SWIM and Horizon 2020 Support Mechanism

Working for a Sustainable Mediterranean, Caring for our Future

Design and simulation of mitigation measures, prioritization and decision-making

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Drought Risk Management (DRM) Mainstreaming" Regional Training

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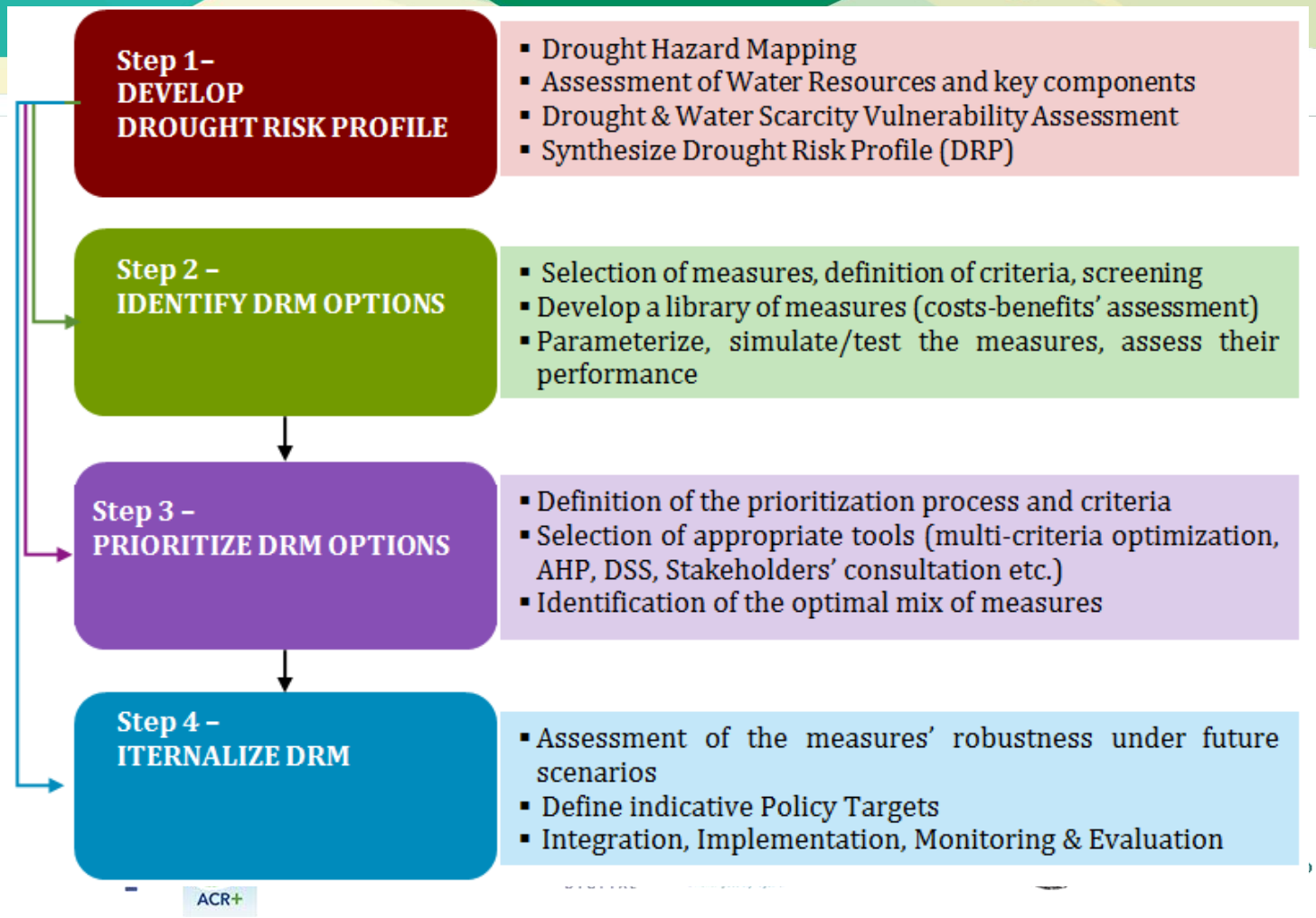
The main 4 steps and actions in DRMM



Measures within a Drought Risk Management Plan (DRMP)

A Drought Risk Management Plan should contain:

- Indicators: Each drought phase is defined by indicators and thresholds establishing the onset, ending, and severity levels of the exceptional circumstances (prolonged drought)
- Measures to be taken in each drought phase in order to prevent deterioration of water status and to mitigate negative drought effects.

Objectives of t

The measures i rve a series of specific objective

- Guarantee wa antities to meet essential hum s health and life
- Avoid or mini on the status of water bodies, and quantitative status for grou ase of <u>prolonged drought</u>, as sta
- Minimize nega ties, according to the priority g the River Basin Management d strategies (e.g. land use plann

Programme of Measures (PoMs) associated to the DRMP

1. Preventative or strategic measures

- These are developed and used under the normal status.
- They belong to the hydrological planning domain and their main objective is reinforcing the structural system to increase its response capacity (to meet supply guarantees and environmental requirements) towards droughts.
- Crucial activity is the determination of the **strategic storage**, an unexploited natural storage (e.g. groundwater aquifer) that will serve as the vital resource during drought.
- These are measures to be taken in River Basin Management Plans (RBMPs).

2. Operational (tactical) measures

- These are typically applied when droughts occur
- These are mainly control and information measures in pre-alert and conservation resources measures
- If the drought is prolonged excessively, the status of water resources can deteriorate to a point in which emergency operational measures might be needed, consisting essentially of applying water restrictions
- Severe Water conservation measures and restrictions, to be adopted if drought worsens to extreme status, should be ranked according to parameters such as: priorities among different uses, environmental requirements, status of drought etc.

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Programme of Measures (PoMs) associated to the DRMP

3. Organizational measures

- Establish competent agents and an appropriate organization to develop and follow-up the DRMP
- Create coordination protocols among administrations and public and private entities directly linked to the problem, in particular to those entities in charge of public supply

4. Follow-up measures

- Serve in the process of watching out for the compliance and application of the DRMP and its effects.

5. Restoration or exit drought measures

- Include the deactivation of adopted measures and the activation of restoration ones over the water resources effects and the aquatic ecosystem

Simulation and testing of the measures

- It is important to **test/ simulate response measures** (and a bundle of them) **against the physical system**, in order to test their application and assess their true potential under specific conditions and constraints
- The process of testing response measures can be **underpinned by their simulation in a physically-based distributed water resources management model (WRMM)**, which can capture all the salient features of water availability and demand per source and user

Methodological steps to simulate/test the measures within WRMM:

- Selection relevant measures (per sector) in consultation with local stakeholders
- Adaption of clear definitions for all measures and interventions
- Parsimonious parameterization of the measures via a small number of variables
- Collection of the input data needed for the simulation (potential saving, costs)
- Investigation on how to simulate them in the physical WRMM model (coding routines)
- Simulation of the selected solutions against a baseline scenario, and assessment of their impact and cost-effectiveness on the physical system

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Prioritization of DRM measures

Some criteria to take into account when selecting measures might include:

- Legal support
- Technical viability
- Cost-effectiveness and cost-benefits analyses
- Compatibility with other measures
- Environmental impact
- Time frame available to achieve effectiveness

Priority according to type of measures

- Measures to **rationalize water demand** (infrastructure improvement and modernization, foster saving, reuse and recycling) → should be the top priority.
- Measures that **address water demand with infrastructures** (regulation, intake, desalination, transport, interconnection etc.) → should be considered as an option when the previous measures have been exhausted, including effective water pricing policy and cost-effective alternatives. They remain in any case subject to EU legislation, in particular to all WFD requirements.
- Environmental protection actions especially oriented to **safeguard aquatic ecosystems.**

Prioritization of DRM Measures: Supporting Tools

- **Purpose**: Selection of the optimum mix of measures across the various sectors (domestic, environment, agriculture, industry, etc.)

- **Tools:**

- Analytical Hierarchy Process (AHP)
- Parameterization-Simulation-Optimization (PSO) framework
- Decision Support Systems (DSS)
- Stakeholders' participatory approaches /consultation

Supporting Tools: AHP, PSO

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
2	Weak or slight	
3	Moderate importance	Experience and judgment slightly favor one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgment strongly favor one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favored very strongly over another; its dominance demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation

Analytic Hierarchy Process (AHP):

- Widely used weight evaluation method (Saaty, 1997) for decision making
- All identified criteria/factors must be set in a priority order according to the goal to be achieved in the decision making process. These criteria are them compared to each other in a pairwise comparison matrix, where their relative importance is expressed by numerical values (1 to 9)

Parameterization-Simulation-Optimization (PSO) :

- Simulation of the hydrosystem by implementing the parameters (variables) that define the measures.
- Definition of appropriate objective function(s) that express the desired performance metric(s).
- Utilization of an optimization algorithm to define the optimum mix of interventions across the sectors (i.e. derive the best management policy)

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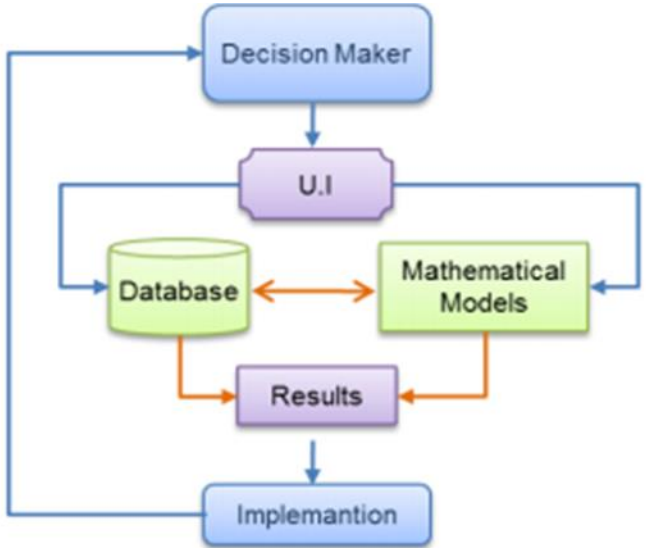
Supporting Tools: DSS



DSS is "a system based on computer that supports the process of making decisions, helping to decide, to develop and to explore the implications of the decisions and thus to decide based on understanding

The main challenges of a DSS are:

- to analyze and forecast the conditions, expected to dominate in the decision
- to simulate the impact of the proposed alternative decisions
- to evaluate the feasibility of decisions
- to quantify the benefits and the cost based an evaluation criterion.

The decision making process is completed with the evaluation and **classification of the alternative decisions** on the basis of the objectives set during formulation of the problem, in order to obtain the most advantageous decision with informed manner

In a DSS the **person who receives the decision has a basic role**, since he develops the problem, sets the goals and determines the valuation of the alternative decisions.

Multi-criteria Optimization with algorithms are commonly used in the DSS

Identification and structure of PoMs according to indicators status

Normal status: This phase should be seen as the hydrological planning one, in which strategic and long-term measures are applied.

Pre-alert status: The objective is to prevent the deterioration of water bodies while ensuring the activation of specific drought management measures, and continuing to meet water demands. These are considered informative and control measures.

Alert status: This is an intensification of the pre-alert status, since drought progresses as well as measures to apply. It is a priority to continue preventing the deterioration of water bodies status. These types of measures should be focused on saving water. Demand restrictions might be applied, depending on the socio-economic impacts, and by consensus of the affected stakeholders. Areas with high ecological value should be monitored more intensively to prevent their deterioration.

Emergency or extreme status: when all previous preventative measures have been applied, but the drought situation prevails to a critical status when no water resources are sufficient for the minimum demands (even affecting and restricting public supply), additional ones will need to be used to minimize impacts on water bodies and on mitigating ecological impacts, and public supply impacts. No measures that can prevent achievement of the WFD objectives should be taken, unless there is clarity about the existence of a **prolonged drought**.

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General Archive of Measures for DRP

TABLE .- GENERAL MEASURES PROGRAMME	
MEASURES	**STATUS OF APPLICATION**
A. REVISION or strategic during normal status	
A.1.Preventing drought start	At the approval of the DMP
• Validating drought status indicators	
• Validating thresholds and drought phases	
A.2. Establishing strategic measures	"Normal" status
• Development of basic RBMP measures	
• Development of complementary RBMP measures	
• Development of operational framework of water rights exchange Centres	
• Inventory and operative maintenance of drought infrastructures	
• Studies for improving knowledge of eater bodies	
• Studies for improving knowledge of hydrological cycles of wetlands	
B. OPERATIVE during "pre-alert", "alert" and "emergency"	
B.1. On demand	
• Voluntary water saving campaigns in urban supply, information, and social awareness	In "pre-alert"
• Voluntary water saving campaigns for irrigation, refocusing irrigation campaigns	In "alert"
• Water volume reduction for irrigation purposes	In "alert" and "emergency"
• Prohibiting uses (watering gardens, swimming pools, street cleaning, high water demand crops, golf courses etc.)	In "emergency"
B.2. On supply	
• Checking functioning of drought infrastructures	In "pre-alert"

General Archive of Measures for DRP

TABLE .- GENERAL MEASURES PROGRAMME	
MEASURES	**STATUS OF APPLICATION**
• Finishing infrastructures for planned droughts (drought wells, desalination plants, reuse systems) –when other possibilities have been taken into account and preventative measures have been applied-	In "pre-alert"
• Increasing groundwater abstraction –when future recovering ensured-	In "alert" and "emergency"
• Activate and increase waste water potential reuse	In "alert" and "emergency"
• Activate and increase the use of desalination plants –already constructed and in-use	In "alert" and "emergency"
• Resources transfers within the basin	In "alert" and "emergency"
• Activating the water rights Exchange centres for ensuring urban supply	In "emergency"
B.3. On the environment	
• Ensuring water quality and environmental objectives under WFD criteria	During all drought scenarios
• Determining use priorities during droughts situations	At the approval of the DMP
• Activating water rights exchange centres to avoid damages on water bodies	In "emergency"
• Maintenance, as a general criterion, of hydrological environmental requirements established in the RBMP-first priority is population supply-	In "alert" and "emergency"
• Restrictions on environmental hydrologic requirements, established in the RBMP, when it is necessary to ensure urban and social supply, as far as restrictions do not damage ecosystems, habitats, and vulnerable species to droughts (Natura 2000 Network and RAMSAR)	In "emergency"
• Maintaining outputs equal to inputs in reservoirs that feed aquatic habitats of Natura 2000 Network and RAMSAR wetlands	In "emergency"
• Avoid the direct use of water from wetlands vulnerable to drought situations	During all drought scenarios
• Avoid the use of minimum volumes in reservoirs presenting eutrophication or in risk.	In "alert" and "emergency"
• Increasing the control for discharges, wastewater treatment plants, agricultural practices and water quality	In "alert" and "emergency"

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General Archive of Measures for DRP

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MEASURES	STATUS OF APPLICATION
• Establishing an environmental watch plan on water bodies of Natura 2000 Networks, RAMSAR wetlands, water bodies feeding vulnerable wetlands and reservoirs	During all drought scenarios but most intensively in "alert" and "emergency"
• Increase Water Police and control of the water public domain to strengthen surveillance, sanctioning procedures and selective monitoring	In "emergency"
• Capture and relocation of endangered fauna and creation of special areas to maintain aquatic species	In "emergency"
C. ORGANIZATIVE or Managing System	
C.1. Related to DMP organisation	
• Establishing organization, responsible entities and resources to apply and follow-up the DMP	At the approval of the DMP
• Follow-up of indicators by the River Basin Authority	In normal and drought status
• Activation of a Drought Technical Office or similar structure –when needed-	In "pre-alert"
• Preparation, agreements approval, and administrative resolutions	In "alert" and "emergency"
• Approval of decrees and drought laws –when needed-	In "emergency"
• Establishment of a management drought commission	In "emergency"
• Approval of recovering measures by the competent authority	When recovering
• Deactivating drought special structures (as the Drought Technical Office)	When recovering
C.2. Related to coordination and participation	
• Coordination among administrations, public and private entities linked to the DMP	In normal status, droughts and when recovering
• Development of guidelines for special urban supply plans	At the DMP approval
• Activation of special urban supply plans or measures.	In "pre-alert" and "alert"
• Establishing public participation activities to inform and promote collaboration to ensure DMP measures effectiveness	During the DMP elaboration and implementation

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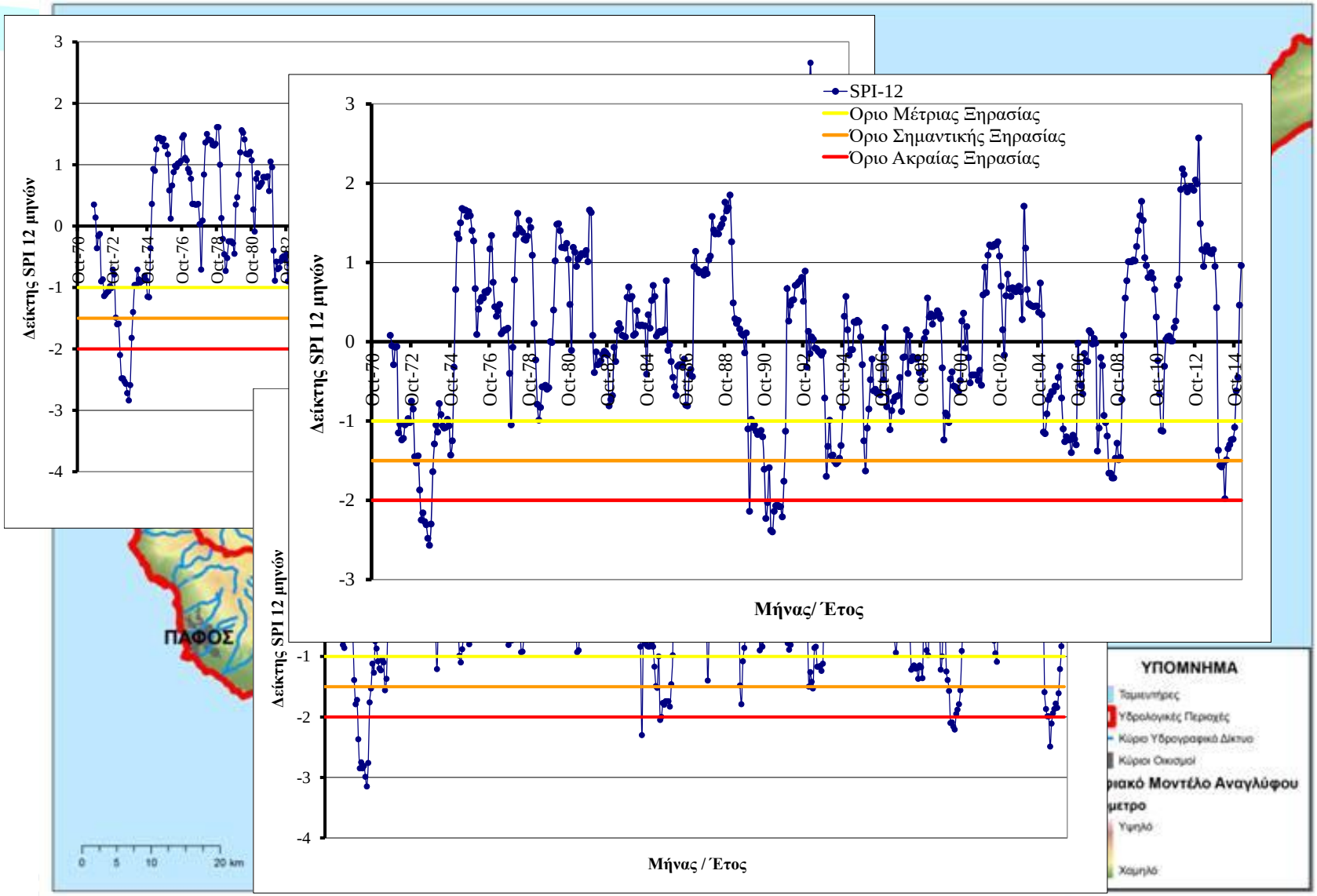
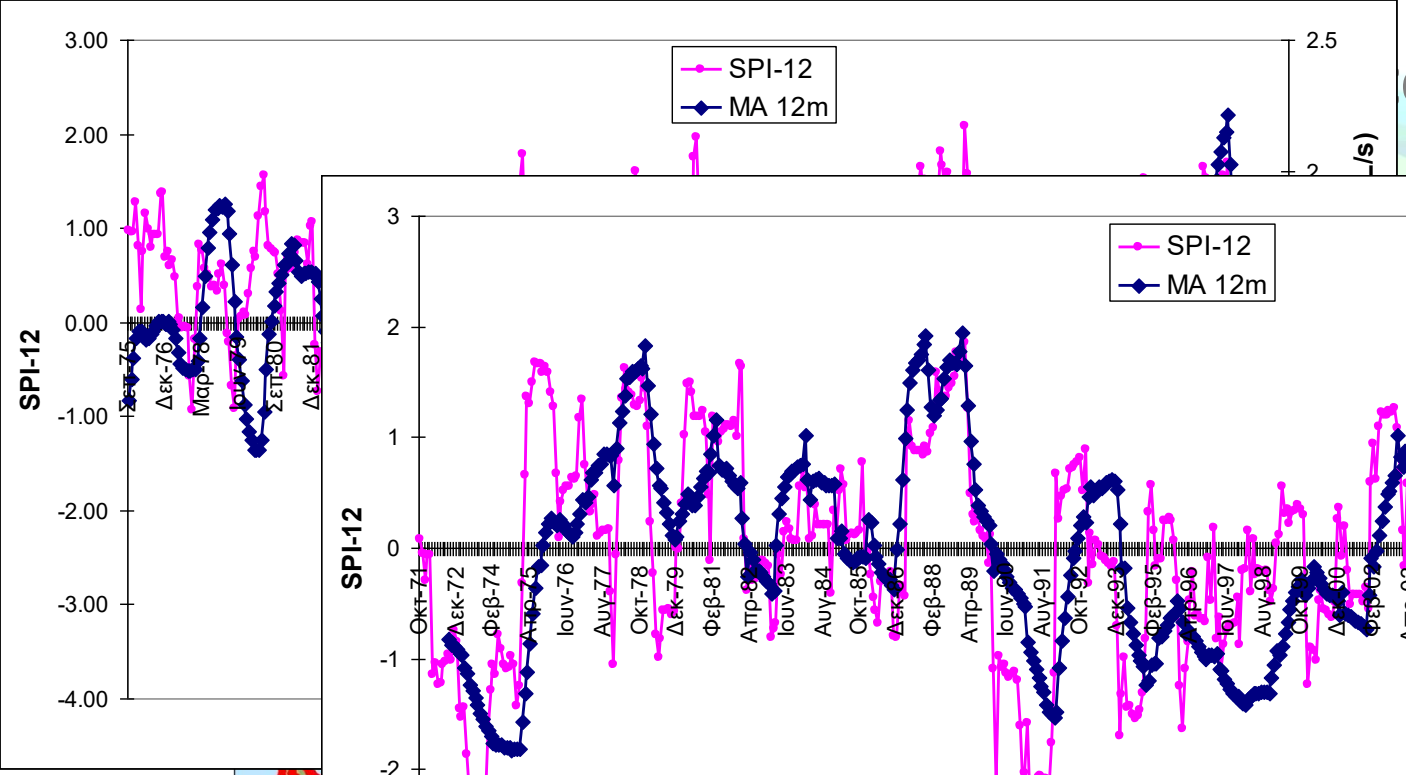
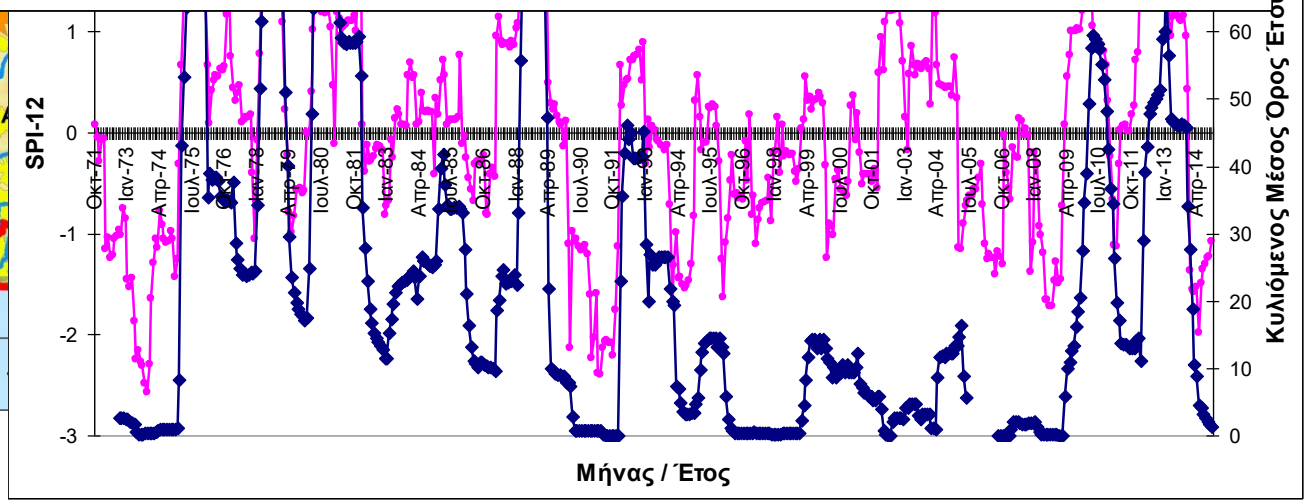
General Archive of Measures for DRP

TABLE .- GENERAL MEASURES PROGRAMME		
MEASURES		**STATUS OF APPLICATION**
D.-DMP FOLLOW-UP		
	• Establishment of follow-up indicators (evolution, effects and efficiency) of the DMP	At the DMP approval
	• Follow-up of drought status indicators	Throughout the whole process
	• Control of DMP follow-up indicators	During drought and after drought
	• Control of DMP measures achievement through post-drought audits	After drought
	• Upgrade or review of the DMP	After drought
E. RECOVERY		
	• Deactivation of supply measures	When recovering
	• Stop supply restrictions	After drought
	• Stop use restrictions	After drought
	• Activation of necessary and correction measures to recover affected ecosystems, habitats, species	After drought

Specific Application to the Republic of Cyprus
SPI main drought indicator







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Specific Application to the Republic of Cyprus – Drought Indicators

ALERT LEVEL	Drought Indicator
	SPI-12
NORMAL	> 0
LOW	-1 < SPI < 0
MODERATE	-1.5 < SPI < -1
HIGH	-2 < SPI < -1.5
EXTREMELY HIGH	< -2

ALERT LEVEL	Main Indicator	Auxiliary Indicators		
	SPI-12	Hydrologic Year Runoff Indicator	Wet Season Runoff Indicator	Reservoir Storage on 1st of April Indicator WATER STORAGE IN DAMS
NORMAL	> 0	> Median Value	> Median Value	SUFFICIENCY
LOW	-1 < SPI < 0	< Median Value	< Median Value	LOW DEFICIT
MODERATE	-1.5 < SPI < -1	< 25%	< 25%	MODERATE DEFICIT
HIGH	-2 < SPI < -1.5	< 15%	< 15%	SEVERE DEFICIT
EXTREMELY HIGH	< -2	< 5 %	< 5 %	EXTREME DEFICIT

Intra-basins Diversion Project in Cyprus

Drought Alert Levels and Desalination in Cyprus

DROUGHT ALERT LEVEL	DESALINATION PERFORMANCE
EXTREMELY HIGH	Full Exploitation of the Desalination Plants Capacity and Storage of Excess Water in Designated Reservoirs.
HIGH, MEDIUM & LOW	Maximization of the Water Production for the Water Supply Demand without Producing Excess Water.
NORMAL	Function of performance from other factors (e.g. Maintenance, fiscal performance).

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Reclaimed Water and Drought in Cyprus – Present and Future projection of Recycled Water for Irrigation in Cyprus (m^3)

Wastewater Treatment Plants	Year 2015 (38%)	Year 2025 (66%)
Municipal Treatment Plants	31,000,000	51,000,000
Rural Water Plants	1,569,865	6,173,975
TOTAL	32,569,865	57,173,975

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Thank you for your attention.

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