the GIS in accordance with the Guideline for implementing the GIS Elements of the WFD. He also suggested transferring the data model on GML which would facilitate the development of a web-based tool. He mentioned knowing other systems simpler than this one, for example for petroleum which however is not a renewable resource.

D. ASSIMACOPOULOS mentioned that database has currently been developed in Arc GIS 8.1 and that some elements of the GIS Guidance Document have already been included in the data model.

Antonio MASSARUTO asked about the opinion of the stakeholders for the particular case studies.. He suggested letting them discover the DSS under an open system. Should we support decision? Should we support participation? We could improve the DSS on a mutual benefit.

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Appendix – Individual Papers and Presentations

WATERSTRATEGYMAN PAPER

THE DEFINITION OF THE TRUE COST OF WATER

BY J.M. BERLAND

The definition of the true cost of water and its value, and how this affects the local society

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1 Introduction

The European Water Framework Directive underlines the following principle: *"The use of economic instruments by Member States may be appropriate as part of a programme of measures. The principle of recovery of the costs of water services, including environmental and resource costs associated with damage or negative impact on the aquatic environment should be taken into account in accordance with, in particular, the polluter-pays principle. An economic analysis of water services based on long-term forecasts of supply and demand for water in the river basin district will be necessary for this purpose."*

In its Article 9 relating to recovery of costs for water services, the Water Framework Directive specifies that *"Member States shall take account of the principle of recovery of the costs of water services, including environmental and resource costs, having regard to the economic analysis conducted according to Annex III, and in accordance in particular with the polluter pays principle.*

Member States shall ensure by 2010:

- *that water-pricing policies provide adequate incentives for users to use water resources efficiently, and thereby contribute to the environmental objectives of this Directive,*
- *an adequate contribution of the different water uses, disaggregated into at least industry, households and agriculture, to the recovery of the costs of water services, based on the economic analysis (…) and taking account of the polluter pays principle.*

Member States may in so doing have regard to the social, environmental and economic effects of the recovery as well as the geographic and climatic conditions of the region or regions affected."

All decision relating to water resource management and/or regulation should take into account the true cost of water that should include the following:

- cost of water infrastructures;
- environmental cost;
- cost incurred to the other possible water uses by the degradation of the resource due to the chosen option

This last component of the water cost is an indicator of the economic impact of a decision on a local society. In this regard, the aims of this paper are:

- to give a clear definition of each component of the true cost and to propose an operational and simple formula to calculate it, and
- to discuss advantages and limits of these concepts to characterise the impact of the chosen option.

2 Cost of water infrastructure

The most known component of the water cost is the present average cost of the different infrastructures used for water. The present average cost is composed by:

- Cost of operation;
- Cost of maintenance;
- Depreciation of initial capital investment.

The annual water cost (when there is a sustainable use of the technical systems it is equal to the Cost of sustainability of technical systems) can be calculated using the following formula:

$$C_{CSTS} = \sum_{ij}\left\{C_{i,j}\cdot\left[\frac{(CostRV_i)}{t_i}\right]+CostAO_i+CostAM_i\right\}+\sum_{kj}\left\{TL_{k,j}\cdot\left[\frac{(CostRV_k)}{t_k}\right]+CostAO_k+CostAM_k\right\}$$

where i, k, j the parameters that are presented in Table 1.

Table 1. Parts of infrastructure and different water users

Plant i	Total network length k	Users j
Dams	Water distribution network	Permanent population
Water catchment	Sewer network	Seasonal population
Water treatment plant	Irrigation network	Irrigation
Distribution systems for freshwater treatment		Industry
Waste water treatment plant		Power generation
Distribution systems for waste water treatment		

and:

C_i	:	Capacity of I (in m^3);
$CostRV_i$	:	Replacement value of i (€/m^3);
$CostAO_i$	:	Average Operating Costs of i (in €/m^3/yr);
$CostAM_i$	:	Average Maintenance Costs of i (in €/ m^3/yr);
t_i	:	Depreciation period (useful life) of x (in yrs);
TL_k	:	Total length of network y (in m);

$CostRV_k$	:	Replacement value of network y (in €/m);
$CostAO_k$	:	Average Operating Costs of network y (in €/m/yr);
$CostAM_k$	:	Average Maintenance Costs network y (in €/m/yr);
t_k	:	Depreciation period (useful life) of network y (in yrs);

In most countries, water prices systems just allow the recovery of this part of the cost of water infrastructures. Even in Northern European countries where water prices are higher, farmers don't pay for the depreciation of initial investment made for irrigation infrastructures.

3 Environmental cost

Different methods are developed and applied to assign monetary values on environmental services. Economic valuation, at the conceptual level is said to be a measure of the preference people hold for different states of the environment. Valuation, as an empirical exercise, rests on the argument that choices individuals make in market exchanges provide the data that analysts can use to translate people preferences into money terms.

Available methods for estimating environmental cost

Different methods can be used:

MARKET METHODS (used as a technique for the valuation of environmental costs and benefits): These methods use values from prevailing prices for goods and services traded in markets. Values of goods in direct markets are revealed by actual market transactions and reflect changes in environmental quality; for example, lower water quality affects the quality of shellfish negatively and hence its price in the market.

Cost-based valuation methods (used as a technique for the valuation of environmental costs and benefits): This method is based on the assumption that the cost of maintaining an environmental benefit is a reasonable estimation of preventive and / or mitigation measures. This assumption is not necessarily correct. Mitigation may not be possible in all cases, for example, in cases where actual mitigation cost could be an underestimation of true environmental cost. On the contrary, mitigation measure might not be cost-effective and these costs might be an over-estimation of environmental costs. A distinction needs to be made between:

- The costs of measures already adopted, which are theoretically already included in financial cost category. These costs should be reported as a distinct financial cost category. Counting them as environmental costs would be double counting.
- The costs of measures that need to be taken to prevent environmental damages up to a certain point, such as the Directive Objectives. These costs can be a good estimate of what society is willing to forego.

Revealed preference methods (used as a technique for the valuation of environmental costs and benefits): The underlying assumption is that the value of goods in a market reflects a set of environmental costs and benefits and that it is possible to isolate the value of the relevant environmental values. These methods include recreational demand methods, hedonic pricing models and averting behaviour models:

Hedonic Pricing: Hedonic pricing methods explain variation in price (in the price of goods) using information on "qualitative and quantitative" attributes. They are used in the context of water to value how environmental attributes and changes affect property prices. In addition to structural features of the property, determinants of property prices may include proximity to, for example, a river or lake. The change in property price corresponding to an environmental degradation, for example the pollution of a river or lake, is the cost of this degradation.

Averting Behaviour: this method derives from observations of how people change defensive behaviour – adapt coping mechanisms – in response to changes in environmental quality. Defensive behaviour can be defined as measures taken to reduce the risk of suffering environmental damages and actions taken to mitigate the impact of environmental damages. The costs for mitigating the impact may entail expenditure on medical care needed as a consequence of drinking poor quality water. The expenditure produces a value of the risk associated with the environmental damage.

Recreation Demand Models (RDM): Improvements or deterioration in the water quality may enhance or reduce recreation opportunities, for example swimming, in one or more sites in a region. However, markets rarely measure the value of these changes. RDM can be used on the choices of trips or visits to sites for recreational purposes and the level of satisfaction, time and money spent in relation to the activity. By assuming that the consumer spends time and money as if he was purchasing access to the goods, for example a river stretch, patterns of travel to particular sites can be used to analyse how an individual values the site and, for example, the water quality of the river stretch. Reductions in trips to a river due to deterioration of water quality and associated changes in expenditures reveal the cost of this deterioration.

STATED PREFERENCE METHODS (used as a technique for the valuation of environmental costs and benefits): These methods are based on measures of willingness to pay through directly eliciting consumer preference on either hypothetical or experimental market. For hypothetical market, data are drawn from surveys presenting a hypothetical scenario to the respondents. The respondents make a hypothetical choice, which is used to derive consumer preferences and value. Methods include contingent valuation and contingent ranking. It is also possible to construct experimental market where money changes hand, e. g. using simulated market models. In the questionnaire, it is possible to ask respondents how much they would pay for avoiding an environmental cost or how much they value a given environmental benefit.

Contingent Valuation: Contingent Valuation is based on survey results. A scenario including the good that would be delivered and how it would be paid for (e.g. through an increase of the water bill) is presented to the respondent. Respondents are asked for their willingness to pay (WTP) for the specified good. The mean willingness to pay is calculated to give an estimated value of the good. One of the difficulties with this approach lies in ensuring that respondents adequately understand the environmental change that is being valued.

Use of Value Transfer (alternative option to direct valuation of environmental costs or benefits - more commonly known as benefit transfer in the case of benefits): This method uses information on environmental costs or benefits from existing studies and uses this information for the analysis in the river basin under consideration. As a result, a data set that has been developed for a unique purpose is being used in an application for a different purpose, i.e. it transfers values from a study site to a policy site, i.e. from the site where the study has been conducted to the site where the results are used. Above all, benefit transfer is suitable when technical, financial or time resources are scarce. However, among other problems, it is important to note that since benefits have been estimated in a different context they are unlikely to be as accurate a primary research. A step-wise approach should be developed in order to ensure that the transfer of values derived in other contexts could minimise the potential for estimation errors.

Methodological difficulties

There are a lot of methodological difficulties in applying Environmental Valuation methods because such methods deal with goods which are:

- **Non-Market Goods**: Clean water in environment is not traded in markets. Its monetary value is not revealed in market prices. The only option for assigning monetary values is to rely on non-market valuation methods.
- **Non-Rival Goods**: One person's consumption of most goods (apples or housing) reduces the amount available for everyone else. Environmental goods are different. Clean water, beautiful views, and some extent outdoor recreation, can be enjoyed by everyone in the same way as radio and television. The economic value of non-rival or public goods is the sum of all people's willingness to pay.
- **Non-exclusive Goods**: People cannot be excluded from enjoying most environmental goods and the cost of trying to exclude them is prohibitive.
- **Inseparable Goods**: Conservation practices at a given site contribute in many roundabout ways to environmental goods and result in environmental and economic benefits that accrue over great distances in time and space. It may be impossible to separate the economic benefits that result from one conservation practice undertaken at one site from another undertaken at another site. Worse, it may be impossible to separate the aggregate benefits of those practices from those of other environmental investments.

A discussion on methods for the estimation of environmental costs

In addition to the above-mentioned methodological difficulties, there is more fundamental criticism on Economic Valuation Methods.

Economic valuation, at the conceptual level, is said to be a measure of the preferences people hold for different states of the environment. Valuation, as an empirical exercise, rests on the argument that choices individuals make in markets exchange provide the data which analysts can use to translate people's preference into money terms (SHABMAN Leonard and STEPHENSON Kurt – 2000).

The logic of the argument is straightforward. In market exchange money income is sacrificed (a price is paid) in order to secure a good or service. By arguing that preferences guide market choices, analysts conclude that the money value of a good or service is at least equal to the amount of income a person spends to obtain the good or service. Thus market prices are the raw data for preference measurement. The often-explicit premises of this revealed choice framework are that individuals know their preference for goods and services (states of the world) before being confronted with choice, that people are willing to pay to satisfy those preferences, and whatever an individual chooses is in the interest of that individual (RANDAL and PETERSON – 1984). It is the benefit-cost analysts' responsibility to measure those preferences in money terms (RANDAL – 1999).

Not all economists support the expanded use of non-market valuation calculation in policy. These critics are supported by concerns about non-market valuation expressed by psychologists, philosophers, and political scientists who are familiar with the valuation research program. In general, the critics question one, or both, of two core assumptions:

- that choices made in real or hypothetical market can be interpreted as a reflection of preferences or value;
- that such interpretations should direct decision-making (SHABMAN Leonard and STEPHENSON Kurt – 2000).

4 A limited but operational method: mitigation cost

An operational method that can be used for the estimation of environmental cost is a *Cost-based* valuation method; in particular the selected approach takes into account the costs of measures that need to be taken in order to prevent environmental damage up to a certain point or the measures needed to meet the Directives' Objectives. The assumption made is that these costs can be a good estimate of what society is willing to forego. According to this assumption, the following equation should be used.

$$\text{costs of preventive and/or mitigation measures} \cong \text{environmental costs}$$

However, the approximation of environmental cost through the cost of mitigation measures may not be possible in all cases as for example, in cases where current mitigation cost could be an underestimation of true environmental cost. On the opposite, a mitigation measure might not be cost-effective and mitigation costs might be an over-estimation of environmental cost.

For one year period, the following equation can be used for the estimation of environmental cost:

$$\mathrm{C_{Env}} = \sum_{xy}\left\{C_{x,y}\cdot\left[\frac{(CostRV_x)}{t_x}\right]+CostAO_x+CostAM_x\right\}+\sum_{zy}\left\{TL_{z,y}\cdot\left[\frac{(CostRV_z)}{t_z}\right]+CostAO_z+CostAM_z\right\}-C_{CSTS}$$

where x and z stand for the parts of infrastructure needed to maintain the environmental benefit of keeping the same quantity of water available per capita for each user y with a quality in compliance with the current legislation. Those are outlined in Table 2.

Table 2. Parts of infrastructure needed to maintain the environmental benefit of keeping the same quantity of water available per capita

Plant x	Total network length z	Users y
Dams	Water distribution net	Future permanent population (based on a scenario)
Water catchment	Sewer network	Future seasonal population (based on a scenario)
Water treatment plant	Irrigation network	Future needs for irrigation (based on a scenario)
Distribution systems for freshwater treatment		Future needs for industry (based on a scenario
Waste water treatment plant		Future needs for power generation (based on a scenario)
Distribution systems for waste water treatment		

and:

C_x : Capacity of x (in m^3);

$CostRV_x$: Replacement value of x (€/m^3);

$CostAO_x$: Average Operating Costs of x (in €/m^3/yr);

$CostAM_x$: Average Maintenance Costs of x (in €/ m^3/yr);

t_x : Depreciation period (useful life) of x (in yrs);

TL_y : Total length of network y (in m);

$CostRV_y$: Replacement value of network y (in €/m);

$CostAO_y$: Average Operating Costs of network y (in €/m/yr);

$CostAM_y$: Average Maintenance Costs network y (in €/m/yr);

t_y : Depreciation period (useful life) of network y (in yrs);

It should however be noted that if local data, provided by a scientific willingness-to-pay survey for the conservation of the resource, are available, it is preferable to use the outcome of this survey as an indicator of environmental cost.

5 Water allocation: Is the opportunity cost doctrine operational to assess the economic impact of a decision on a local society?

A simple concept but…

Another part of the real cost of water is cost induced for the activities B, C, D… by the use of water resource caused by the activity A. Opportunity cost is defined as the cost of any activity measured in terms of the benefit from the best alternative forgone (Chris Rodda: http://www.cr1.dircon.co.uk/TB/1/1.1.3.htm – 2003)

Eli Feinermann (Deliverable 7, WSM project – 2002) gives the following example to illustrate the application of opportunity cost doctrine in water management: *"If farmer A will increase water use by 1 cubic meter, the amount of water available for farmer B will decrease by 1 cubic meter. The reduction in the* **value** *of production on farm B is the cost to society resulting from the increased water use on farm A. Similarly, the reduction in the value of production on farm A is the cost to society resulting from the increased water use on farm B. This cost, which is equal to P dollars per cubic meter, is an* **opportunity cost** *– the benefits forgone when a scarce resource is used for one purpose instead of the next best alternative."* **An important comment: It should be emphasised that ALL costs in the economy are always "opportunity costs": energy, capital and labour used to extract and convey water to farm A are not available to serve farm B and do not contribute to its production. But, for the sake of presentation, we will adopt the commonly used term of "direct costs" to represent here the costs of the relevant inputs (like energy, capital, labour, etc.) that can be bought in the markets and their prices are known. The input "natural stock of water in the lake" is the only input in our example that cannot be purchased in the markets.** In this example, where the direct pumping and conveyance costs are assumed to be zero, the opportunity costs is also the **scarcity rent** of water -- rent (per unit) of a scarce resource (water in our case) is a surplus, the difference between the opportunity cost of water (equal to the market cleaning price P) and the per unit (marginal) direct costs (such as extraction, treatment, environmental and conveyance) of turning that natural resource into relevant products (agricultural crops in our example). The scarcity rent is the result of the fact that the total amount of water in the lake is scarce (the **total** annual demand for water by the two plots, at zero cost, is greater than the available supply) and is limited to $\bar{Q}$. In our example, the optimal price, P, is also the **scarcity rent** of water since reduction of 1 cubic meter of the limited supply $\bar{Q}$ will reduce the value of products in the (two-farm) economy by P dollars. **In case that water in the lake is not limited—the opportunity costs and the scarcity rent are zero.** (WaterStrategyMan – 2002)

Using opportunity cost doctrine seems to be very interesting for company's decision-making processes, when decision makers have to choose between **only** two options. But what is the efficiency of this doctrine to understand the economic impact of a decision (allocation of X m^3 of water to the activity A) on a local society (cost induce by the lost of these X m^3 for the activities A, B, C…) ? Until now we did not find any application of this doctrine in such complex situation and these other short definition of opportunity cost show us that this concept seems to be a good concept (but only a concept?) when you have to deal between only two options:

"Opportunity cost is defined as the advantage forgone as the result of the acceptance of **an** alternative. It is measured as the benefits that would result from **the next best** alternative use of the same resources that were rejected in favour of the one accepted. **Opportunity cost is difficult, perhaps impossible, to measure precisely.** (International Institute for Applied System Analysis) (Source: http://pespmc1.vub.ac.be/ASC/OPPORT_COST.html) "

What can be done now?

The aim of the utilisation of concepts such as the opportunity cost and scarcity rent is to place monetary values on the impact cause by use A on the other uses B, C, D, etc. It appears however that it would be very difficult to find a simple formula to express in monetary terms this kind of cost. Another option is to organise a panel of experts of a local society to fill in the following table to qualify the level of the scarcity rent.

Table 3. Sample Questionnaire for the estimation of opportunity costs

It has been decided to allocated X m3 to the following user, Volumes are distributed as follow		At the local level, the inconvenience for following uses will be…				
		Permanent population	Tourism	Irrigation	Industry	Power generation
	Xa permanent population		☐ very high ☐ high ☐ average ☐ low ☐ very low	☐ very high ☐ high ☐ average ☐ low ☐ very low	☐ very high ☐ high ☐ average ☐ low ☐ very low	☐ very high ☐ high ☐ average ☐ low ☐ very low
	Xb tourism	☐ very high ☐ high ☐ average ☐ low ☐ very low		☐ very high ☐ high ☐ average ☐ low ☐ very low	☐ very high ☐ high ☐ average ☐ low ☐ very low	☐ very high ☐ high ☐ average ☐ low ☐ very low
	Xc irrigation	☐ very high ☐ high ☐ average ☐ low ☐ very low	☐ very high ☐ high ☐ average ☐ low ☐ very low		☐ very high ☐ high ☐ average ☐ low ☐ very low	☐ very high ☐ high ☐ average ☐ low ☐ very low
	Xd for industry	☐ very high ☐ high ☐ average ☐ low ☐ very low	☐ very high ☐ high ☐ average ☐ low ☐ very low	☐ very high ☐ high ☐ average ☐ low ☐ very low		☐ very high ☐ high ☐ average ☐ low ☐ very low
	Xe power generation	☐ very high ☐ high ☐ average ☐ low ☐ very low	☐ very high ☐ high ☐ average ☐ low ☐ very low	☐ very high ☐ high ☐ average ☐ low ☐ very low	☐ very high ☐ high ☐ average ☐ low ☐ very low	

Note that: $X = X_a + X_b + X_c + X_d + X_e$

6 A great concern: the impact of full cost recovery in south European local societies.

All this discussion relating to the estimation of different components of water cost is essential for two aspects:

- The economic evaluation of the different options (calculation of the cost benefit balance[1]);
- The determination of the true cost of water to calculate the right price every user should pay with cost recovery principle.

The fact that nobody manages to integrate the notion given by opportunity cost / scarcity rent into these calculations of cost and the fact that there is a lot of imprecision on the estimation of environmental cost may be considered as an obstacle for the implementation of cost recovery principle and a limit to a serious economic evaluation.

This vision must be moderated by the following observations:

1) taking into account all the components of cost of infrastructure (cost of operation; cost of maintenance; depreciation of initial investment) and even just a part of the environmental cost would be a very important evolution compared to present practices;
2) the integration of all these costs should have a great impact on the water price for the different users. This could have some very important consequences for local societies and this impact should be evaluated;
3) there is a need of a real reflection on the assumption that says that the integration of the opportunity cost/ scarcity rent will be a real progress for water management and local societies.

We underlined that in most countries, water prices systems just allow the recovery of a part of the cost of water infrastructures. Even in Northern European countries, where water prices are higher, farmers don't pay for the depreciation of initial capital investments made for irrigation infrastructures. The considerable rises of the cost of water that would be caused by the integration of the total cost of water infrastructures and a part of environmental cost in water price will most probably threaten different users and particularly farmers.

If farmers can't pay for water and if this would cause a decrease of the agricultural population, what should be the social cost and the environmental cost of this decrease? Agricultural employment is very important in local societies of arid areas in Southern European countries and original landscapes which make these areas a popular tourist destination are often the result of current agricultural practices. If the rise of the water prices is too high and damaging to the local economic equilibrium, the price to pay for the cost recovery of water cost maybe too important.

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[1] Benefit-cost Balance (BCBalance) should be calculated by the following formula

$$BCBalance = \frac{\left(\sum_{t=0}^{T} \frac{B_t}{(1+d)^t}\right) - \left(\sum_{t=0}^{T} \frac{C_t}{(1+d)^t}\right)}{\left(\sum_{t=0}^{T} \frac{C_t}{(1+d)^t}\right)}$$

Where :
the planning period begins in the current year, t = 0, and extends to some future planning horizon T (in years) ;
B = total benefit in the subcripted year (in €) ;
C = total cost in the subcripted year (in €) ;
d = discount rate expressed in decimal form

Sometimes the application of cost-recovery principle can have counterproductive effects. For example, in an area near Montpellier, France, the drinking water price rose considerably just after the integration of the cost recovery principle. A considerable reduction of drinking water consumption occurred. We may say “a too important reduction” because now the local water service does not sell enough water to have a sufficient income for maintaining infrastructure. A very detailed scientific enquiry was realised to understand the importance of the consumption decrease and it shows the following user’s behaviour change. Of course some people reduced the use of drinking water for gardening. But this was not the main cause of the drastic reduction of consumption. A large proportion of people found other sources of water (recovery of rainwater, drilling, well, connection to rough water networks…). Some of these “solutions” like drilling and well induce an uncontrolled abstraction of water that could be non-sustainable at the local level in arid areas. In this particular case, the strict application of the cost recovery principle has the following results: drastic reduction of water service budget and emergence of non-sustainable practices… This is definitely not a dream for economists and planners.

Before every decision related to water pricing, a real and serious study must be conducted on the affordability of the projected tariff system. Omitting this step may have some serious environmental and social consequences on local societies in arid areas. A too simplified application of economic principles can seriously damage local economy. One of the major challenges of the application of the cost recovery principle is to prevent such a situation.

7 Acknowledgements

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PRESENTATION 1

PRESENT INTEGRATED WATER RESOURCES MANAGEMENT AND THE SCOPE OF THE WSM PROJECT

BY B. BARRAQUE

LATTS

Integrated Water Resources Management today
and the scope of the WSM project

Bernard Barraqué, DR CNRS
Laboratory Technology Territories & Societies

WaterStrategyMan Paris meeting October 2003

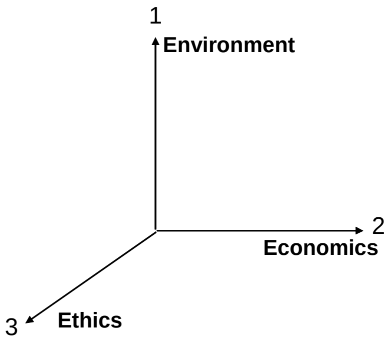
LATTS

Water crisis or water policy crisis?

- Hydrologists, géographers & engineers often stay on the supply side, with the « basic needs figure of 1000 to 1500 m3/cap/yr
- Media & « demagogic conservatives » amalgamate privatisation of resources (water markets) and privatisation of services
- Ecologists oppose hydraulic projects for their environmental impacts, but they have no economic and social analysis
- **And** environmental economists often want to apply their toolbox to a sector which is very specific (high capital costs, long term life), and poses serious problems.

LATTS

The Water Framework Directive & the 3 E's



1 – **Aquatic environment :** good ecological & chemical status within 15 years

2 – **Economic objective:** water users should pay the full cost of the water services

3 – **Acceptability:** water policy should be transparent and public must be invited to participate

Not easy to implement!

LATTS

Economists and Natural Resources

- Néo-classical economists: scarcity handled through markets
- Externalities (A. Marshall) and their taxation (A. Pigou)
- R. Coase's answer: less State and more bargaining
- Tragédy of the Commons (G. Hardin) : privatisation
- S. Ciriacy Wantrup's answer, natural resources economics
- The transaction costs problem and institutions for the management of common property (E. Ostrom)

LATTS

The Spirit of WSM project

- Focuses on the second axis of sustainability: economics
- Tries to help water managers rationalise water resources allocation through introduction of « demand management »
- Typically, economists consider that « demand side » is synonym to full cost pricing, i.e. marginal internal costs (incl. depreciation) + marginal environmental costs + marginal user / resource costs
- Ideally, these 3 dimensions do correspond to the 3 E 's, but there are many implementation difficulties (see Wateco group)
- WSM is not pure economics ; rather focuses on a comparison of various technical possibilities for matching supplies & demands

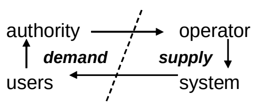
LATTS

The 3 Ages of Water Industry

Thomas Hughes and the Reverse Salient

- Until recently in history, **water uses were almost only instream** uses, but in the XIXth century, there are increasing types and quantities of abstractions and consumptive uses
- **Age of Quantity and Civil Engineering**
  more from further, and cheap money
- Model starts with public water supply, but extends to other uses with the **Multipurpose projects**, in particular to irrigation

The crisis comes
with explosive effects



LATTS

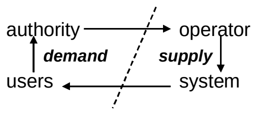
The 3 Ages of Water Industry
continued

- **Age of Quantity and Civil Engineering**
  more from further, and cheap money

is then supplemented with the:

- **Age of Quality and Chemical/Sanitary Engineering**
  closer and cleaner; operating costs grow and pricing the service becomes acceptable

The crisis continues with explosive effects, this time in quality



LATTS

The 3 Ages of water industry
(end)

- **Age of quantity and of quality were on the supply side**

The crisis then leads to:

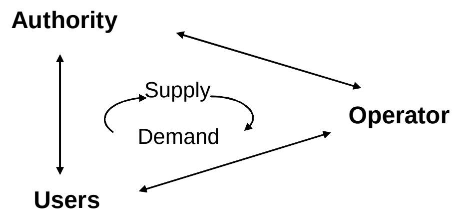
- **Age of Territorial Heritage and Environmental Engineering**
  demand side management;
  water conservation;
  water allocation flexibilisation;
  land use policies
  From farmer better than from further!

- **But policies of the previous ages are still available: typically, sea water desalination**

LATTS

Towards environmental engineering: what is demand management?

It is the governance of the interaction between supply and demand



LATTS

Examples of WSM-type demand side

- Water conservation in each sector is usually the cheapest way to liberate extra water. Pricing is not necessarily the best way: information campaigns and incentives to change facilities are frequent
- Desalination is at the edge of demand side, because it has low investment but high operations costs, which are easierly passed on to consumers. Waste water reuse is on demand side (dual)
- Reallocation of irrigation water to water supplies is very interesting because of difference of value of water and conversely of quantities used/polluted
- But differentiate between occasional/structural deficit situation, and avoid the dispaition of farmers (landscape & erosion issue)

LATTS

Conclusion

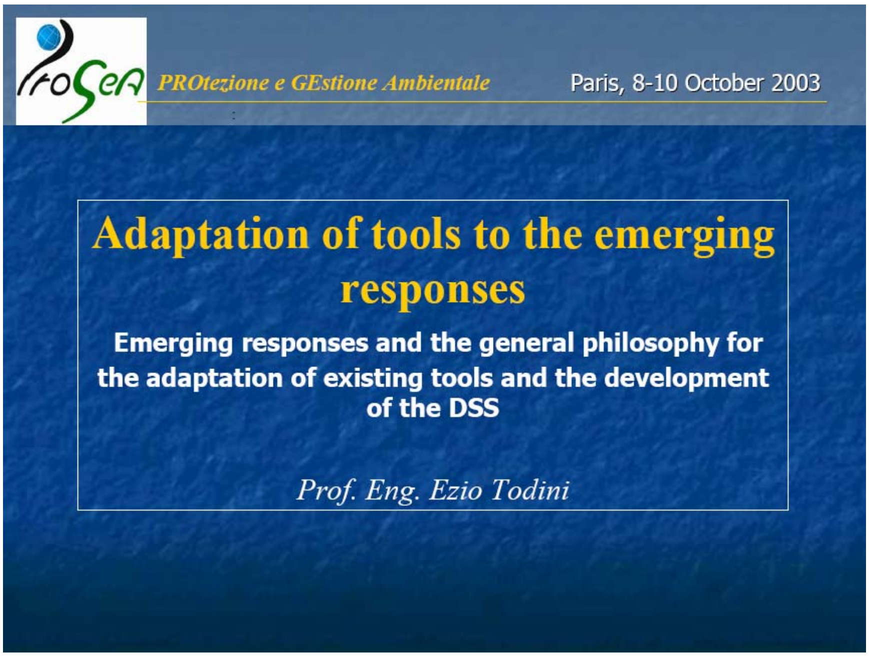
- The master State increasingly considered Undemocratic, which implies a new balance between sovereignty and efficiency
- Market mechanisms and excessive commodification destroy confidence
- When a given system is not mature: cost recovery impossible
- Learning and decision together through community and customary approaches: implications for DSS
- Environmental engineering needs social science

- ***Thank you***

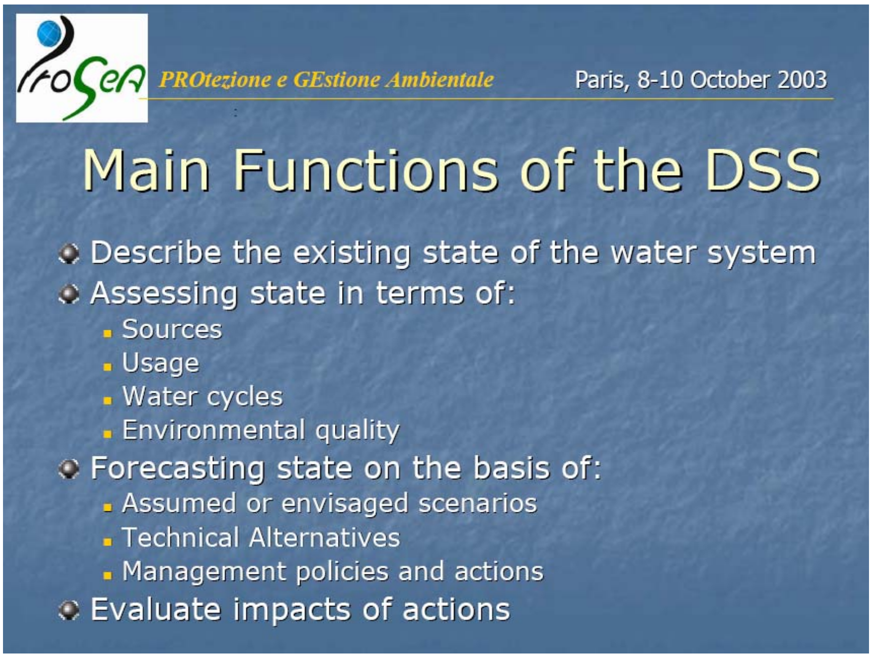
PRESENTATION 2

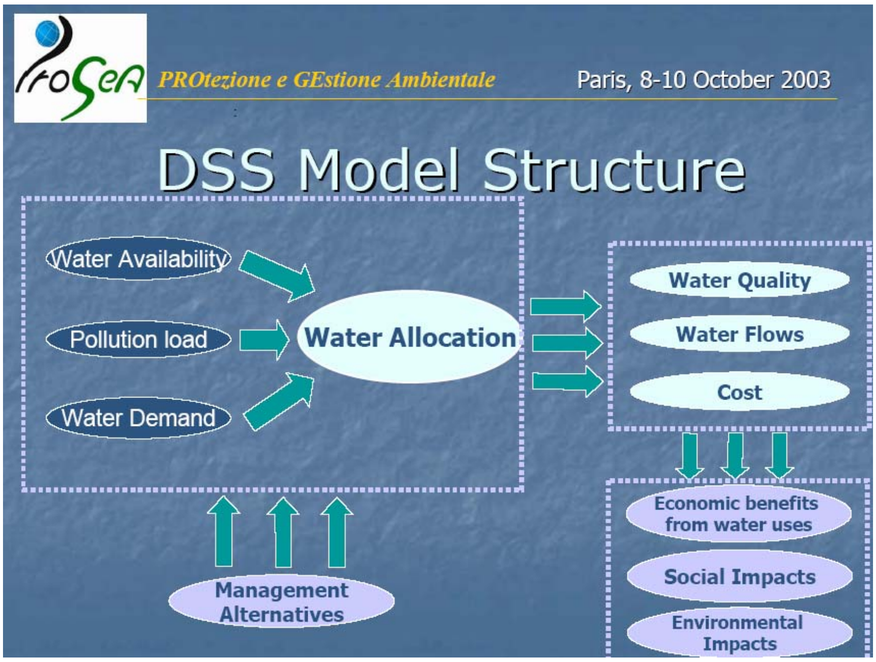
SUPPORTING DECISION MAKERS IN DEVELOPING WATER RESOURCES STRATEGIES: THE WSM APPROACH AND METHODOLOGY

BY E. TODINI


PROtezione e GEstione Ambientale
Paris, 8-10 October 2003
Adaptation of tools to the emerging responses
Emerging responses and the general philosophy for the adaptation of existing tools and the development of the DSS
Prof. Eng. Ezio Todini


PROtezione e GEstione Ambientale
Paris, 8-10 October 2003
Objectives of the DSS
To support the strategy analysis at regional level
To compare strategies on the basis of different indicators
To help decision-makers to decide upon the best strategy, taking into account:
Regional development priorities
Social and economic constraints
Environmental constraints
Local, national or international
legal constraints and directives


ProGeA
PROtezione e GEstione Ambientale
Paris, 8-10 October 2003
Main Functions of the DSS
Describe the existing state of the water system
Assessing state in terms of:
Sources
Usage
Water cycles
Environmental quality
Forecasting state on the basis of:
Assumed or envisaged scenarios
Technical Alternatives
Management policies and actions
Evaluate impacts of actions


ProGeA
PROtezione e GEstione Ambientale
Paris, 8-10 October 2003
DSS Model Structure
Water Availability
Pollution load
Water Demand
Water Allocation
Water Quality
Water Flows
Cost
Economic benefits from water uses
Social Impacts
Environmental Impacts
Management Alternatives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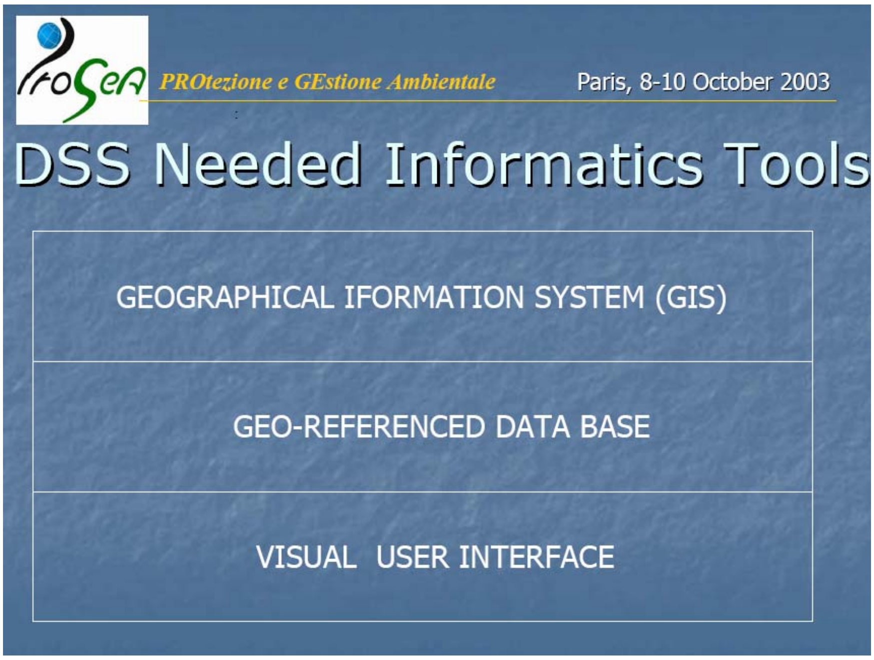
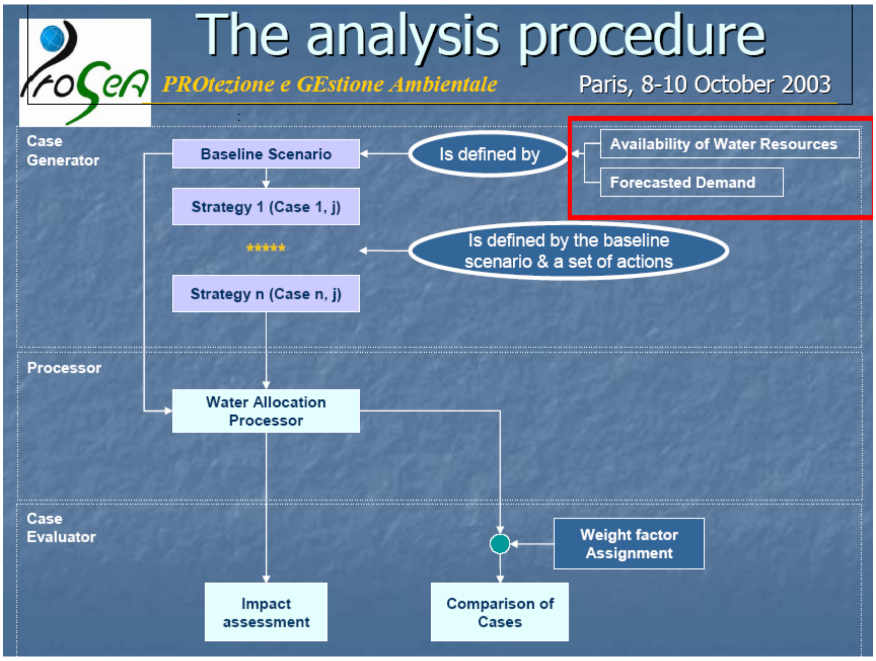
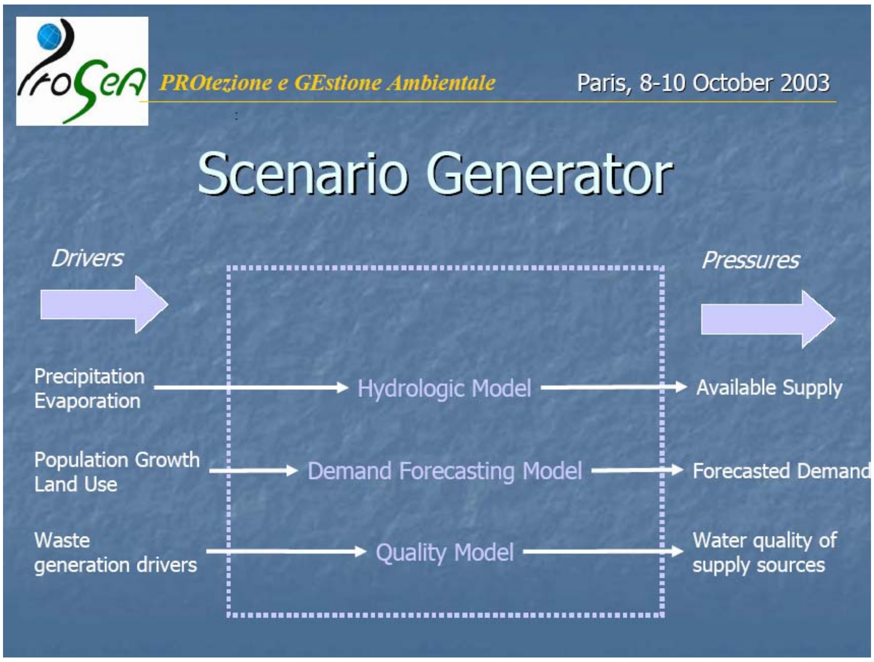
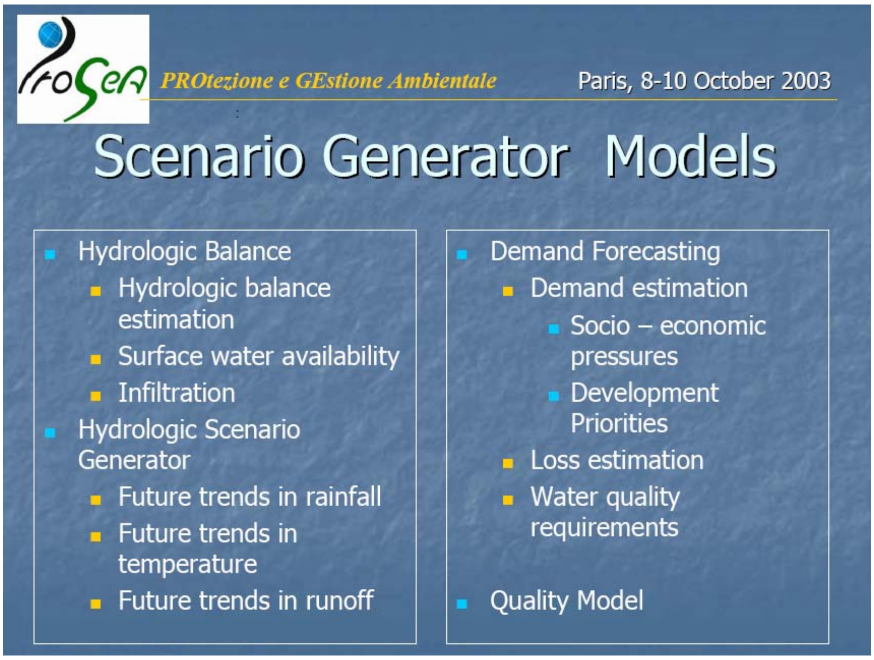
DSS Needed Components
I
BASIC DATA TREATMENT MODULE
II
CASE GENERATOR
III
WATER ALLOCATION MODULE
IV
ALTERNATIVES EVALUATION MODULE


PROtezione e GEstione Ambientale
Paris, 8-10 October 2003
DSS Needed Informatics Tools
GEOGRAPHICAL IFORMATION SYSTEM (GIS)
GEO-REFERENCED DATA BASE
VISUAL USER INTERFACE


The analysis procedure
PROtezione e GEstione Ambientale
Paris, 8-10 October 2003
Case Generator
Baseline Scenario
Is defined by
Availability of Water Resources
Forecasted Demand
Strategy 1 (Case 1, j)
*****
Is defined by the baseline scenario & a set of actions
Strategy n (Case n, j)
Processor
Water Allocation Processor
Case Evaluator
Weight factor Assignment
Impact assessment
Comparison of Cases

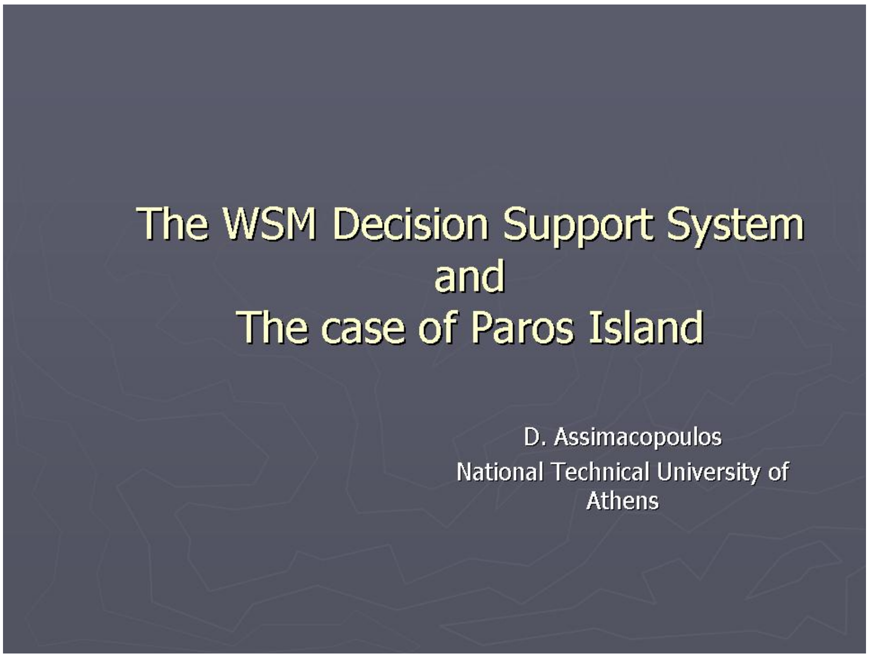

PROtezione e GEstione Ambientale
Paris, 8-10 October 2003
Scenario Generator
Drivers
Pressures
Precipitation
Evaporation
Hydrologic Model
Available Supply
Population Growth
Land Use
Demand Forecasting Model
Forecasted Demand
Waste
generation drivers
Quality Model
Water quality of supply sources


ProGeA
PROtezione e GEstione Ambientale
Paris, 8-10 October 2003
Scenario Generator Models
Hydrologic Balance
Hydrologic balance estimation
Surface water availability
Infiltration
Hydrologic Scenario Generator
Future trends in rainfall
Future trends in temperature
Future trends in runoff
Demand Forecasting
Demand estimation
Socio – economic pressures
Development Priorities
Loss estimation
Water quality requirements
Quality Model

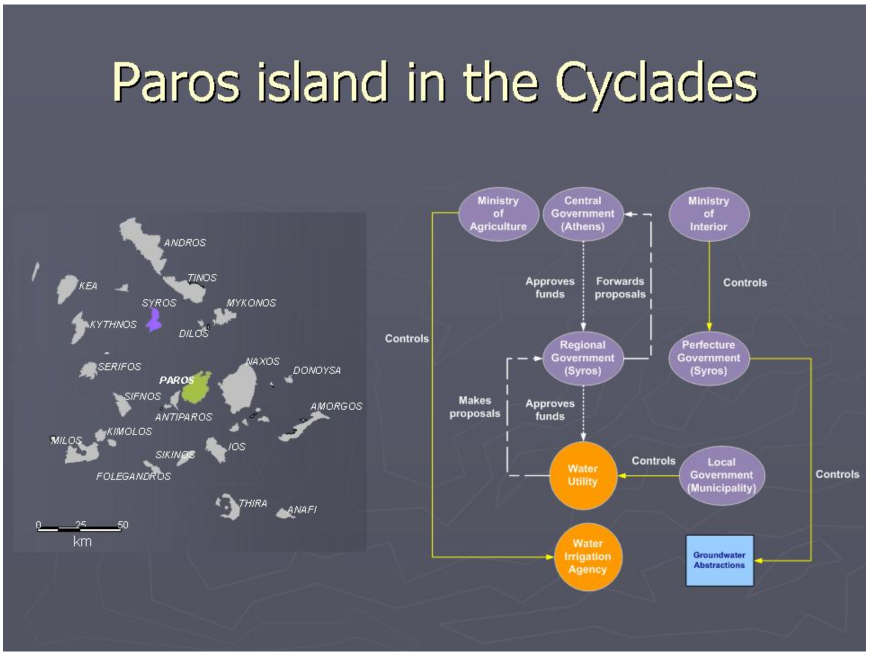
PRESENTATION 3

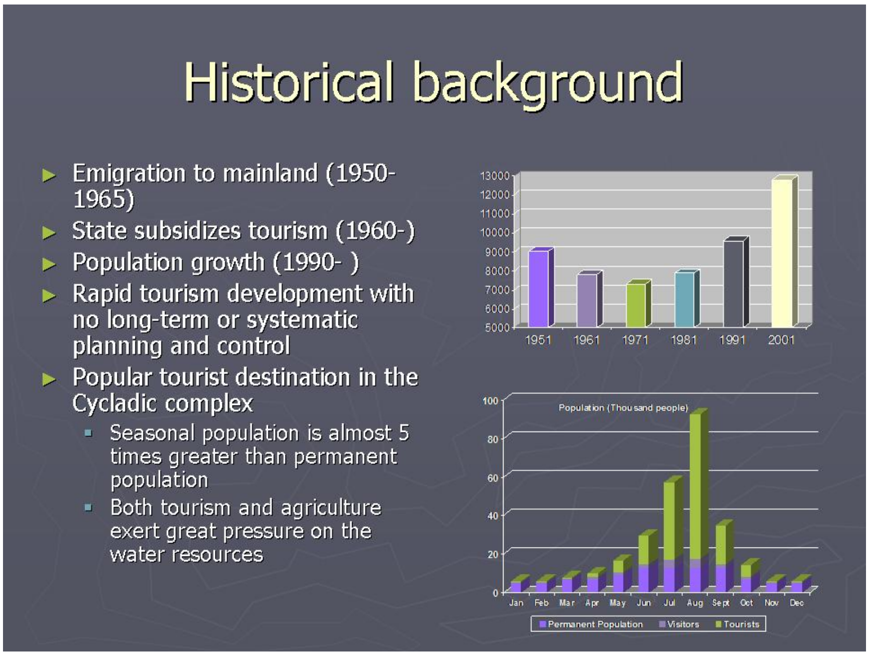
THE WSM DECISION SUPPORT SYSTEM AND THE PAROS CASE STUDY

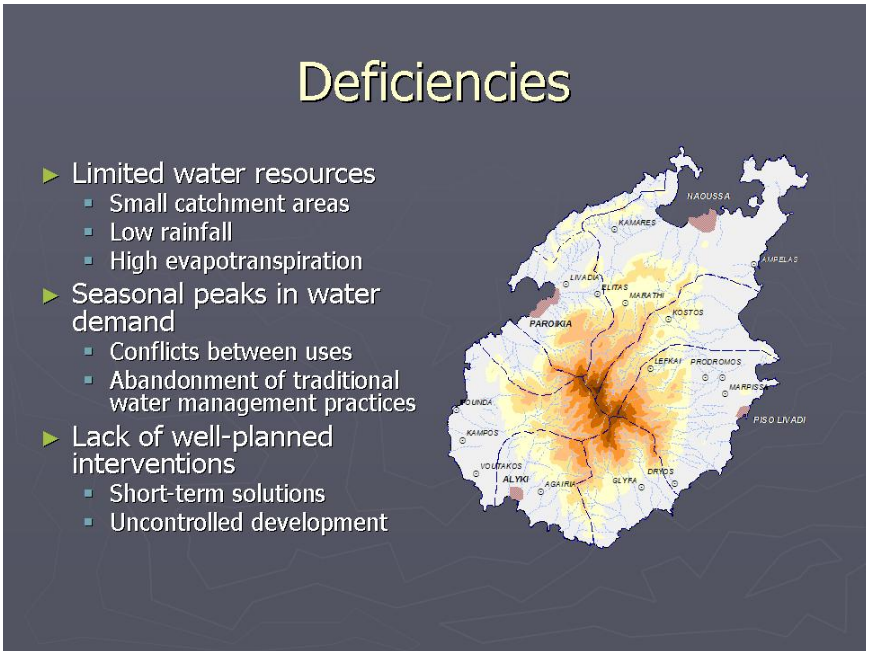
BY D. ASSIMACOPOULOS

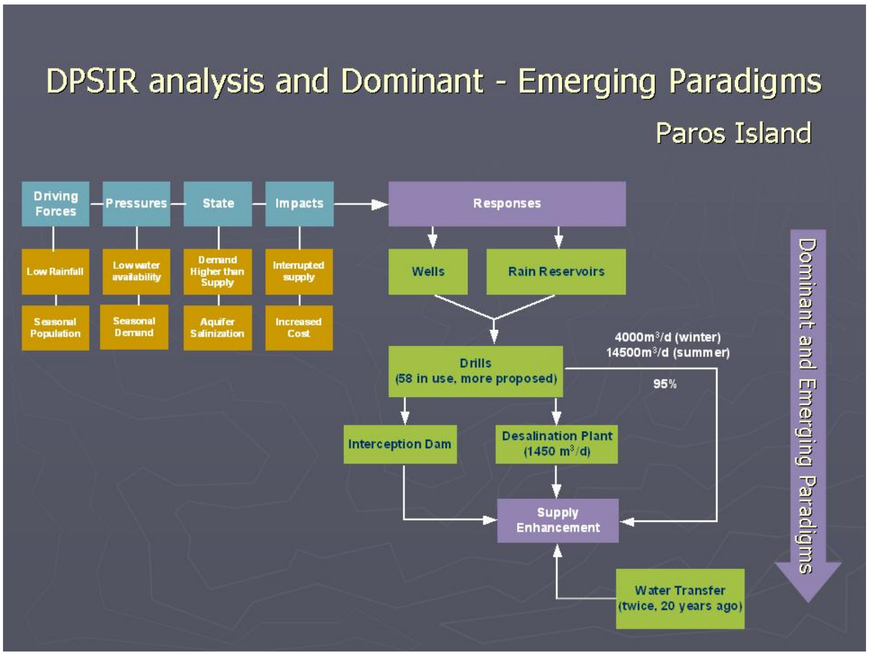

The WSM Decision Support System
and
The case of Paros Island
D. Assimacopoulos
National Technical University of Athens


The Cyclades in Greece
Athens
Cycladic Complex
0 100 200 km

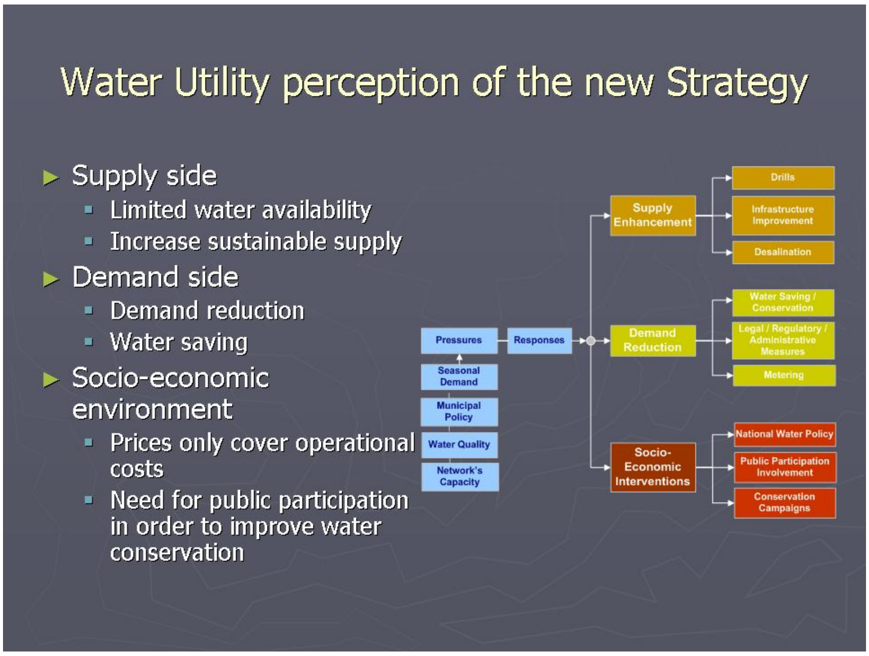

Paros island in the Cyclades
ANDROS
TINOS
KEA
SYROS
MYKONOS
KYTHNOS
DILOS
SERIFOS
NAXOS
DONOYSA
PAROS
SIFNOS
AMORGOS
ANTIPAROS
KIMOLOS
MILOS
IOS
SIKINOS
FOLEGANDROS
THIRA
ANAFI
0 25 50
km
Ministry of Agriculture
Central Government (Athens)
Ministry of Interior
Approves funds
Forwards proposals
Controls
Controls
Regional Government (Syros)
Perfecture Government (Syros)
Makes proposals
Approves funds
Water Utility
Controls
Local Government (Municipality)
Controls
Water Irrigation Agency
Groundwater Abstractions

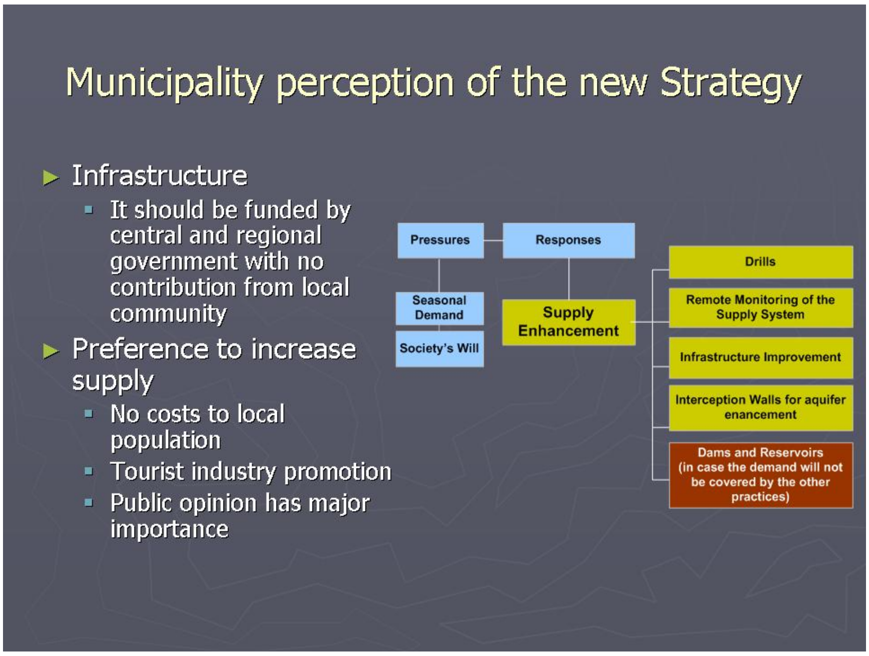

Historical background
Emigration to mainland (1950-1965)
State subsidizes tourism (1960-)
Population growth (1990-)
Rapid tourism development with no long-term or systematic planning and control
Popular tourist destination in the Cycladic complex
Seasonal population is almost 5 times greater than permanent population
Both tourism and agriculture exert great pressure on the water resources
13000
12000
11000
10000
9000
8000
7000
6000
5000
1951 1961 1971 1981 1991 2001
Population (Thousand people)
100
80
60
40
20
0
Jan Feb Mar Apr May Jun Jul Aug Sept Oct Nov Dec
Permanent Population
Visitors
Tourists

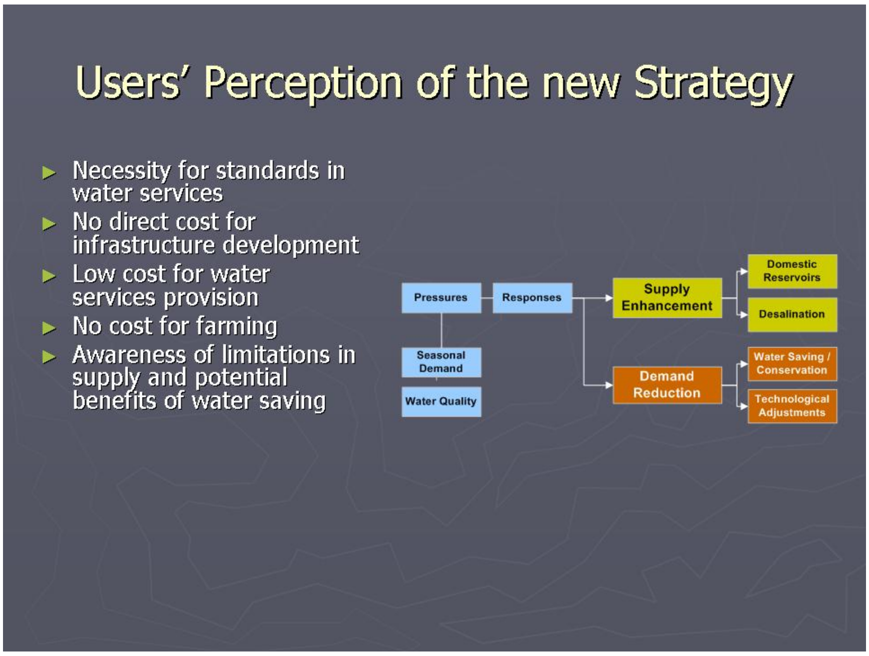

Deficiencies
► Limited water resources
▪ Small catchment areas
▪ Low rainfall
▪ High evapotranspiration
► Seasonal peaks in water demand
▪ Conflicts between uses
▪ Abandonment of traditional water management practices
► Lack of well-planned interventions
▪ Short-term solutions
▪ Uncontrolled development
NAOUSSA
KAMARES
AMPELAS
LIVADIA
ELITAS
MARATHI
KOSTOS
PAROIKIA
LEFKAI
PRODROMOS
MARPISSA
PISO LIVADI
KAMPOS
VOUTAKOS
ALYKI
GLYFA
DRYOS

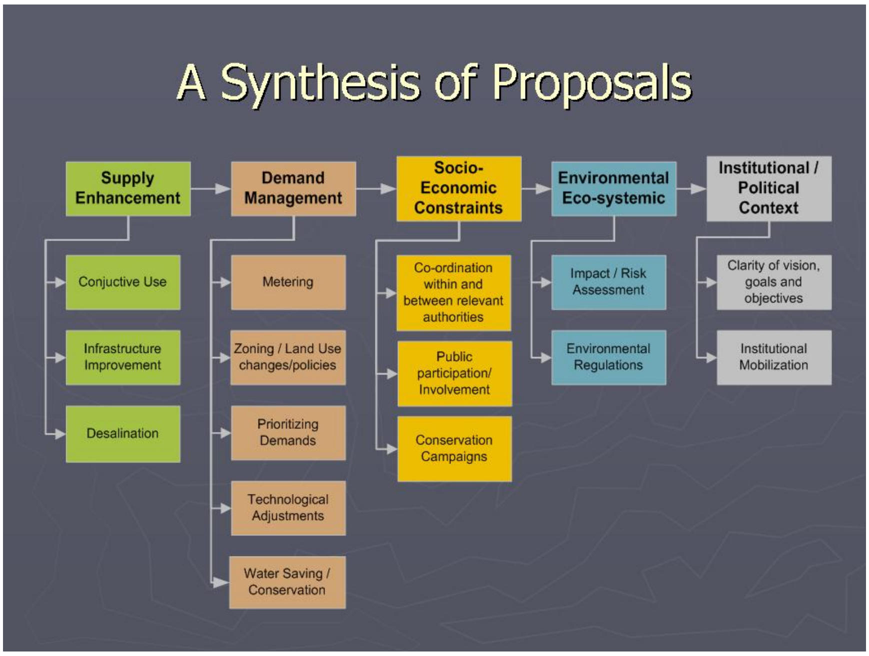

DPSIR analysis and Dominant - Emerging Paradigms
Paros Island
Driving Forces
Pressures
State
Impacts
Responses
Low Rainfall
Low water availability
Demand Higher than Supply
Interrupted supply
Seasonal Population
Seasonal Demand
Aquifer Salinization
Increased Cost
Wells
Rain Reservoirs
Drills (58 in use, more proposed)
4000m³/d (winter)
14500m³/d (summer)
95%
Interception Dam
Desalination Plant (1450 m³/d)
Supply Enhancement
Water Transfer (twice, 20 years ago)
Dominant and Emerging Paradigms


Towards a WRM Strategy
Stakeholders consulted
The Water Utility of Paros
The Municipality of Paros
The Union of Agricultural Associations
The Union of Hotel and Room Owners

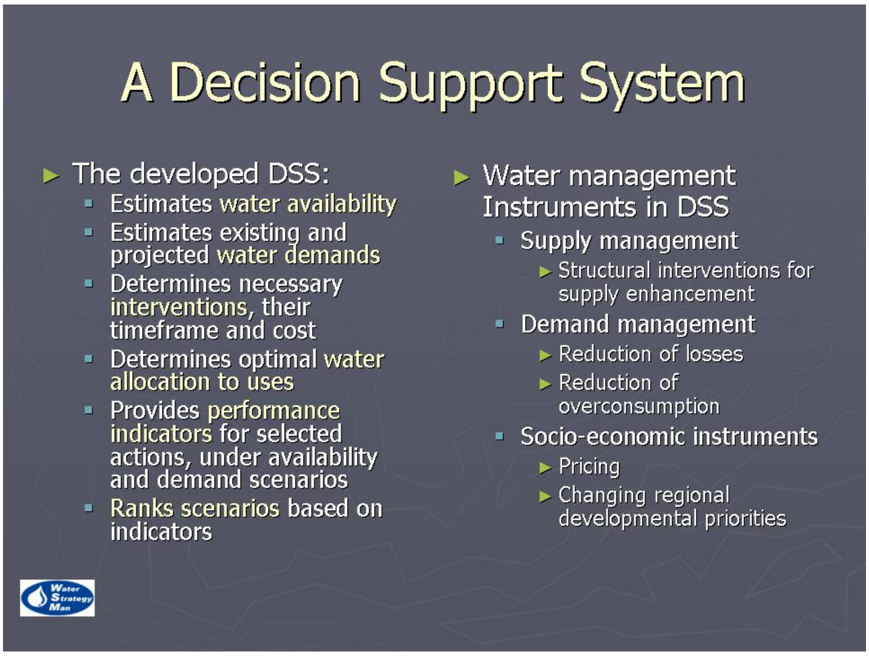

Water Utility perception of the new Strategy
Supply side
Limited water availability
Increase sustainable supply
Demand side
Demand reduction
Water saving
Socio-economic environment
Prices only cover operational costs
Need for public participation in order to improve water conservation
Pressures
Responses
Seasonal Demand
Municipal Policy
Water Quality
Network's Capacity
Supply Enhancement
Demand Reduction
Socio-Economic Interventions
Drills
Infrastructure Improvement
Desalination
Water Saving / Conservation
Legal / Regulatory / Administrative Measures
Metering
National Water Policy
Public Participation Involvement
Conservation Campaigns


Municipality perception of the new Strategy
Infrastructure
It should be funded by central and regional government with no contribution from local community
Preference to increase supply
No costs to local population
Tourist industry promotion
Public opinion has major importance
Pressures
Responses
Seasonal Demand
Society's Will
Supply Enhancement
Drills
Remote Monitoring of the Supply System
Infrastructure Improvement
Interception Walls for aquifer enancement
Dams and Reservoirs (in case the demand will not be covered by the other practices)

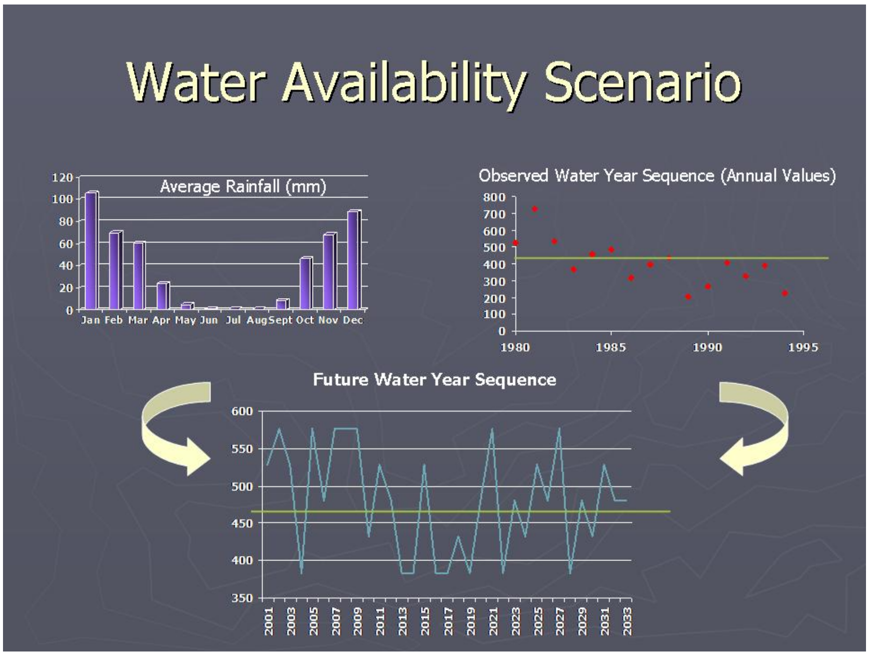

Users' Perception of the new Strategy
Necessity for standards in water services
No direct cost for infrastructure development
Low cost for water services provision
No cost for farming
Awareness of limitations in supply and potential benefits of water saving
Pressures
Responses
Seasonal Demand
Water Quality
Supply Enhancement
Demand Reduction
Domestic Reservoirs
Desalination
Water Saving / Conservation
Technological Adjustments

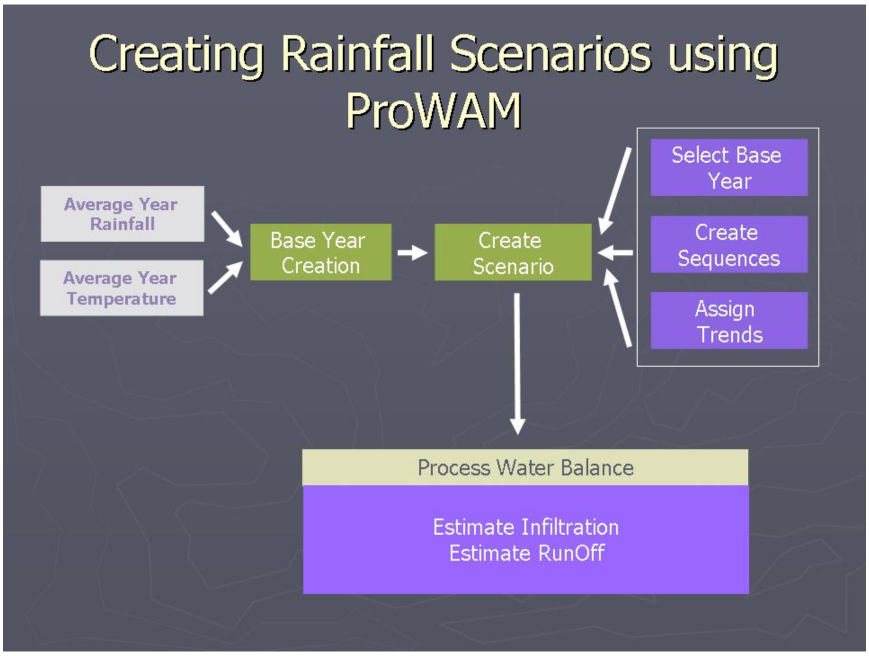

A Synthesis of Proposals
Supply Enhancement
Demand Management
Socio-Economic Constraints
Environmental Eco-systemic
Institutional / Political Context
Conjuctive Use
Infrastructure Improvement
Desalination
Metering
Zoning / Land Use changes/policies
Prioritizing Demands
Technological Adjustments
Water Saving / Conservation
Co-ordination within and between relevant authorities
Public participation/ Involvement
Conservation Campaigns
Impact / Risk Assessment
Environmental Regulations
Clarity of vision, goals and objectives
Institutional Mobilization

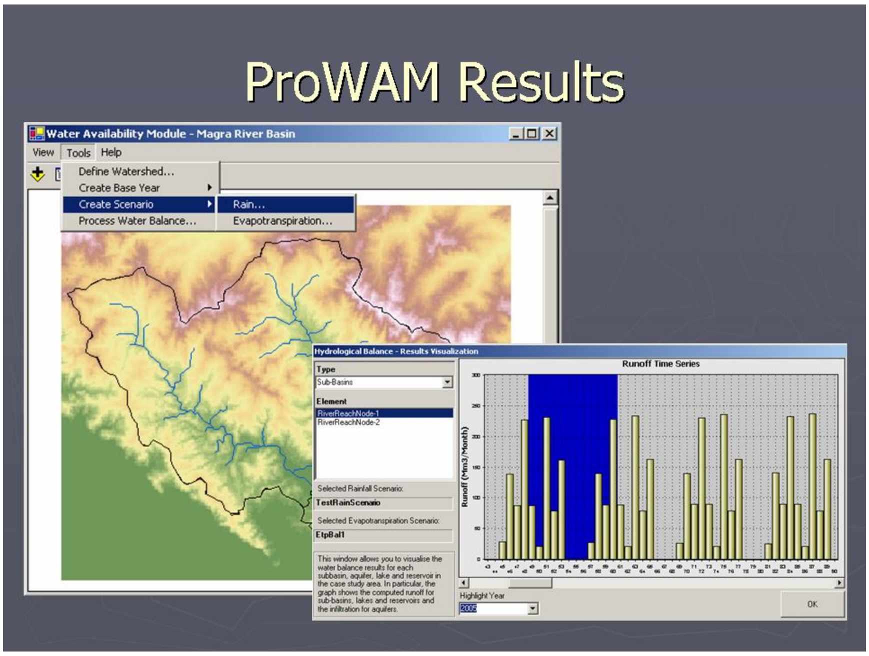

What is next ?

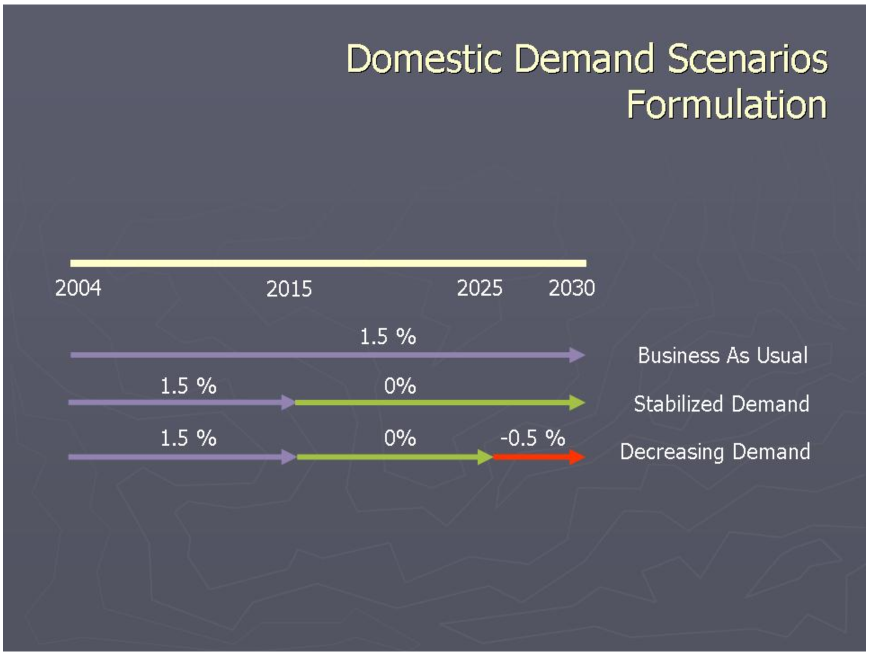

A Decision Support System
The developed DSS:
Estimates water availability
Estimates existing and projected water demands
Determines necessary interventions, their timeframe and cost
Determines optimal water allocation to uses
Provides performance indicators for selected actions, under availability and demand scenarios
Ranks scenarios based on indicators
Water management Instruments in DSS
Supply management
Structural interventions for supply enhancement
Demand management
Reduction of losses
Reduction of overconsumption
Socio-economic instruments
Pricing
Changing regional developmental priorities
Water Strategy Man

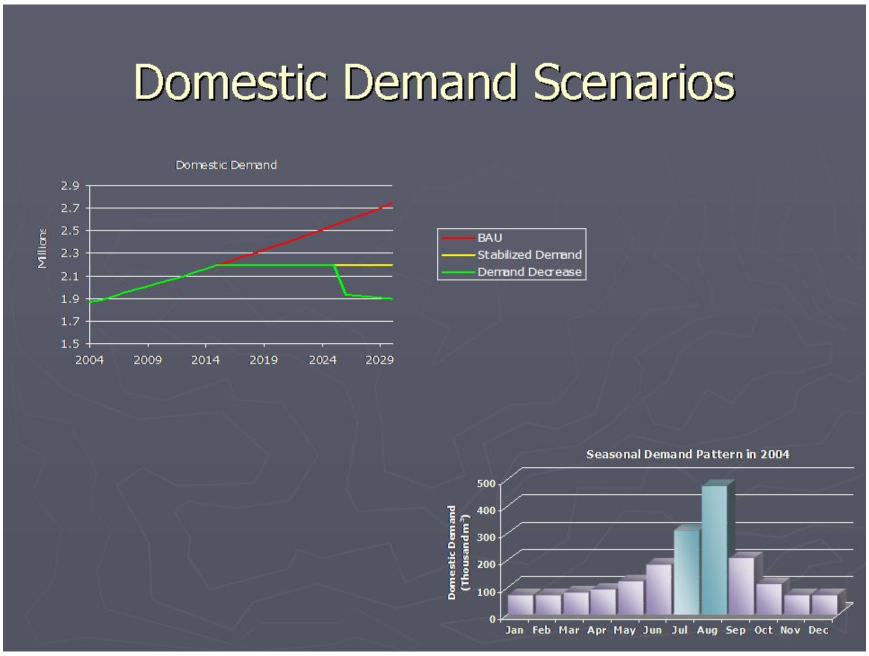

Results

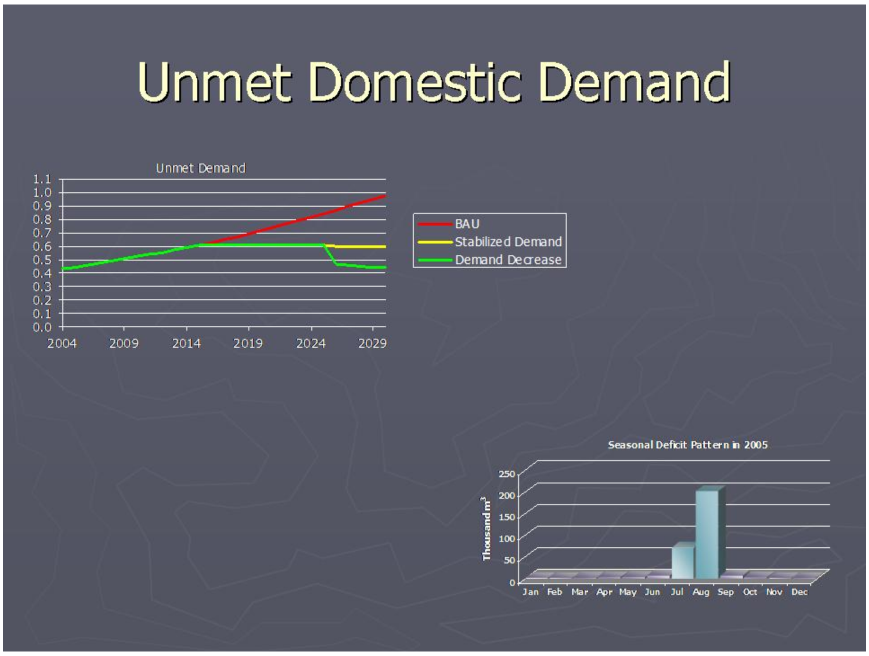

Water Availability Scenario
Average Rainfall (mm)
Jan Feb Mar Apr May Jun Jul Aug Sept Oct Nov Dec
Observed Water Year Sequence (Annual Values)
1980 1985 1990 1995
Future Water Year Sequence


Creating Rainfall Scenarios using ProWAM
Average Year Rainfall
Average Year Temperature
Base Year Creation
Create Scenario
Select Base Year
Create Sequences
Assign Trends
Process Water Balance
Estimate Infiltration
Estimate RunOff


ProWAM Results
Water Availability Module - Magra River Basin
View Tools Help
Define Watershed...
Create Base Year
Create Scenario
Process Water Balance...
Rain...
Evapotranspiration...
Hydrological Balance - Results Visualization
Runoff Time Series
OK


Domestic Demand Scenarios Formulation
2004
2015
2025
2030
1.5 %
Business As Usual
1.5 %
0%
Stabilized Demand
1.5 %
0%
-0.5 %
Decreasing Demand


Domestic Demand Scenarios
Domestic Demand
Millions
2.9
2.7
2.5
2.3
2.1
1.9
1.7
1.5
2004 2009 2014 2019 2024 2029
BAU
Stabilized Demand
Demand Decrease
Seasonal Demand Pattern in 2004
Domestic Demand (Thousand m³)
500
400
300
200
100
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec


Unmet Domestic Demand
Unmet Demand
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2004 2009 2014 2019 2024 2029
BAU
Stabilized Demand
Demand Decrease
Seasonal Deficit Pattern in 2005
Thousand m³
250
200
150
100
50
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

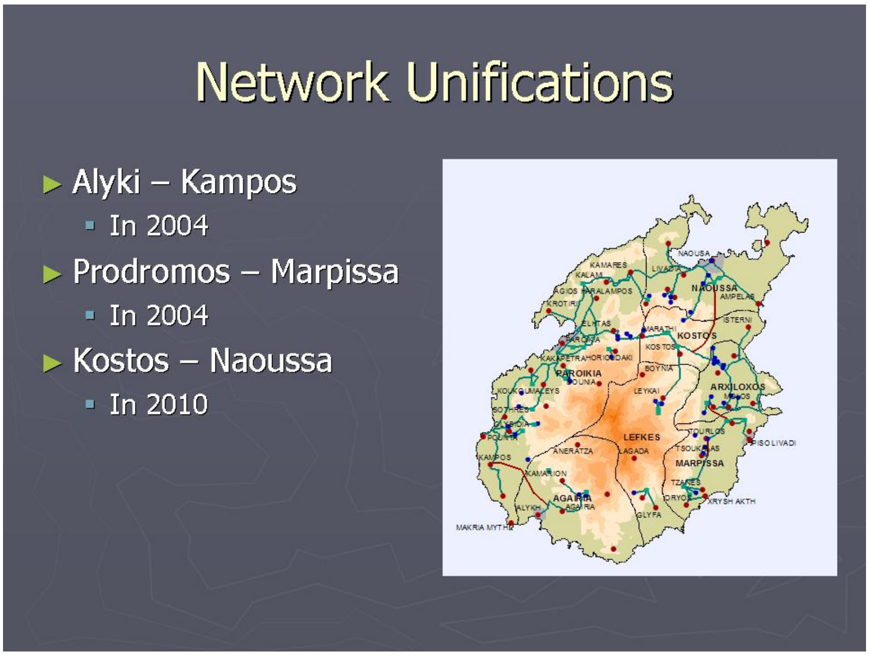
Selected Water Management Interventions

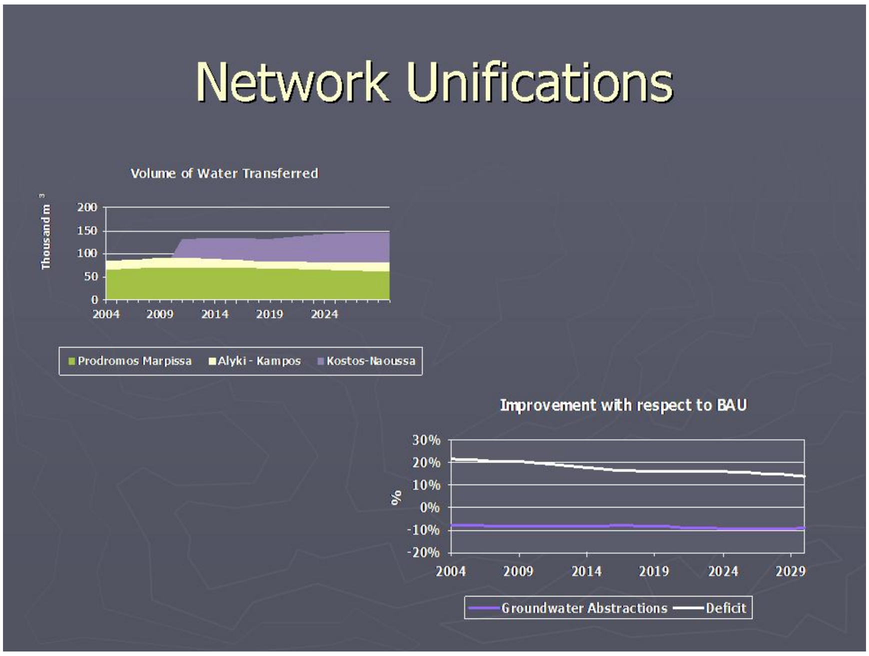
- Desalination
  - A brackish desalination plant of 1450 m³/d already exists
  - 4 seawater desalination plants and 1 brackish
- Cisterns
  - For the major settlements of the island that face shortage
    - Southern Paroikia, Naoussa, Agairia, Marpissa, Kostos
- Network unifications between the major settlements and a small increase in abstractions
- Pricing
  - Gradual increase of water selling prices up to 2.0 €/m³
    - Parametric analysis
      - Elasticity of -0.1
      - Elasticity of -0.5

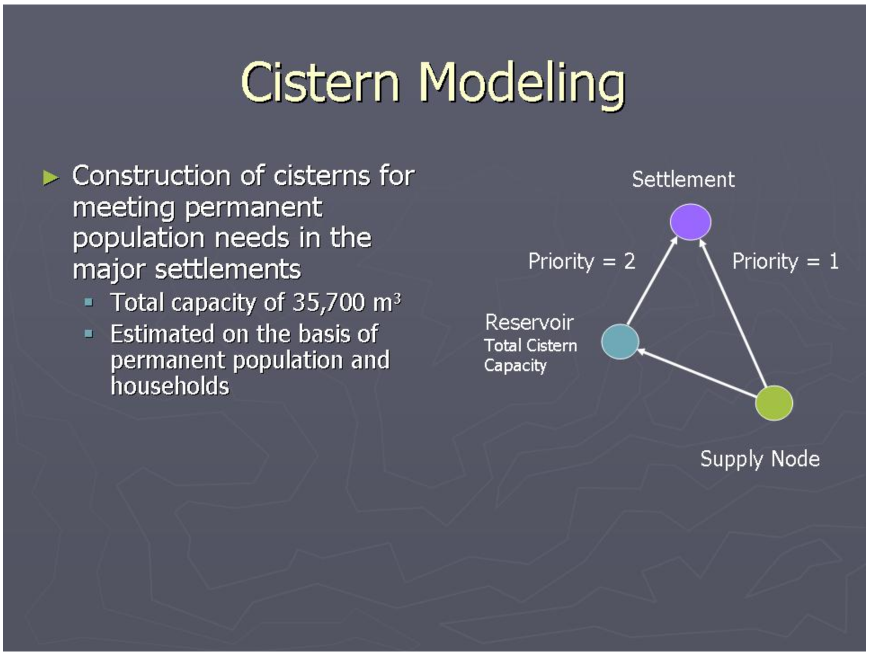
Desalination

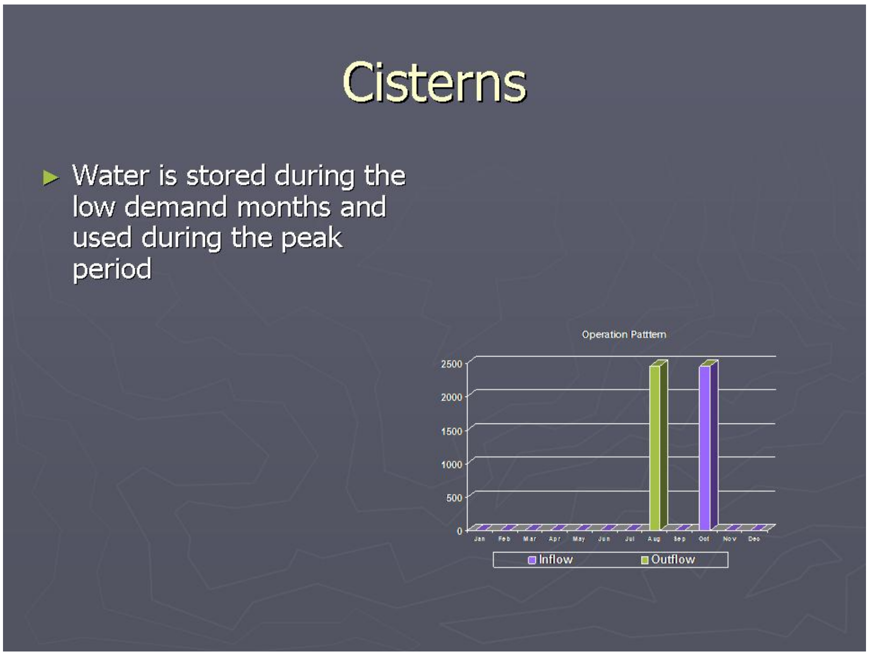
- 6 units
  - 1,450 m³/d in 2002 (brackish)
  - 1,000 m³/d in 2004 (seawater)
  - 2,000 m³/d in 2004 (brackish)
  - 1,000 m³/d in 2008 (seawater)
  - 600 m³/d in 2008 (seawater)
  - 600 m³/d in 2018 (seawater)
- Units are replaced on the 15th year of operation
- Capacity increase on replacement


Desalination
Improvement with respect to BAU
80%
60%
40%
20%
0%
%
2004 2009 2014 2019 2024 2029
Groundwater Abstractions
Deficit
Drinking water production
Thousand m3
2,000
1,500
1,000
500
0
2004 2009 2014 2019 2024 2029
Dryos
Livadia
Existing Plant (Naoussa A)
Naoussa B
Parasporos
Syrigos
Seasonal production pattern (2009)
Thousand m3
50
45
40
35
30
25
20
15
10
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Dryos
Parasporos

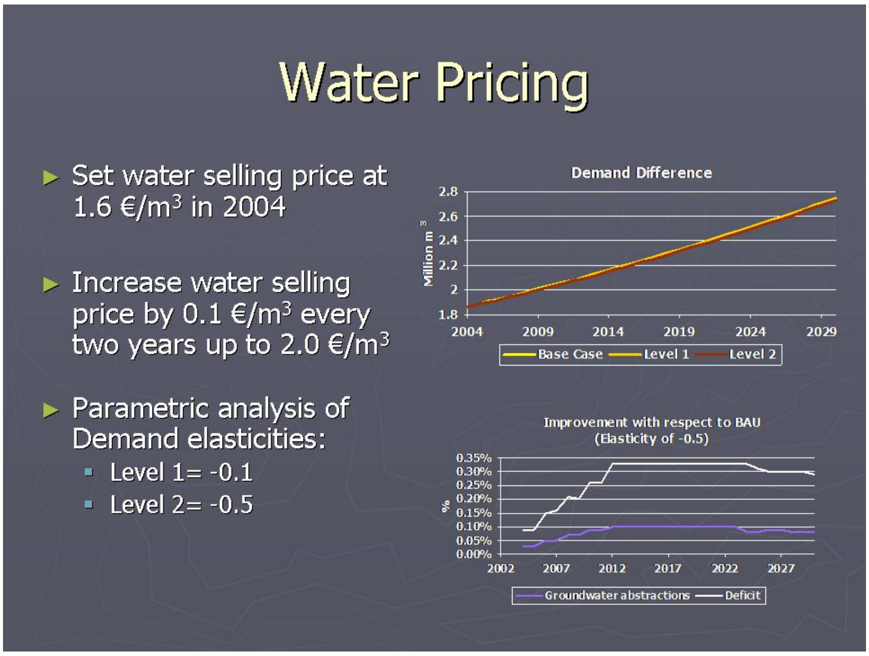

Network Unifications
Alyki – Kampos
In 2004
Prodromos – Marpissa
In 2004
Kostos – Naoussa
In 2010
NAOUSSA
KOSTOS
PAROIKIA
ARXILOXOS
LEFKES
MARPISSA
AGAIRIA
KAMPOS
ALYKI
DRYOS

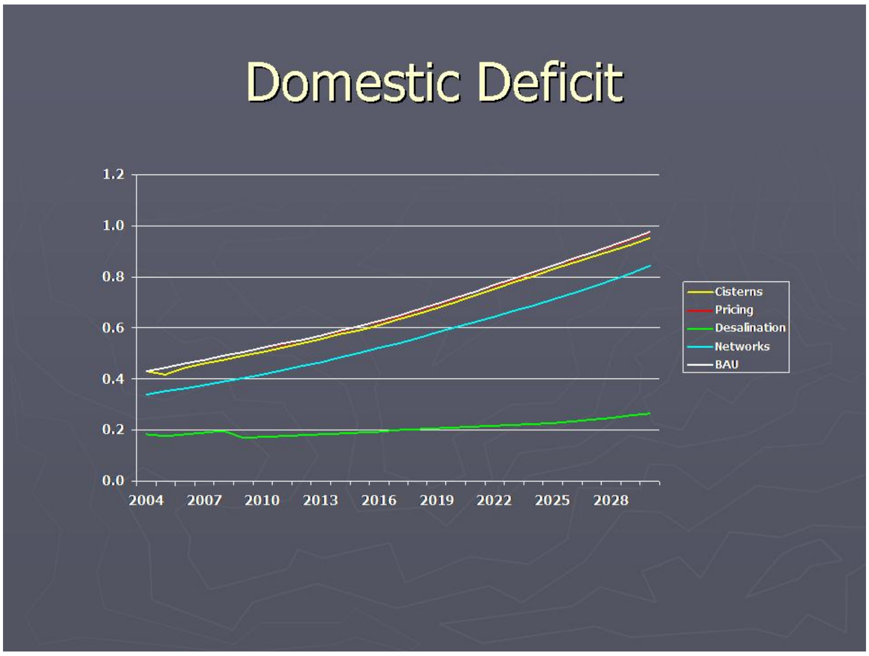

Network Unifications
Volume of Water Transferred
Thousand m 3
200
150
100
50
0
2004
2009
2014
2019
2024
Prodromos Marpissa
Alyki - Kampos
Kostos-Naoussa
Improvement with respect to BAU
30%
20%
10%
0%
-10%
-20%
%
2004
2009
2014
2019
2024
2029
Groundwater Abstractions
Deficit


Cistern Modeling
Construction of cisterns for meeting permanent population needs in the major settlements
Total capacity of 35,700 m³
Estimated on the basis of permanent population and households
Settlement
Priority = 2
Priority = 1
Reservoir
Total Cistern
Capacity
Supply Node

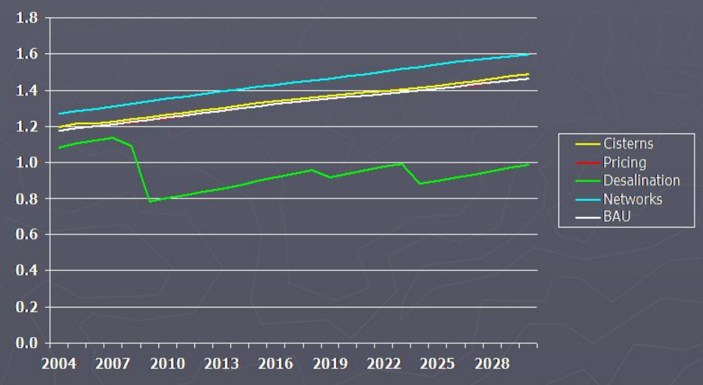

Cisterns
Water is stored during the low demand months and used during the peak period
Operation Patttern
2500
2000
1500
1000
500
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Inflow
Outflow


Cisterns
Supply Distributed
Thousand m3
40
30
20
10
0
2004
2009
2014
2019
2024
2029
Agairia
Paroikia
Marpissa
Kostos
Naoussa
Improvement with respect to BAU
2004
2009
2014
2019
2024
2029
8%
6%
4%
2%
0%
-2%
-4%
%
Groundwater abstractions
Deficit


Water Pricing
Set water selling price at 1.6 €/m³ in 2004
Increase water selling price by 0.1 €/m³ every two years up to 2.0 €/m³
Parametric analysis of Demand elasticities:
Level 1= -0.1
Level 2= -0.5
Demand Difference
Million m 3
2.8
2.6
2.4
2.2
2
1.8
2004
2009
2014
2019
2024
2029
Base Case
Level 1
Level 2
Improvement with respect to BAU
(Elasticity of -0.5)
%
0.35%
0.30%
0.25%
0.20%
0.15%
0.10%
0.05%
0.00%
2002
2007
2012
2017
2022
2027
Groundwater abstractions
Deficit

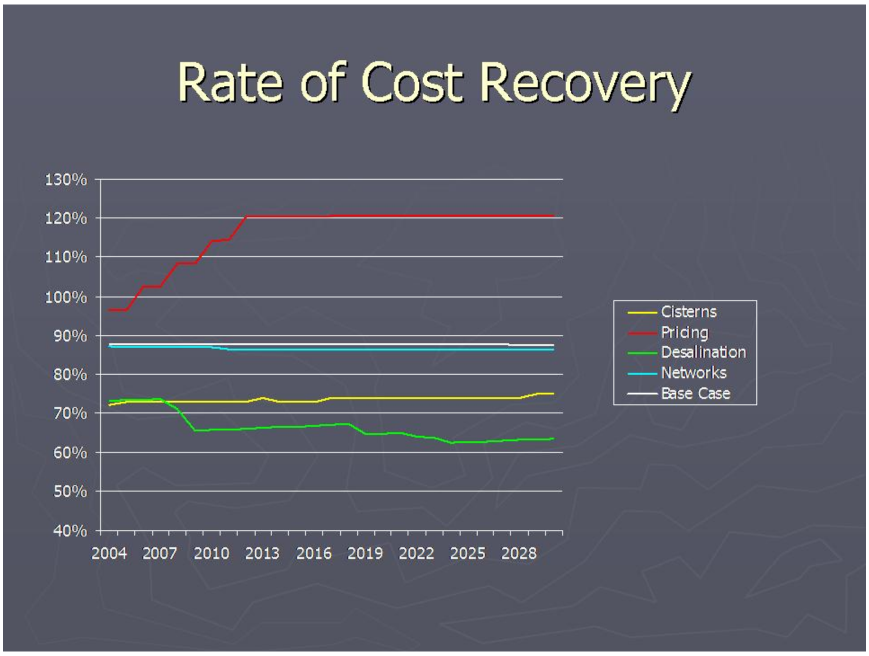

Domestic Deficit
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2004
2007
2010
2013
2016
2019
2022
2025
2028
Cisterns
Pricing
Desalination
Networks
BAU

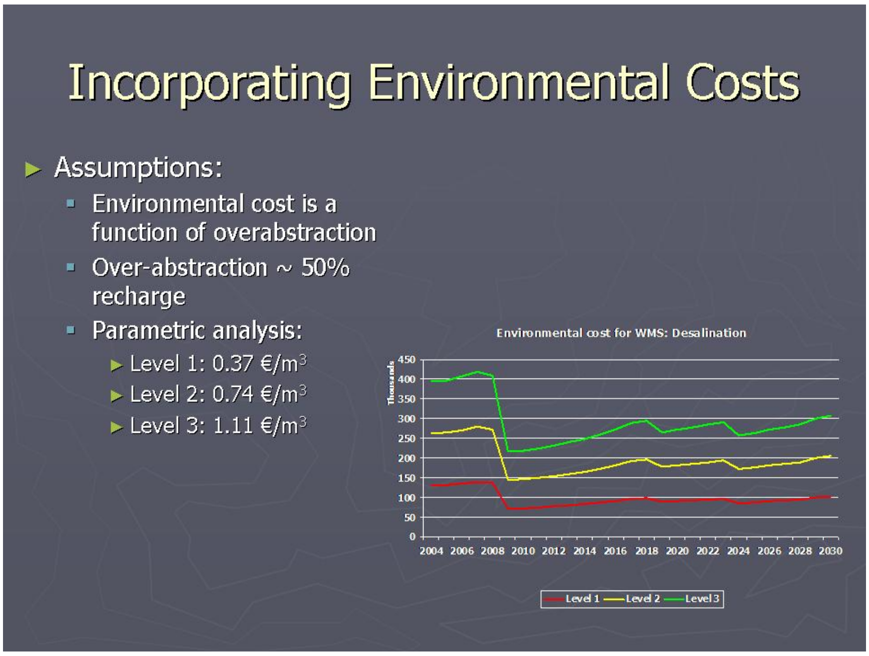
Groundwater Abstractions

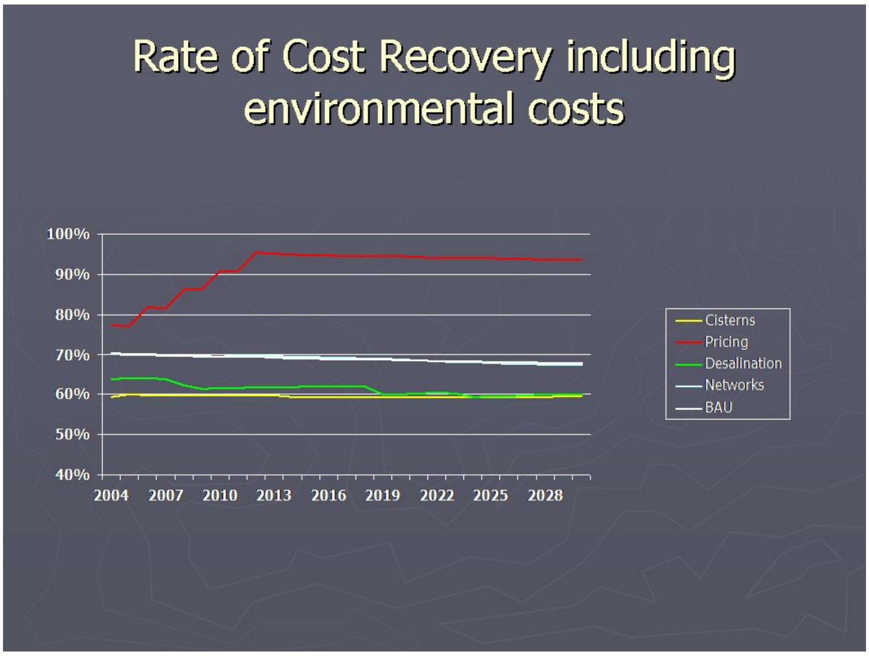


Effectiveness
(Domestic Demand Coverage equal to 90%)

	BAU	Desalination	Networks	Cisterns	Pricing
Average	0.801	0.928	0.839	0.805	0.814
Reliability	0.626	0.732	0.629	0.629	0.626
Resilience	0.230	0.321	0.231	0.231	0.230
1- Rel. Extent	0	0.778	0.182	0.026	0.001
1- Rel. Max Extent	0	0.972	0.102	0.012	0
1- Rel. Duration	0	0.286	0.007	0.007	0
Overall Score	0	0.005	0.00019	$2*10^{-6}$	0


Rate of Cost Recovery
130%
120%
110%
100%
90%
80%
70%
60%
50%
40%
2004 2007 2010 2013 2016 2019 2022 2025 2028
Cisterns
Pricing
Desalination
Networks
Base Case


Incorporating Environmental Costs
Assumptions:
Environmental cost is a function of overabstraction
Over-abstraction ~ 50% recharge
Parametric analysis:
Level 1: 0.37 €/m³
Level 2: 0.74 €/m³
Level 3: 1.11 €/m³
Environmental cost for WMS: Desalination
Thousands
450
400
350
300
250
200
150
100
50
0
2004 2006 2008 2010 2012 2014 2016 2018 2020 2022 2024 2026 2028 2030
Level 1
Level 2
Level3

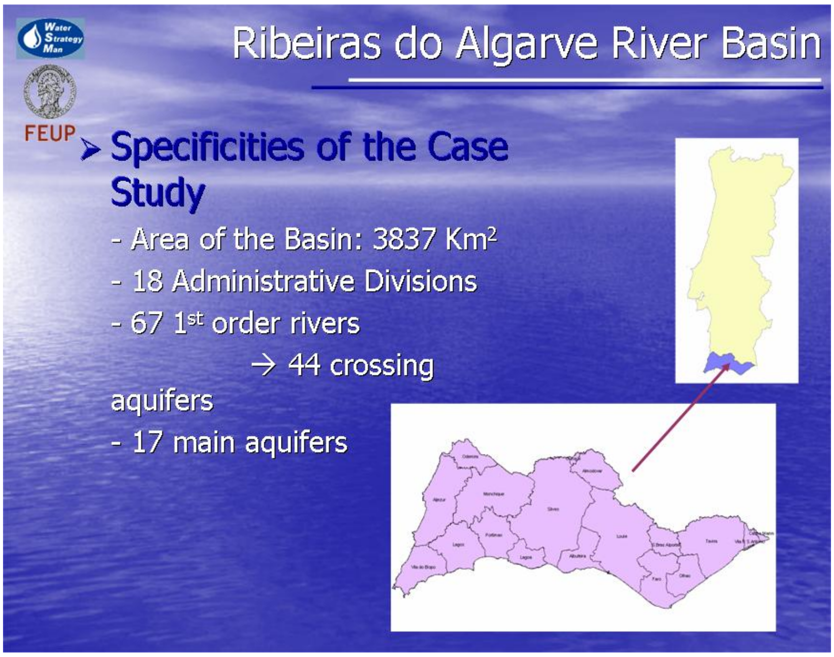

Rate of Cost Recovery including environmental costs
100%
90%
80%
70%
60%
50%
40%
2004
2007
2010
2013
2016
2019
2022
2025
2028
Cisterns
Pricing
Desalination
Networks
BAU

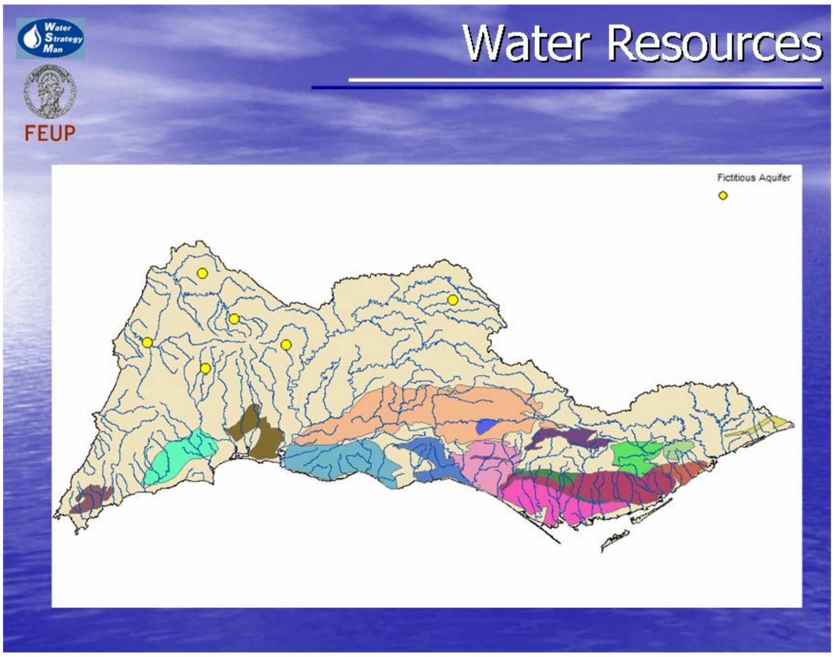
PRESENTATION 5

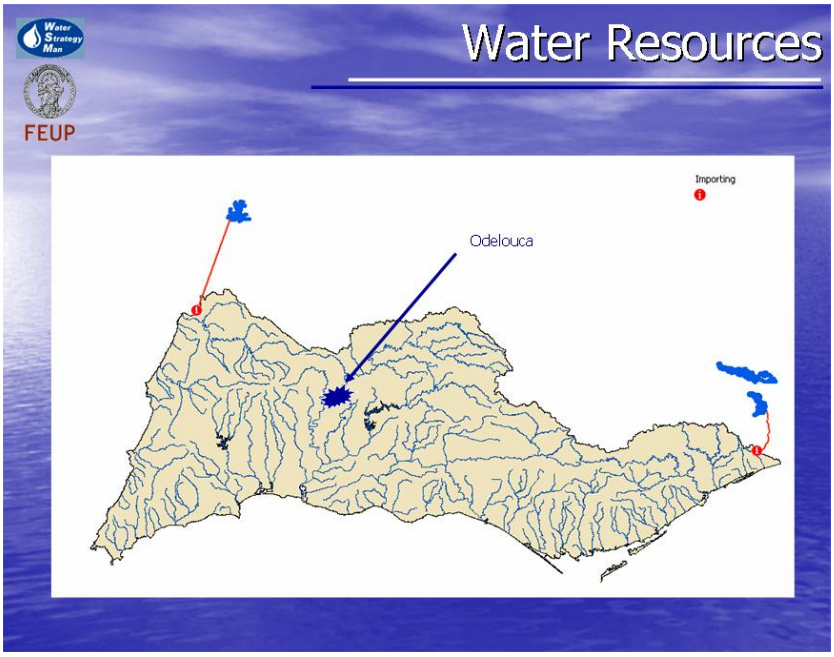
SURFACE AND GROUND WATER USE: TRYING TO ACHIEVE A CORRECT BALANCE AND PROTECTION IN ALGARVE: THE PORTUGUESE CASE STUDY

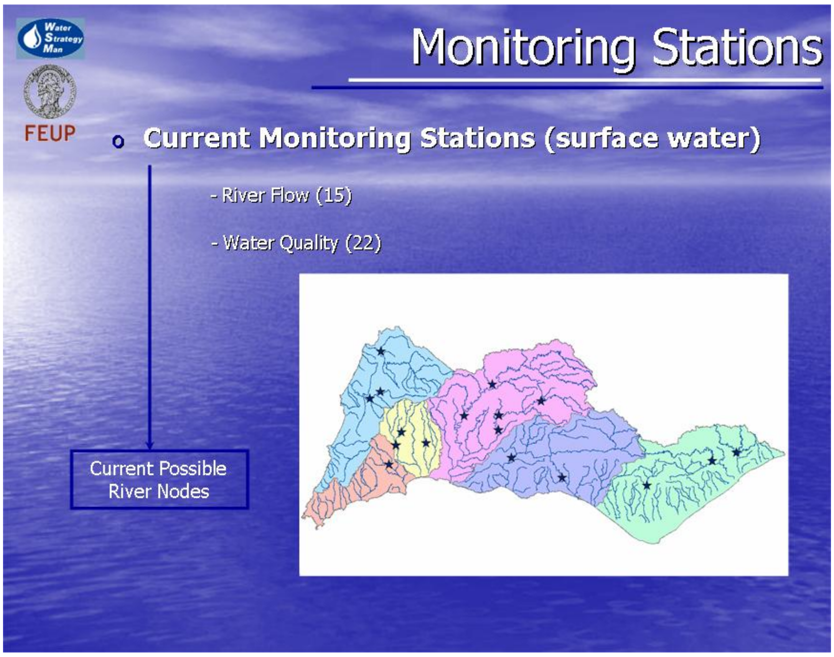
BY R. MAIA

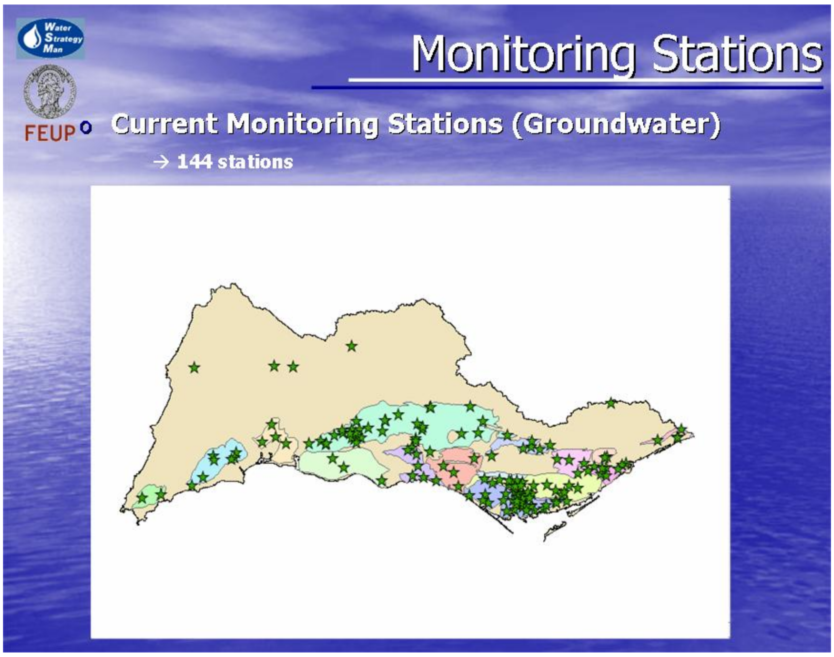

Water Strategy Man
FEUP
Ribeiras do Algarve Basin
Portuguese Case Study
Paris Meeting
8th-10th October 2003

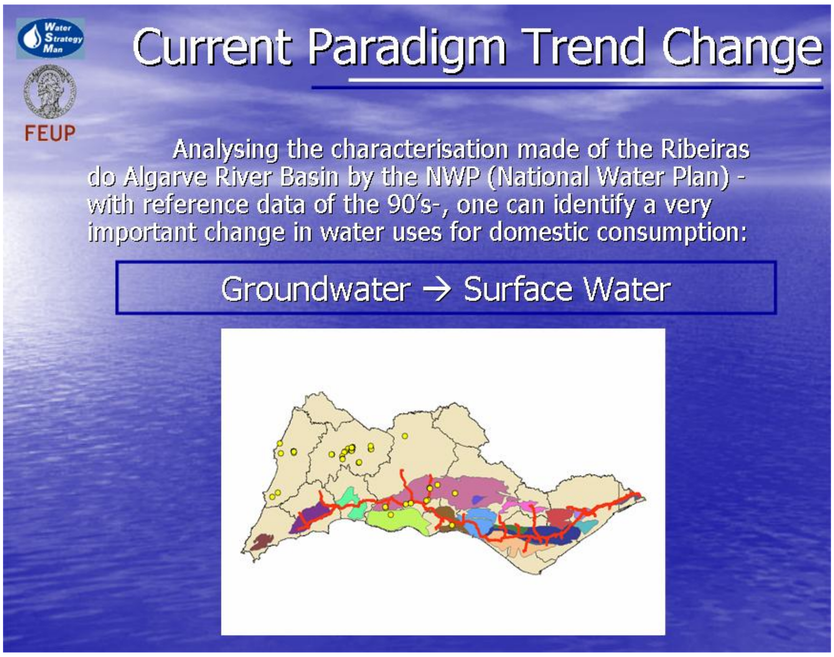

Ribeiras do Algarve River Basin
FEUP
Specificities of the Case Study
- Area of the Basin: 3837 Km2
- 18 Administrative Divisions
- 67 1st order rivers
→ 44 crossing aquifers
- 17 main aquifers

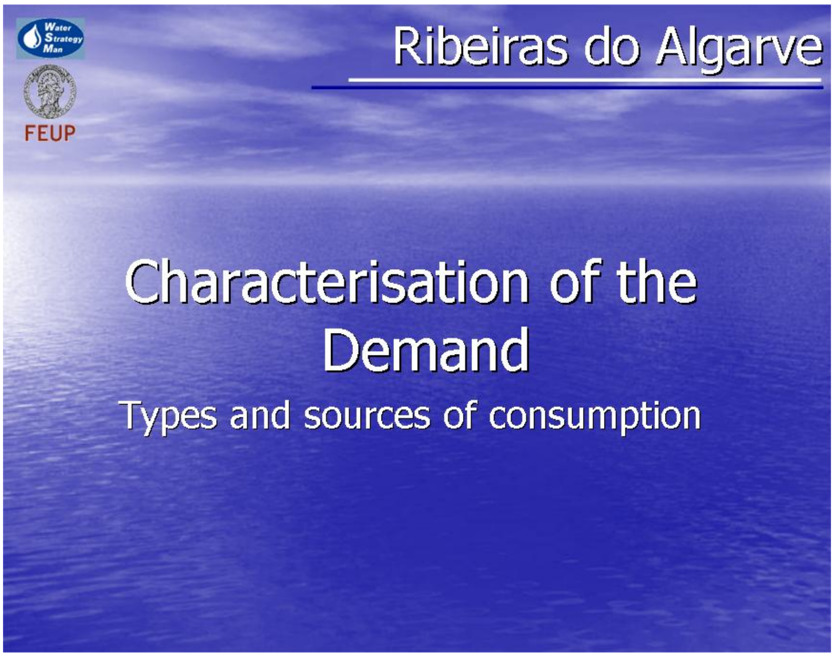

Water Resources
FEUP
Fictitious Aquifer

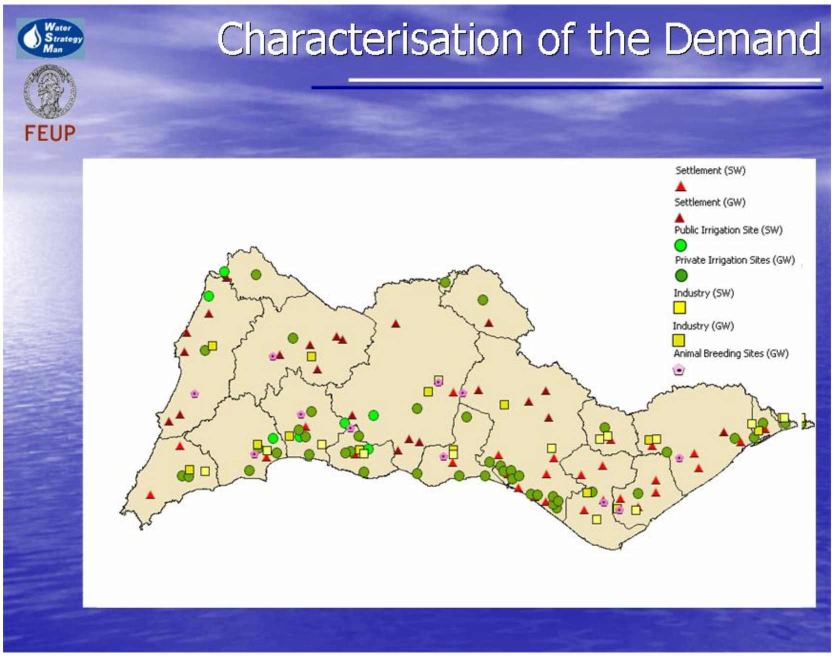

Water Resources
FEUP
Importing
Odelouca


Monitoring Stations
FEUP
Current Monitoring Stations (surface water)
- River Flow (15)
- Water Quality (22)
Current Possible River Nodes


Monitoring Stations
FEUP
Current Monitoring Stations (Groundwater)
→ 144 stations


FEUP
Current Paradigm Trend Change
Analysing the characterisation made of the Ribeiras do Algarve River Basin by the NWP (National Water Plan) - with reference data of the 90's-, one can identify a very important change in water uses for domestic consumption:
Groundwater → Surface Water


FEUP
Ribeiras do Algarve
Characterisation of the Demand
Types and sources of consumption

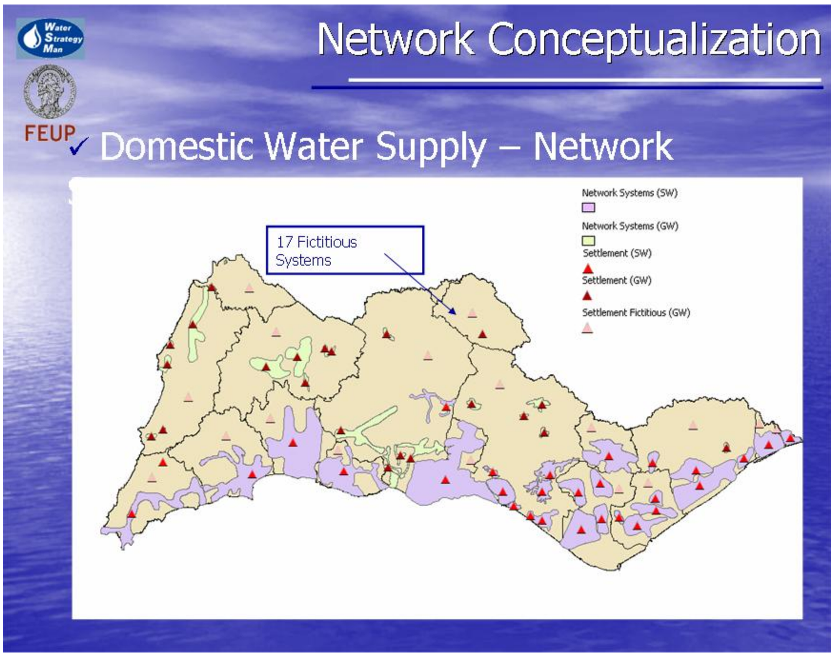


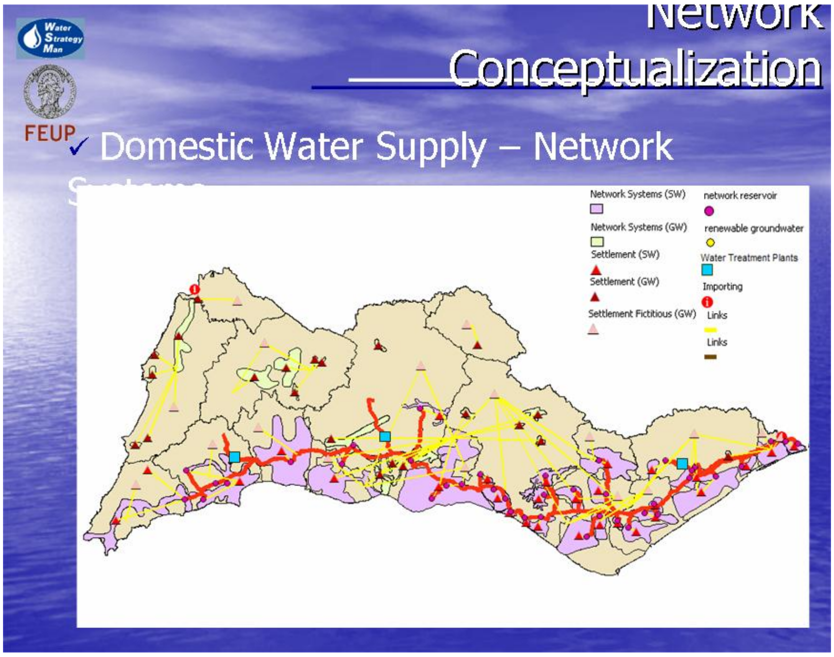
Characterisation of the Demand

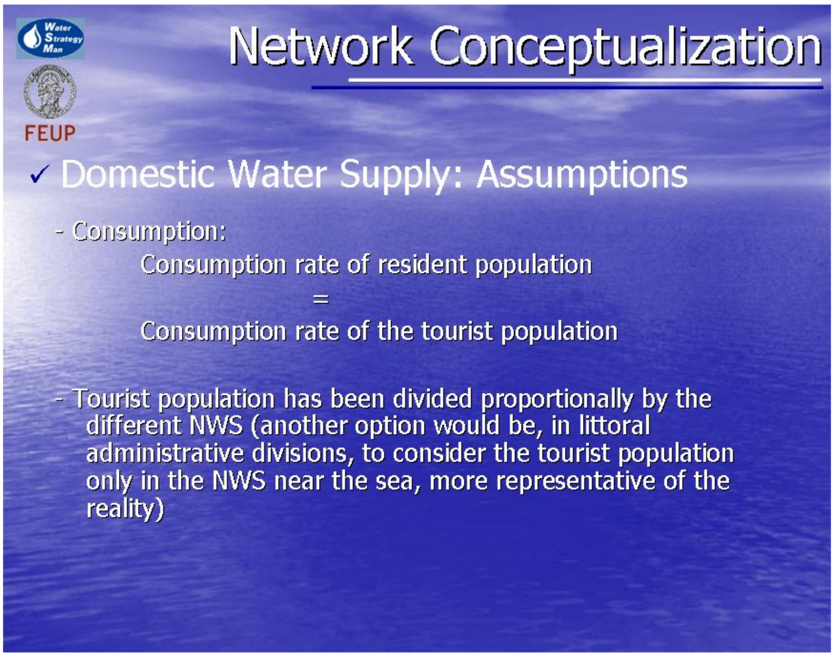
FEUP

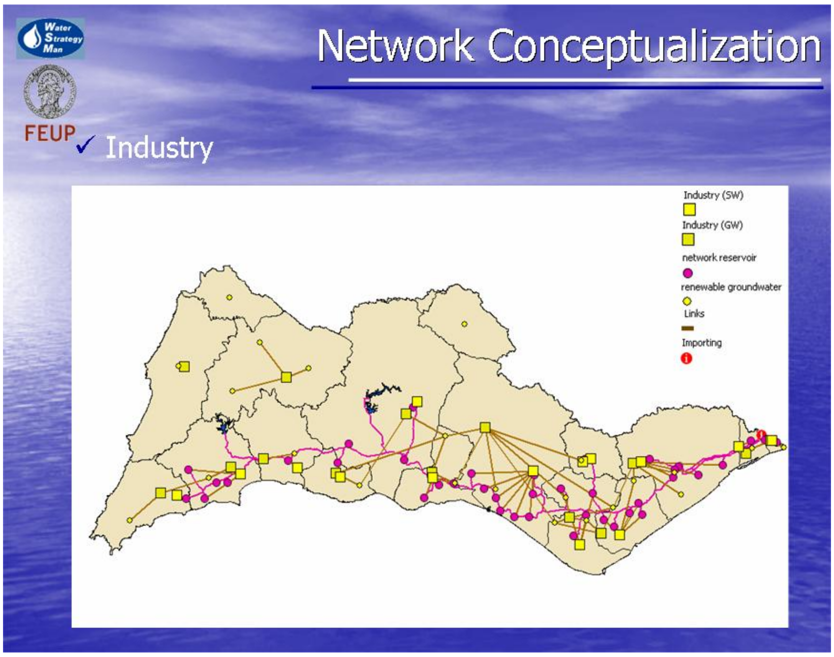
		Demand (hm^3/year)
Population	Surface Water	40,5
	Groundwater	8
Industry	Surface Water	0,86
	Groundwater	1,34
Animal Breeding	Surface Water	-
	Groundwater	0,2
Agriculture	Surface Water	80
	Groundwater	225
Golf Courses	Groundwater (mostly)	10

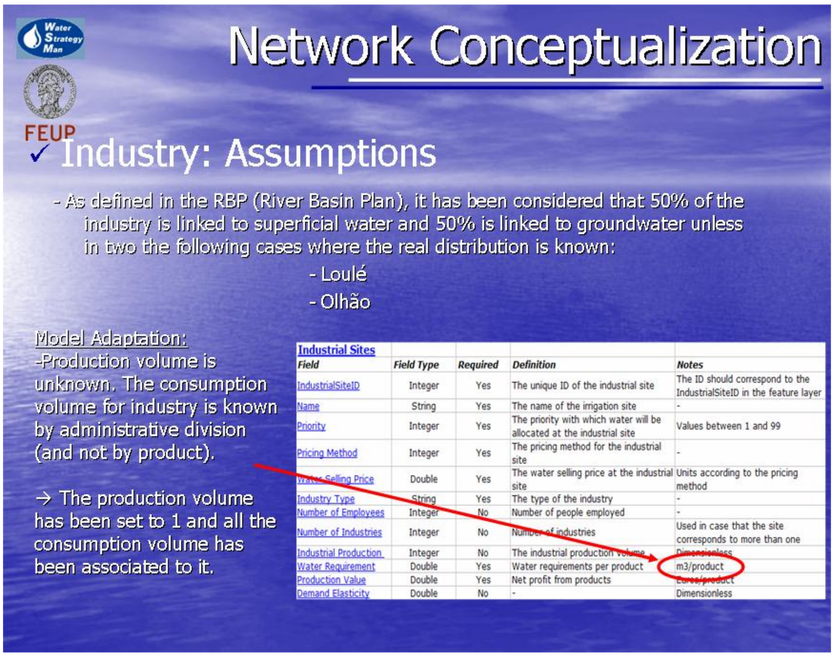

Ribeiras do Algarve
FEUP
Network Conceptualization


Network Conceptualization
FEUP
Domestic Water Supply – Network
17 Fictitious Systems
Network Systems (SW)
Network Systems (GW)
Settlement (SW)
Settlement (GW)
Settlement Fictitious (GW)


Network
Conceptualization
FEUP
✓ Domestic Water Supply – Network
Network Systems (SW)
network reservoir
Network Systems (GW)
renewable groundwater
Settlement (SW)
Water Treatment Plants
Settlement (GW)
Importing
Settlement Fictitious (GW)
Links
Links


Network Conceptualization
FEUP
✓ Domestic Water Supply: Assumptions
- Consumption:
Consumption rate of resident population
=
Consumption rate of the tourist population
- Tourist population has been divided proportionally by the different NWS (another option would be, in littoral administrative divisions, to consider the tourist population only in the NWS near the sea, more representative of the reality)



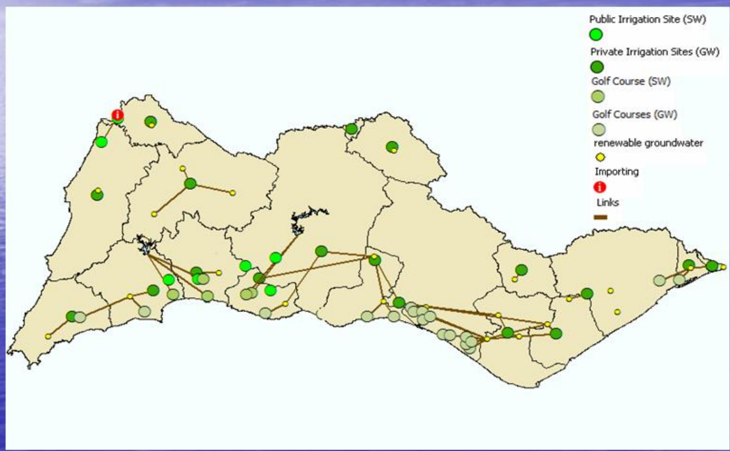


Industrial Sites				
Field	Field Type	Required	Definition	Notes
IndustrialSiteID	Integer	Yes	The unique ID of the industrial site	The ID should correspond to the IndustrialSiteID in the feature layer
Name	String	Yes	The name of the irrigation site	-
Priority	Integer	Yes	The priority with which water will be allocated at the industrial site	Values between 1 and 99
Pricing Method	Integer	Yes	The pricing method for the industrial site	-
Water Selling Price	Double	Yes	The water selling price at the industrial site	Units according to the pricing method
Industry Type	String	Yes	The type of the industry	-
Number of Employees	Integer	No	Number of people employed	-
Number of Industries	Integer	No	Number of industries	Used in case that the site corresponds to more than one
Industrial Production	Integer	No	The industrial production volume	Dimensionless
Water Requirement	Double	Yes	Water requirements per product	m3/product
Production Value	Double	Yes	Net profit from products	Euros/product
Demand Elasticity	Double	No	-	Dimensionless

Network Conceptualization

FEUP

✓ Agriculture



Network Conceptualization

FEUP

✓ Agriculture: Data and Assumptions

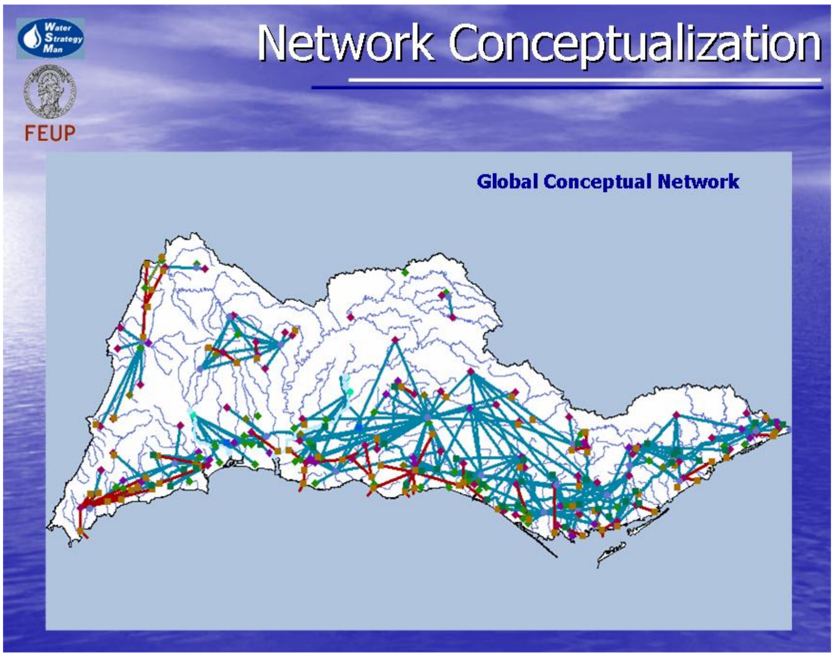
- Crop Types

	Public Irrigation Site (3190 ha)	Private Irrigation Site (19471 ha)
Citrus	69%	49%
Peach-tree	-	12%
Wine	-	8%
Tomato	7%	24%
Maize	14%	3%
Lucerne	10%	4%

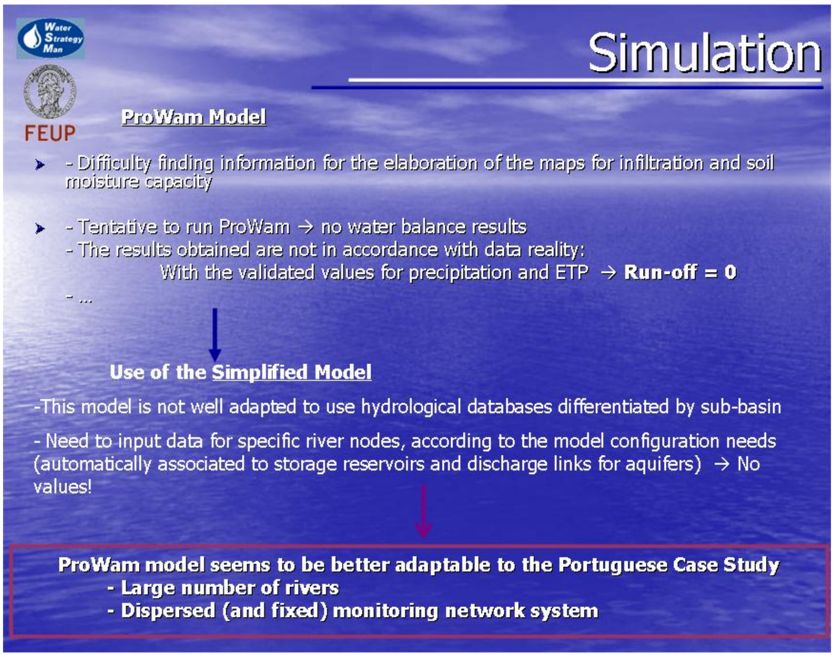
- "Touristic" agriculture

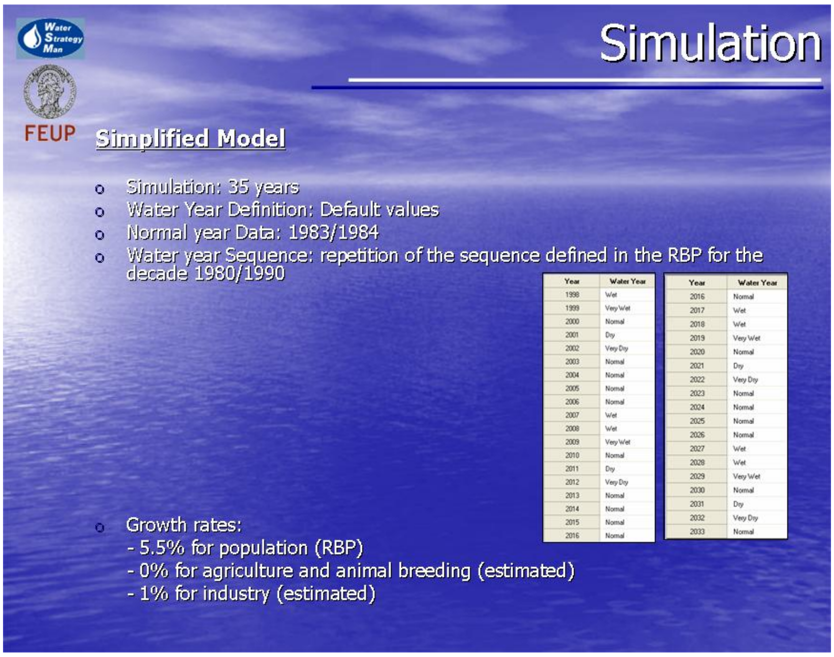
25 Golf courses:

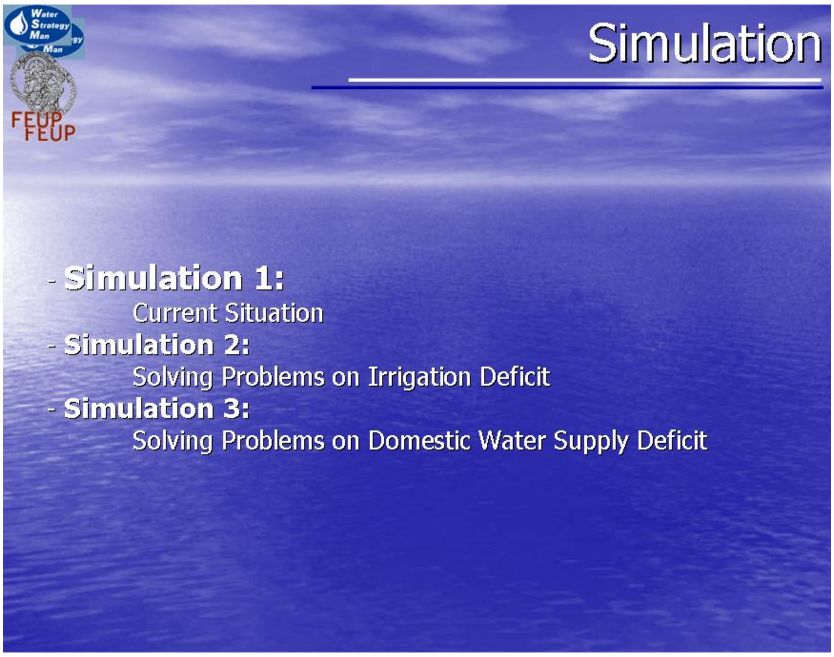
. Considered as Irrigations Sites with one crop type (grass)

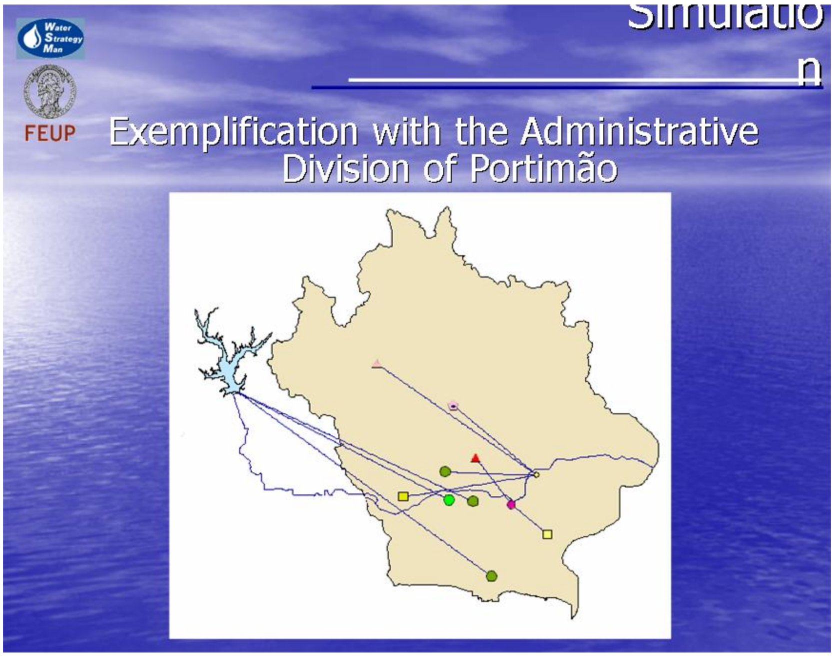

Network Conceptualization
FEUP
Global Conceptual Network

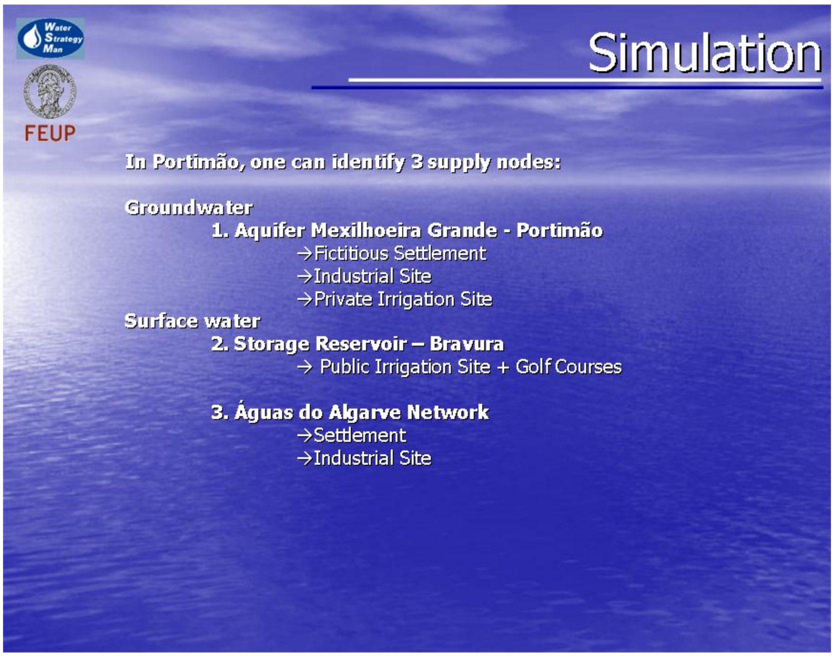

Ribeiras do Algarve
FEUP
Simulation

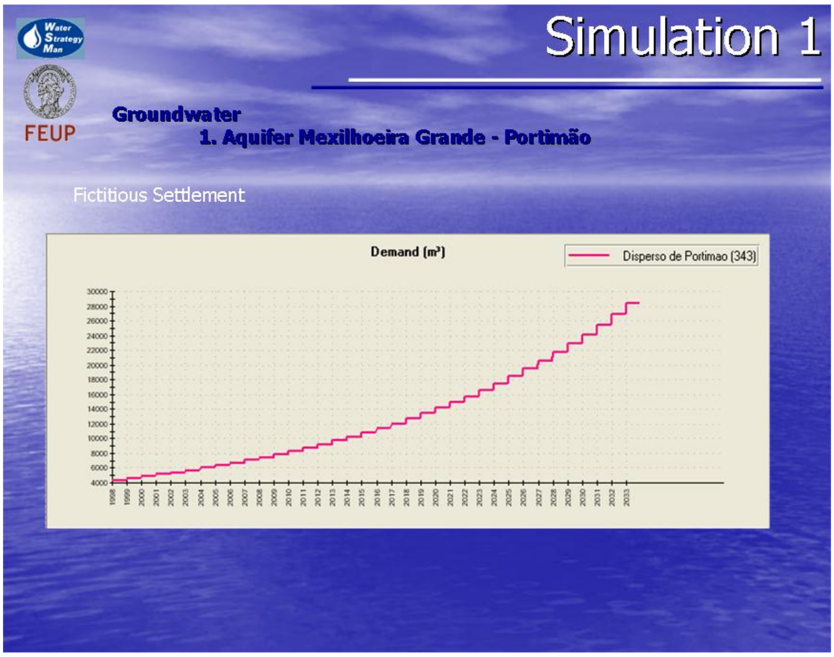

Simulation
FEUP
ProWam Model
- Difficulty finding information for the elaboration of the maps for infiltration and soil moisture capacity
- Tentative to run ProWam → no water balance results
- The results obtained are not in accordance with data reality:
With the validated values for precipitation and ETP → Run-off = 0
- ...
Use of the Simplified Model
-This model is not well adapted to use hydrological databases differentiated by sub-basin
- Need to input data for specific river nodes, according to the model configuration needs (automatically associated to storage reservoirs and discharge links for aquifers) → No values!
ProWam model seems to be better adaptable to the Portuguese Case Study
- Large number of rivers
- Dispersed (and fixed) monitoring network system

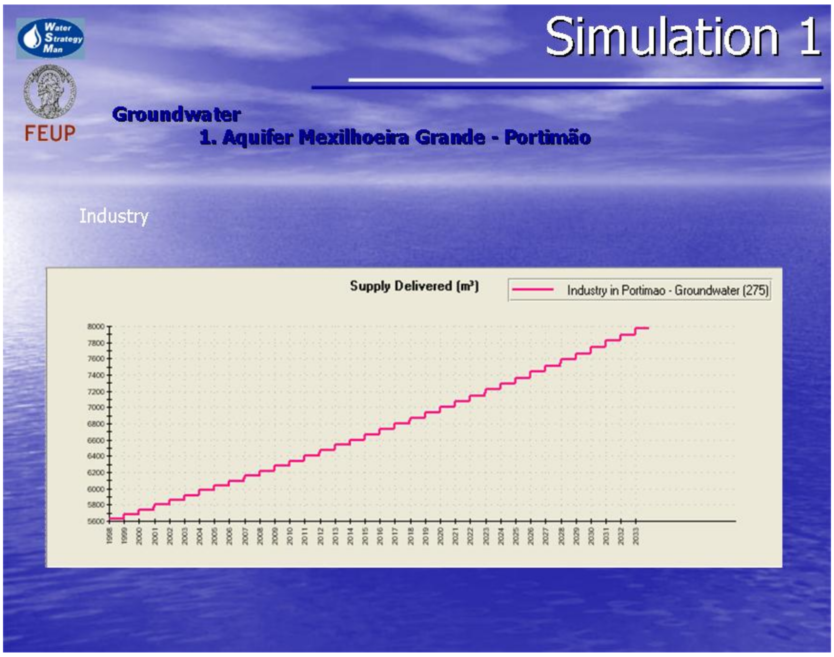

Simulation
FEUP
Simplified Model
Simulation: 35 years
Water Year Definition: Default values
Normal year Data: 1983/1984
Water year Sequence: repetition of the sequence defined in the RBP for the decade 1980/1990
Year Water Year
1998 Wet
1999 Very Wet
2000 Normal
2001 Dry
2002 Very Dry
2003 Normal
2004 Normal
2005 Normal
2006 Normal
2007 Wet
2008 Wet
2009 Very Wet
2010 Normal
2011 Dry
2012 Very Dry
2013 Normal
2014 Normal
2015 Normal
2016 Normal
Year Water Year
2016 Normal
2017 Wet
2018 Wet
2019 Very Wet
2020 Normal
2021 Dry
2022 Very Dry
2023 Normal
2024 Normal
2025 Normal
2026 Normal
2027 Wet
2028 Wet
2029 Very Wet
2030 Normal
2031 Dry
2032 Very Dry
2033 Normal
Growth rates:
- 5.5% for population (RBP)
- 0% for agriculture and animal breeding (estimated)
- 1% for industry (estimated)


Simulation
FEUP
- Simulation 1:
Current Situation
- Simulation 2:
Solving Problems on Irrigation Deficit
- Simulation 3:
Solving Problems on Domestic Water Supply Deficit


Simulation
FEUP
Exemplification with the Administrative Division of Portimão


FEUP
Simulation
In Portimão, one can identify 3 supply nodes:
Groundwater
1. Aquifer Mexilhoeira Grande - Portimão
→Fictitious Settlement
→Industrial Site
→Private Irrigation Site
Surface water
2. Storage Reservoir – Bravura
→ Public Irrigation Site + Golf Courses
3. Águas do Algarve Network
→Settlement
→Industrial Site


FEUP
Simulation 1
Groundwater
1. Aquifer Mexilhoeira Grande - Portimão
Fictitious Settlement
Demand (m³)
Disperso de Portimao (343)


Water Strategy Man
FEUP
Simulation 1
Groundwater
1. Aquifer Mexilhoeira Grande - Portimão
Industry
Supply Delivered (m³)
Industry in Portimao - Groundwater (275)
8000
7800
7600
7400
7200
7000
6800
6600
6400
6200
6000
5800
5600
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
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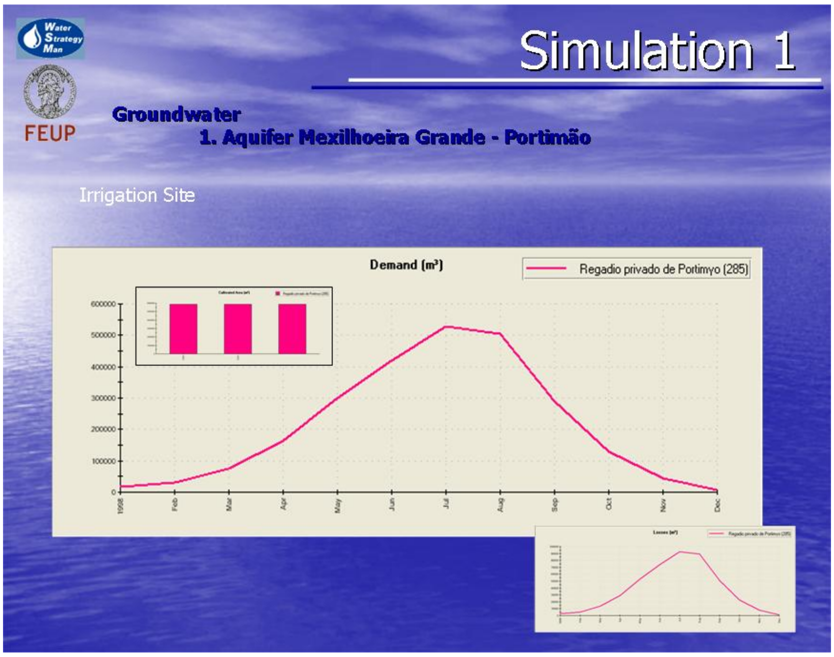
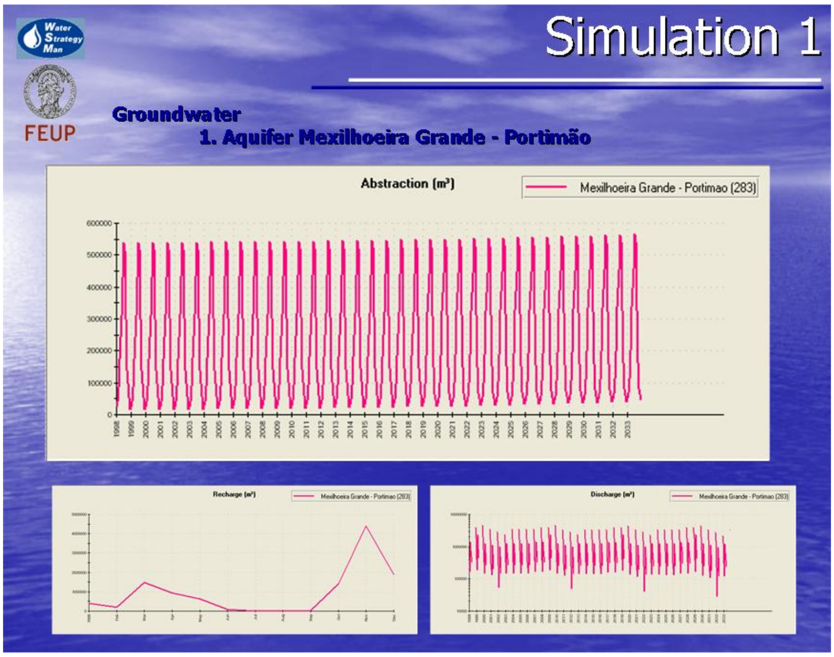
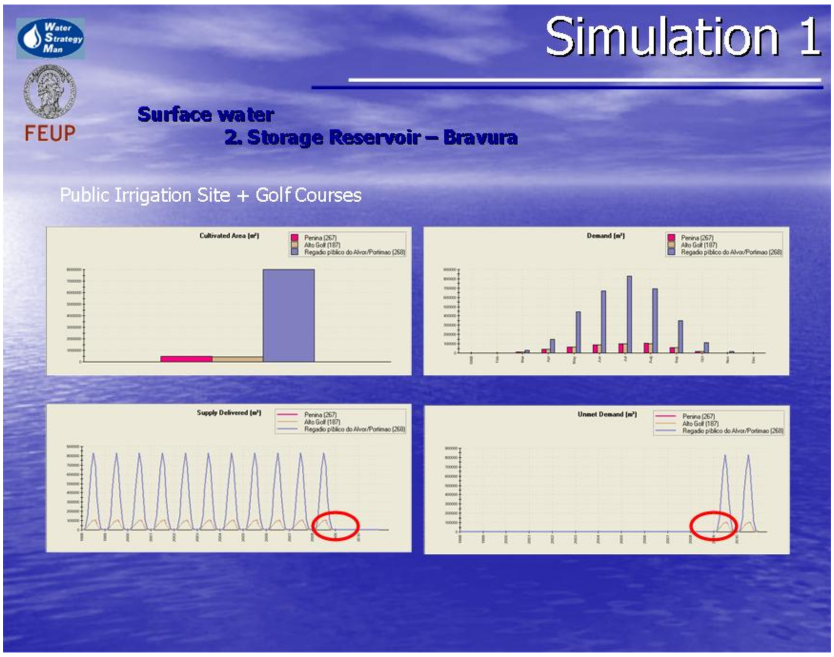
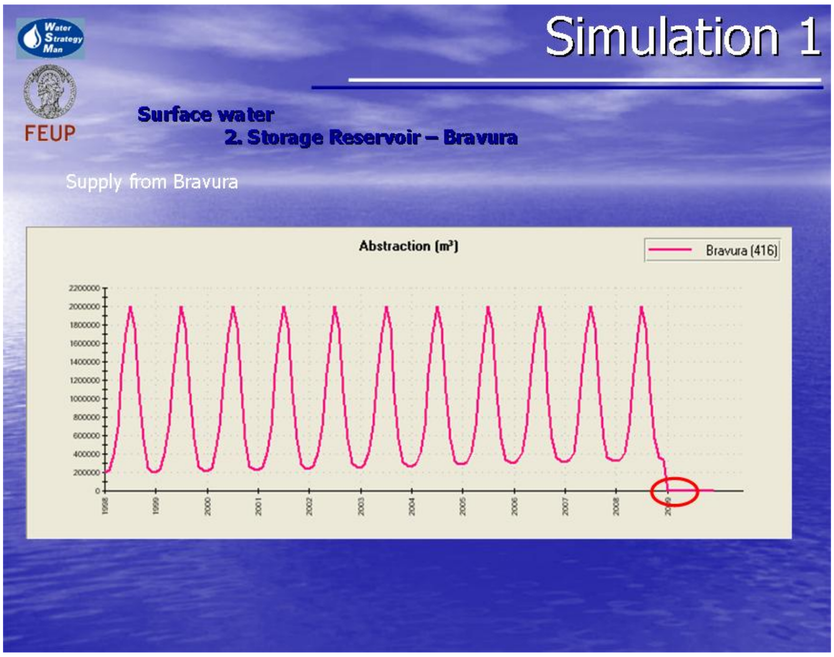
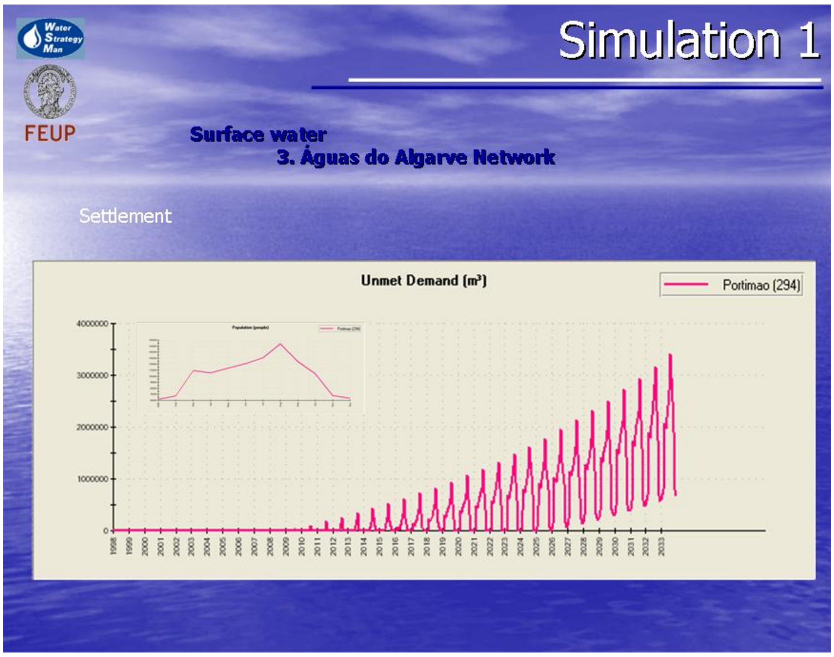
2030
2031
2032
2033

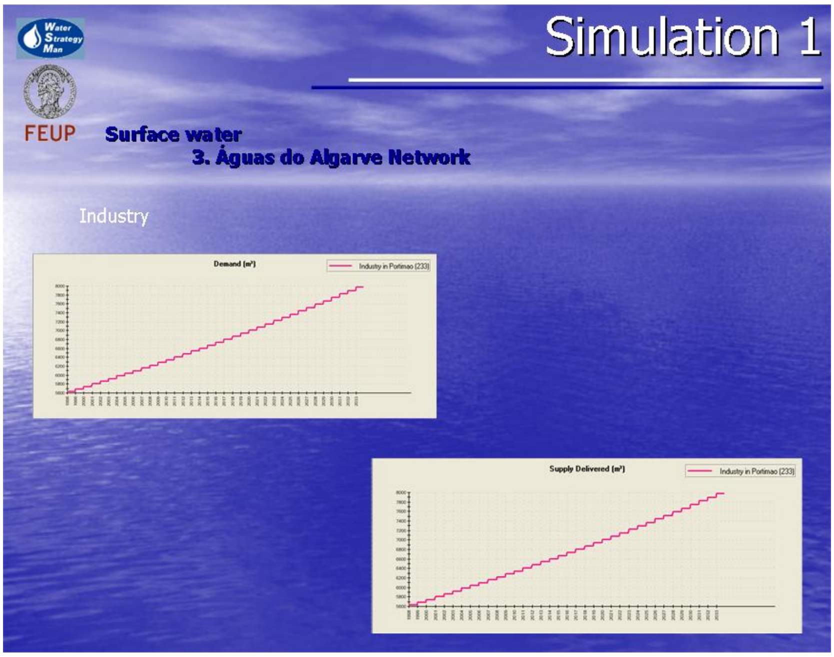

Water Strategy Man
FEUP
Simulation 1
Groundwater
1. Aquifer Mexilhoeira Grande - Portimão
Irrigation Site
Demand (m³)
Regadio privado de Portimyo (285)
600000
500000
400000
300000
200000
100000
0
1998
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

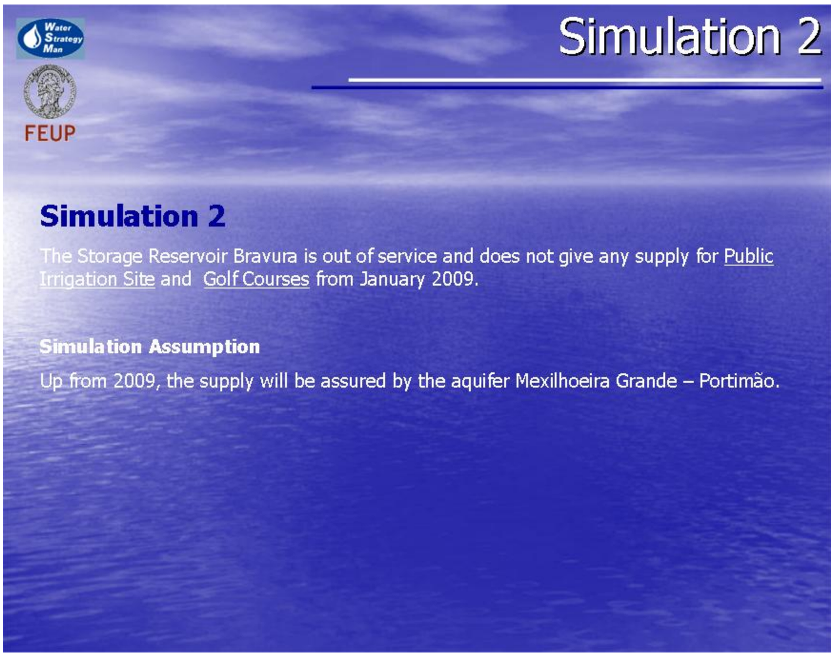

Simulation 1
FEUP
Groundwater
1. Aquifer Mexilhoeira Grande - Portimão
Abstraction (m³)
Mexilhoeira Grande - Portimao (283)
Recharge (m³)
Discharge (m³)

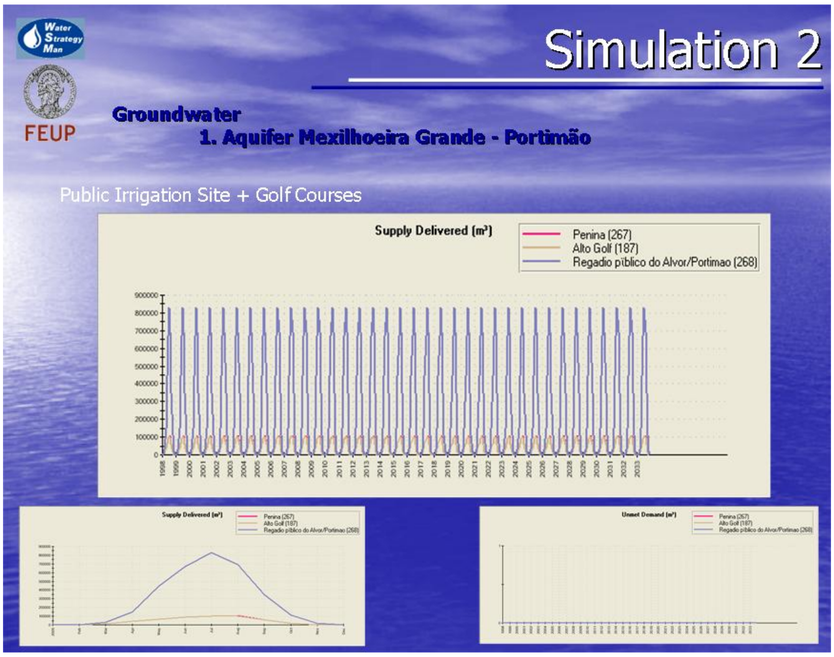

Simulation 1
FEUP
Surface water
2. Storage Reservoir – Bravura
Public Irrigation Site + Golf Courses
Cultivated Area (m²)
Demand (m³)
Supply Delivered (m³)
Unmet Demand (m³)

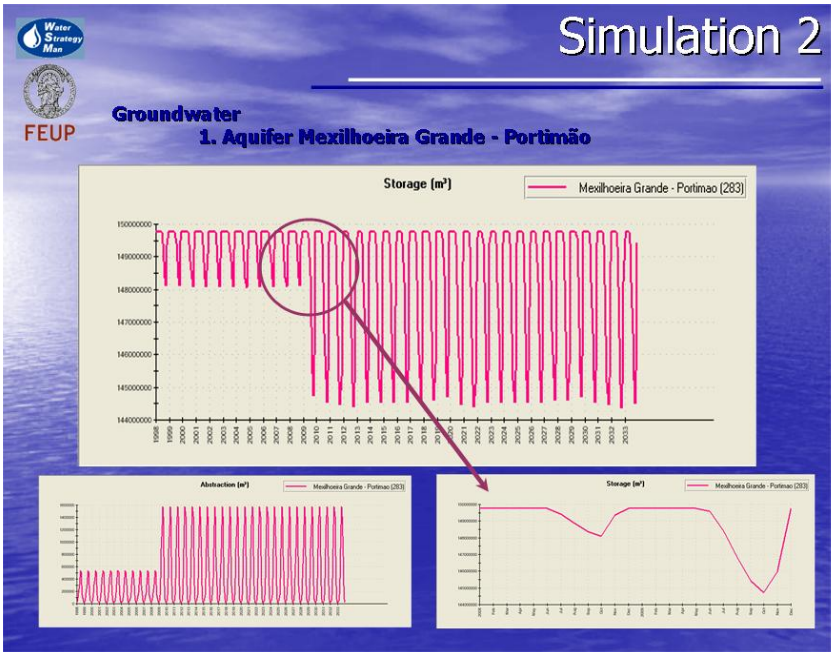

Simulation 1
FEUP
Surface water
2. Storage Reservoir – Bravura
Supply from Bravura
Abstraction (m³)
Bravura (416)

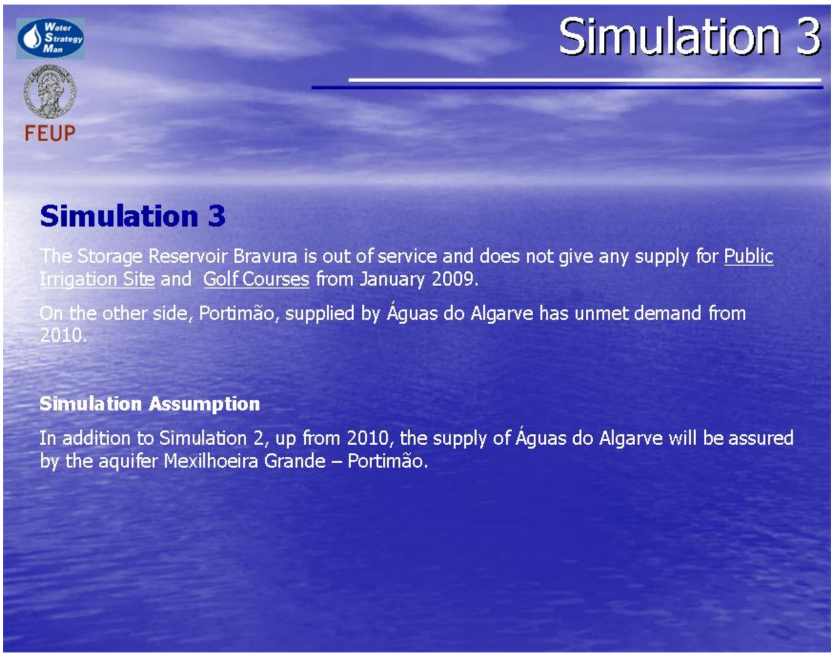

Simulation 1
FEUP
Surface water
3. Águas do Algarve Network
Settlement
Unmet Demand (m³)
Portimao (294)

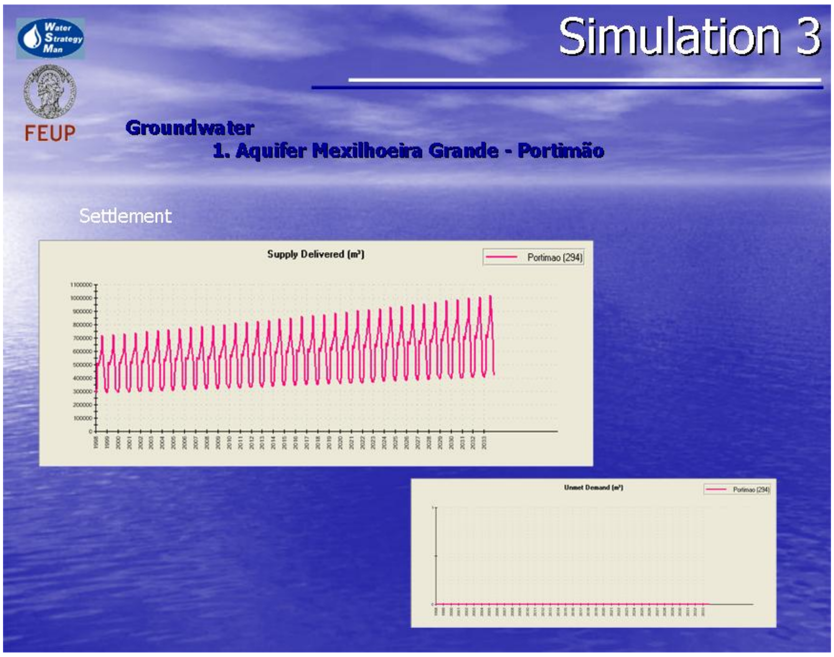

Simulation 1
FEUP
Surface water
3. Águas do Algarve Network
Industry
Demand (m³)
Industry in Portimao (233)
Supply Delivered (m³)
Industry in Portimao (233)

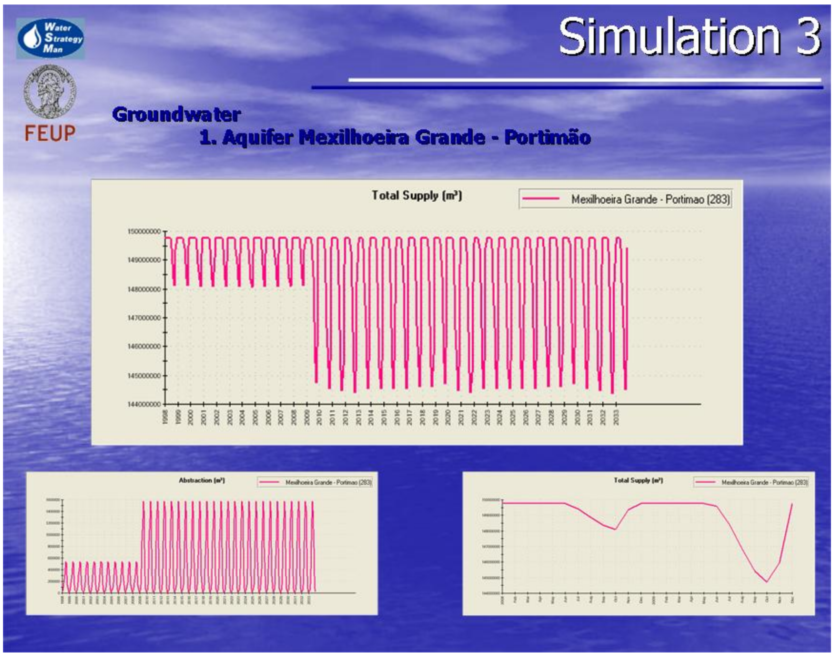

Simulation 2
FEUP
Simulation 2
The Storage Reservoir Bravura is out of service and does not give any supply for Public Irrigation Site and Golf Courses from January 2009.
Simulation Assumption
Up from 2009, the supply will be assured by the aquifer Mexilhoeira Grande – Portimão.

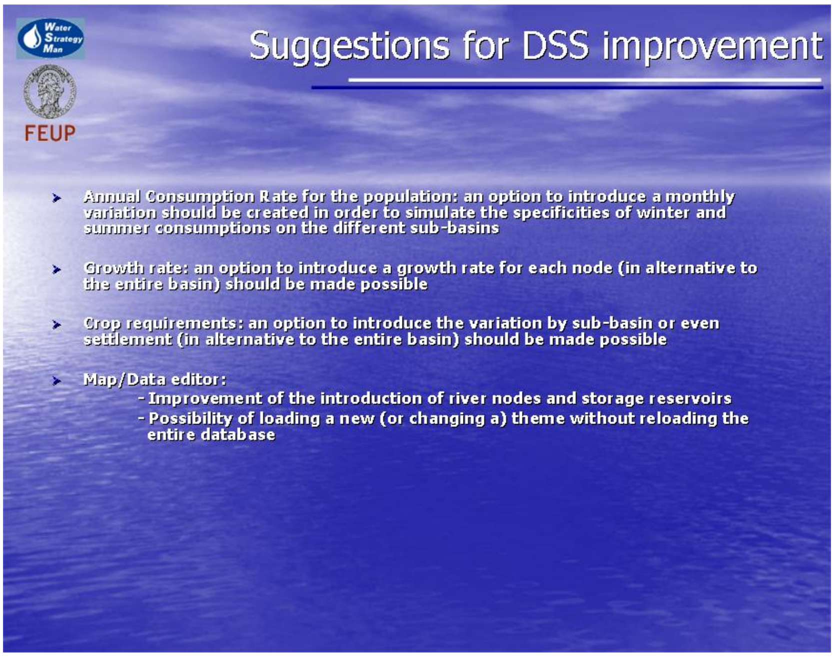

Simulation 2
FEUP
Groundwater
1. Aquifer Mexilhoeira Grande - Portimão
Public Irrigation Site + Golf Courses
Supply Delivered (m³)
Penina (267)
Alto Golf (187)
Regadio píblico do Alvor/Portimao (268)


Simulation 2
FEUP
Groundwater
1. Aquifer Mexilhoeira Grande - Portimão
Storage (m³)
Mexilhoeira Grande - Portimao (283)


Simulation 3
FEUP
Simulation 3
The Storage Reservoir Bravura is out of service and does not give any supply for Public Irrigation Site and Golf Courses from January 2009.
On the other side, Portimão, supplied by Águas do Algarve has unmet demand from 2010.
Simulation Assumption
In addition to Simulation 2, up from 2010, the supply of Águas do Algarve will be assured by the aquifer Mexilhoeira Grande – Portimão.


Simulation 3
FEUP
Groundwater
1. Aquifer Mexilhoeira Grande - Portimão
Settlement
Supply Delivered [m³]
Portimao (294)


Water Strategy Man
FEUP
Simulation 3
Groundwater
1. Aquifer Mexilhoeira Grande - Portimão
Total Supply (m³)
Mexilhoeira Grande - Portimao (283)


Water Strategy Man
FEUP
Suggestions for DSS improvement
Annual Consumption Rate for the population: an option to introduce a monthly variation should be created in order to simulate the specificities of winter and summer consumptions on the different sub-basins
Growth rate: an option to introduce a growth rate for each node (in alternative to the entire basin) should be made possible
Crop requirements: an option to introduce the variation by sub-basin or even settlement (in alternative to the entire basin) should be made possible
Map/Data editor:
- Improvement of the introduction of river nodes and storage reservoirs
- Possibility of loading a new (or changing a) theme without reloading the entire database

PRESENTATION 6

THE SEARCH FOR THE "TRUE COST"

BY J.M. BERLAND

Office International de l'Eau

The true cost of water and its value, consequences for local societies.

- The aim of this contribution is to give a clear definition of each component of the true cost and to propose an operational and simple formula to calculate it.
- The other aim of this contribution is to discuss advantages and limits of these concepts to characterise the impact of the chosen option.

Office International de l'Eau

The true cost of water and its value, consequences for local societies.

- "*Member States shall take account of the principle of recovery of the costs of water services, including environmental and resource costs…"*

  Water Framework Directive - Article 9

- All decision relating to water resource management and/or regulation should take into account the true cost of water that should include the following items:
  - ⇨ cost of water infrastructures;
  - ⇨ environmental cost;
  - ⇨ cost induces for the other possible water uses by the degradation of the resource due to the chosen option

The true cost of water and its value, consequences for local societies.

Cost of water infrastructures

- The most known component of the water cost is the present average cost of the different infrastructures for water. It is composed by:
  - Cost of operation;
  - Cost of maintenance;
  - Depreciation of initial investment.

The true cost of water and its value, consequences for local societies.

Cost of water infrastructures

The annual water cost when there is a sustainable use of the technical systems (Cost of sustainability of technical systems) is obtained with the help of physical data relating to water infrastructure

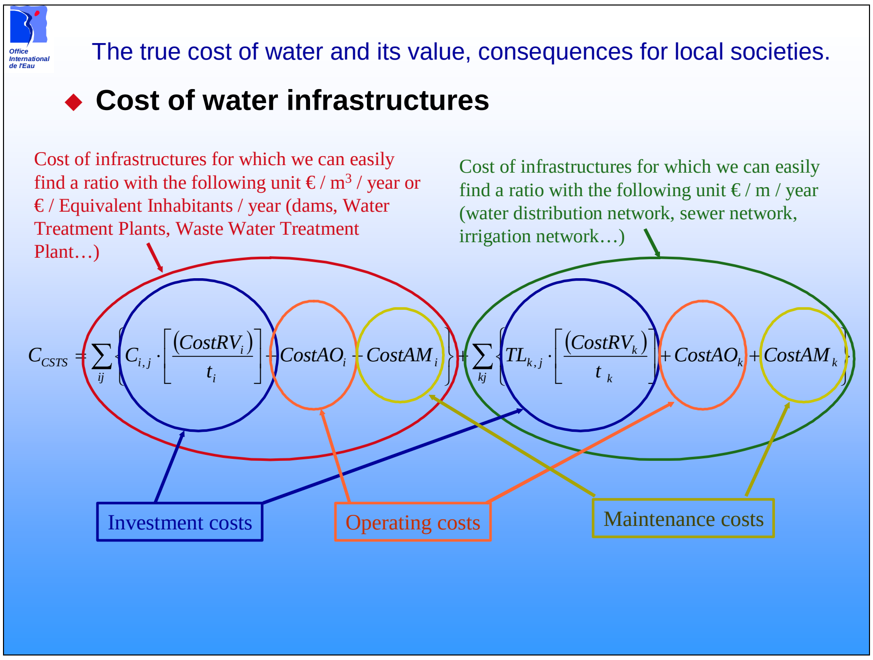
$$C_{CSTS} = \sum_{ij} \left\{ C_{i,j} \cdot \left[\frac{(CostRV_i)}{t_i} \right] + CostAO_i + CostAM_i \right\} + \sum_{kj} \left\{ TL_{k,j} \cdot \left[\frac{(CostRV_k)}{t_k} \right] + CostAO_k + CostAM_k \right\}$$

Where *i*, *k*, *j* the parameters that are presented in the following table.

Plant *i*	**Total network length *k***	**Users *j***
Dams	Water distribution net	Permanent population
Water catchment	Sewer network	Seasonal population
Water treatment plant	Irrigation network	Irrigation
Distribution systems for freshwater treatment		Industry
Waste water treatment plant		Power generation
Distribution systems for waste water treatment		

and:

C_i:	Capacity of i (in m^3)
$CostRV_i$:	Replacement value of i (Euros / m^3)
$CostAO_i$:	Average Operating Costs of i (in Euros / m^3/ year)
$CostAM_i$:	Average Maintenance Costs of i (in Euros / m^3/ year)
t_i:	Depreciation period (useful life) of i (in year)
TL_k:	Total length of network k (in m)
$CostRV_k$:	Replacement value of network k (in Euros / m)
$CostAO_k$:	Average Operating Costs of network k (in Euros / m / year)
$CostAM_k$:	Average Maintenance Costs network k (in Euros / m / year)
t_k:	Depreciation period (useful life) of network k (in year)



Office International de l'Eau

The true cost of water and its value, consequences for local societies.

- Available methods for estimating environmental cost

a) *Market methods;*

b) *Cost-based* valuation methods;

c) *Revealed preference methods*:

- Hedonic Pricing;
- Averting Behavior;
- Recreation Demand Models (RDM)

d) *Stated preference methods*;

e) *Contingent Valuation;*

f) *Use of Value Transfer.*

The true cost of water and its value, consequences for local societies.

- Available methods for estimating environmental cost

All these methods are surrounded by controversies

In general, the critics question one, or both, of two core assumptions:

⇨that choices made in real or hypothetical market can be interpreted as a reflection of preferences or value;

⇨that such interpretations should be used for direct decision-making.

The true cost of water and its value, consequences for local societies.

- Available methods for estimating environmental cost

Our proposition, a limited but operational method: a *cost-based* valuation method based on mitigation costs

The assumption made is that the costs of measures that need to be taken to prevent environmental damages up to a certain point, such as the Directives' Objectives are a good estimate of what society is willing to forego.

According to this assumption, the following equation should be used.

C_{Env} = ***costs of preventive and / or mitigation measures ≅ environmental costs***

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The true cost of water and its value, consequences for local societies.

- The following equation should be used for estimating environmental cost

$$C_{Env} = \sum_{xy}\left\{C_{x,y}\cdot\left[\frac{(CostRV_x)}{t_x}\right] + CostAO_x + CostAM_x\right\} + \sum_{zy}\left\{TL_{z,y}\cdot\left[\frac{(CostRV_z)}{t_z}\right] + CostAO_z + CostAM_z\right\} - C_{CSTS}$$

Where x, y, z the parameters that are presented in the following table

Plant x needed to maintain the environmental benefit of keeping the same quantity of water available per capita (for each user) with a quality in compliance with legislation	Total network length *z* needed to maintain the environmental benefit of keeping the same quantity of water available per capita (for each user) with a quality in compliance with legislation	Users *y*
Dams	Water distribution net	Future permanent population (based on a scenario)
Water catchment	Sewer network	Future seasonal population (based on a scenario)
Water treatment plant	Irrigation network	Future needs for irrigation (based on a scenario)
Distribution systems for freshwater treatment		Future needs for industry (based on a scenario
Waste water treatment plant		Future needs for power generation (based on a scenario)
Distribution systems for waste water treatment		

and:

- C_x: Capacity of x (in m^3)
- $CostRV_x$: Replacement value of x (Euros / m^3)
- $CostAO_x$: Average Operating Costs of x (in Euros / m^3/ year)
- $CostAM_x$: Average Maintenance Costs of x (in Euros / m^3/ year)
- t_x: Depreciation period (useful life) of x (in year)
- TL_y: Total length of network y (in m)
- $CostRV_y$: Replacement value of network y (in Euros / m)
- $CostAO_y$: Average Operating Costs of network y (in Euros / m / year)
- $CostAM_y$: Average Maintenance Costs network y (in Euros / m / year)
- t_y: Depreciation period (useful life) of network y (in year)

Office International de l'Eau

The true cost of water and its value, consequences for local societies.

- The following equation should be used for estimating environmental cost

Cost of water infrastructures C_{CSTS} <u>in the future</u> (based on scenarios)

$$C_{Env} = \sum_{xy}\left\{C_{x,y}\cdot\left[\frac{(CostRV_x)}{t_x}\right] + CostAO_x + CostAM_x\right\} + \sum_{zy}\left\{TL_{z,y}\cdot\left[\frac{(CostRV_z)}{t_z}\right] + CostAO_z + CostAM_z\right\} - C_{CSTS}$$

The present cost of water infrastructures C_{CSTS} <u>must be subtracted</u>

The true cost of water and its value, consequences for local societies.

Water allocation: Is the opportunity cost doctrine operational to assess the economic impact of a decision on a local society?

Another part of the real cost of water is cost induced for the activities B, C, D… by the use of water resource caused by the activity A.

The precise definition of opportunity cost is the cost of any activity measured in terms of the benefit from the best alternative forgone

The true cost of water and its value, consequences for local societies.

Using opportunity cost doctrine seems to be very interesting for company's decision-making processes, when decision makers have to choose between **only** two options.

But what is the efficiency of this doctrine to understand the economic impact of a decision (allocation of X m^3 of water to the activity A) on a local society (cost induce by the lost of these X m^3 for the activities A, B, C…) ?

Until now we did not find any application of this doctrine in such complex situation and these other short definition of opportunity cost show us that this concept seems to be a good concept (but only a concept?) when you have to deal between only two option:

"Opportunity cost is defined as the advantage forgone as the result of the acceptance of ***an*** *alternative. It is measured as the benefits that would result from* ***the next best*** *alternative use of the same resources that were rejected in favour of the one accepted.* ***Opportunity cost is difficult, perhaps impossible, to measure precisely****. (International Institute for Applied System Analysis)*

The true cost of water and its value, consequences for local societies.

The aim of the utilisation of concepts such as the opportunity cost and scarcity rent is to place monetary values on the impact caused by use A on the other uses B, C, D…

It seems that it should be very difficult to find a simple formula to express in monetary terms this kind of cost.

Another option is to organise a panel of experts of a local society to fill in the following table to qualify the level of the scarcity rent.

The true cost of water and its value, consequences for local societies.

		At the local level, the inconvenience for following uses will be…				
		Permanent population	Tourism	Irrigation	Industry	Power generation
It has been decided to allocated X m^3 to the following user, Volumes are distributed as follow	**X_a for permanent population**		☐ very high ☐ high ☐ average ☐ low ☐ very low	☐ very high ☐ high ☐ average ☐ low ☐ very low	☐ very high ☐ high ☐ average ☐ low ☐ very low	☐ very high ☐ high ☐ average ☐ low ☐ very low
	X_b for tourism	☐ very high ☐ high ☐ average ☐ low ☐ very low		☐ very high ☐ high ☐ average ☐ low ☐ very low	☐ very high ☐ high ☐ average ☐ low ☐ very low	☐ very high ☐ high ☐ average ☐ low ☐ very low
	X_c for irrigation	☐ very high ☐ high ☐ average ☐ low ☐ very low	☐ very high ☐ high ☐ average ☐ low ☐ very low		☐ very high ☐ high ☐ average ☐ low ☐ very low	☐ very high ☐ high ☐ average ☐ low ☐ very low
	X_d for industry	☐ very high ☐ high ☐ average ☐ low ☐ very low	☐ very high ☐ high ☐ average ☐ low ☐ very low	☐ very high ☐ high ☐ average ☐ low ☐ very low		☐ very high ☐ high ☐ average ☐ low ☐ very low
	X_e for power generation	☐ very high ☐ high ☐ average ☐ low ☐ very low	☐ very high ☐ high ☐ average ☐ low ☐ very low	☐ very high ☐ high ☐ average ☐ low ☐ very low	☐ very high ☐ high ☐ average ☐ low ☐ very low	

Nota : $X_a + X_b + X_c + X_d + X_e = X$

The true cost of water and its value, consequences for local societies.

The fact that nobody manages to integrate the notion given by opportunity cost / scarcity rent into these calculations of cost and the fact that there are a lot of imprecision on the estimation of environmental cost may be considered as an obstacle for the implementation of cost recovery principle and a limit to a serious economics evaluation.

This vision must be moderate by the following observations:

1°) taking into account all the components of cost of infrastructure (cost of operation; cost of maintenance; depreciation of initial investment) and even just a part of the environmental cost would be a very important evolution in comparison with present practices;

2°) the integration of all these costs should have a great impact on the water price for the different users. This could have some very important consequences for local societies and this impact should be evaluated;

3°) there is a need of a real reflection on the assumption that says that the integration of the opportunity cost / scarcity rent should be a real progress for the water management and the local societies.

The true cost of water and its value, consequences for local societies.

If farmers can’t pay water and if it caused the decrease of farmers’ number, what should be the social cost and the environmental cost of this decrease?

Sometimes the application of cost-recovery principle can have counterproductive effects. For example, in an area near Montpellier (France), the drinking water price rises considerably just after the integration of cost recovery principle.

=> A large proportion of people found substitution source of water (recovery of rainwater, drilling, well, connection to rough water network…). Some of these “solutions” like drilling and well induce an uncontrolled water intake of water that could be non-sustainable at the local level in arid areas.

The true cost of water and its value, consequences for local societies.

Before every decision relating to the price of water, a real and serious study must be done on the affordability of the projected tarification system.

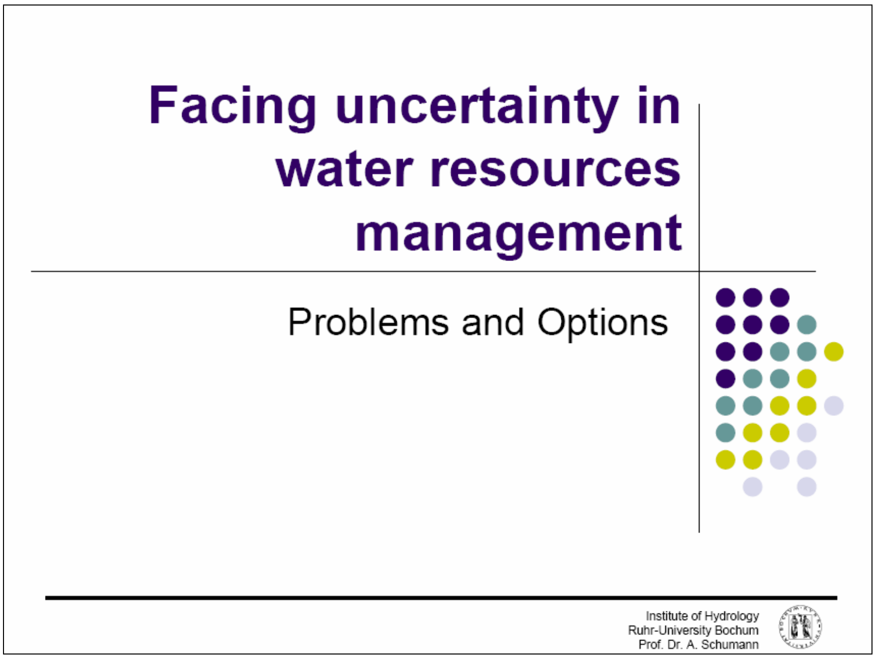
Forgotten this step may have some strength and bad consequences on local societies in arid areas.

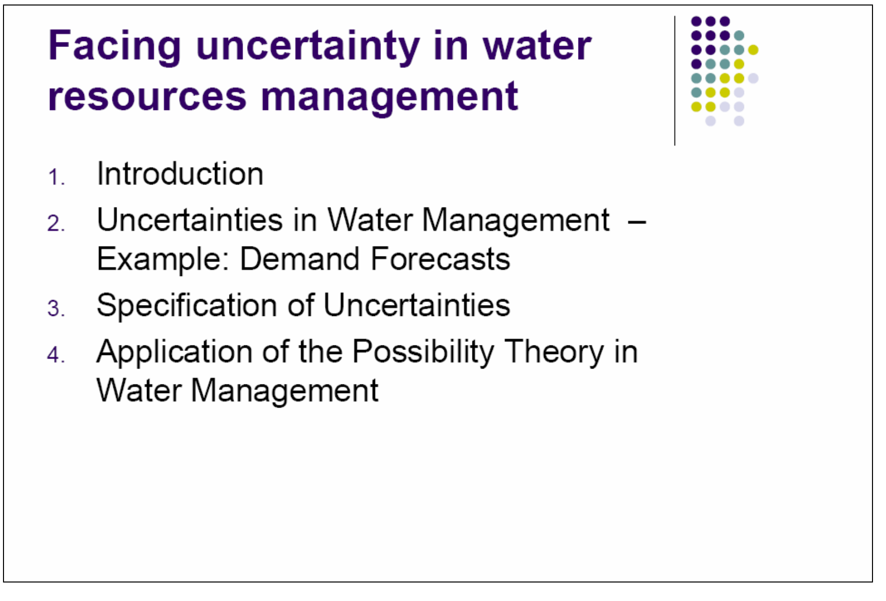
A too simple application of economic principle can kill local economy. A major challenge of the application of the cost recovery principle is to prevent such a situation.

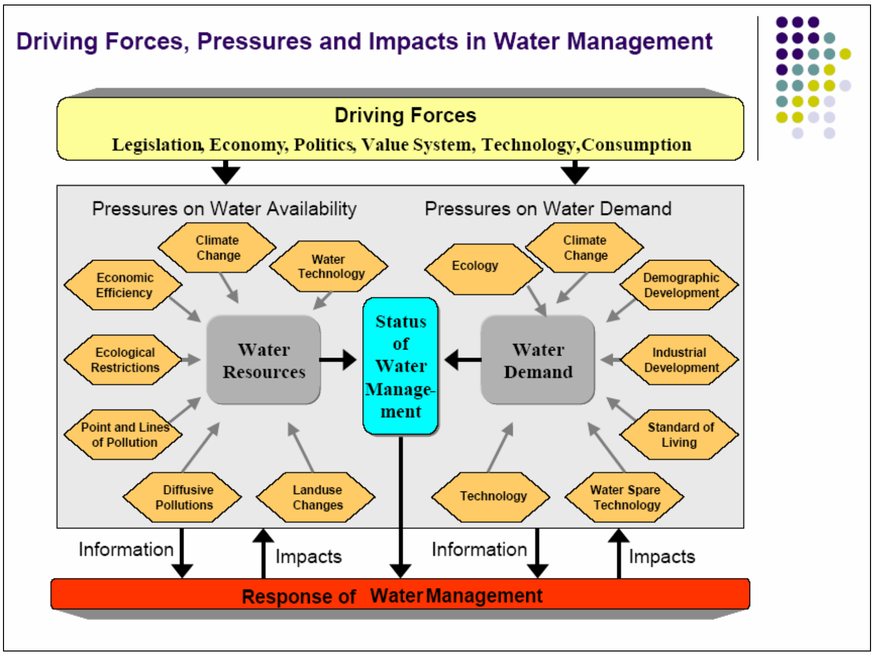
PRESENTATION 7

FACING UNCERTAINTY IN WATER RESOURCES MANAGEMENT

BY A. SCHUMANN

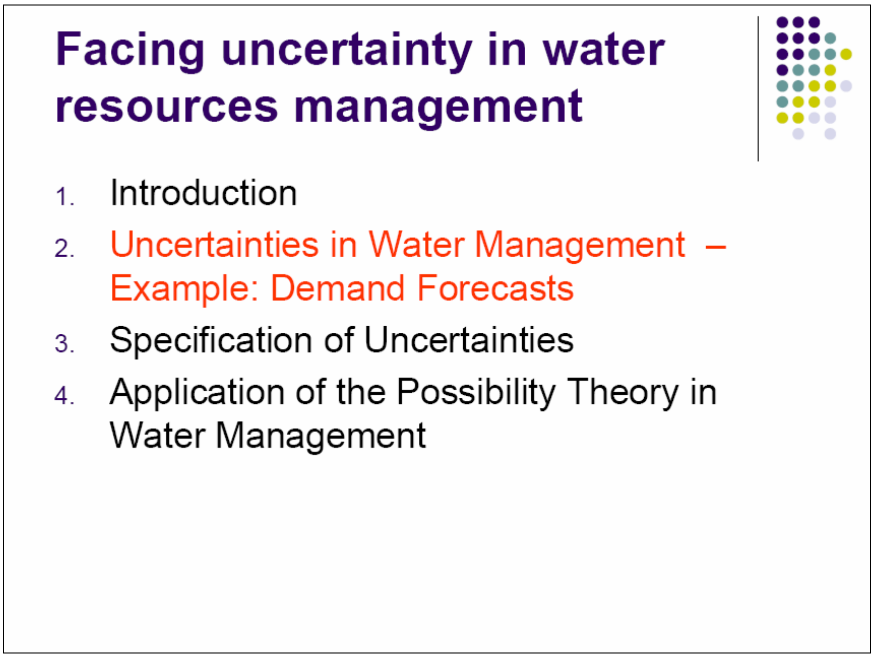

Facing uncertainty in water resources management
Problems and Options
Institute of Hydrology
Ruhr-University Bochum
Prof. Dr. A. Schumann


Facing uncertainty in water resources management
1. Introduction
2. Uncertainties in Water Management – Example: Demand Forecasts
3. Specification of Uncertainties
4. Application of the Possibility Theory in Water Management



Sources of Uncertainty

- Models (deterministic relationships, parameters)
- Data
- Future Developments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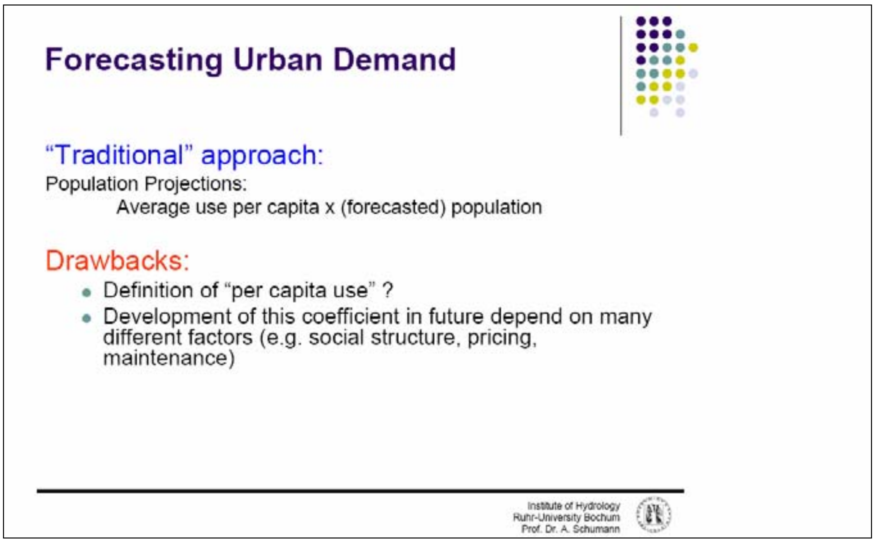
Forecasting Urban Demand
"Traditional" approach:
Population Projections:
Average use per capita x (forecasted) population
Drawbacks:
Definition of "per capita use" ?
Development of this coefficient in future depend on many different factors (e.g. social structure, pricing, maintenance)
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Prognosis of domestic water demand

“Traditional” approach

Statistical based methods

- Trend estimations
- Statistical Relationships between Input and Output
- Pure Statistics

Drawbacks:

- based on data from the past, but often changed boundary conditions (e.g. new technologies)

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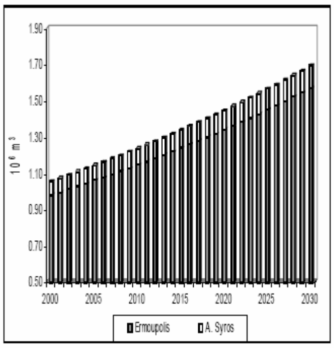
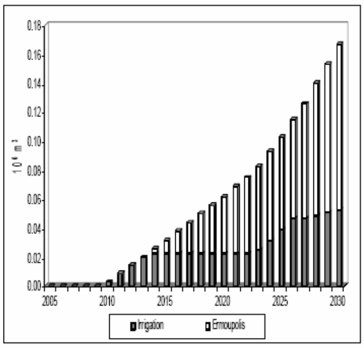
Trendbased Forecast





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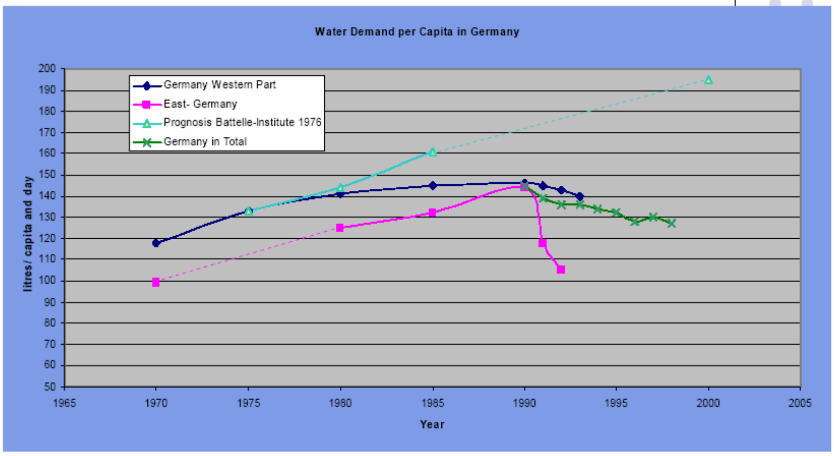
Development of Domestic Water Demand in Germany



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Prognosis of uncertain developments

"Traditional" approach

Statistical based methods

Simulation models:

- Based on detailed theories of deterministic relationships
- Limited options for extrapolations in time and space

Drawbacks:

- High data demand
- Many subjective components

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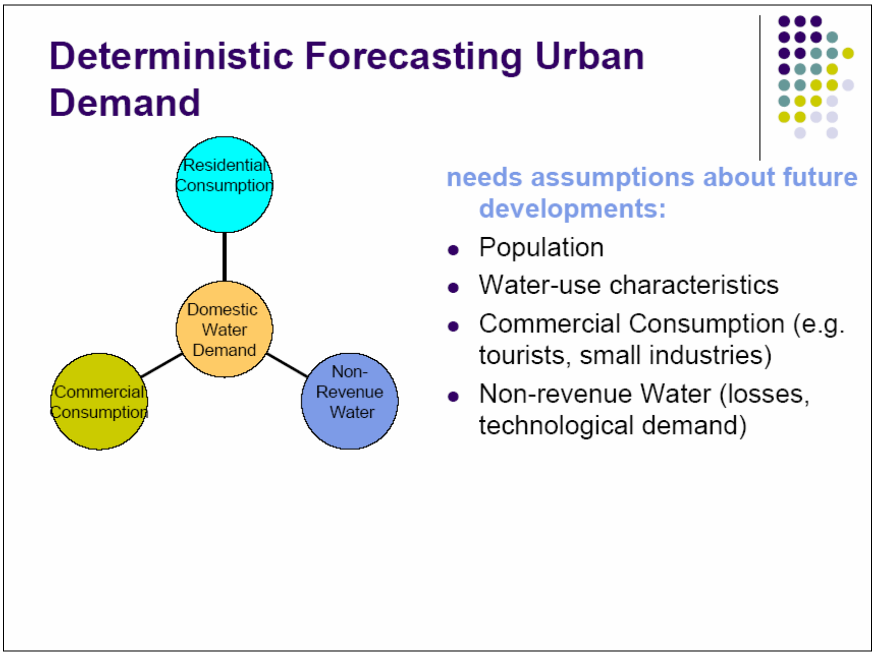
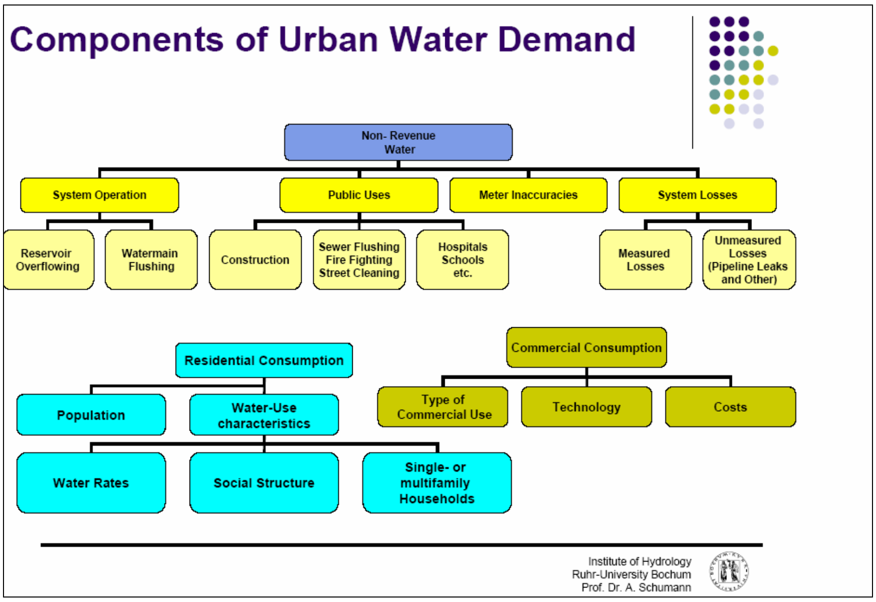

Deterministic Forecasting Urban Demand
Residential Consumption
Domestic Water Demand
Commercial Consumption
Non-Revenue Water
needs assumptions about future developments:
Population
Water-use characteristics
Commercial Consumption (e.g. tourists, small industries)
Non-revenue Water (losses, technological demand)


Components of Urban Water Demand
Non- Revenue Water
System Operation
Public Uses
Meter Inaccuracies
System Losses
Reservoir Overflowing
Watermain Flushing
Construction
Sewer Flushing Fire Fighting Street Cleaning
Hospitals Schools etc.
Measured Losses
Unmeasured Losses (Pipeline Leaks and Other)
Residential Consumption
Population
Water-Use characteristics
Water Rates
Social Structure
Single- or multifamily Households
Commercial Consumption
Type of Commercial Use
Technology
Costs
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Prognosis of uncertain developments

"Traditional" approach
Statistical based methods
Simulation models
Scenario techniques:

- Based on quantitative and qualitative information
- Multi-dimensional approach

Drawbacks:

- Different results, depending on assumptions
- Results have to be weighted
- Impact of influencing factors ?

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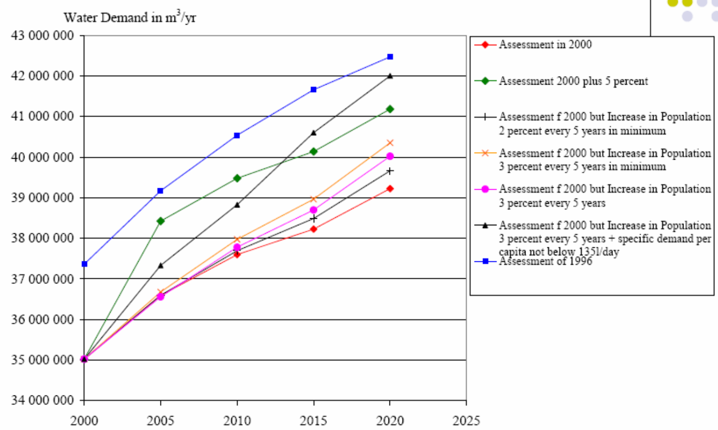
Example for Urban Water Demand Scenarios



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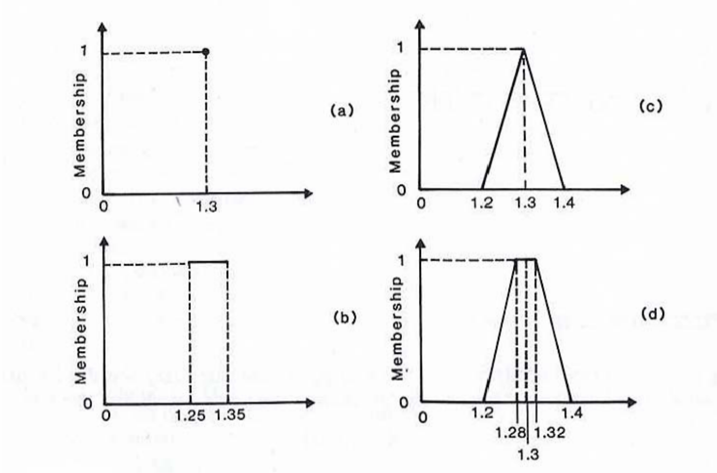
Facing uncertainty in water resources management

1. Introduction
2. Uncertainties in Water Management – Example: Demand Forecasts
3. Specification of Uncertainties
4. Application of the Possibility Theory in Water Management

Specification of Uncertainties

- **Deterministic** – the difference between a known real number value and its approximation is a real number (a single number)
- **Interval** – uncertainty is an interval.
- **Probabilistic** – uncertainty is a probability distribution function
- **Fuzzy** – uncertainty is a fuzzy membership function
- **Possibilistic** - uncertainty is a possibility distribution function, generated by nested sets (monotone)

Real Number, interval, fuzzy number and fuzzy interval (from Klir &Yuan)



How to specify uncertainties ?

SET THEORY

PROBABILITY

POSSIBILITY THEORY

FUZZY SET THEORY

DEMPSTER/SHAFER THEORY

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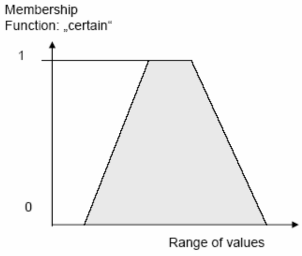
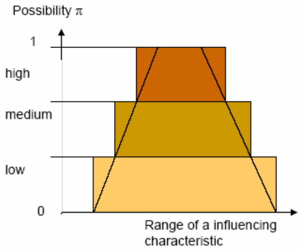
Possibilities



Fuzzy Logic



Possibility Theory

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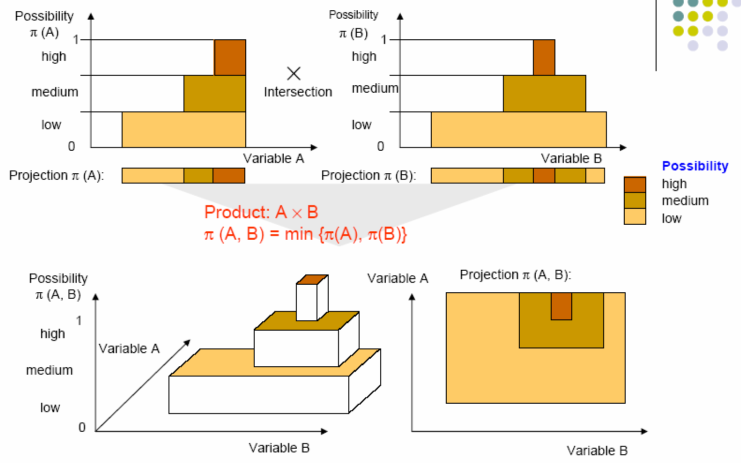
Possibility Arithmetics



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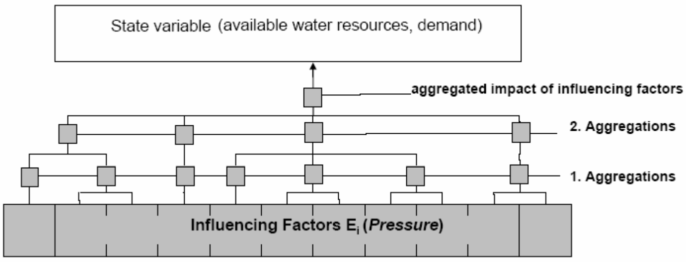
Application of the Possibilty Theory

1. Structuring the system, data management
2. Management Scenarios, related to planning variable
3. Effects of future developments under consideration of the assumed impact of influencing factors and management strategies on planning variable
4. Aggregation of the prognosis of different influencing factors

1. Structuring the system, data management



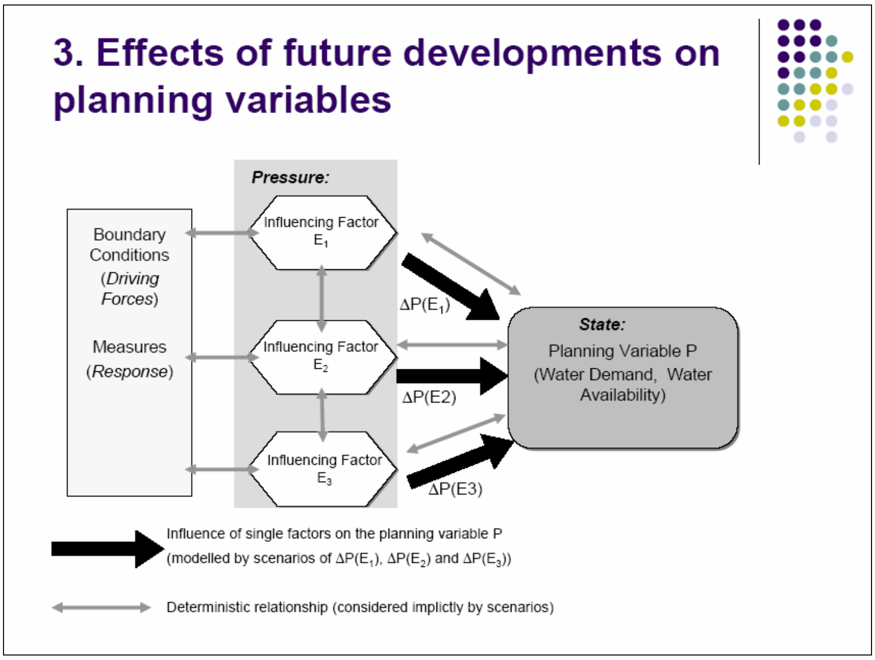
2. Management Scenarios, related to planning variable

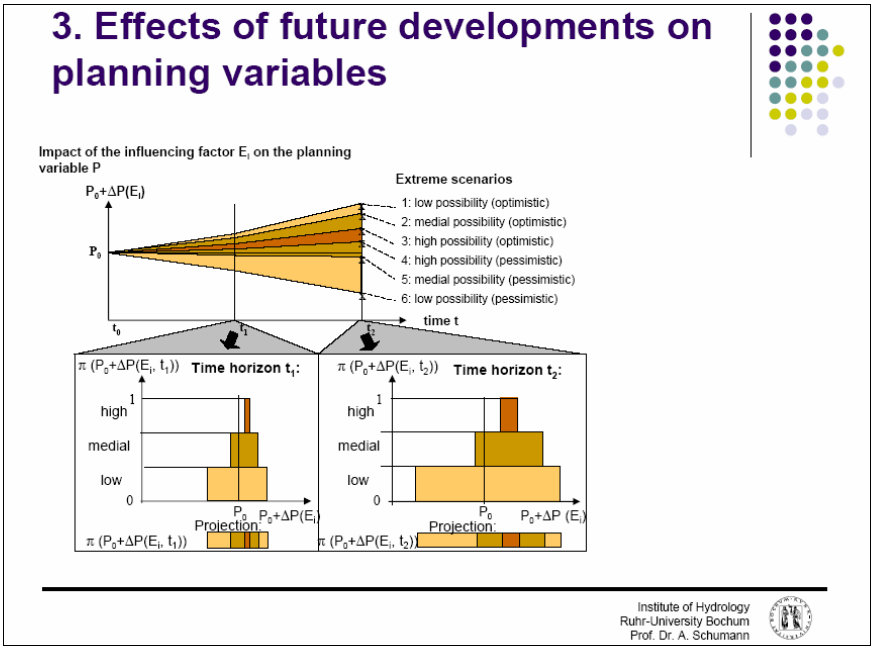
To increase of Water Availibity e.g.:

- New reservoirs
- Desalination Plants
- Water Transfer
- Protection of endangered resources

To influence water demand, e.g.:

- Economic means
- Substitution of water
- Increase water use efficiency


3. Effects of future developments on planning variables
Pressure:
Boundary Conditions (Driving Forces)
Measures (Response)
Influencing Factor E1
Influencing Factor E2
Influencing Factor E3
ΔP(E1)
ΔP(E2)
ΔP(E3)
State:
Planning Variable P (Water Demand, Water Availability)
Influence of single factors on the planning variable P (modelled by scenarios of ΔP(E1), ΔP(E2) and ΔP(E3))
Deterministic relationship (considered implictly by scenarios)


3. Effects of future developments on planning variables
Impact of the influencing factor Ei on the planning variable P
P0+ΔP(Ei)
P0
Extreme scenarios
1: low possibility (optimistic)
2: medial possibility (optimistic)
3: high possibility (optimistic)
4: high possibility (pessimistic)
5: medial possibility (pessimistic)
6: low possibility (pessimistic)
t0
t1
t2
time t
π (P0+ΔP(Ei, t1)) Time horizon t1:
π (P0+ΔP(Ei, t2)) Time horizon t2:
high
medial
low
1
0
P0
P0+ΔP(Ei)
Projection:
π (P0+ΔP(Ei, t1))
π (P0+ΔP(Ei, t2))
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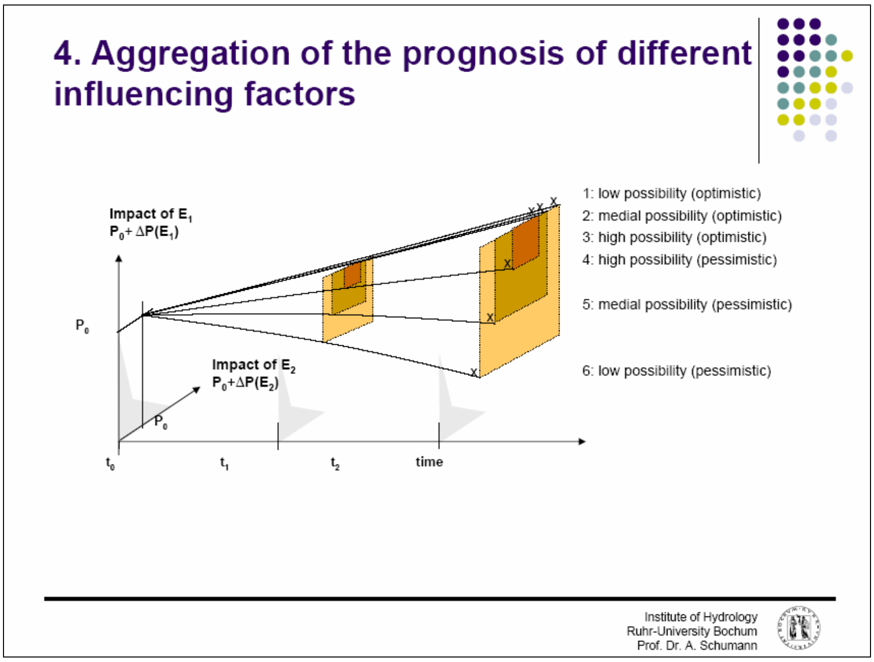
4. Aggregation of the prognosis of different influencing factors
Impact of E1
P0+ ΔP(E1)
P0
Impact of E2
P0+ΔP(E2)
P0
t0
t1
t2
time
1: low possibility (optimistic)
2: medial possibility (optimistic)
3: high possibility (optimistic)
4: high possibility (pessimistic)
5: medial possibility (pessimistic)
6: low possibility (pessimistic)
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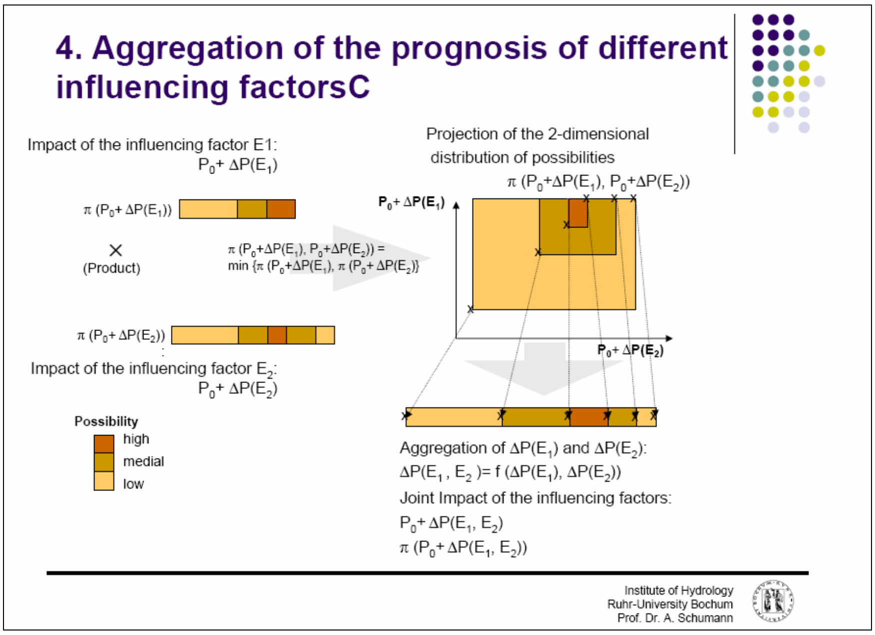
4. Aggregation of the prognosis of different influencing factorsC
Impact of the influencing factor E1:
P0+ ΔP(E1)
π (P0+ ΔP(E1))
(Product)
π (P0+ΔP(E1), P0+ΔP(E2)) =
min {π (P0+ΔP(E1), π (P0+ ΔP(E2)}
π (P0+ ΔP(E2))
Impact of the influencing factor E2:
P0+ ΔP(E2)
Possibility
high
medial
low
Projection of the 2-dimensional
distribution of possibilities
π (P0+ΔP(E1), P0+ΔP(E2))
P0+ ΔP(E1)
P0+ ΔP(E2)
Aggregation of ΔP(E1) and ΔP(E2):
ΔP(E1 , E2)= f (ΔP(E1), ΔP(E2))
Joint Impact of the influencing factors:
P0+ ΔP(E1, E2)
π (P0+ ΔP(E1, E2))
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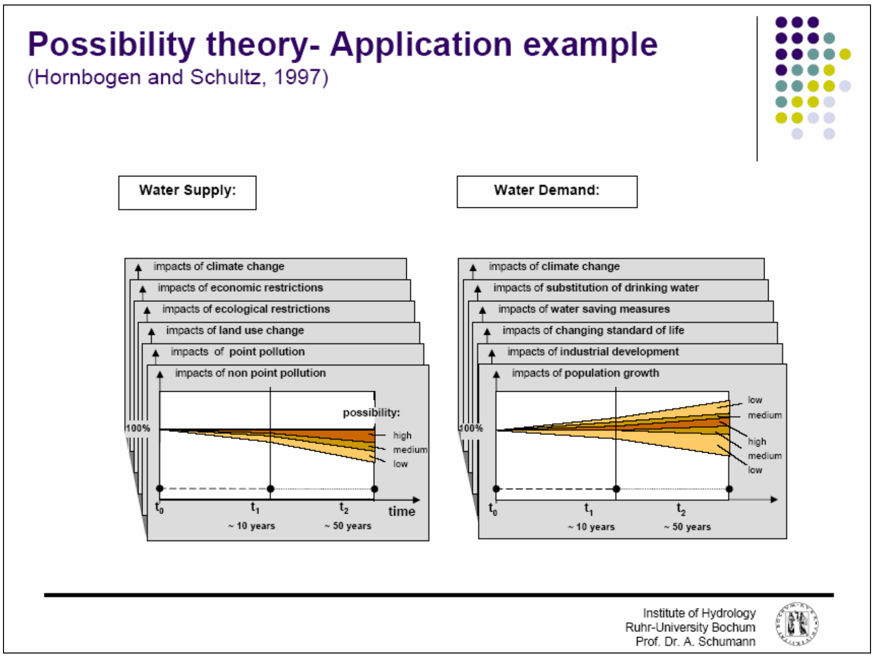
Possibility theory- Application example
(Hornbogen and Schultz, 1997)
Water Supply:
Water Demand:
impacts of climate change
impacts of economic restrictions
impacts of ecological restrictions
impacts of land use change
impacts of point pollution
impacts of non point pollution
possibility:
high
medium
low
100%
time
~ 10 years
~ 50 years
impacts of climate change
impacts of substitution of drinking water
impacts of water saving measures
impacts of changing standard of life
impacts of industrial development
impacts of population growth
low
medium
high
medium
low
100%
~ 10 years
~ 50 years
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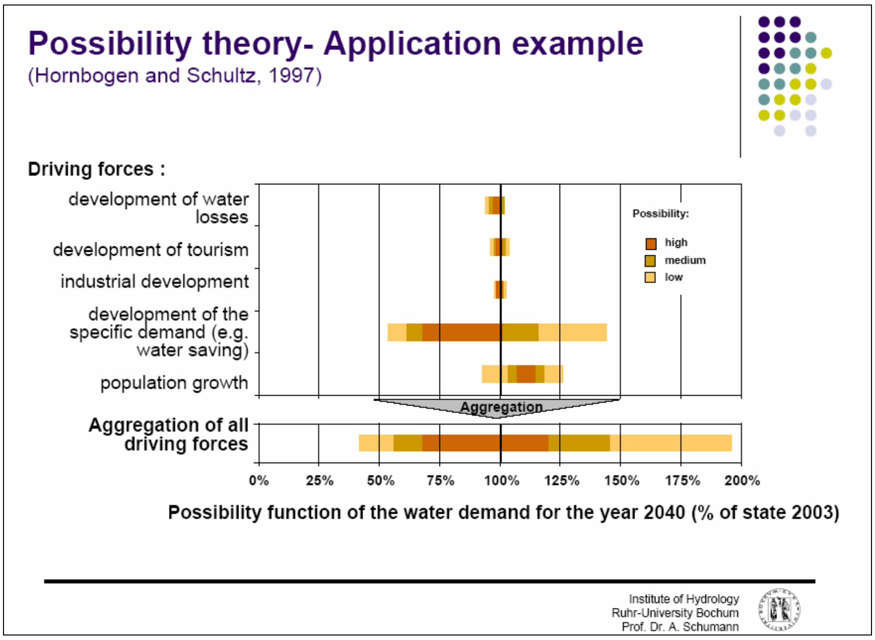
Possibility theory- Application example
(Hornbogen and Schultz, 1997)
Driving forces :
development of water losses
development of tourism
industrial development
development of the specific demand (e.g. water saving)
population growth
Possibility:
high
medium
low
Aggregation
Aggregation of all driving forces
0%
25%
50%
75%
100%
125%
150%
175%
200%
Possibility function of the water demand for the year 2040 (% of state 2003)
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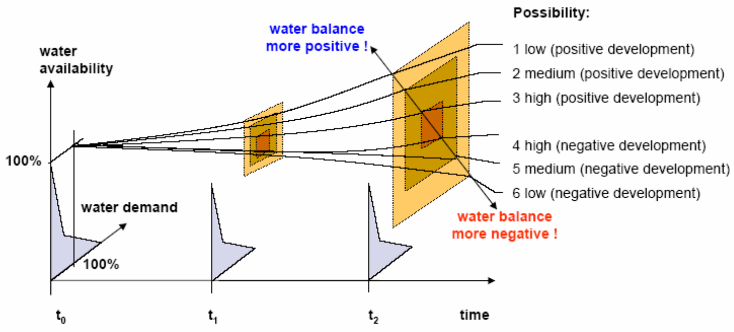
Possibility theory- Application example

(Hornbogen and Schultz, 1997)



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Conclusions

- Uncertainty can not be avoided.
- A good DSS considers uncertainties explicitly.
- The user should be able to express his opinion about future developments.
- Possibility theory offers a way to consider the personal experience of user.