Water and Environment Support
in the ENI Southern Neighbourhood region

Activity Number: RW-7-REG/ST

Event Title:

Training module 1: Water management at the scheme level

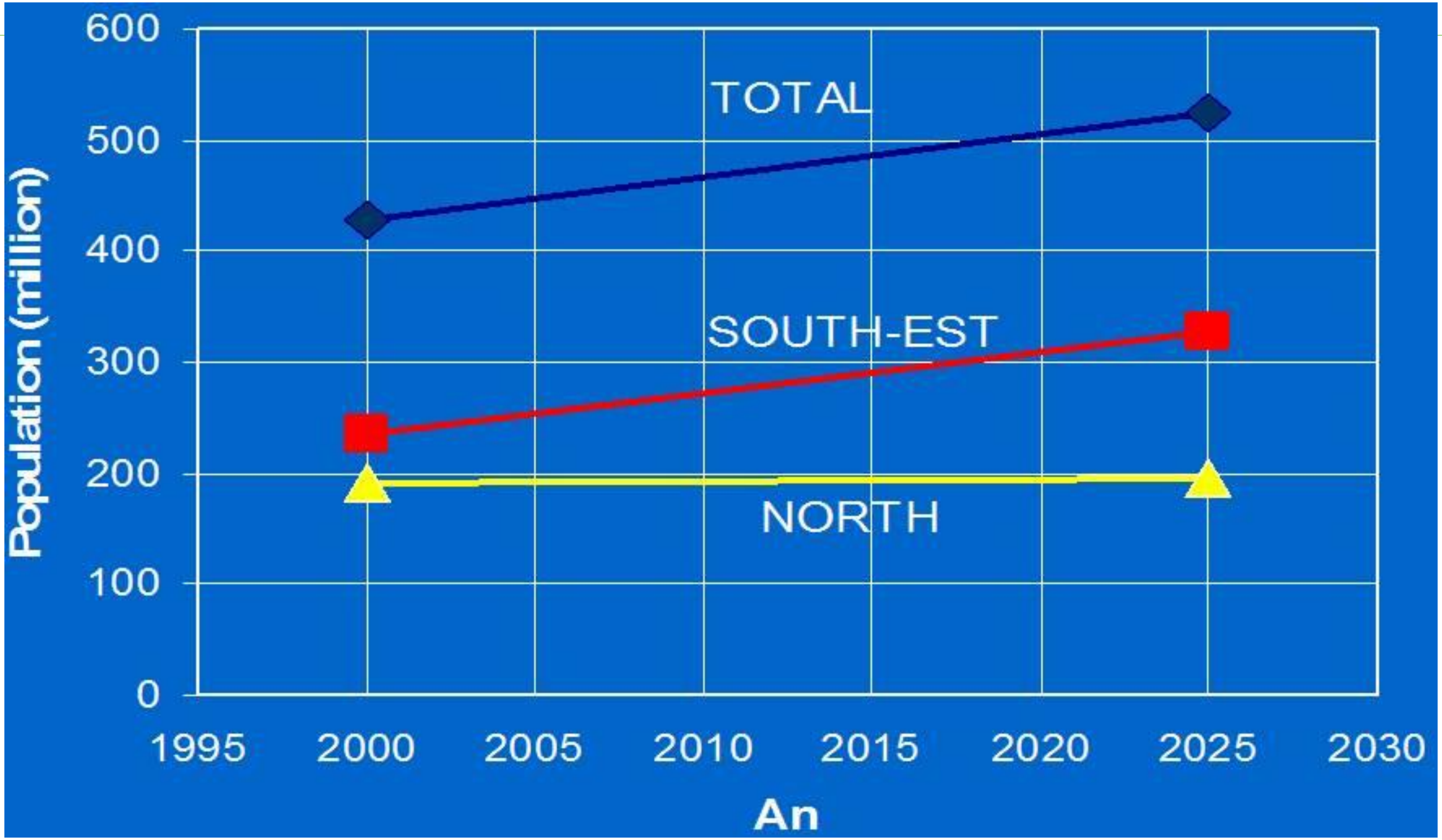
Presented by: Nicola Lamaddalena, Deputy Director at CIHEAM Bari - Partner in WES project

LDK CONSULTANTS LDK Consultants Global EEIG

This Project is funded by the European Union

IL CIHEAM

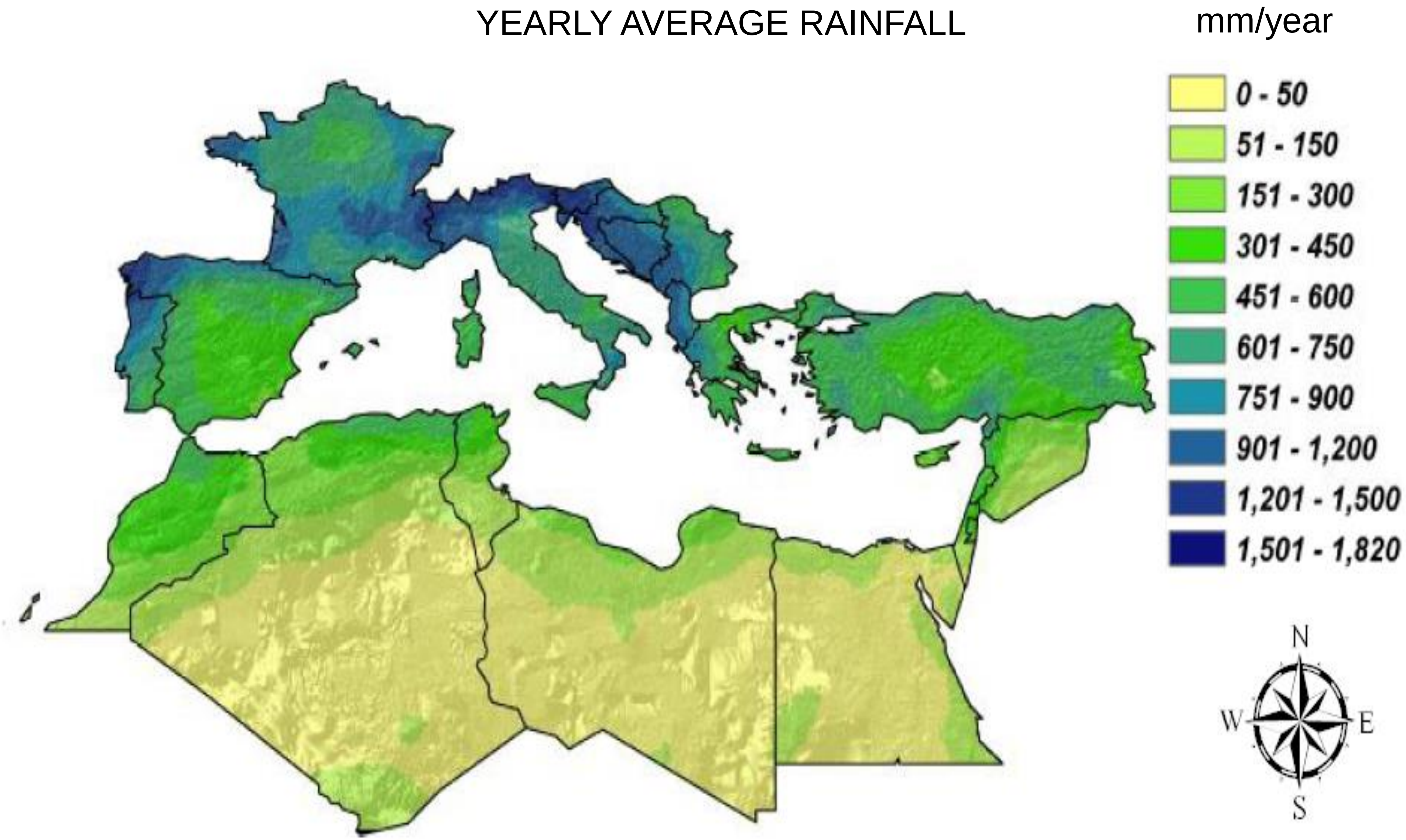
POPULATION IN THE MEDITERRANEAN COUNTRIES



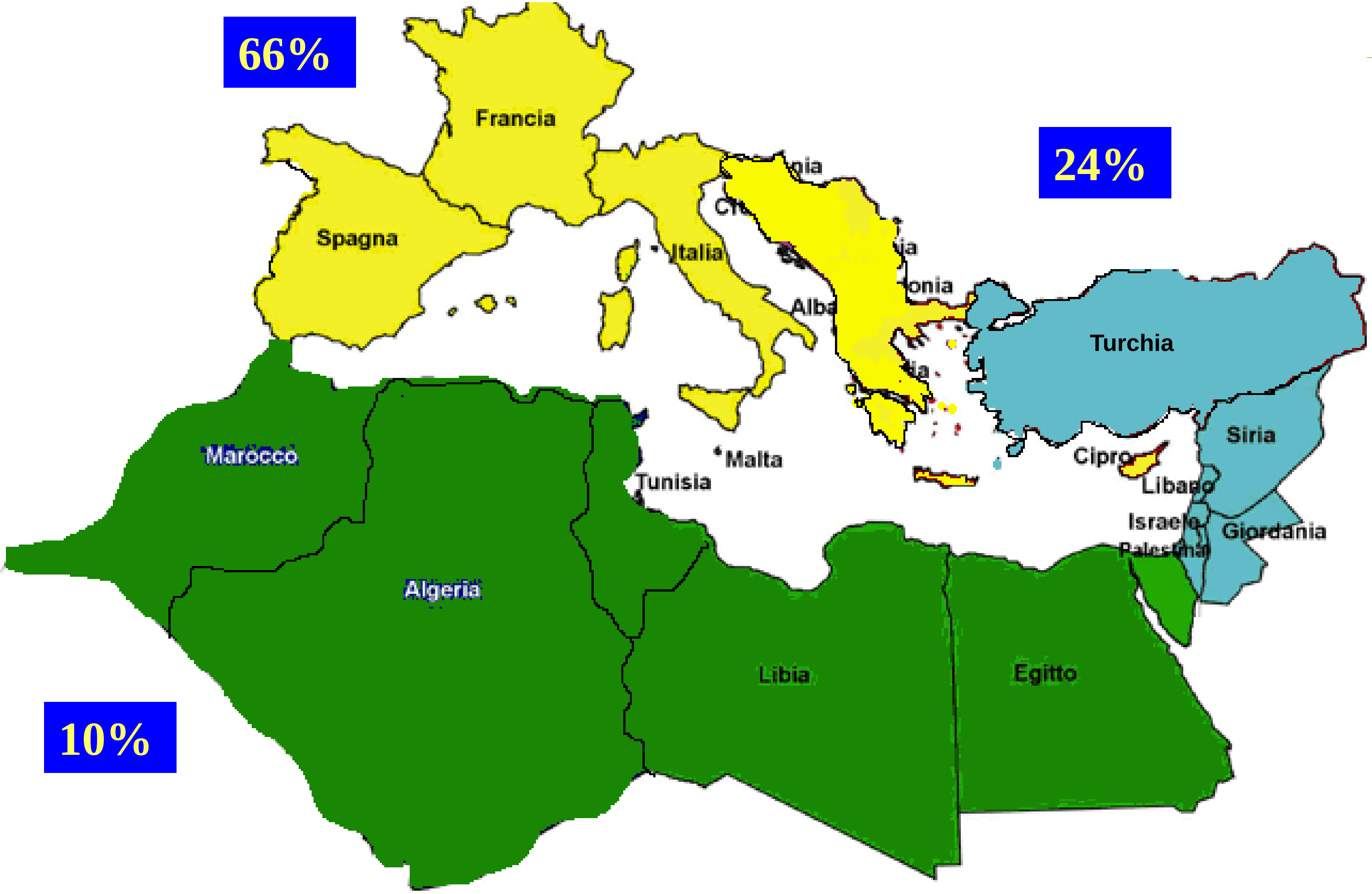
SOURCE:

PLAN BLUE, 2019

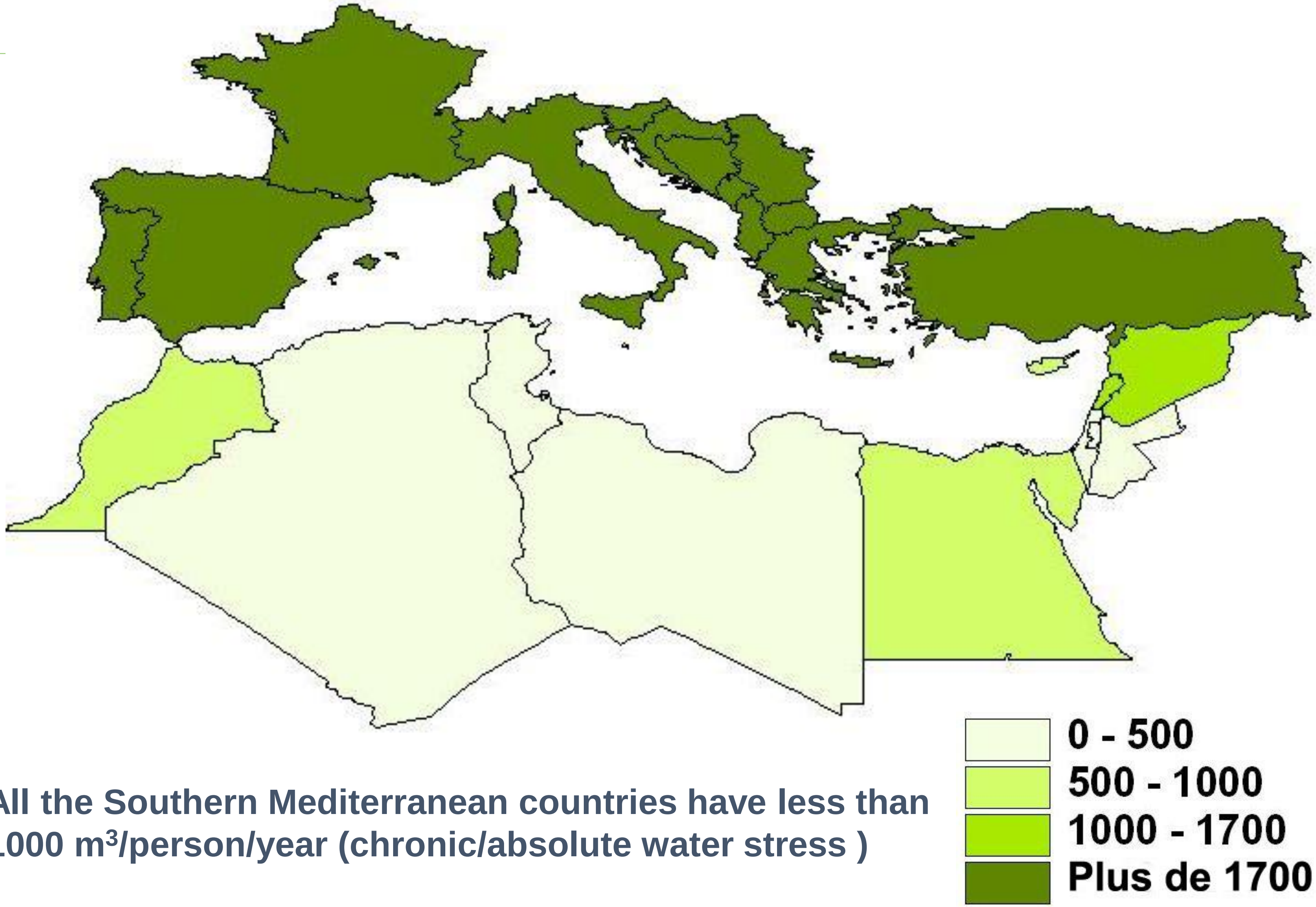
YEARLY AVERAGE RAINFALL



DISTRIBUTION OF WATER RESOURCES IN THE MEDITERRANEAN REGION

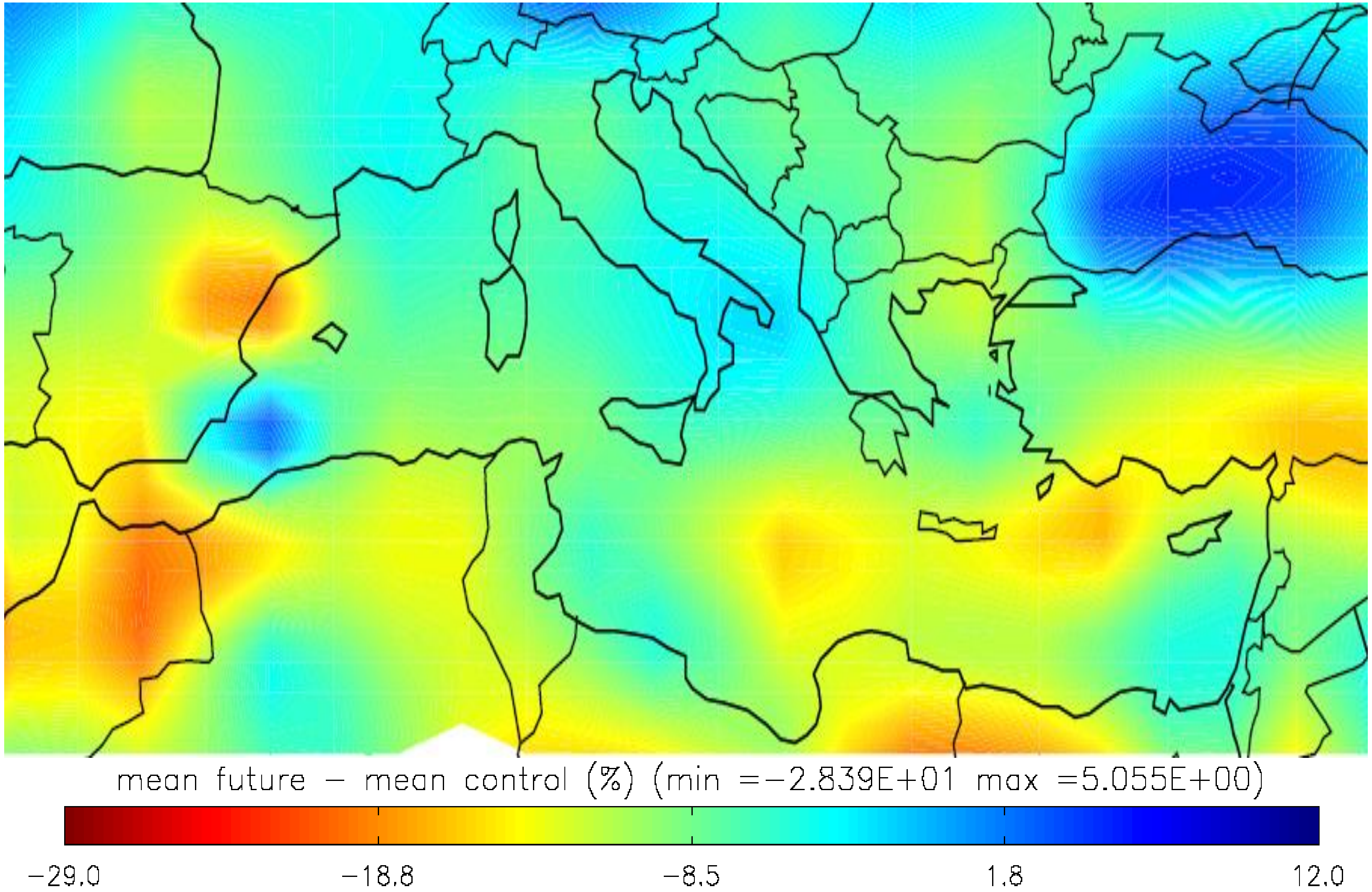


AVAILABLE WATER RESOURCES (m^3/person/year)
Current Situation

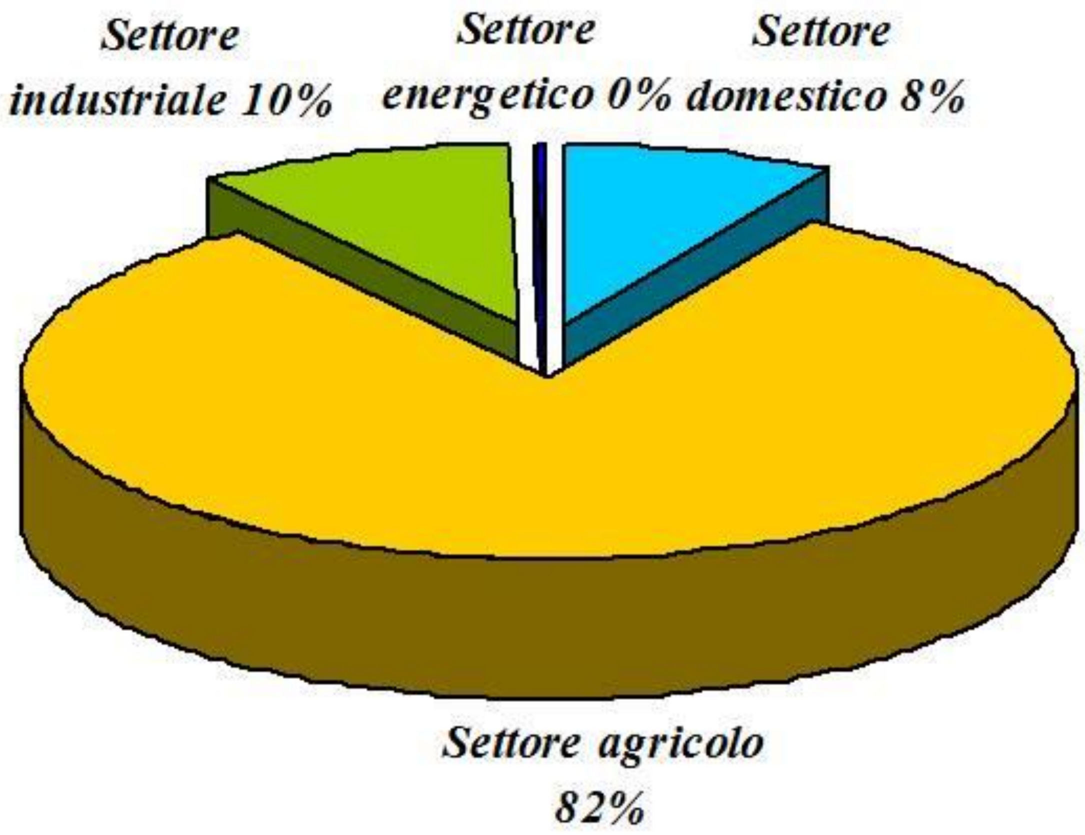


All the Southern Mediterranean countries have less than 1000 m^3/person/year (chronic/absolute water stress)

Variation of annual average precipitation in the next sixty years (A2 scenario)



WATER DEMAND PER SECTOR IN SOUTHERN MEDITERRANEAN COUNTRIES (YEAR 2000)



From: PLAN BLEU, 2019

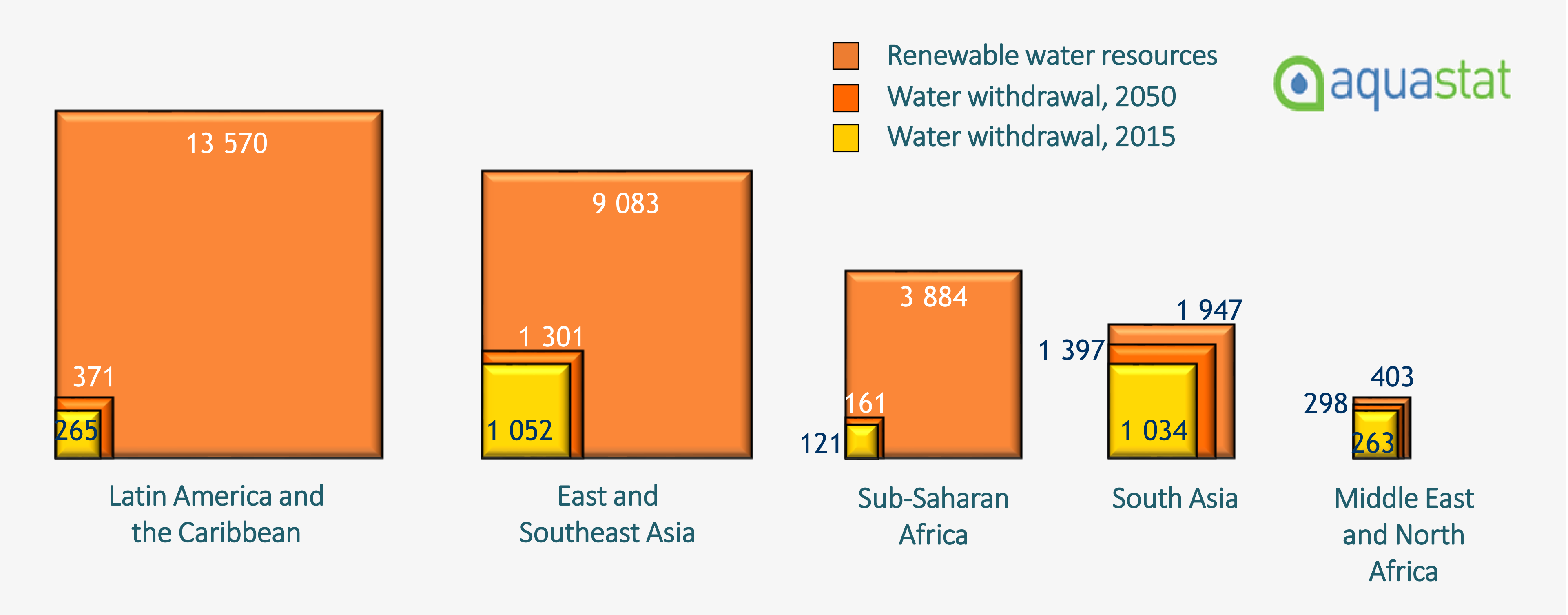
THE CHALLENGE

PAST STRATEGIES

- In the last 50 years the policy choices privileged the big hydraulic infrastructures in irrigation giving priorities to the quantitative aspect rather than the qualitative (Supply Management).

ATATÜRK DAM – Completed in 1990

Freshwater resources: current (2015) and predicted (2050) water withdrawal (km3)

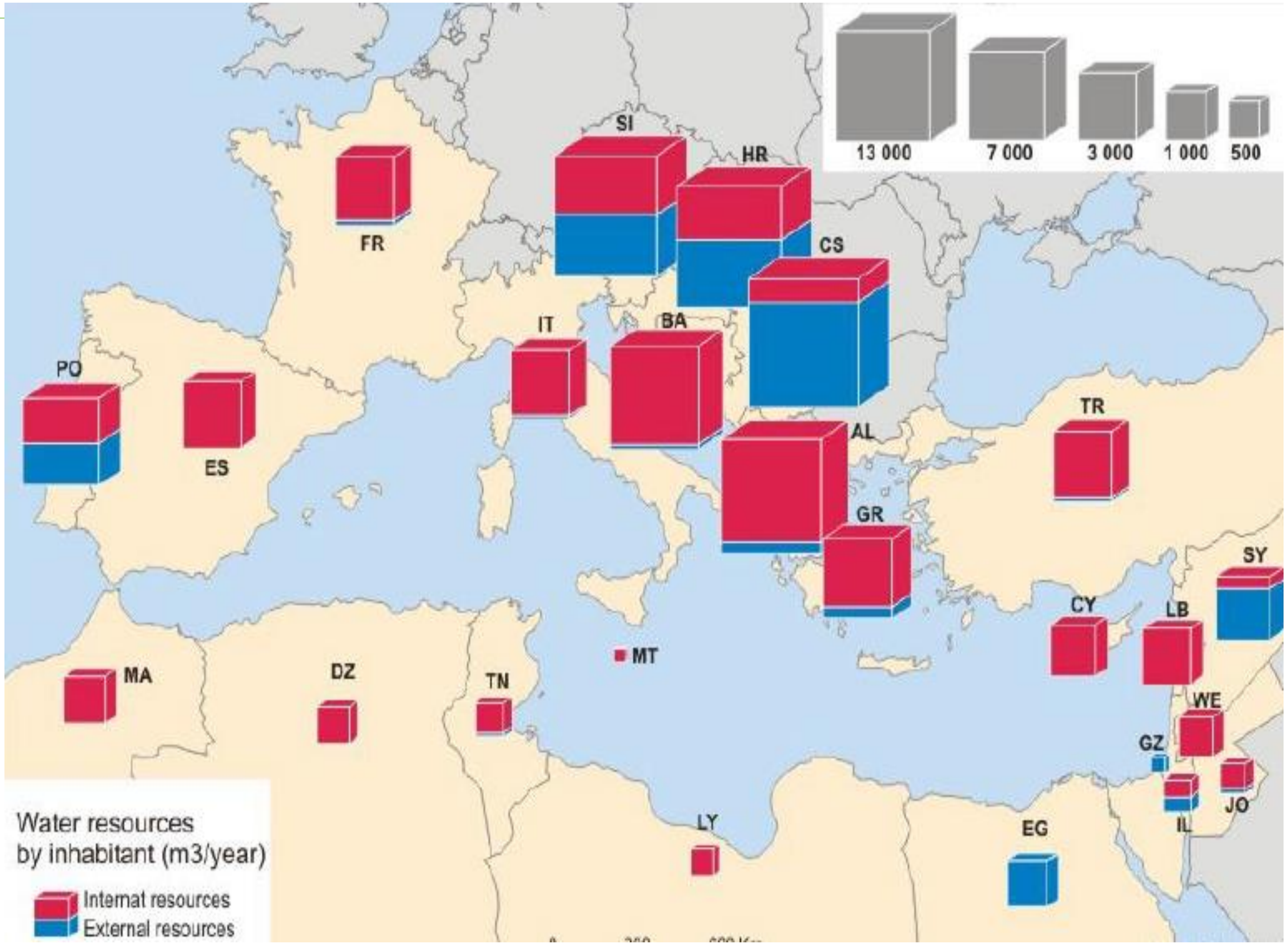


TOTAL RENEWABLE WATER RESOURCES PER CAPITA IN THE MEDITERRANEAN

- SITUATION IN 2004

Six Mediterranean countries experience absolute water scarcity (<500 m3 per capita per year) and five additional ones are under the water scarcity threshold of 1000 m3 per capita per year (AQUASTAT, FAO, 2014). Most northern Mediterranean countries are water-secure with over 1700 m3 per capita per year.

In North Africa and the Middle East, shared aquifers are the most important source of fresh



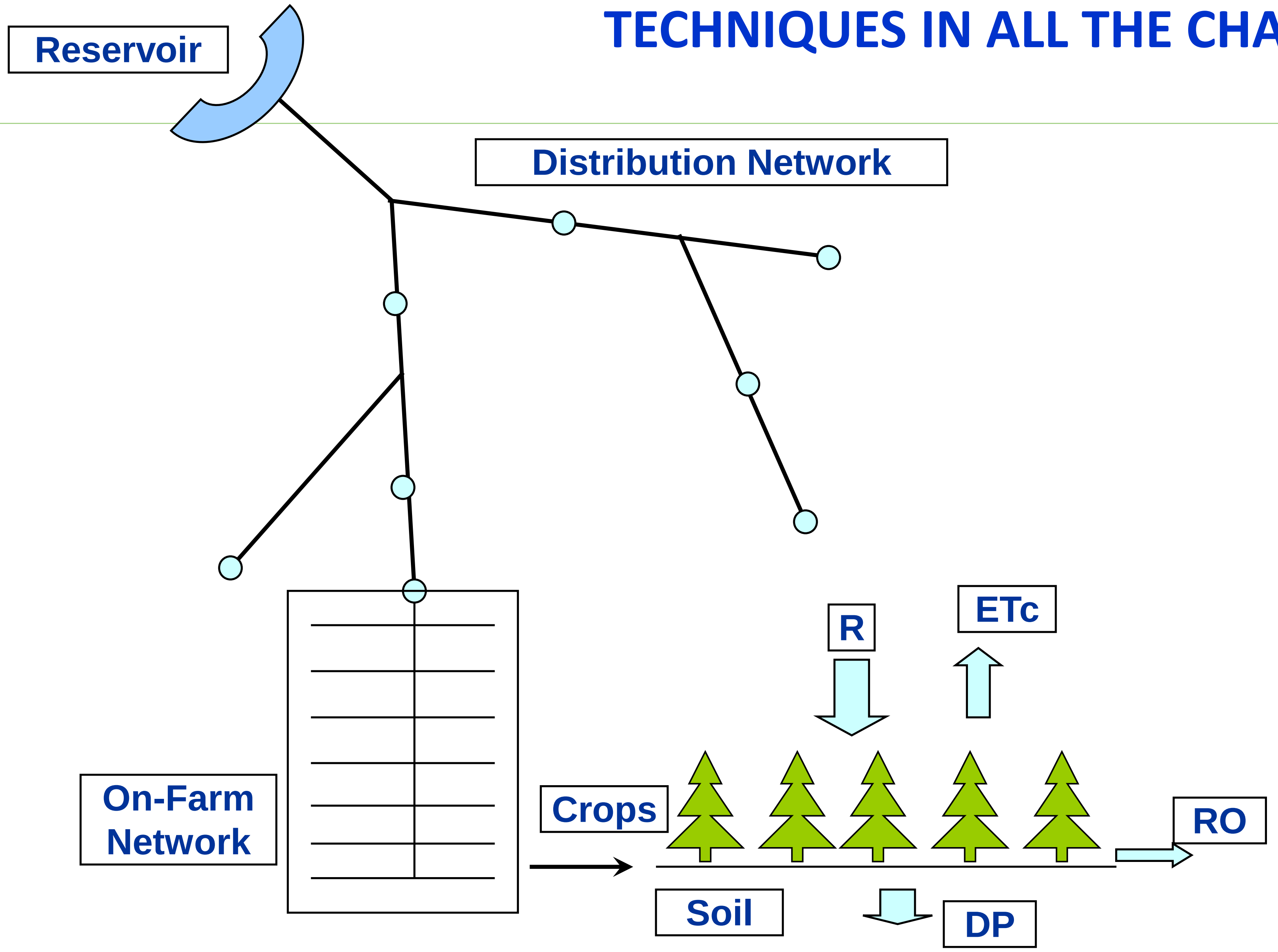
Source: Plan Bleu, 2004

PRESENT STRATEGIES

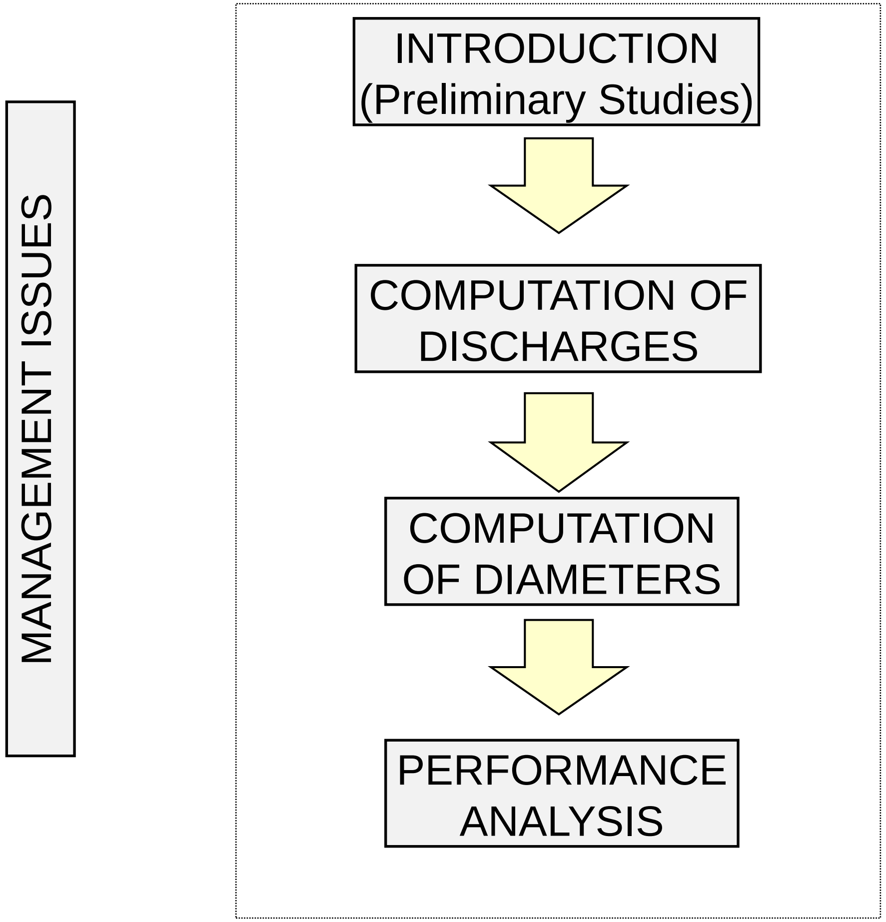
The current policy choices highlighted the importance of Operation, Maintenance and Management activities (DEMAND MANAGEMENT)

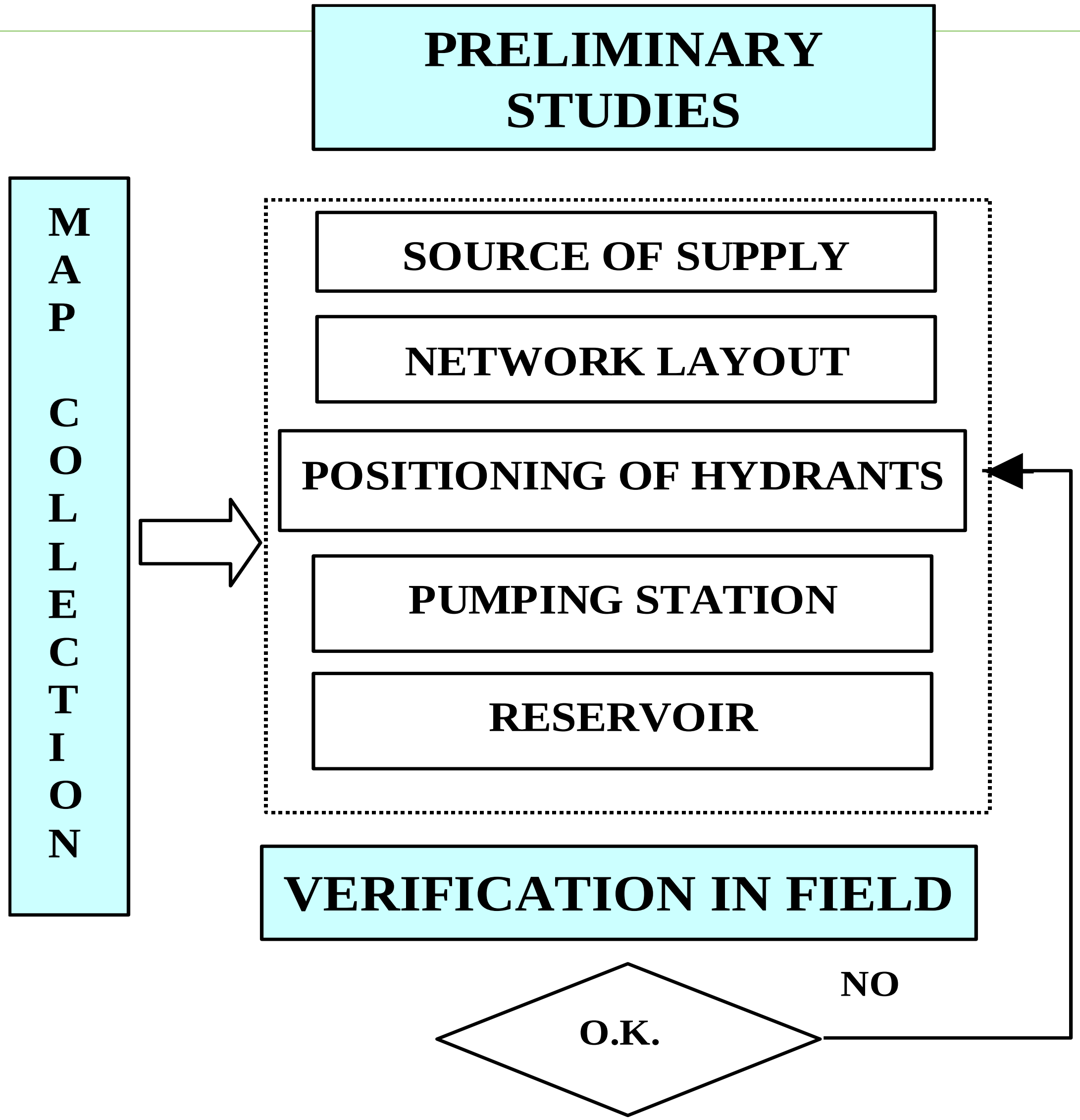
- TECHNICAL APPROACHES (improving WUE at the whole chain of the system, use of unconventional waters, use of new technologies, ...)
- INSTITUTIONAL APPROACHES (PIM, Governance, Capacity Development,...)

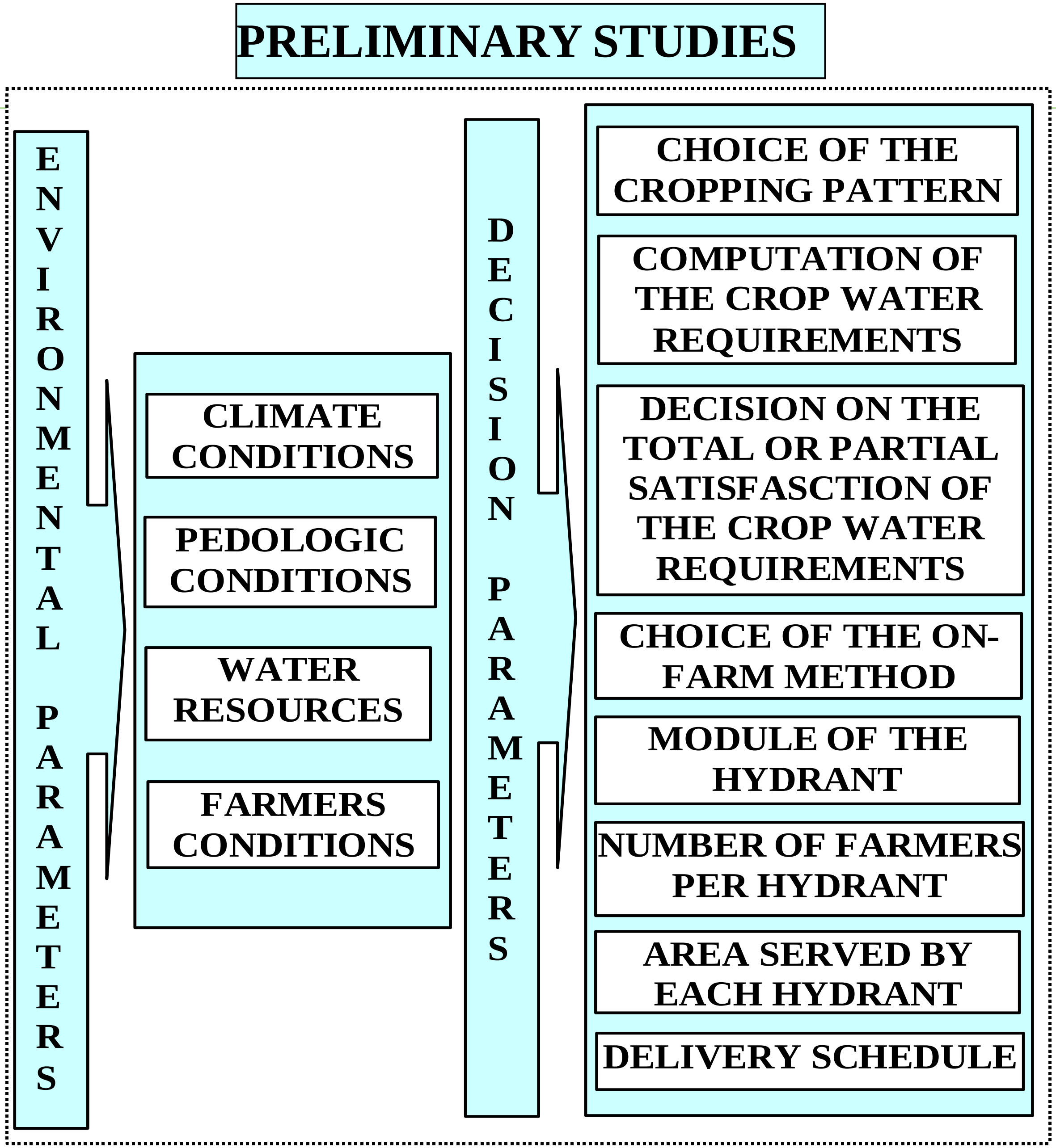
IMPROVE IRRIGATION EFFICIENCY TECHNIQUES IN ALL THE CHAIN



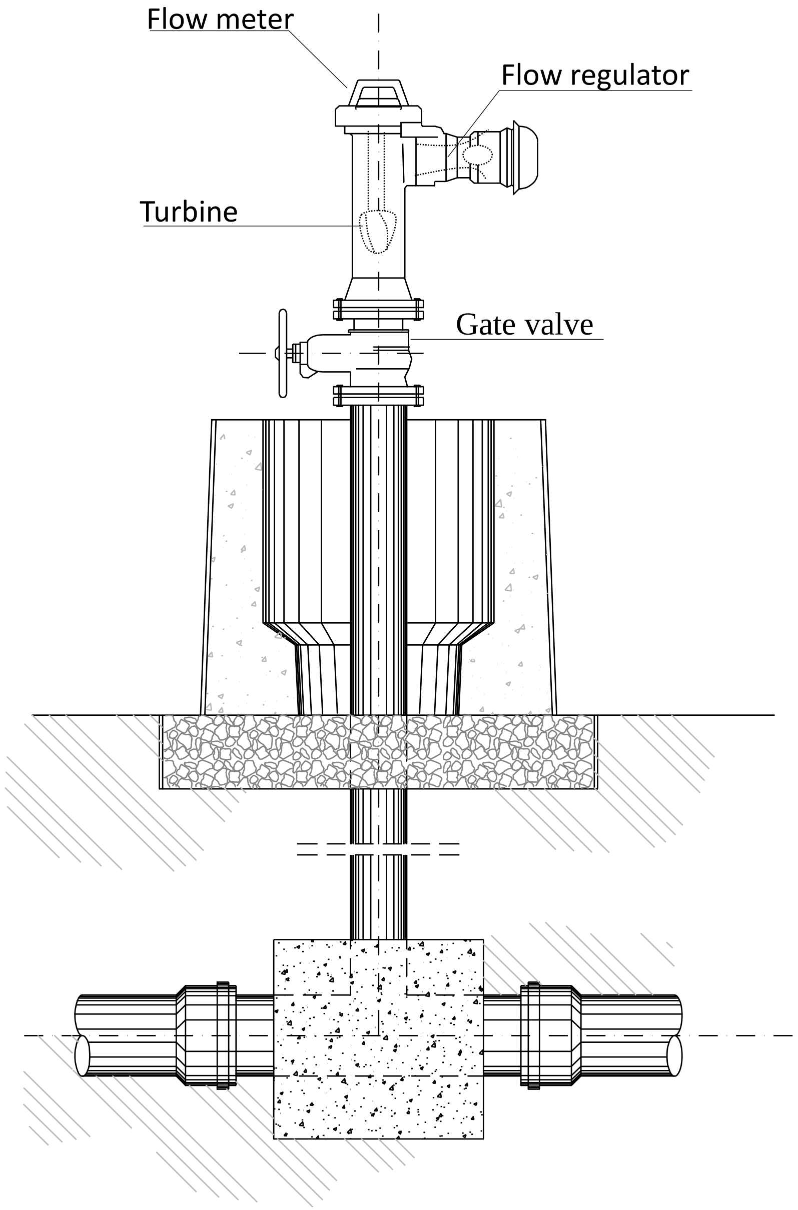
CONTENTS


MANAGEMENT ISSUES
INTRODUCTION (Preliminary Studies)
COMPUTATION OF DISCHARGES
COMPUTATION OF DIAMETERS
PERFORMANCE ANALYSIS


PRELIMINARY STUDIES
MAP COLLECTION
SOURCE OF SUPPLY
NETWORK LAYOUT
POSITIONING OF HYDRANTS
PUMPING STATION
RESERVOIR
VERIFICATION IN FIELD
O.K.
NO


PRELIMINARY STUDIES
E N V I R O N M E N T A L P A R A M E T E R S
CLIMATE CONDITIONS
PEDOLOGIC CONDITIONS
WATER RESOURCES
FARMERS CONDITIONS
D E C I S I O N P A R A M E T E R S
CHOICE OF THE CROPPING PATTERN
COMPUTATION OF THE CROP WATER REQUIREMENTS
DECISION ON THE TOTAL OR PARTIAL SATISFASCTION OF THE CROP WATER REQUIREMENTS
CHOICE OF THE ON-FARM METHOD
MODULE OF THE HYDRANT
NUMBER OF FARMERS PER HYDRANT
AREA SERVED BY EACH HYDRANT
DELIVERY SCHEDULE

SCHEME OF A HYDRANT



HYDRANT

FLOW METER

ELECTRONIC WATER
DELIVERY SYSTEM

ELECTRONIC CARD

Table 1. Definitions of delivery scheduling methods.

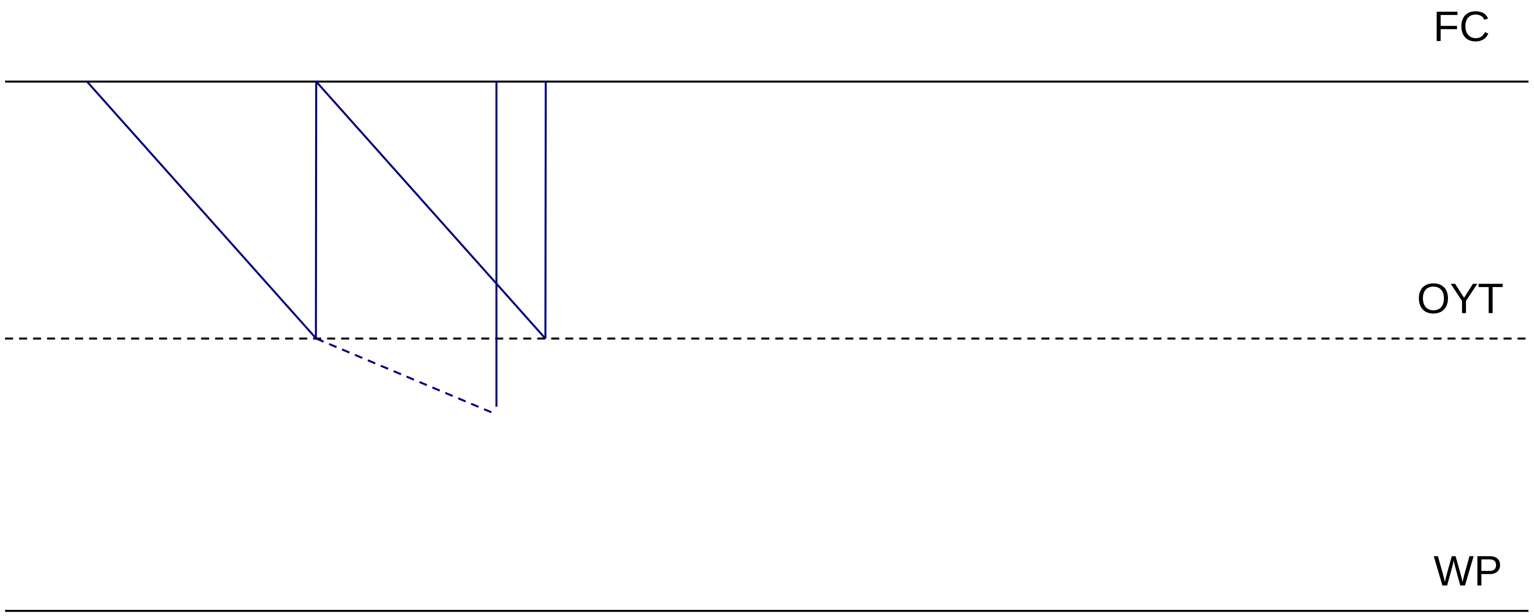
Schedule catagories	System constraints Frequency	Rate	Duration
Local control			
Demand schedules			
Demand	U	U	U
Limited rate demand	U	L	U
Arranged frequency demand	A	L	U
Intermediate Control			
Arranged schedules			
Arranged	A	A	A
Limited rate arranged	A	L	A
Restricted arranged	A	C	C
Fixed duration arranged	A	C	F
Fixed rate/restr. arranged	A	F	C
Central control			
Central system schedules			
Central System	V	V	V
Fixed amount	V	F	F
Rotation schedules			
Rotation	F	F	F
Varied amount rotation	F	F(V)	F(V)
Varied frequency rotation	F(V)	F	F(V)
Continuous flow	-	F(V)	-

Terminology:
- U: unlimited, no restriction, under user control
- L: limited to maximum flow rate, but still arranged
- A: arranged between user and water authority
- C: constant during irrigation as arranged
- F: fixed by central policy
- V: varied by central authority, at authority's discretion
- (V) varied by central authority, seasonally by policy

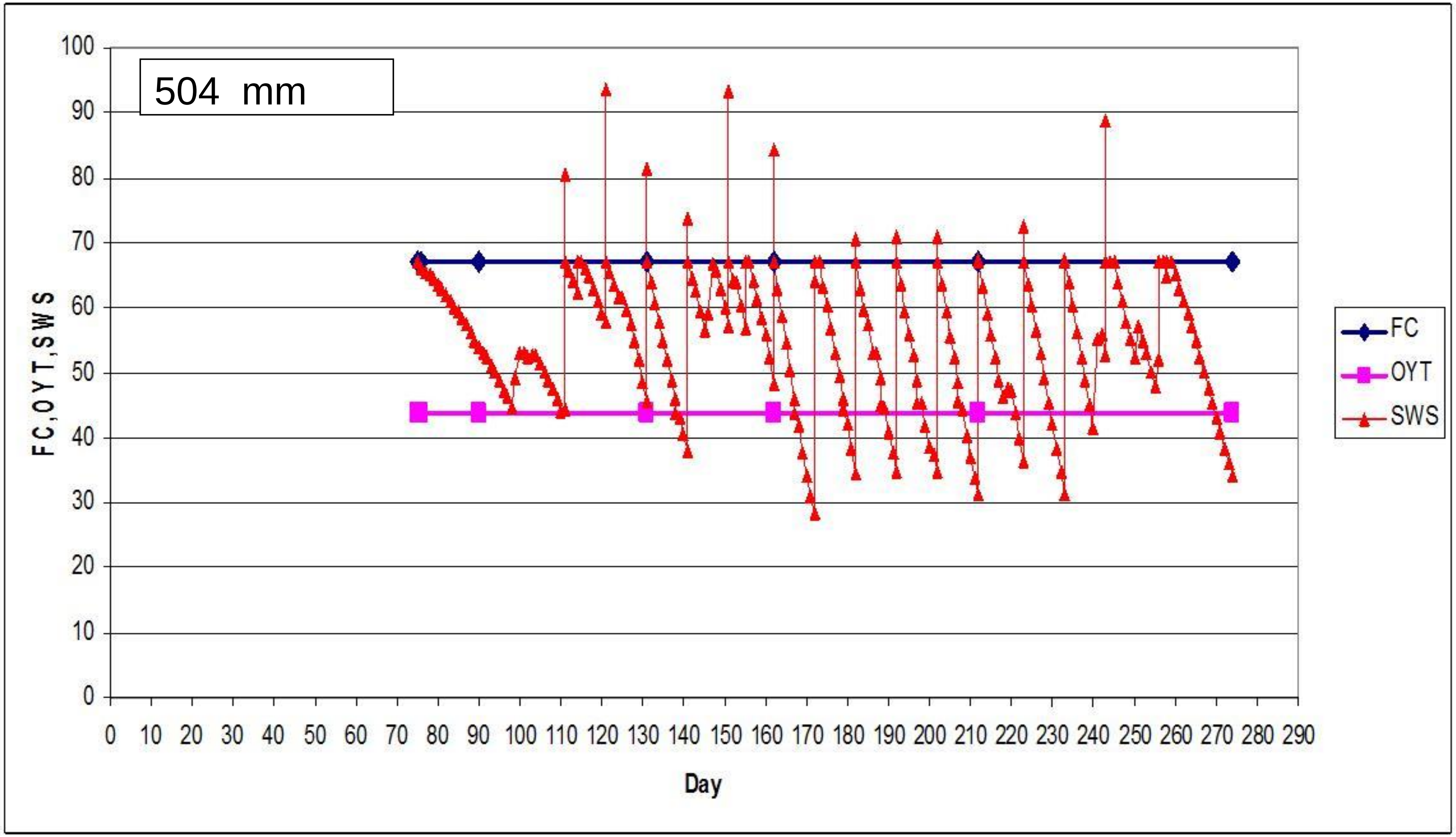
Ref.: Clemmens, 1987

PREFER ON-DEMAND DELIVERY SCHEDULE RATHER THAN ROTATION

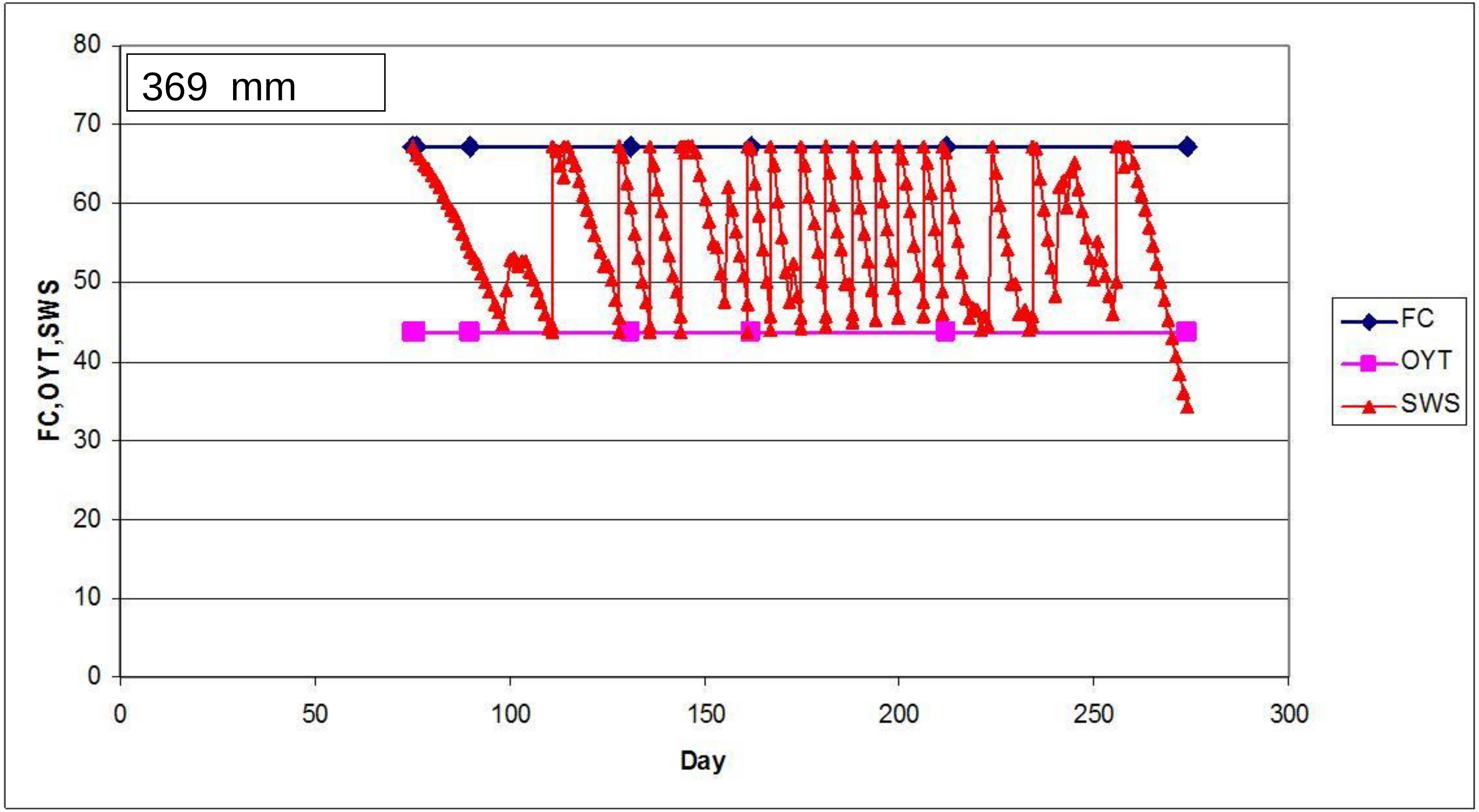
SOIL-WATER BALANCE



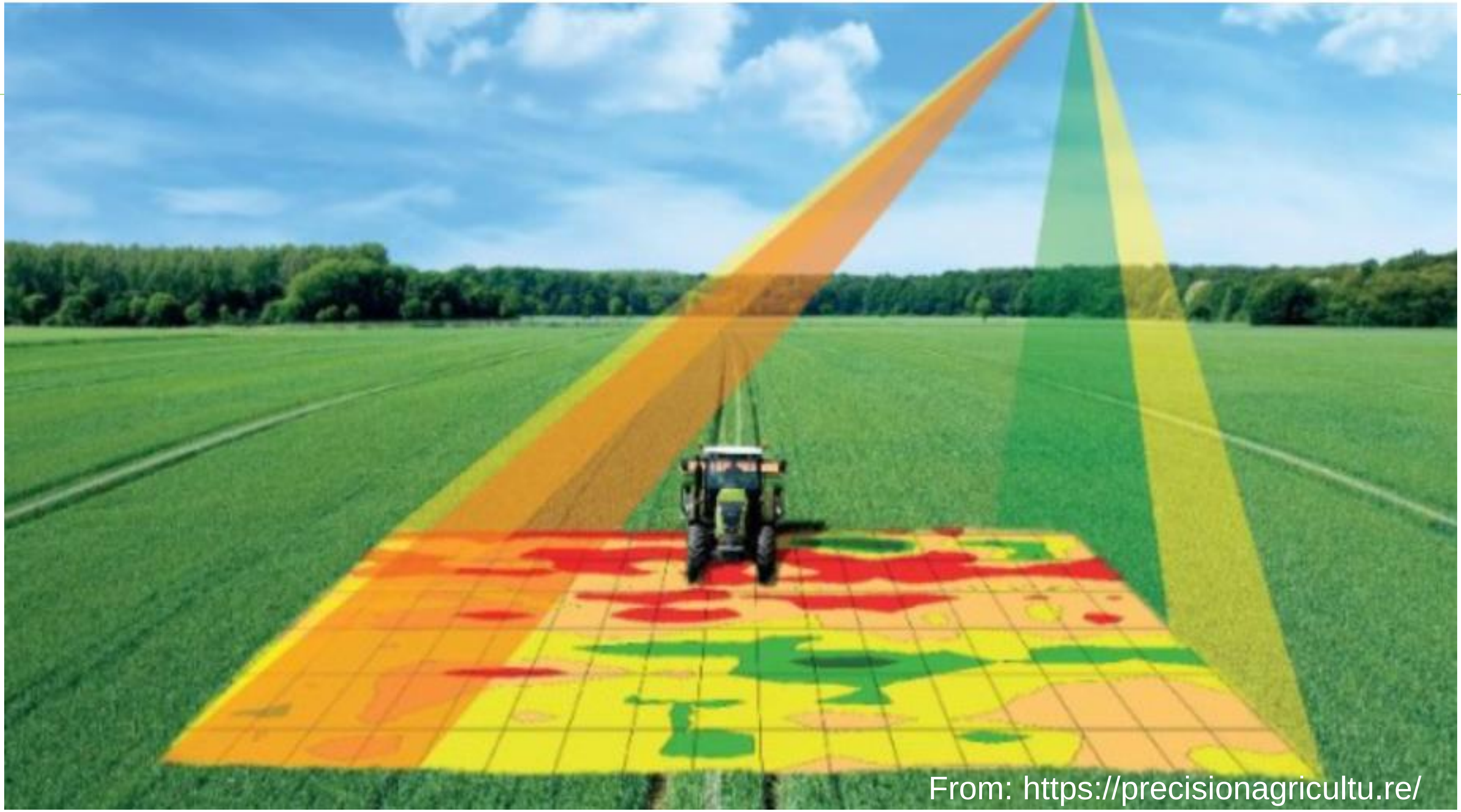
Simulated soil-water balance for TABLE GRAPES according to the rotational delivery schedule conducted by the Water Users Association



Simulated soil-water balance for Table grapes according to the on-demand delivery schedule



PRECISION AGRICULTURE



From: https://precisionagricultu.re/

MAIN TECHNOLOGIES TO BE USED

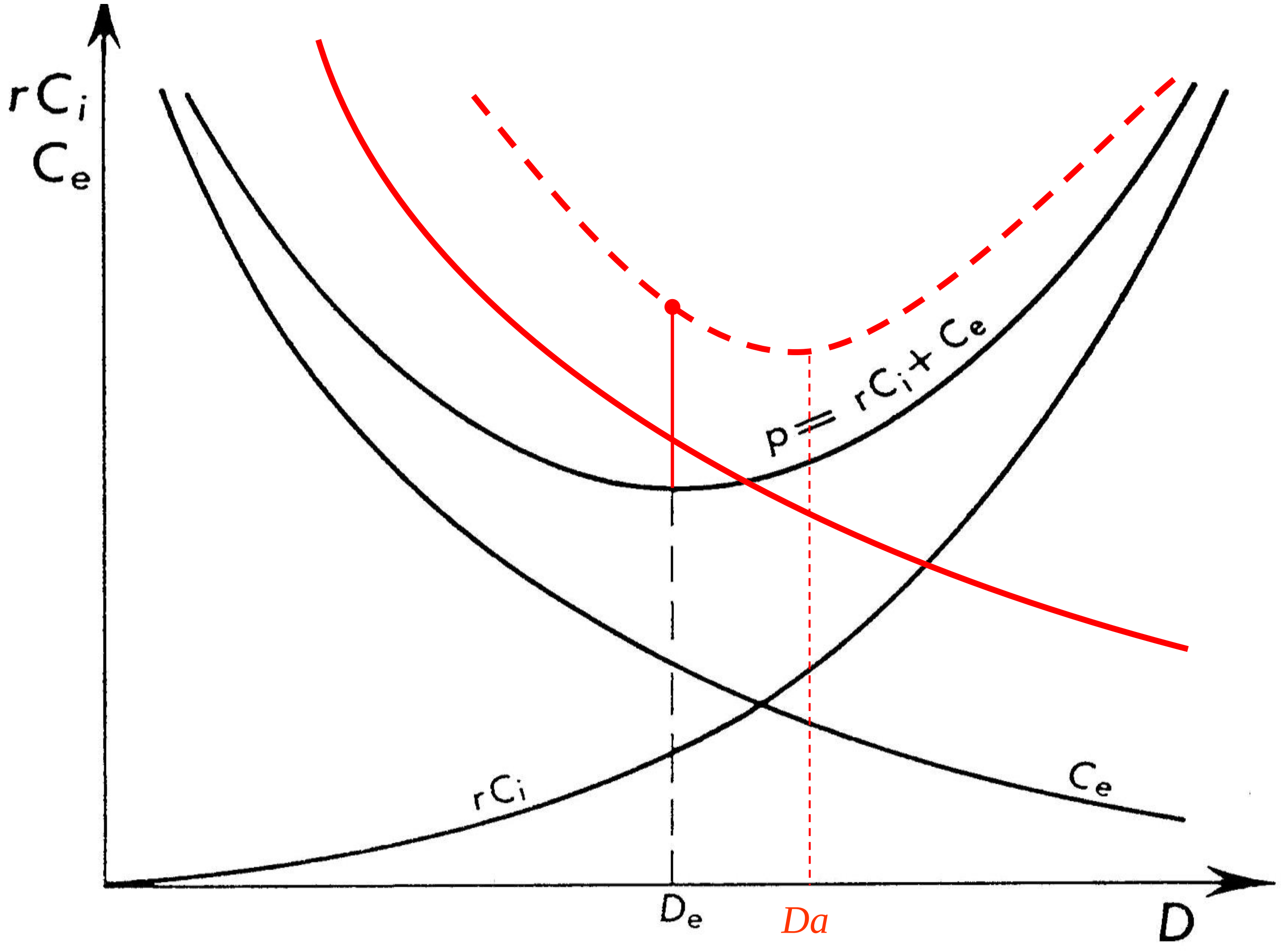
GPS, Mobile devices, Robotics, Sensors, Irrigation, IoT, Weather modeling, Nitrogen modeling, ...

ENERGY SAVING

EU funded Project

Example from Morocco

Agadir - Morocco



rC_i
C_e
$p = rC_i + C_e$
rC_i
C_e
D_e
Da
D


NETAFIM
SPIS LAB PROJECT
CIHEAM IAM BARI
DWS HYDRO SYSTEMS
DN50 PN16
CE
Mat. A001

COMPUTATION OF DISCHARGES

THE FIRST CLÉMENT MODEL

In the on-demand irrigation systems, the nominal discharge of the hydrants (d) is selected much higher than the duty, D (the duty is the flow based on peak period water requirement on a 24-hour basis: $D=q_s A_p$, where q_s is the continuos specific discharge and A_p is the area of the plot irrigated by the hydrant). It allows farmers to irrigate for a duration lower than 24 hours. This condition implies that the event to find all the hydrants simultaneously operating has very low probability. Thus, it is not reasonable to calculate the irrigation network by adding the discharges delivered at all the hydrants simultaneously. Therefore, probabilistic approaches for computing the discharges into the sections of an on-demand collective network have been widely used in the past and are still used actually.

Knowing $U(P_q)$, it is possible to calculate the number of hydrants simultaneously operating, N, through the relationship (3.9). In fact, for u = $U(P_q)$ we have:

$$N = R\,p + U(P_q)\sqrt{R\,p\,(1-p)}$$

that is the first formula of Clément.

Considering hydrants with the same discharge, the total discharge downstream a generic section k is given by:

$$Q_k = R\,p\,d + U(P_q)\sqrt{R\,p(1-p)\,d^2}$$

and, when different classes, i, of hydrants discharges, di, are considered

$$Q_k = \sum_i R_i\, p_i\, d_i + U(P_q)\sqrt{\sum_i R_i\, p_i\,(1-p_i)\,d_i^{\,2}}$$

COMPUTATION OF DIAMETERS

To minimize the cost of the network, P_{NET}, the objective function is:

$$\min P_{NET} = \min \sum_{K=1}^{N} P_k L_k$$

The optimal solution is obtained by solving the above Equation respecting the following constraints:

- If $L_k = X1 + X2$ Then
- $X1 > 0$ and $X2 > 0$
- $V_{max} > V > V_{min}$
- $(Z_0) - \sum Y_k - ZT_j = H_j >= H_{j,min}$

The approach proposed by Labye (1981), called Labye's Iterative Discontinuous Method (LIDM), for optimizing pipe sizes in an irrigation network is described in this section. This method may be developed in two stages.

In the first stage, an initial solution is constructed giving, for each section k of the network, the minimum commercial diameter (D_{min}) according to the maximum allowable flow velocity (v_{max}) in a pipe, when the pipe conveys the calculated discharge (Q_k).

The diameter for the section k is calculated by the relationship:

$$(D_{min})_k = \sqrt{\frac{4\,Q_k}{\pi \quad v_{max}}}$$

After knowing the initial diameters, it is possible to calculate the piezometric elevation $(Z_0)_{in}$ at the upstream end of the network, which satisfies the minimum head ($H_{j,min}$) required at the most unfavorable hydrant (j):

$$(Z_0)_{in} = H_{j,min} + ZT_j + \sum Y_k$$

where $\sum Y_k$ are the head losses along the pathway (Mj) connecting the upstream end of the network to the most unfavorable hydrant.

In the second stage, the optimal solution is obtained by iteratively decreasing the upstream piezometric elevation $(Z_0)_{in}$ until reaching the effectively available upstream piezometric elevation, Z_0, by selecting, for each iteration, the sections for which an increase in diameter produces the minimum increase of the network cost.
The selection process at each iteration is carried out as described below.

$$\beta_s = \frac{P_{s+1} - P_s}{J_s - J_{s+1}}$$

where P [€] and J [m m-1] are, respectively, the cost and the friction loss per unit length of pipe diameter Ds [m], and Ps+1 [It£] and Js+1 [m m-1] are, respectively, the cost and the friction loss per unit length of pipe diameter Ds+1 [m].

SYSTEM ANALYSIS

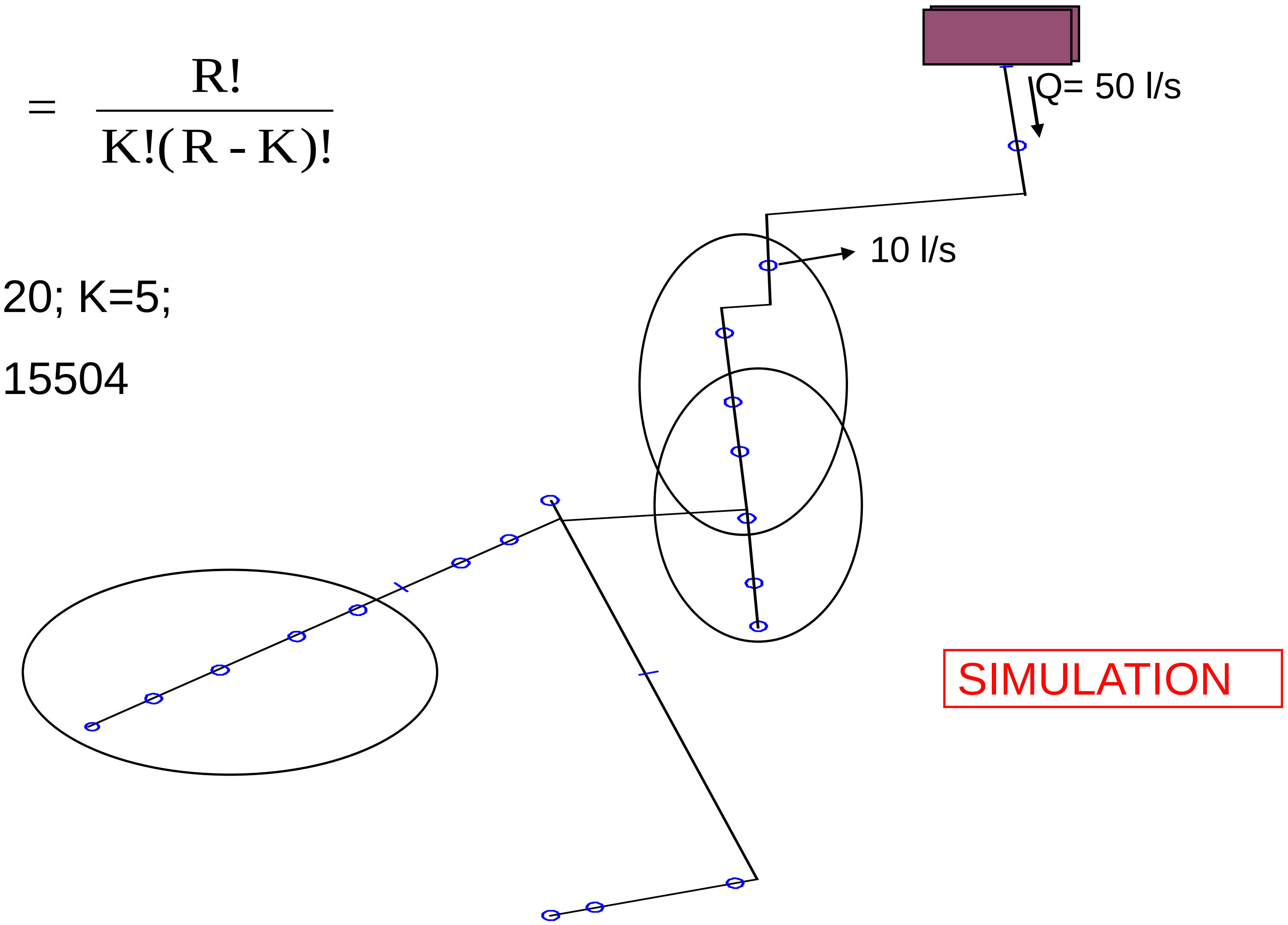
IRRIGATION SYSTEMS ANALYSIS
IS THE PROCESS OF USING
A COMPUTER SIMULATION MODEL
TO ANALYZE
PERFORMANCE CAPABILITIES

PERFORMANCE =
SYSTEM REQUIREMENTS
NECESSARY TO MEET
DESIGN STANDARDS FOR
PRESSURE AND/OR DISCHARGE

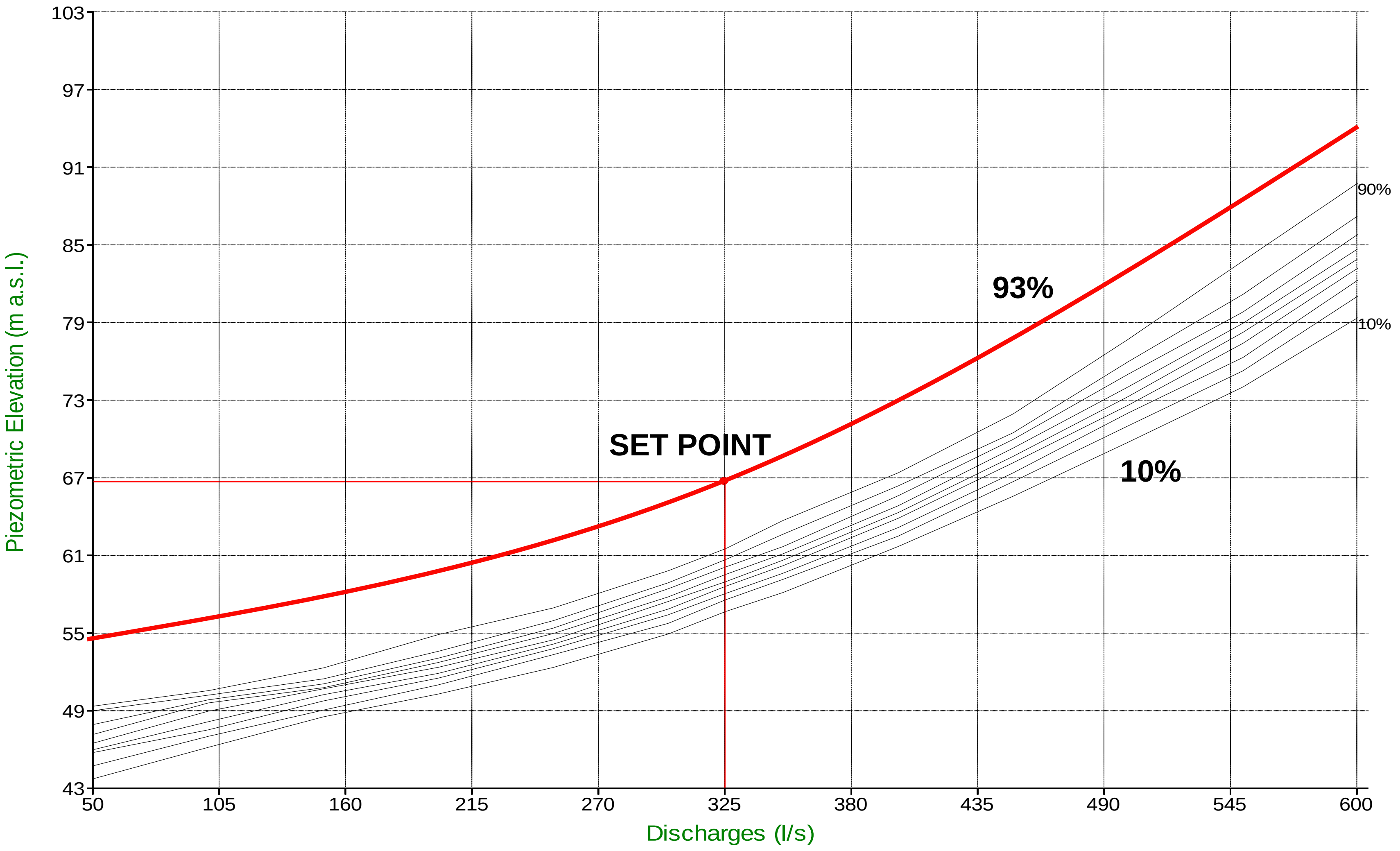
$$C_R^K = \frac{R!}{K!(R-K)!}$$

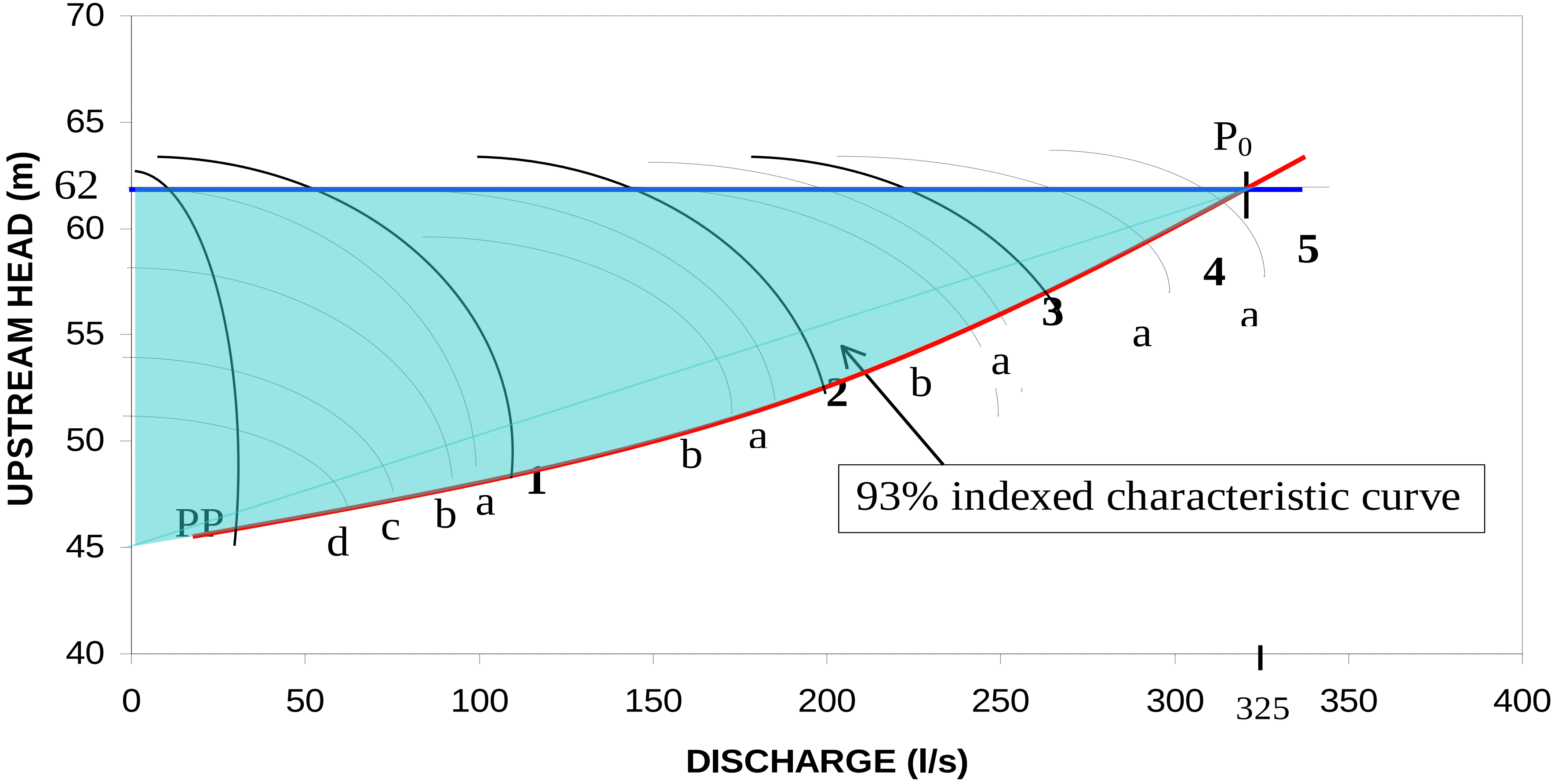
R=20; K=5;

C=15504



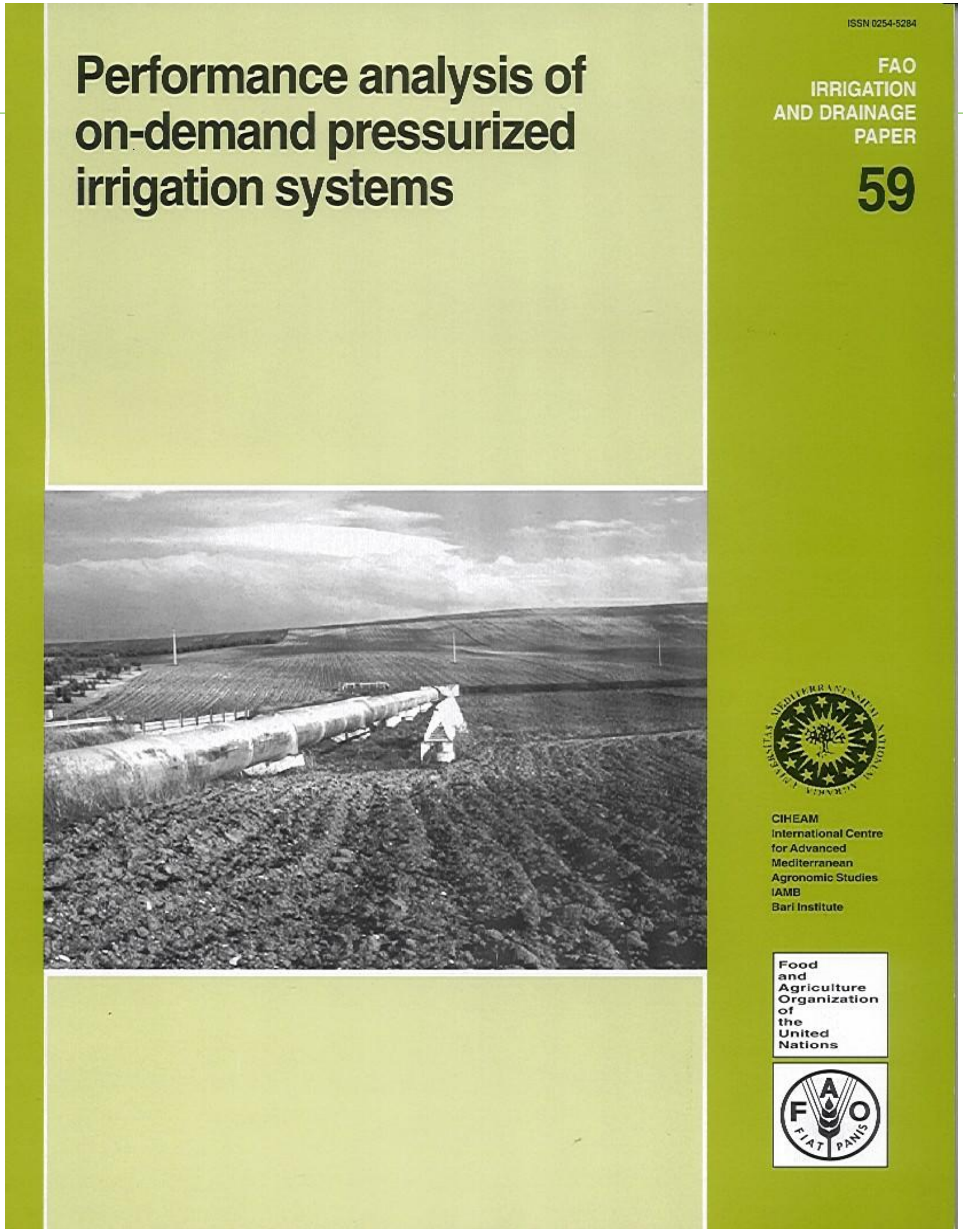
Configuration Analysis





70
65
62
60
55
50
45
40
UPSTREAM HEAD (m)
0
50
100
150
200
250
300
325
350
400
DISCHARGE (l/s)
P0
5
4
3
2
1
a
b
c
d
PP
93% indexed characteristic curve

COPAM
an integrated software package for design and performance analysis of on-demand pressurized irrigation systems


ISSN 0254-5284
Performance analysis of on-demand pressurized irrigation systems
FAO IRRIGATION AND DRAINAGE PAPER
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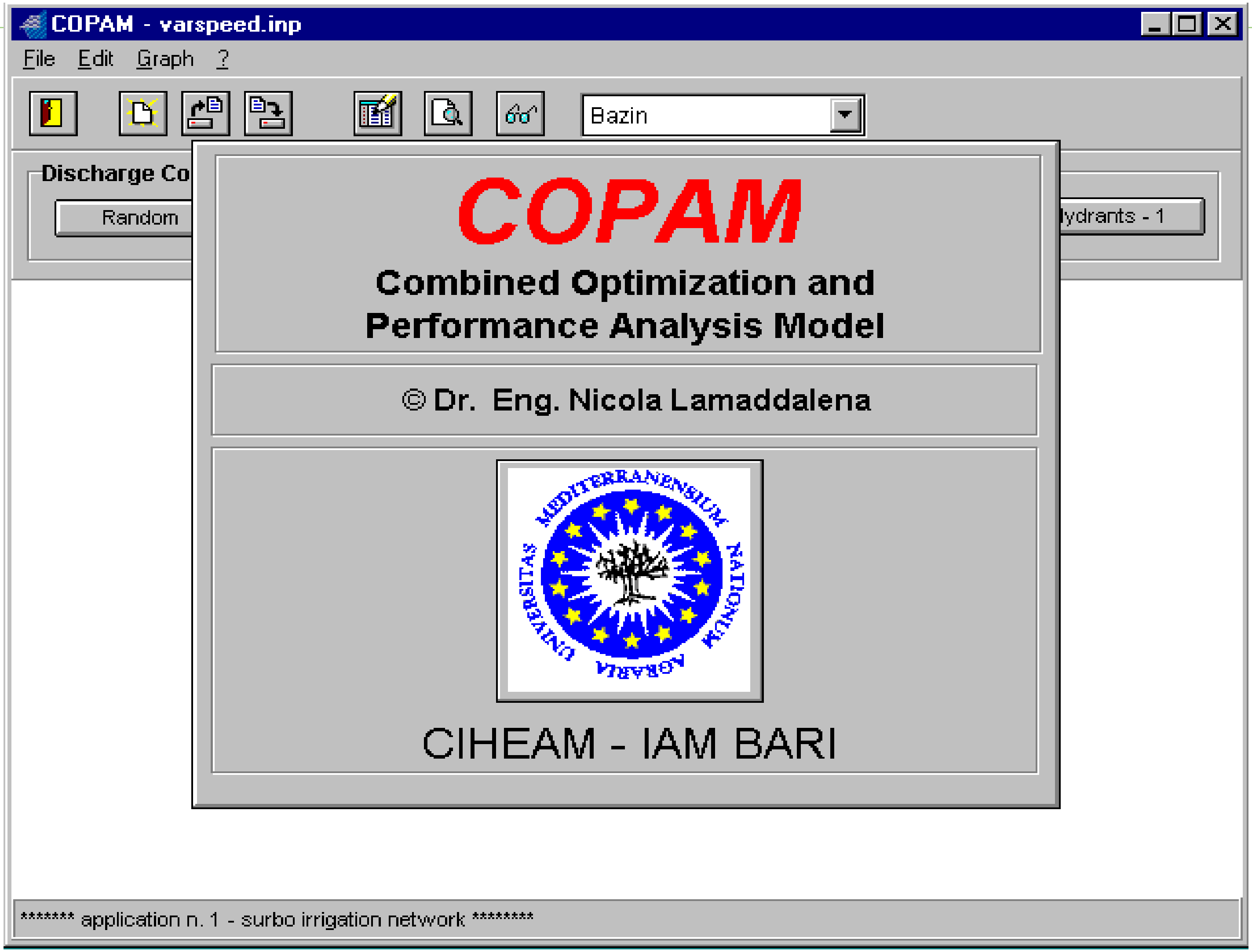
FIAT PANIS


COPAM - varspeed.inp
File
Edit
Graph
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Bazin
Discharge Co
Random
ydrants - 1
COPAM
Combined Optimization and
Performance Analysis Model
© Dr. Eng. Nicola Lamaddalena
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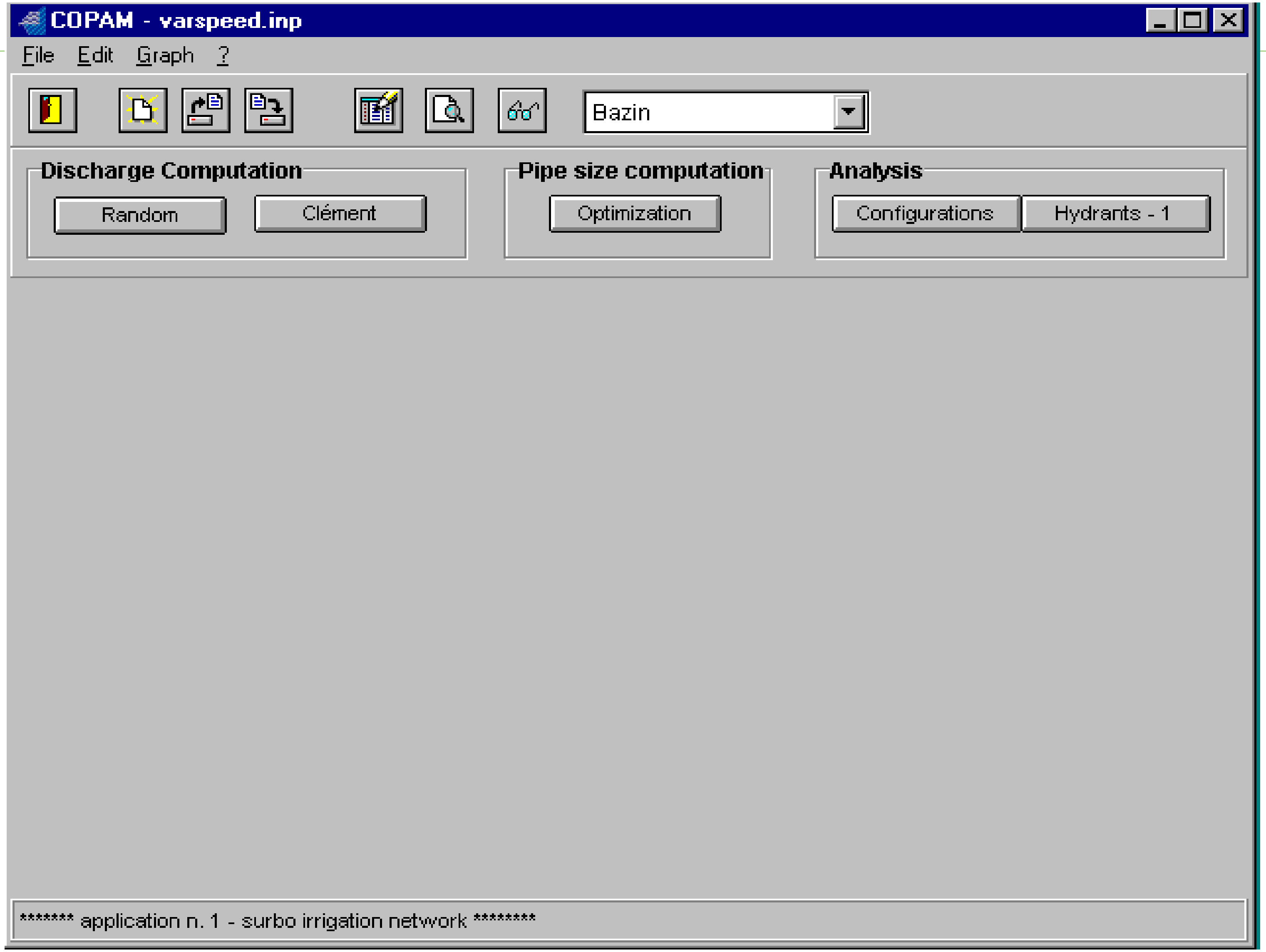
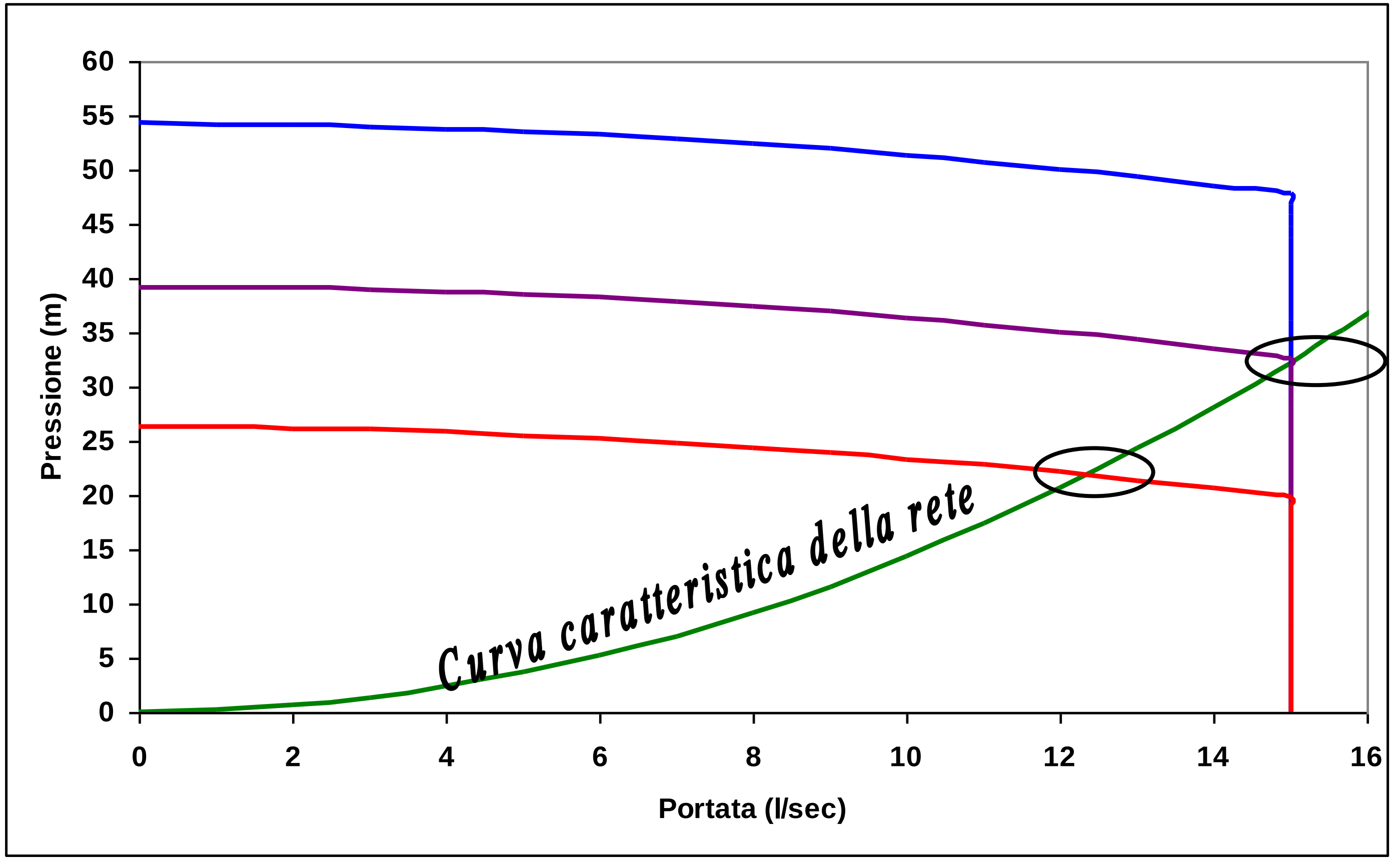
CIHEAM - IAM BARI
******* application n. 1 - surbo irrigation network ********



COPAM - varspeed.inp
File Edit Graph ?
Bazin
Discharge Computation
Random
Clément
Pipe size computation
Optimization
Analysis
Configurations
Hydrants - 1
******* application n. 1 - surbo irrigation network ********

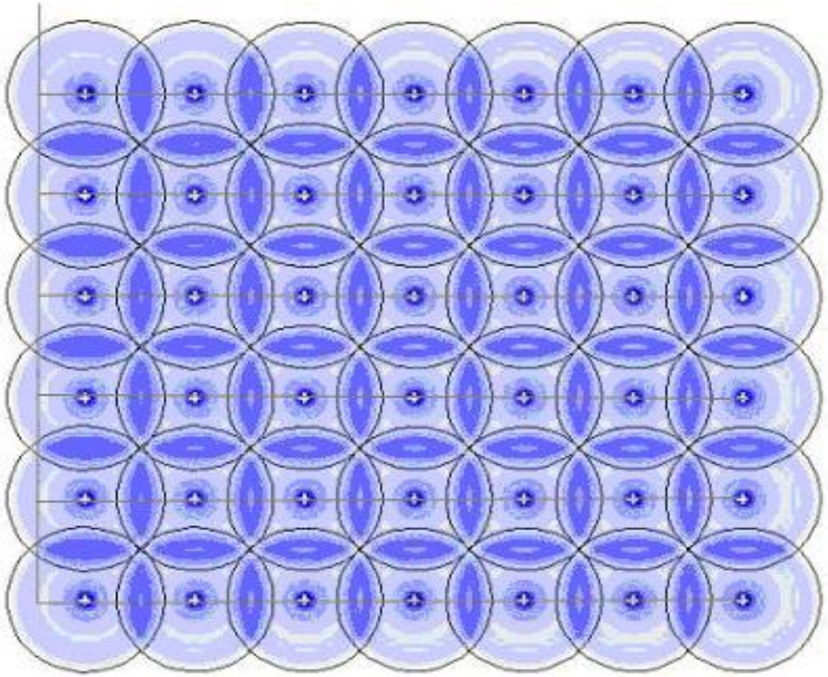
Working parameters of the on-farm network



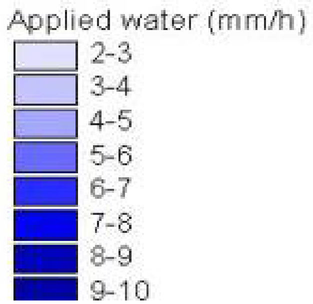
H_{max}=54 m
H_{min} =26 m

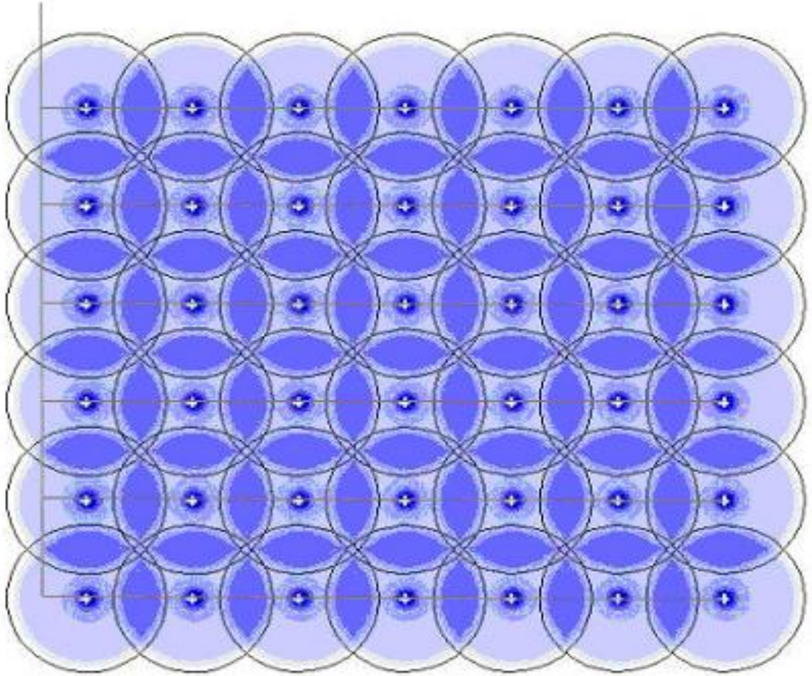
H=33 m
Q=15.31 l/s

H=21 m
Q=12.84 l/s



H = 21 m
CU = 63%
DU = 67%
DE_{90} = 60%
Dn_{90} = 3mm/h





H = 33 m
CU = 74%
DU = 80%
DE_{90} = 80%
Dn_{90} = 4.5mm/h

SIMPLE CALCULATION

CASE 1:

$E_{G,1} = 0.95 \times 0.60 = 0.57$

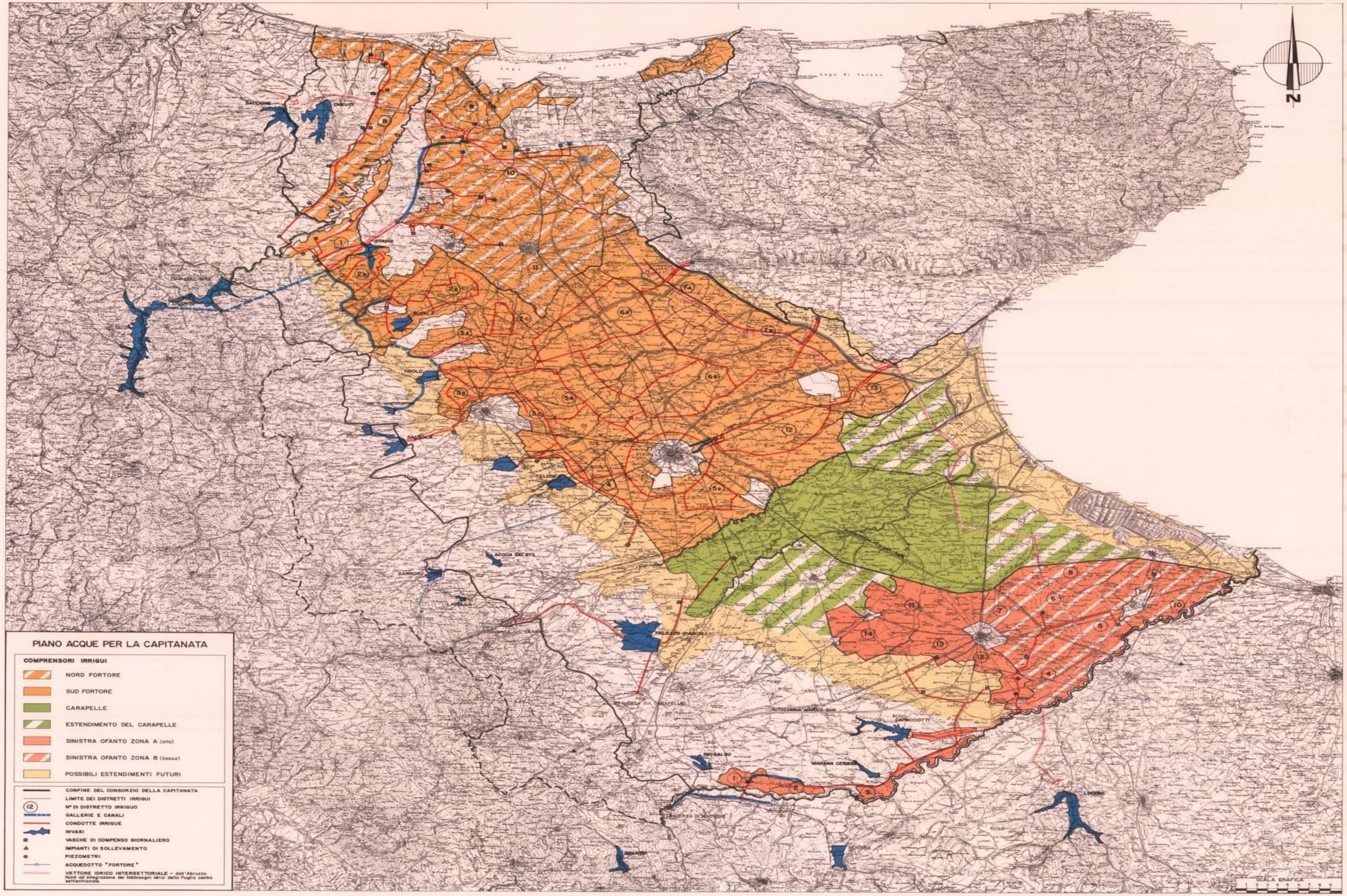
CASE 2:

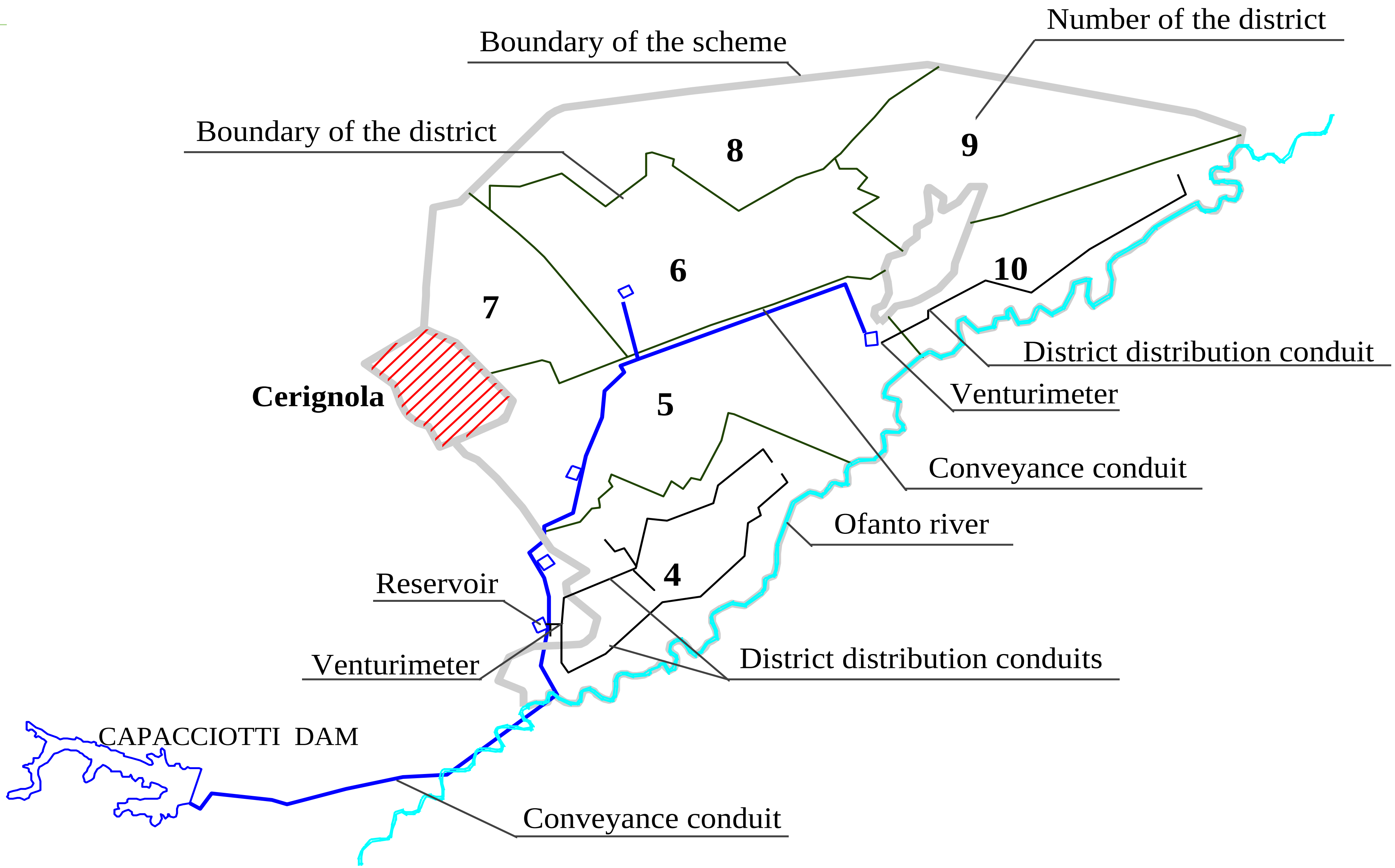
$E_{G,2} = 0.95 \times 0.80 = 0.76$

$$DE = (0.76 - 0.57)/0.57 = 0.33 = +33\%$$

CASE STUDY
AND
MANAGEMENT ISSUES

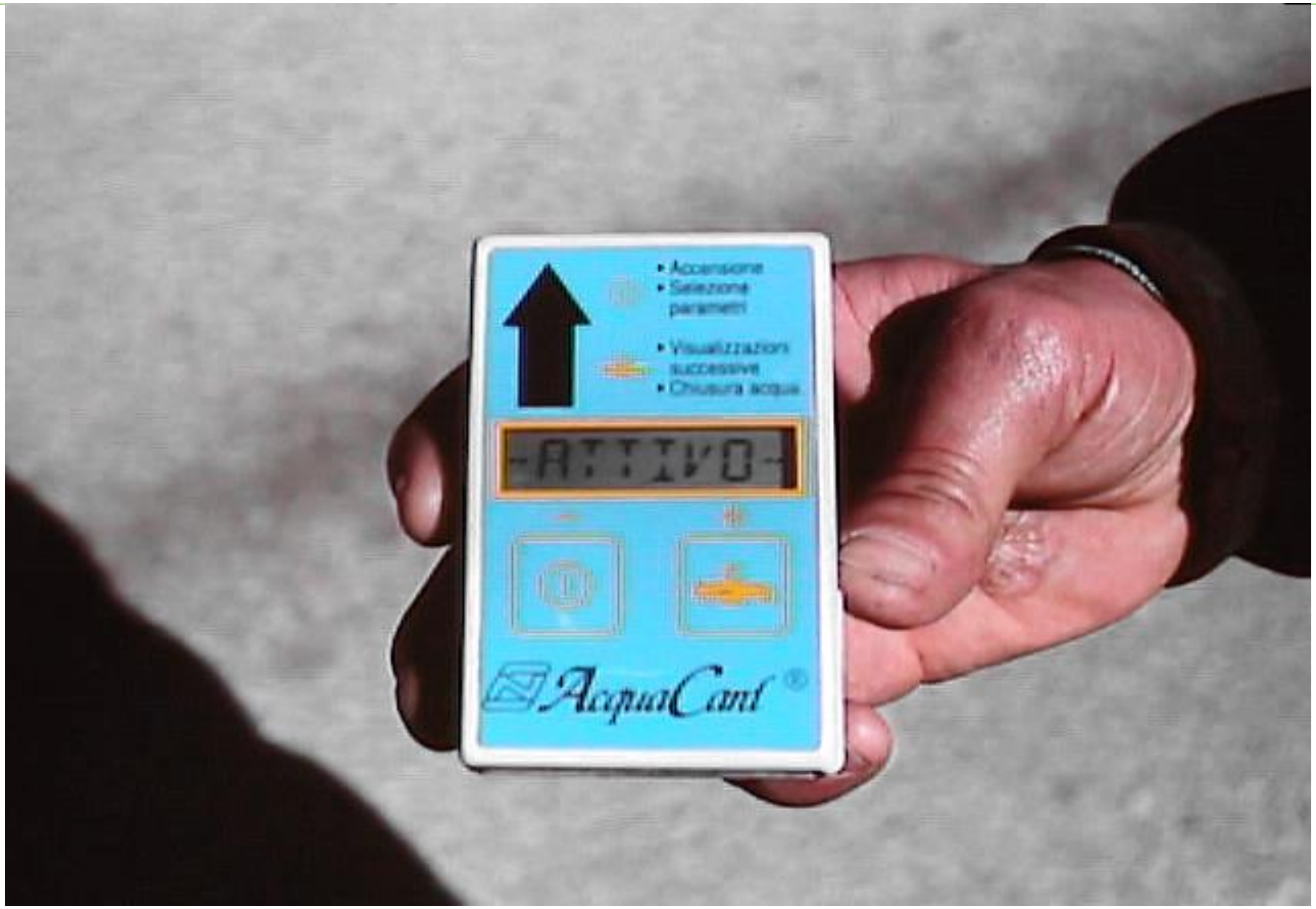

UNGHERIA
BOSNIA-ERZEGOVINA
T I R R E N O
Livorno
Bari
Palermo
Catania
TUNISIA


PIANO ACQUE PER LA CAPITANATA
COMPRENSORI IRRIGUI
NORD FORTORE
SUD FORTORE
CARAPELLE
ESTENDIMENTO DEL CARAPELLE
SINISTRA OFANTO ZONA A (alta)
SINISTRA OFANTO ZONA B (bassa)
POSSIBILI ESTENDIMENTI FUTURI
CONFINE DEL CONSORZIO DELLA CAPITANATA
LIMITE DEI DISTRETTI IRRIGUI
N° DI DISTRETTO IRRIGUO
GALLERIE E CANALI
CONDOTTE IRRIGUE
INVASI
VASCHE DI COMPENSO GIORNALIERO
IMPIANTI DI SOLLEVAMENTO
PIEZOMETRI
ACQUEDOTTO "FORTORE"
VETTORE IDRICO INTERSETTORIALE – dall'Abruzzo Nord ad integrazione dei fabbisogni idrici della Puglia centro settentrionale.
SCALA GRAFICA
N



Number of the district
Boundary of the scheme
Boundary of the district
8
9
6
10
7
5
4
Cerignola
District distribution conduit
Venturimeter
Conveyance conduit
Ofanto river
Reservoir
Venturimeter
District distribution conduits
CAPACCIOTTI DAM
Conveyance conduit


AcquaCard
Nicotra
Sistemi spa - MI


• Accensione
• Selezione parametri
• Visualizzazioni successive
• Chiusura acqua
-ATTIVO-
AcquaCant ®

For more information:

Water and
Environment Support
in the ENI Southern Neighbourhood region

Thank you for your attention!