



Integrated Water Management Strategy in Oman

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**Ministry of Regional Municipalities
and Water Resources**

Sultanate of Oman

content



General background

Water Resources In The Sultanate of Oman

Challenges

Integrated Water Resources Management (IWRM)

Objectives and benefits of (IWRM).

Tools for (IWRM).

Study area.

Future expansion

Sultanate of Oman

- Lies in arid and Semi-arid Regions
- Hot and Dry Weather
- Annual Average Rainfall 100 mm
- Limited Water Resources
- Rapid development in all Sectors
- Diversification of the economy
- Increasing Water Demand
- Water Deficit and imbalanced Water Budget



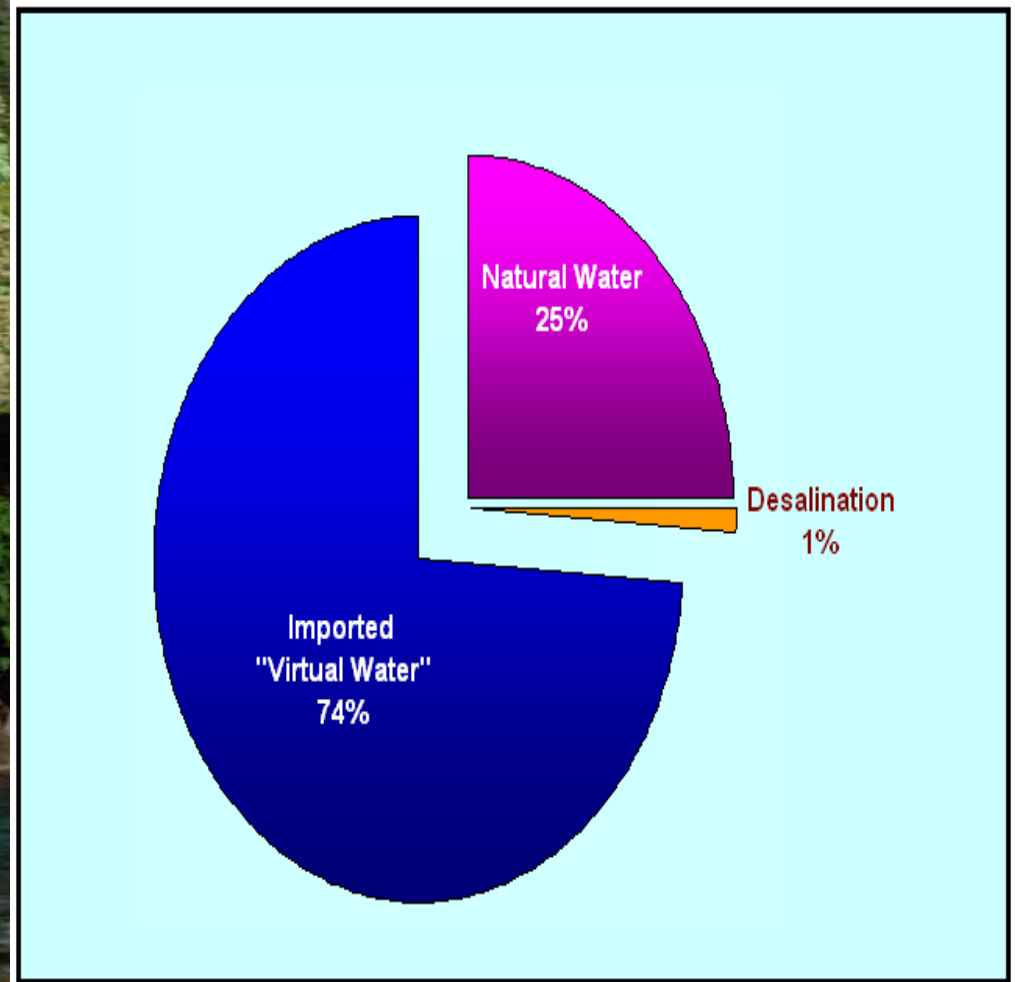


Facts & Statistics

- Annual renewable water resources = 1300 Mm³
- 70 % of them is used and the rest is lost to the sea or desert
- Annual per capita of renewable water is 500 m³.
- The Sultanate classified among the countries falling below the water poverty line
- 92 % of water resources used in agriculture

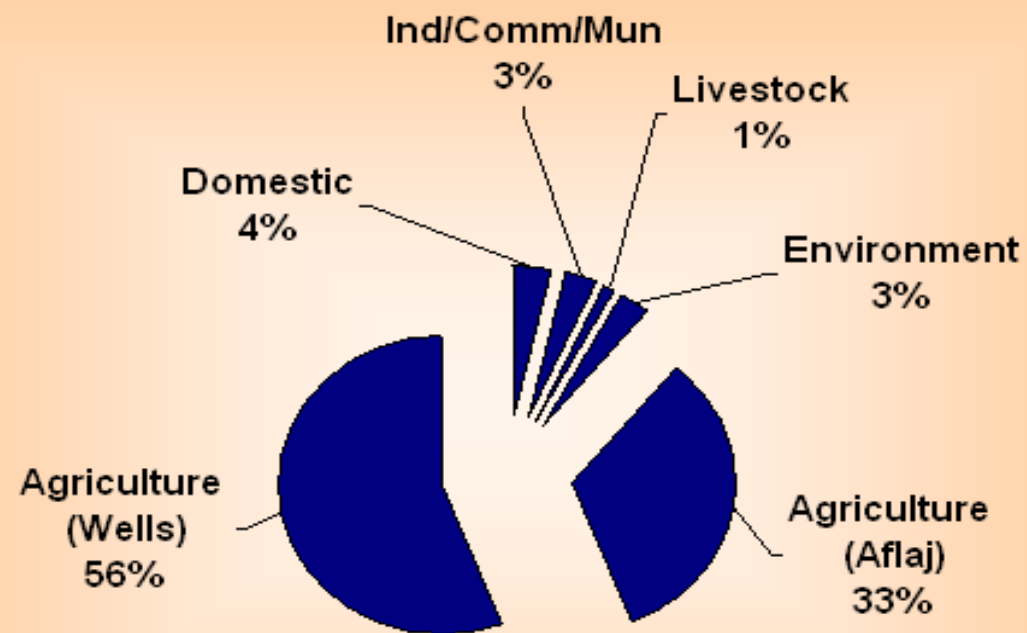
Water Resources In Oman

- Natural Sources (Rainfall, Groundwater)
- Desalination (Sea water or brackish Water)
- Virtual Water
- Treated Waste Water
- Other Sources



Current Water Consumption

Current Use of Water Resources





Main Challenges

- **Balance between demand and renewable water resources**
- **Protection of water resources from both pollution and depletion**
- **Secure safe potable water supply**
- **Increase in collection and reuse of treated wastewater**
- **Secure industrial and commercial water demand according to the available water resources**
- **Protect and save the accomplished investments in the water sector's infrastructure**

A photograph of a waterfall cascading down a rocky cliff face into a pool of water. The text "What is the solution?" is overlaid in yellow.

What is the solution?

Integrated Water Resources Management (IWRM)

- Integrated water resources management helps making decisions and taking actions on how water should be managed.
- The decisions and actions relate e.g. water project planning, land development, irrigation management, flood protection measures, optimal reservoir management
- The need for multiple viewpoints regarding the socio economic, environmental and economic development.

Identifying a Best Management Policy (BMP) requires mandatory:

- A reliable portrayal of natural processes and man made systems (irrigation, water backbone, recharge systems etc.)
- A powerful, reliable and computationally efficient multicriterial optimization tool
- A robust user friendly application through a tailor-made Decision Support System

Integrated Water Resources Management in an Irrigation Dominated Arid Environment: Problems

- planning & management in a changing Environment
- planning scenarios (projects)
- Limited observation data

Physically based models for predicting future situations beyond the observation range

Computation :
High effort and Numerical problems

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climate uncertainties
data uncertainty

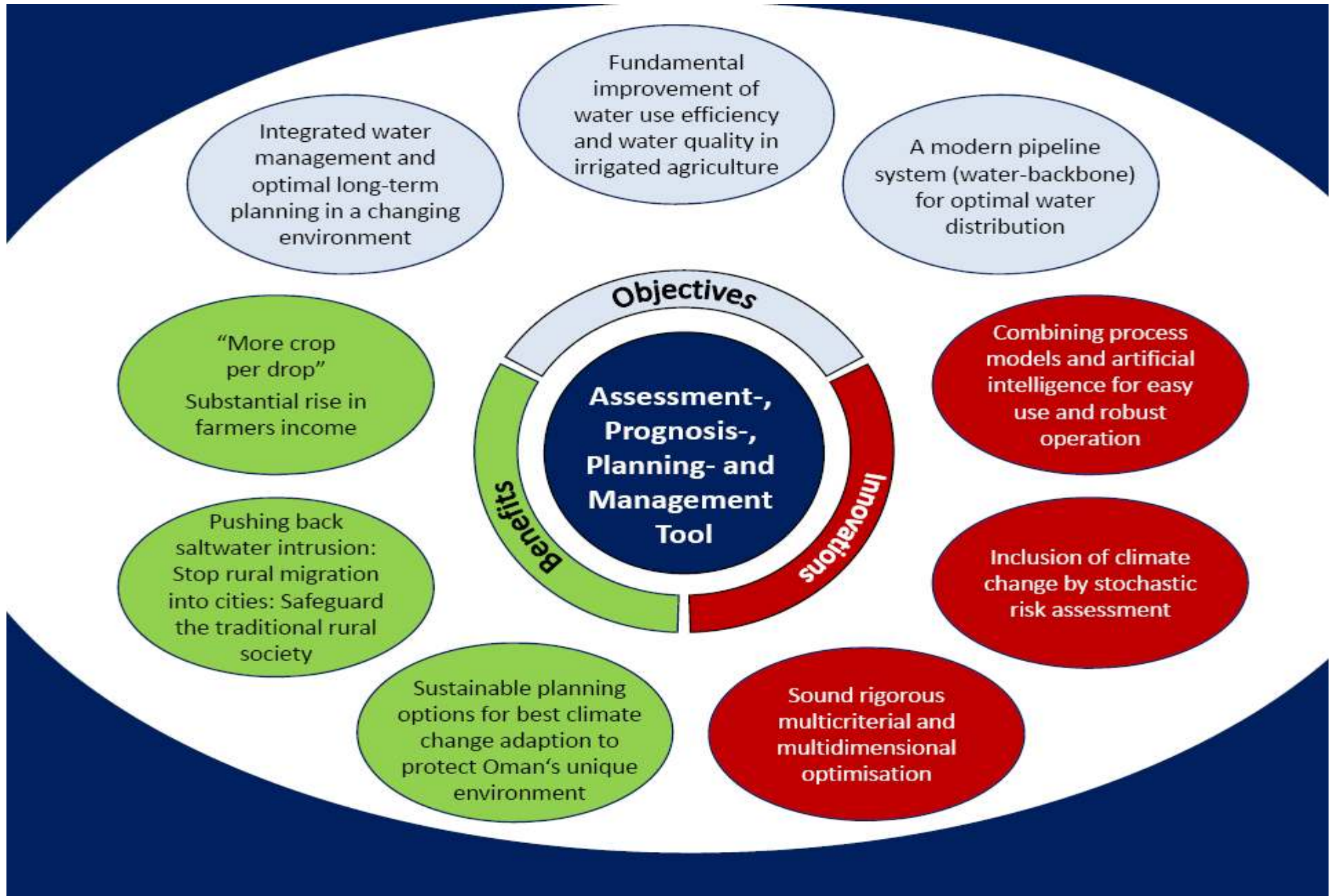
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Comprehensive Nonlinear Optimization

Computationally unfeasible

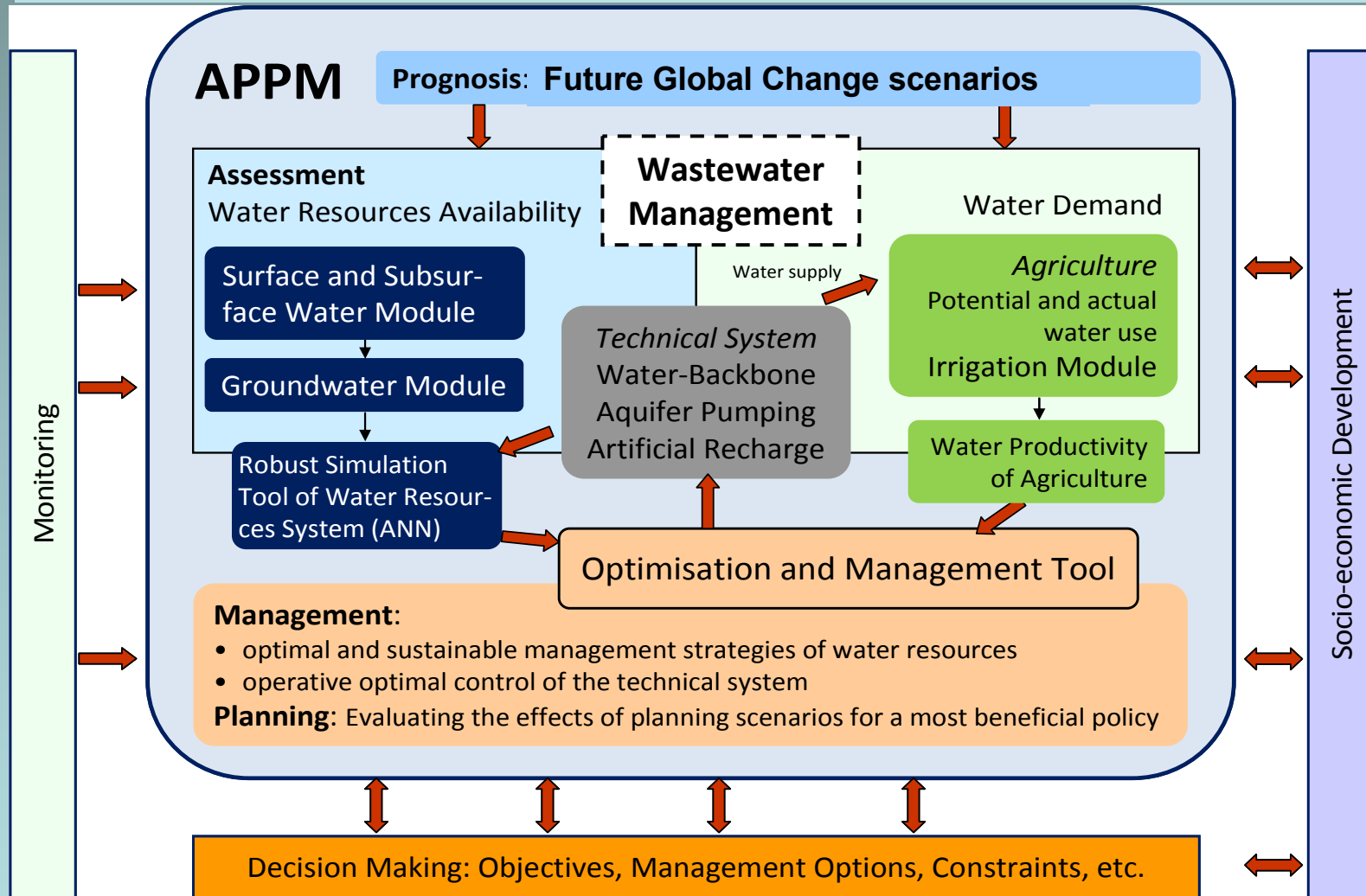
Required: robust and fast but nonetheless rigorous models and a Powerful tailor made optimization Tool

APPM: A Tailor Made new Approach for IWRM in an Irrigation Dominated Arid Environment



Tool & IWRM development

A new Generation of Tools for IWRM Implementation and Operation



APPM - Assessment Prognosis Planning and Management Tool:

a) water resources assessment

Water resources availability

- Meteorology and regional climate change
 - ☞ historic rainfall time series
 - ☞ local model of climate development
- Integrated Catchment modelling
- Constructional measures

Stochastic series of water use

Water consumers

- Planning scenarios
 - ☞ maximum benefits
 - ☞ minimum costs
- target performance comparison
- **Identify the biggest potential to improve water use efficiency ?**

Stochastic series of groundwater recharge

Groundwater reservoir

- Consequences of operations
- Restrictions:
e.g. sustainable yield

security of supply



APPM - Assessment Prognosis Planning and Management Tool:

b) optimal operation

Water consumers

Water resources availability

- Meteorological conditions
 - ☞ actual data
 - ☞ local model of climate development
- Catchments
 - ☞ actual data from groundwater level

Actual data of water use

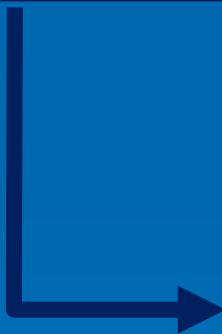
- point tracing of actual consumption
- state of plants, soils
- target performance comparison
- maximum benefit ?
 - ☞ Most beneficial operation e.g. **irrigation control,**

Groundwater reservoir

- Optimized operation** with respect to a most desirable reservoir management (e.g. aquifers, recharge basins)
- ☞ Comparison of planned and actual state
 - ☞ Optimal Backbone operation: water allocation (pumping, storage)

Actual and predicted state of water resources

“Best” management



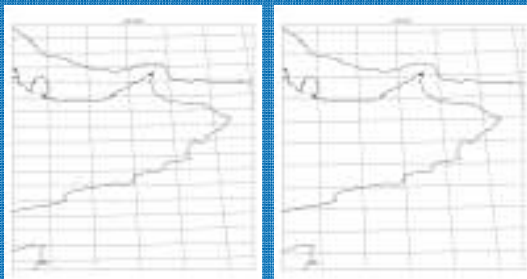
The APPM Climate Module: Analysis of Present and Future Climatologic Conditions

Step I – Setting Up a Regional Climate Model (RGM)

Global Climate Models (GCM)

Spatial Resolution:

Resolution of GCM-Output is too coarse for the assessment of regional impact from climate change



Validation of GCM-Results - Comparison with measured Values:

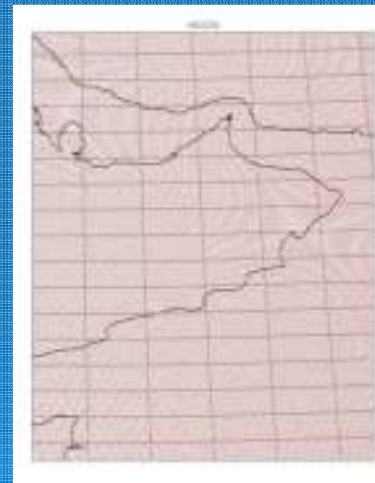
Reanalysis of the historic climate differs considerably due to GCM physics and setup

Downscaling

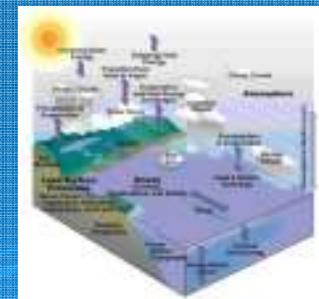


Regional Climate Models (RGM)

- higher resolution compared to GCM
- consideration of relevant processes

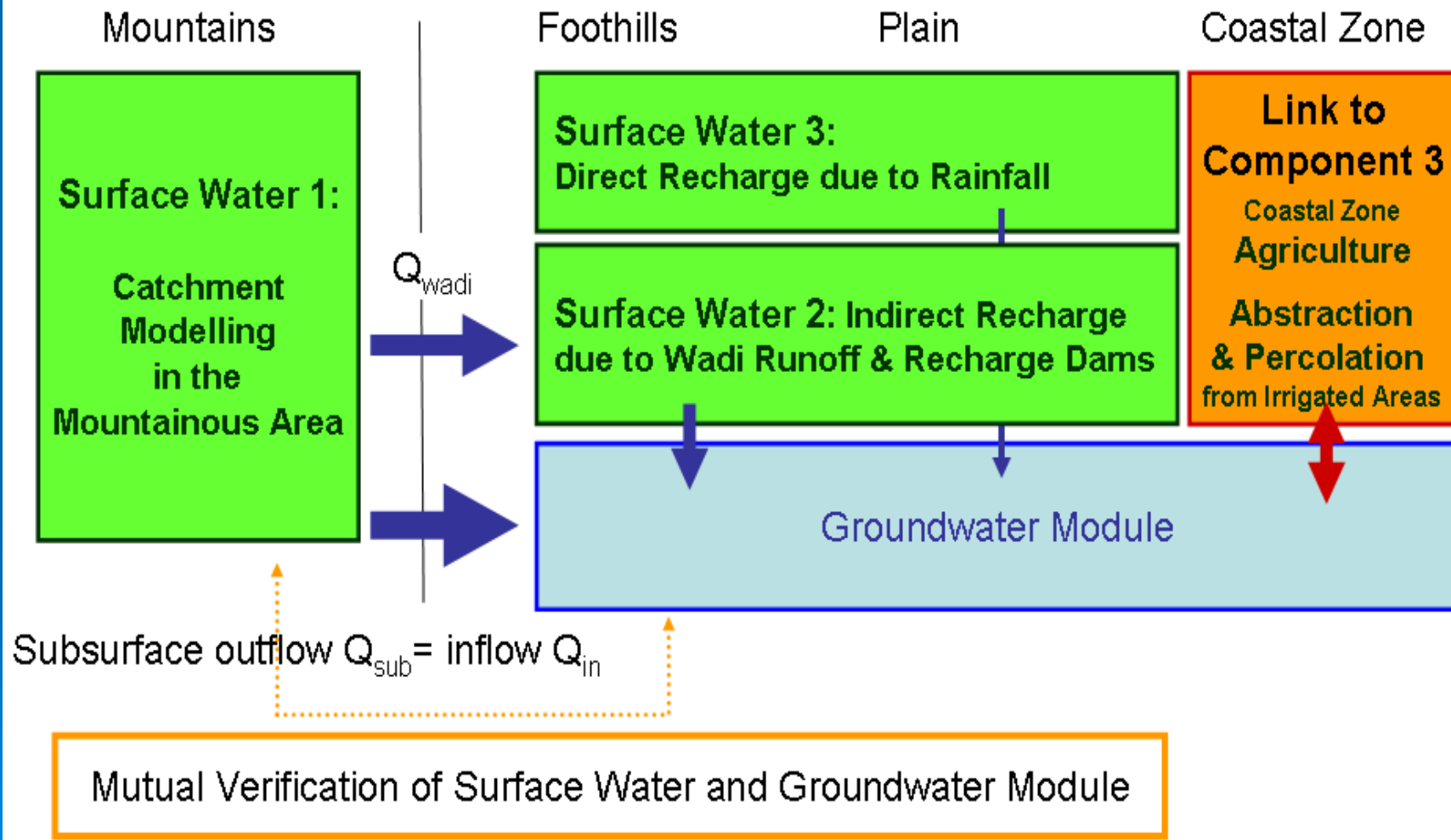


⇒ appropriate for assessment of regional climate



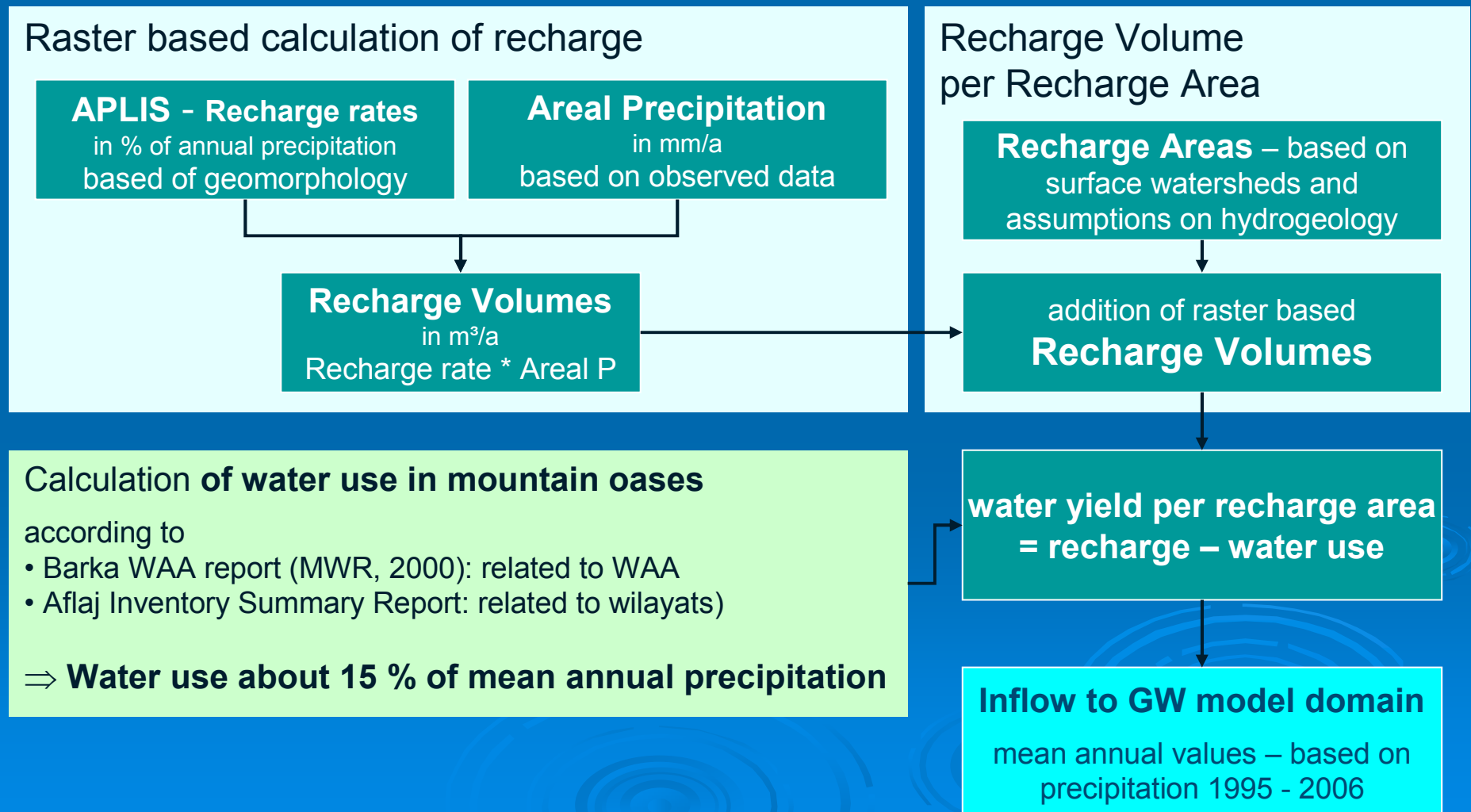
Water Resources Assessment

Rainfall: Analysis, Areal Precipitation and Stochastic Simulation



Water Resources Assessment – Surface Water

Estimate of upstream inflow to the groundwater model domain

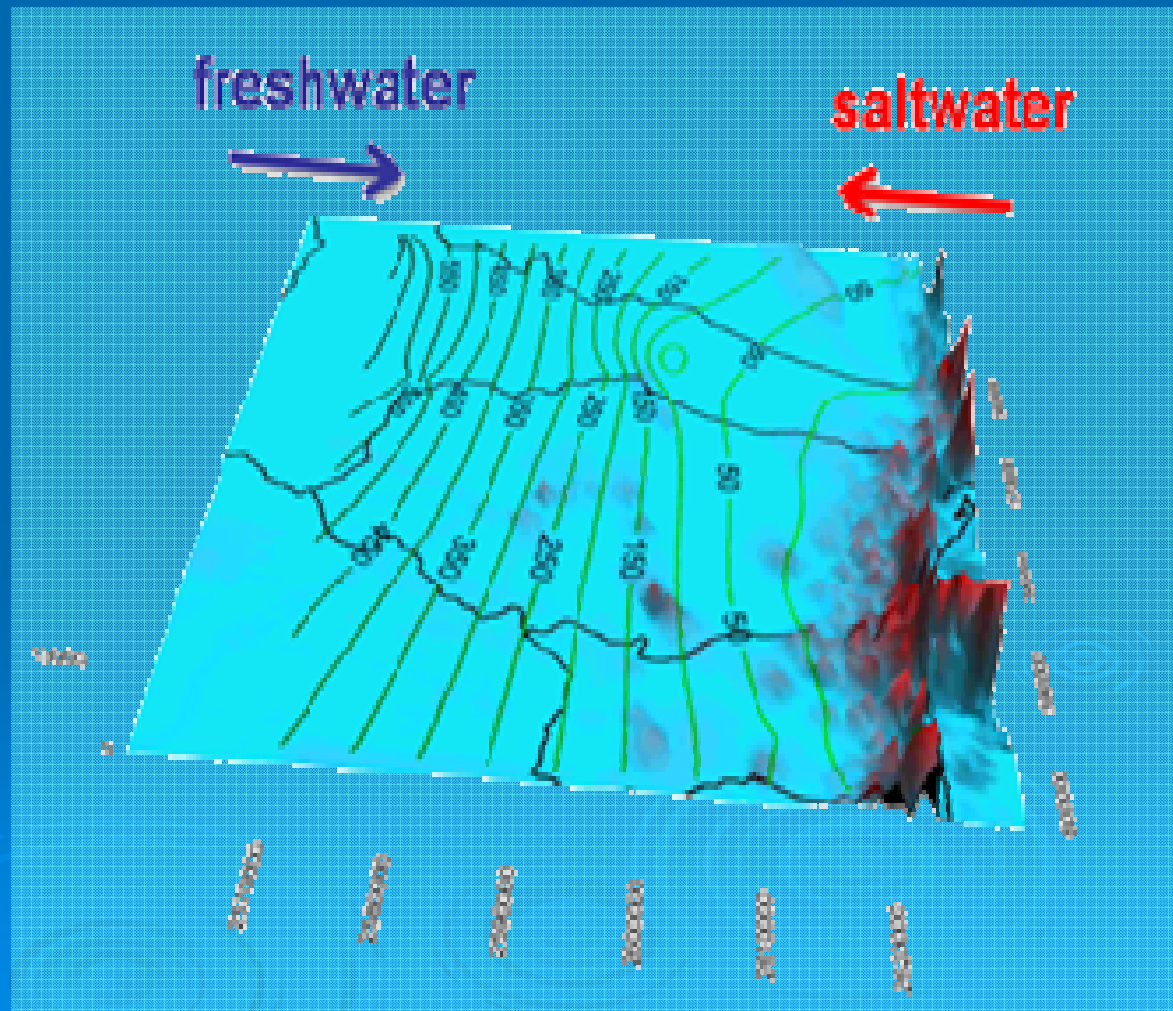
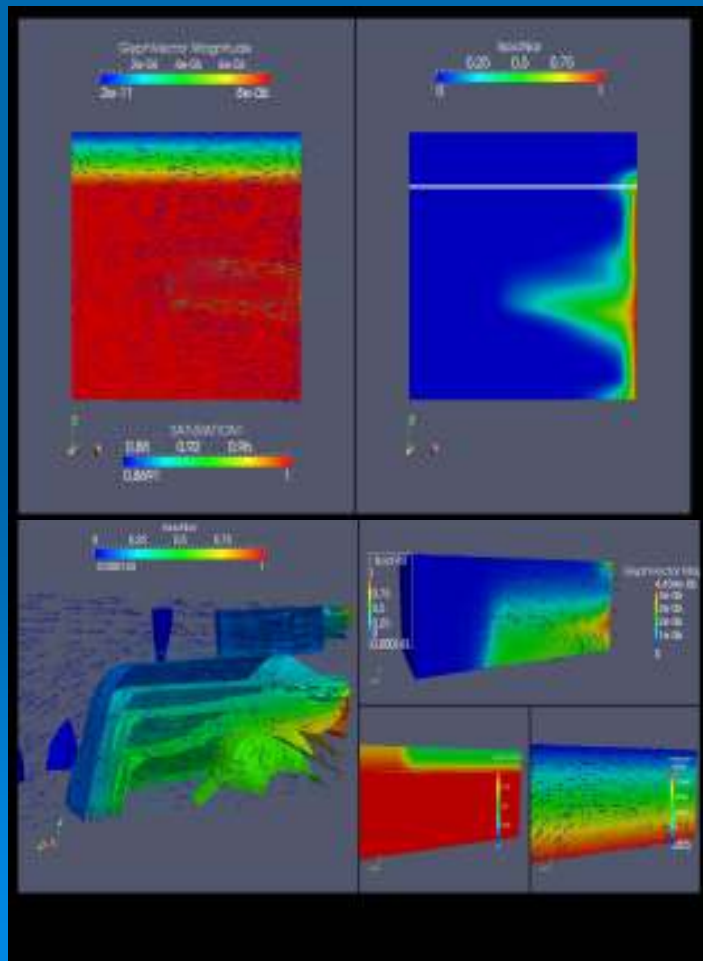


The APPM Groundwater Resources Module:

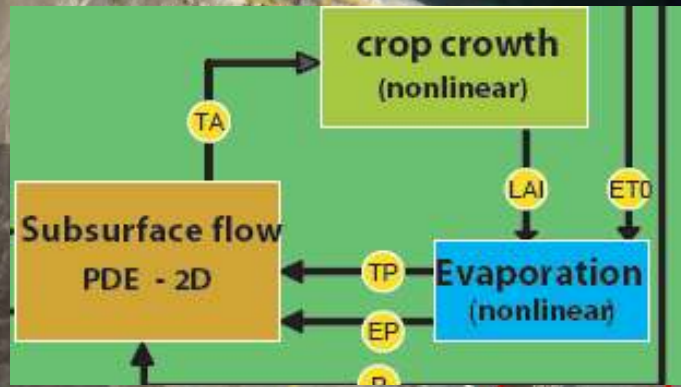
Modelling as a basis for sound assessment

Density driven flow

Saltwater intrusion

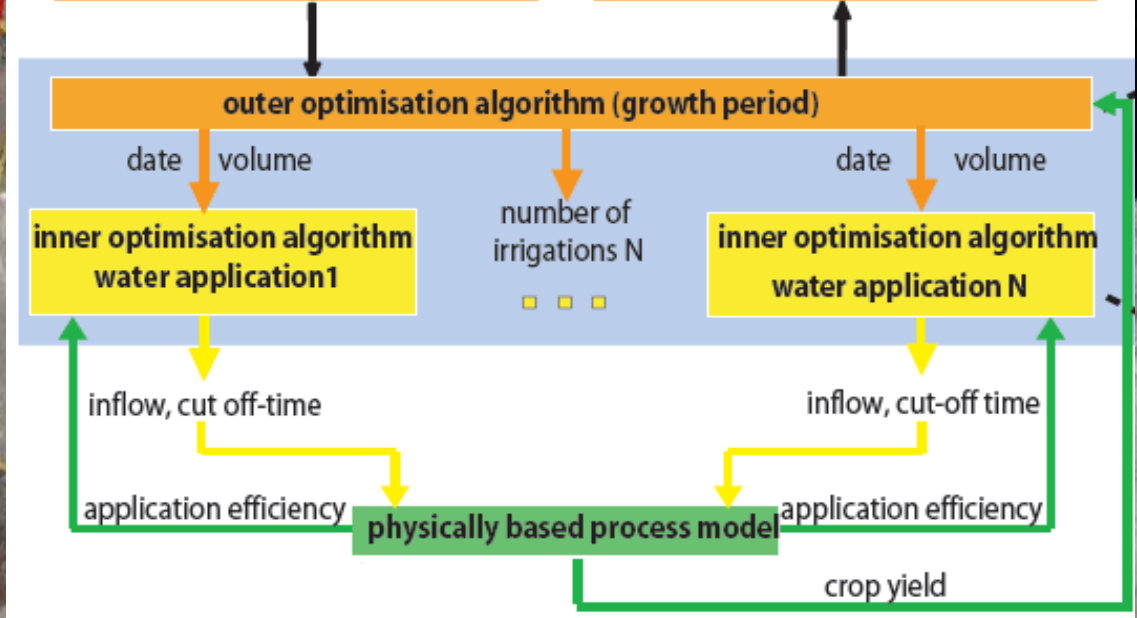


Irrigation Tool Development



Restrictions and Input:
available water volume
minimal time between

Results: max. yield, optimal
schedule
(number of irrigations, dates,
volumes, intensities, irrigation)

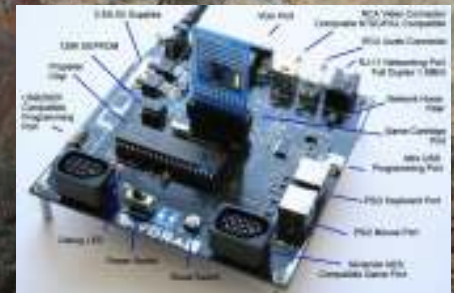


**Genetic Algorithm
&
Artificial Neural Networks**

**Optimum Efficiency
&
Simple Application**

**New automatic &
cheap water saving
device**

**best yield & optimal water
use efficiency for farmers**



Micro-controller

Integrated Water Resources Management: Pilot Area

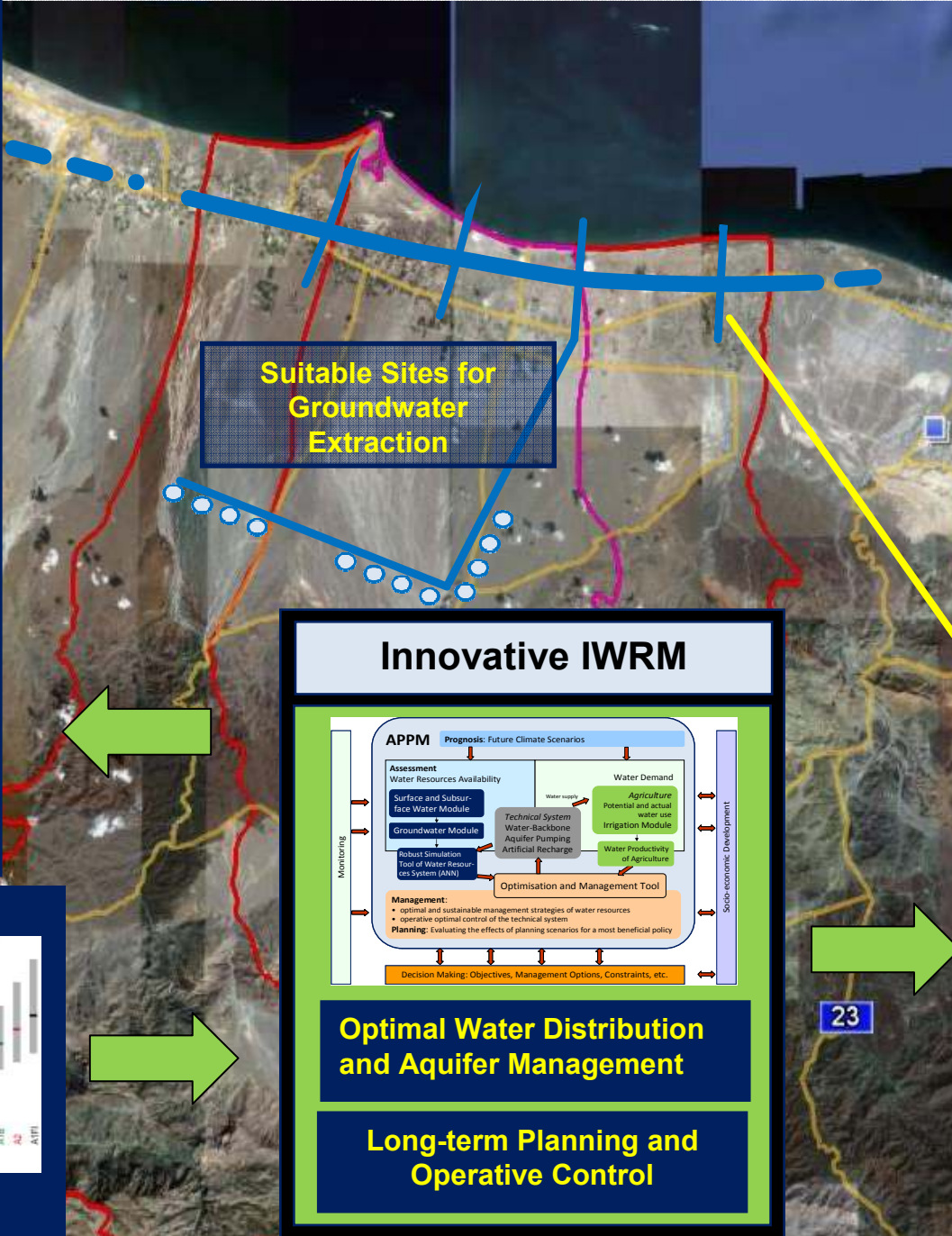
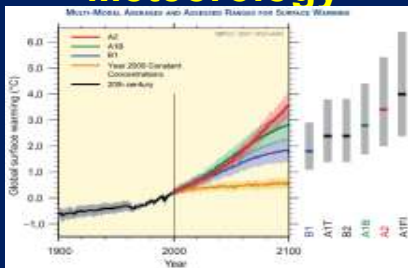
Agriculture:

Most beneficial and sustainable Irrigation operation and



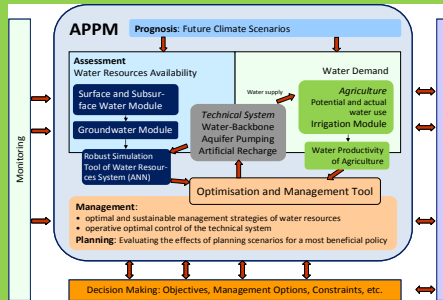
- Simple automatic irrigation device
- Less water consumption and higher yield
- Increased productivity
- Included: climate change uncertainties

Meteorology



Suitable Sites for Groundwater Extraction

Innovative IWRM



Optimal Water Distribution and Aquifer Management

Long-term Planning and Operative Control

Profitable and Sustainable Agriculture



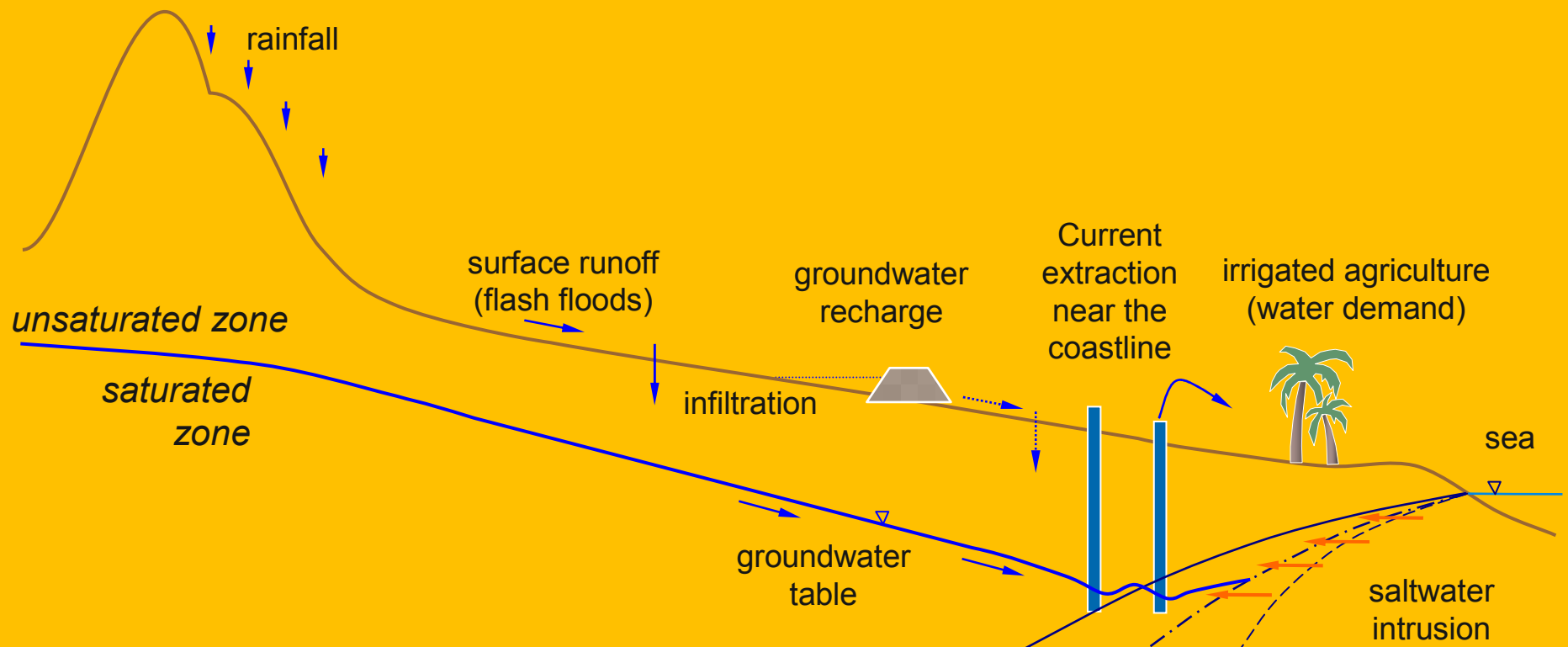
- Recovery of Groundwater Levels
- Stopping Saltwater Intrusion by Intelligent Aquifer Management

Technical realisation by Water-Backbone:

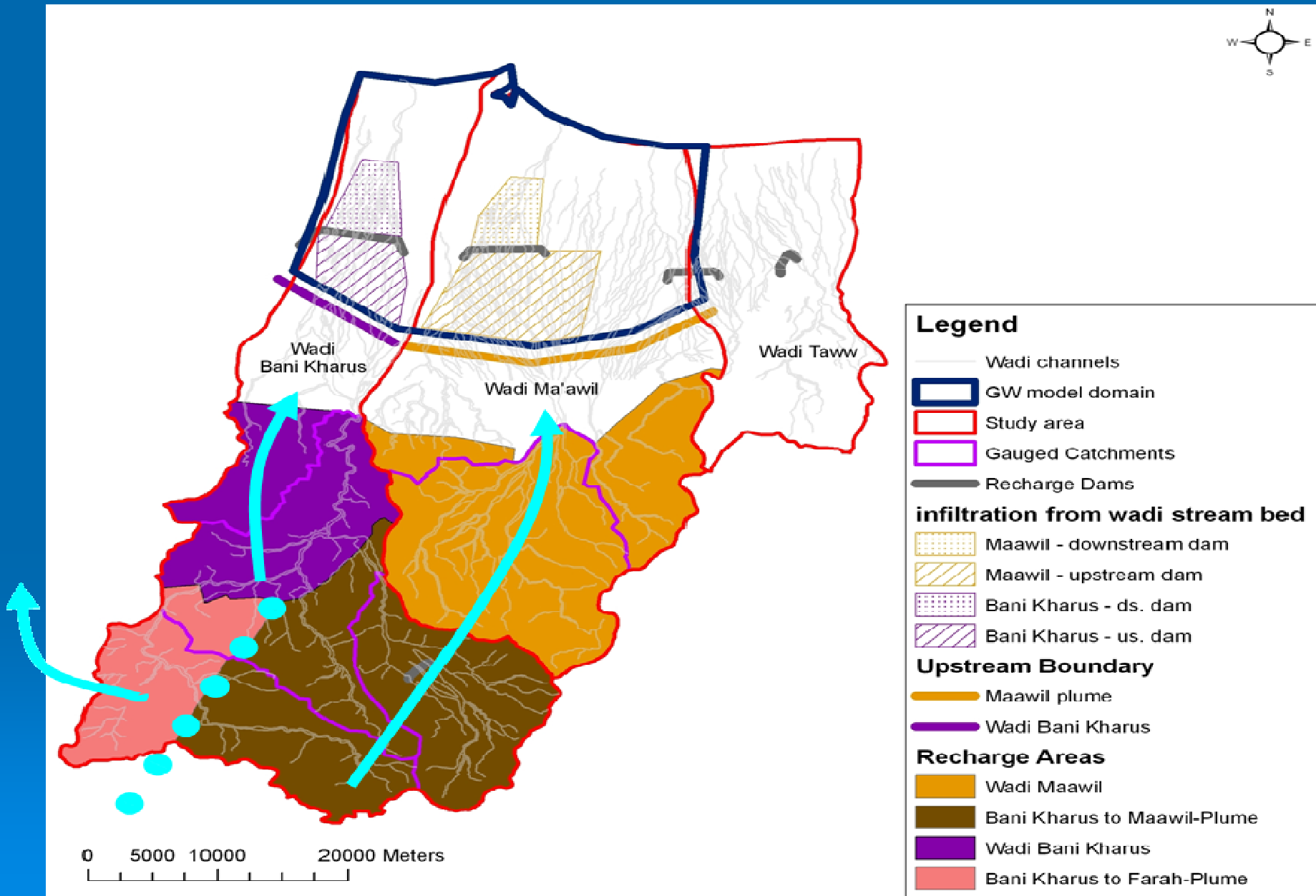
- Extraction of groundwater at suitable sites
- Water of better quality delivered to consumers
- Intelligent aquifer management by optimal reallocation of water resources
- Wastewater treatment and re-use

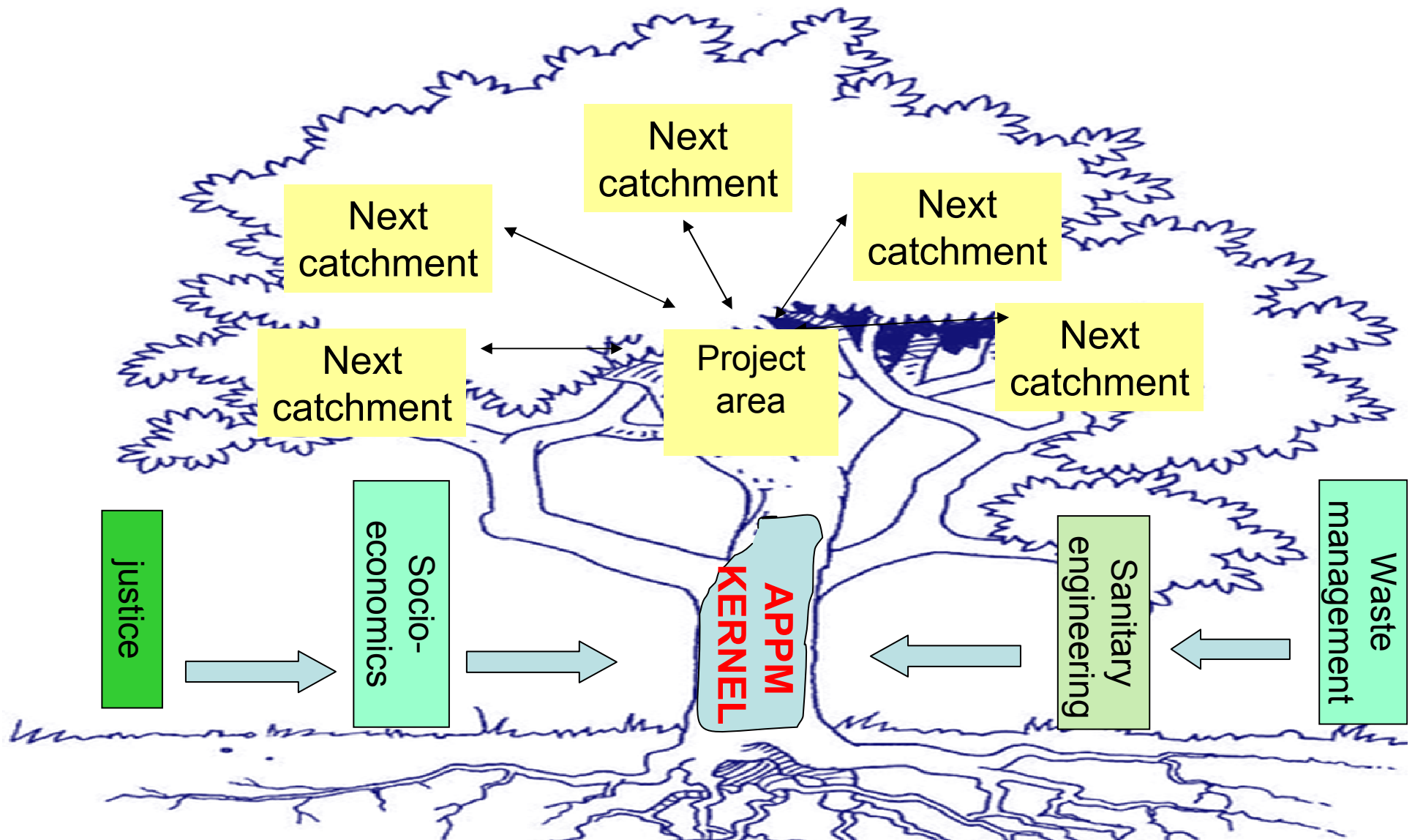
The APPM Water Resources Module: Assessment of Groundwater Recharge and Aquifer Management

Management of interacting nonlinear processes



Water Resources Assessment





**Data Analysis & Processing, Research & Development
NEW TAILOR MADE APPROACHES**

NEW APPROACH FOR OMAN'S WATER MANAGEMENT

**Optimal Decisions
need**

**Best solutions for different goals :
sustainability, water saving, high
benefit for farmers**

**Autonomous Water
Management needs**

**Reliable and simple management tool
& databank for routine application -
ownership via active participation &
capacity development**

NEW SOLUTION

SYNTHESIS OF

**ANN: Artificial
Neural Networks:
fast & simple use**

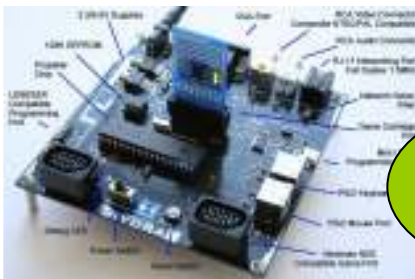
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**Physically based
models: better for
Global Change**

**Artificial Intelligence
& optimal irrigation
via automatic device**

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**Innovative, tailor
made multi-objective
optimization**



**Micro-
controller**



Thank you for your attention