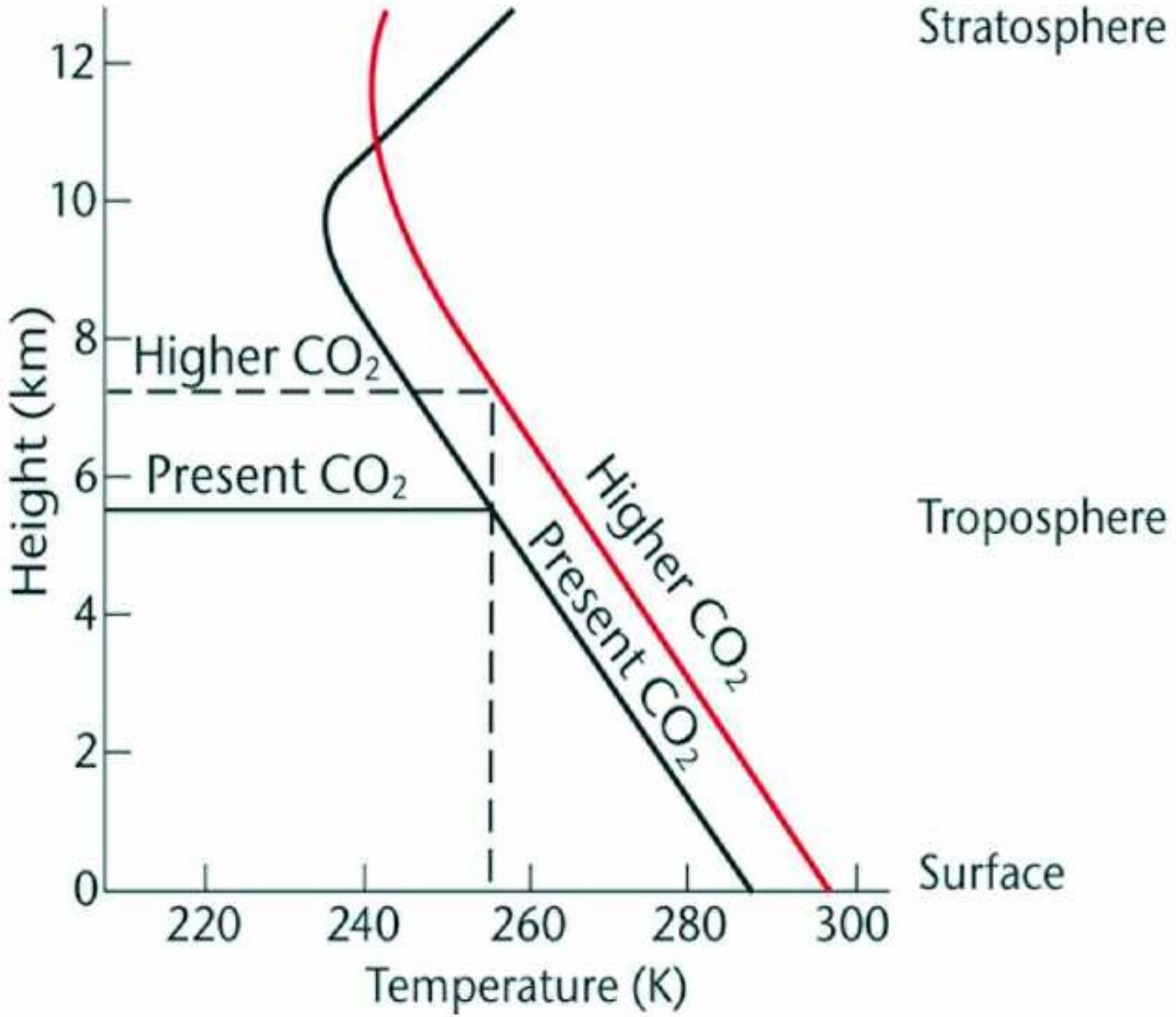
VALUING ENVIRONMENTAL IMPACTS FROM CLIMATE CHANGE AND HYDROPOWER : A CASE STUDY FROM GREECE

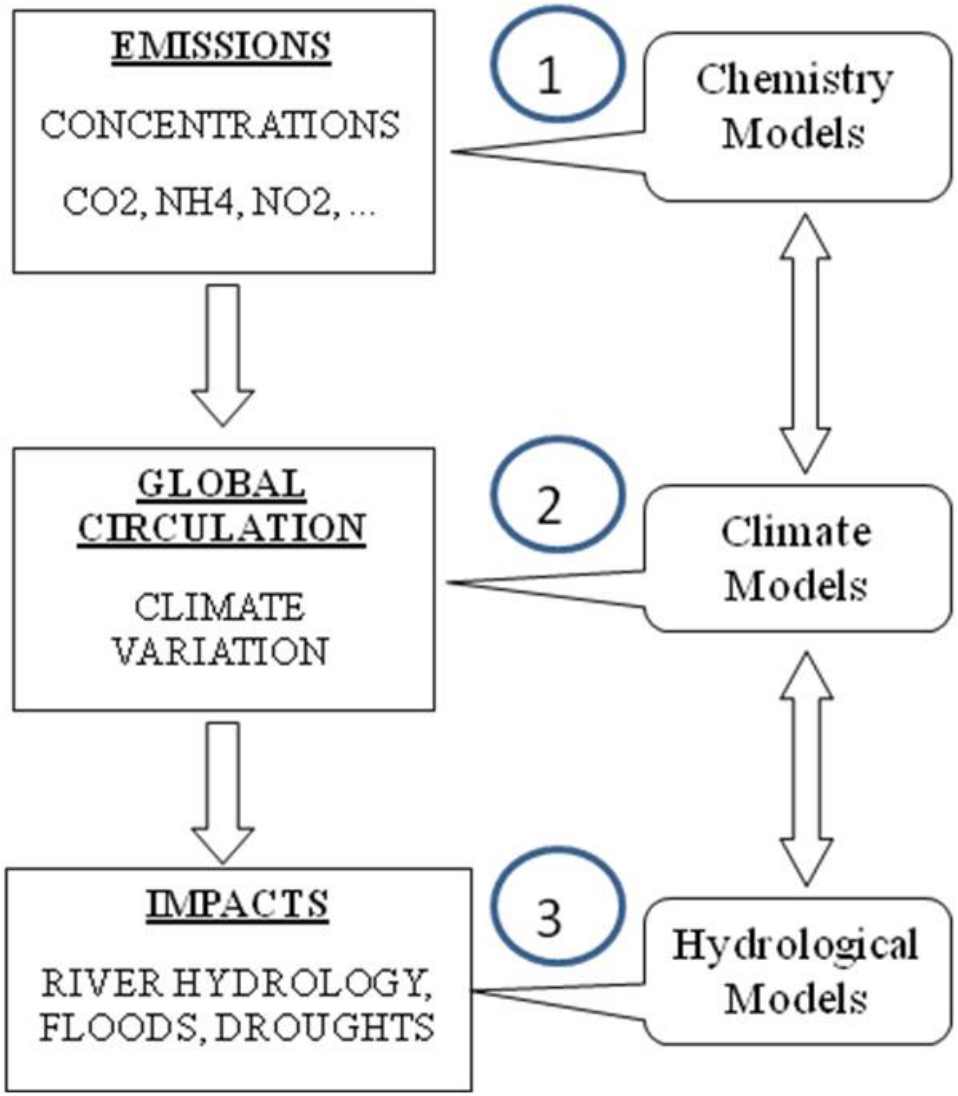
by

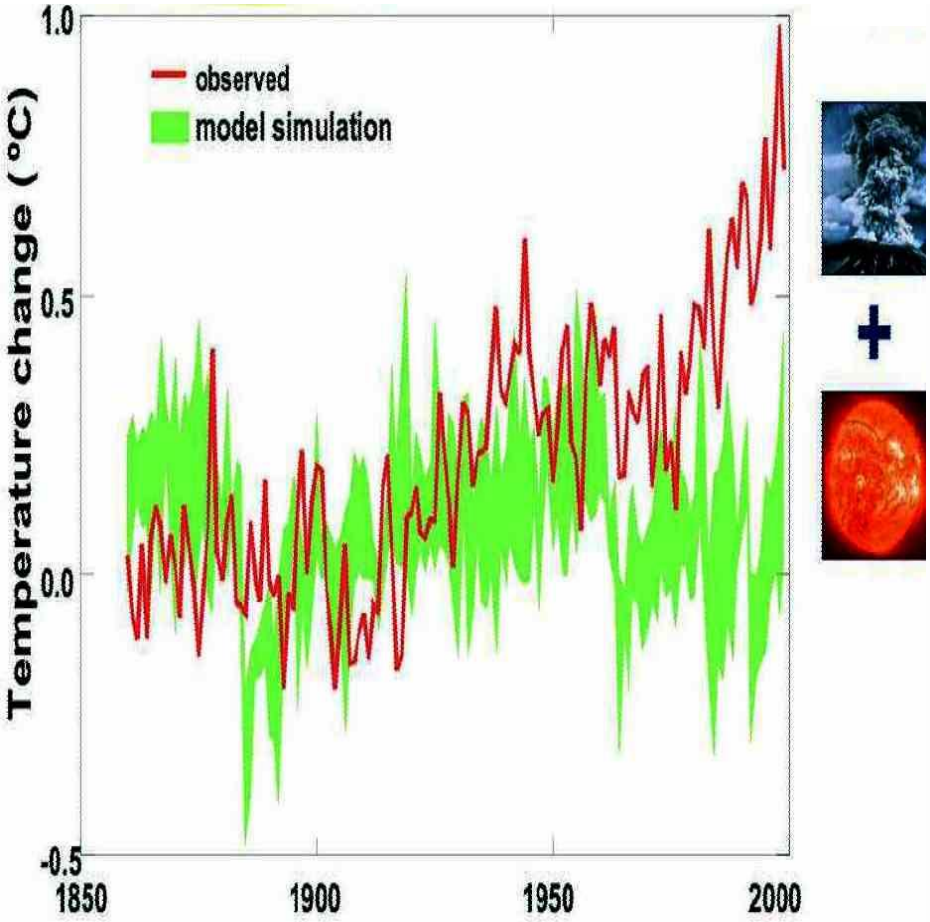
Prof. J. Ganoulis, Coordinator

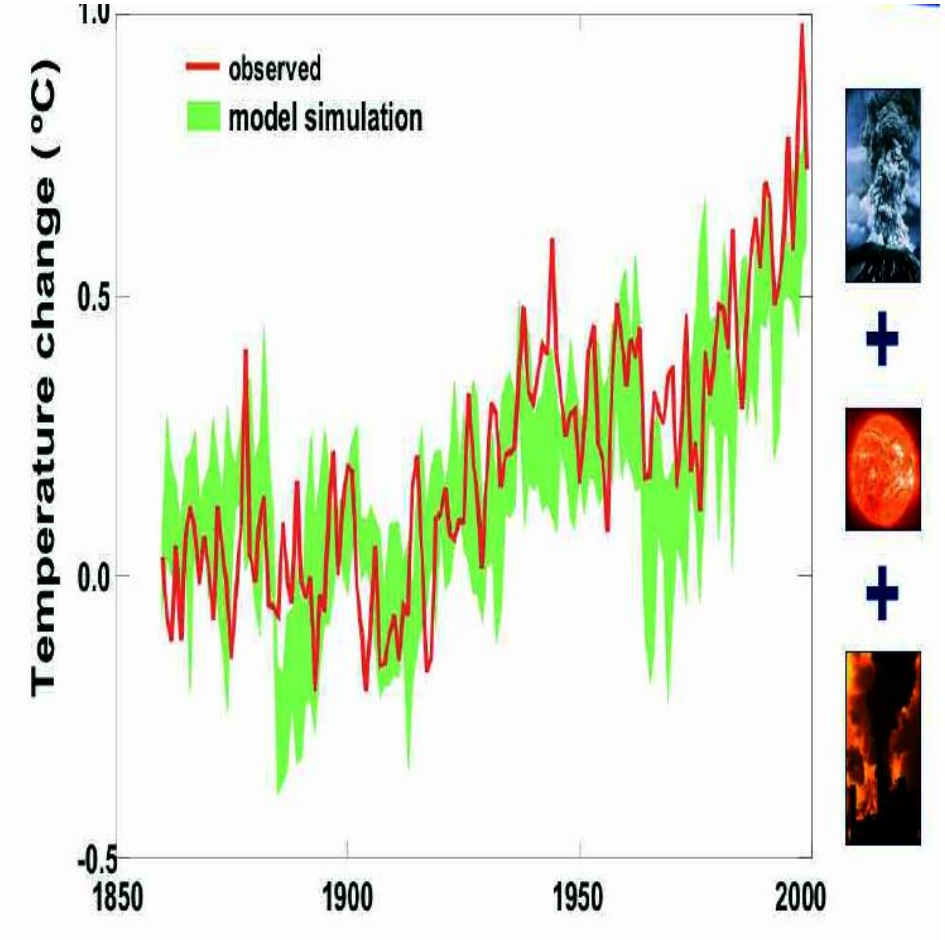
UNESCO Chair/INWEB
International Network of Water/Environment Centres for the Balkans
Aristotle University of Thessaloniki, Greece

http:// www.inweb.gr


Stratosphere
Troposphere
Surface
Height (km)
12
10
8
6
4
2
0
Higher CO_2
Present CO_2
Higher CO_2
Present CO_2
220
240
260
280
300
Temperature (K)


EMISSIONS
CONCENTRATIONS
CO2, NH4, NO2, ...
1
Chemistry Models
GLOBAL CIRCULATION
CLIMATE VARIATION
2
Climate Models
IMPACTS
RIVER HYDROLOGY, FLOODS, DROUGHTS
3
Hydrological Models

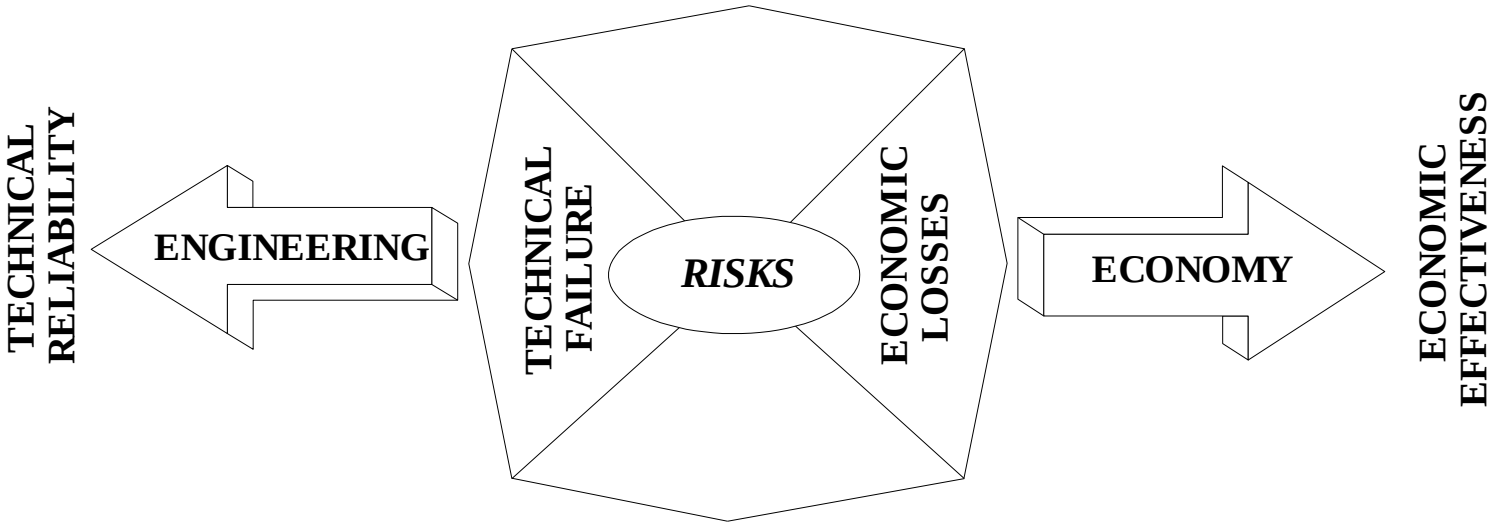

observed
model simulation
Temperature change (°C)
1.0
0.5
0.0
-0.5
1850
1900
1950
2000


observed
model simulation
Temperature change (°C)
1.0
0.5
0.0
-0.5
1850
1900
1950
2000

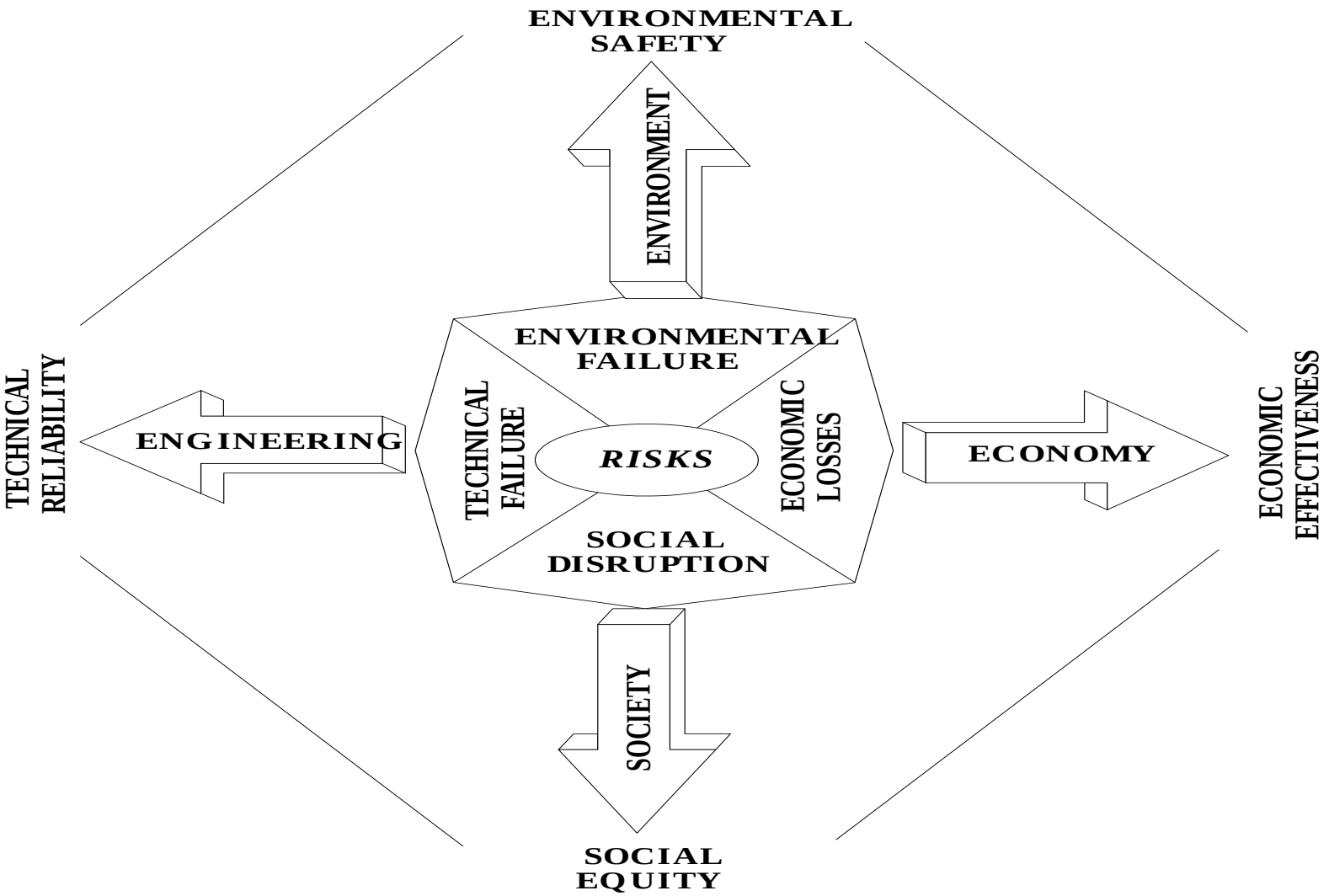
MAIN DRIVERS OF THE «Global Water Crisis»

- GEO-POLITICAL CHANGES
- TECHNOLOGICAL CHANGES
- POPULATION GROWTH
- CLIMATE CHANGE

TECHNICAL & ECONOMIC OBJECTIVES



MULTIPLE OBJECTIVES



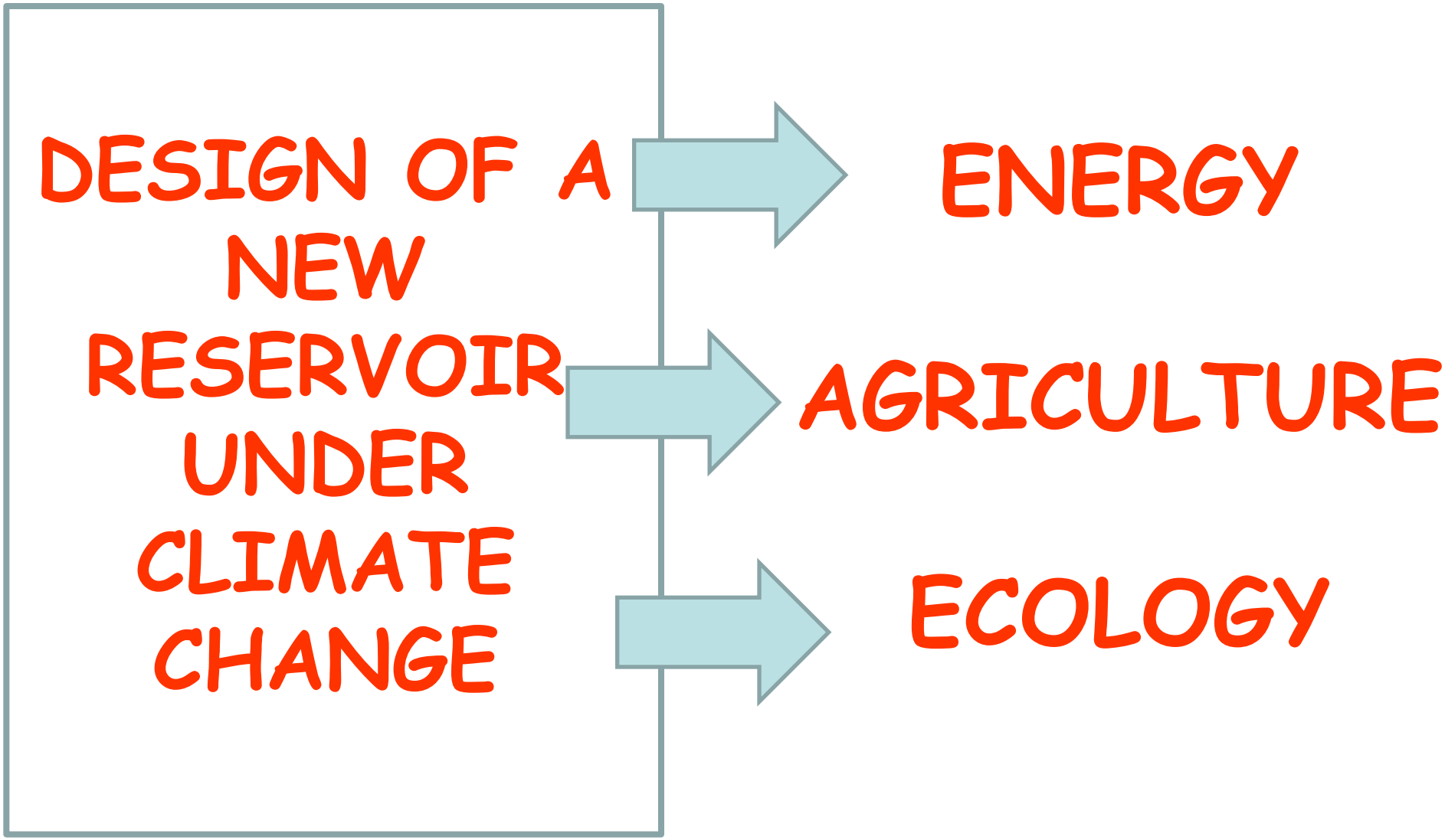
Ganoulis

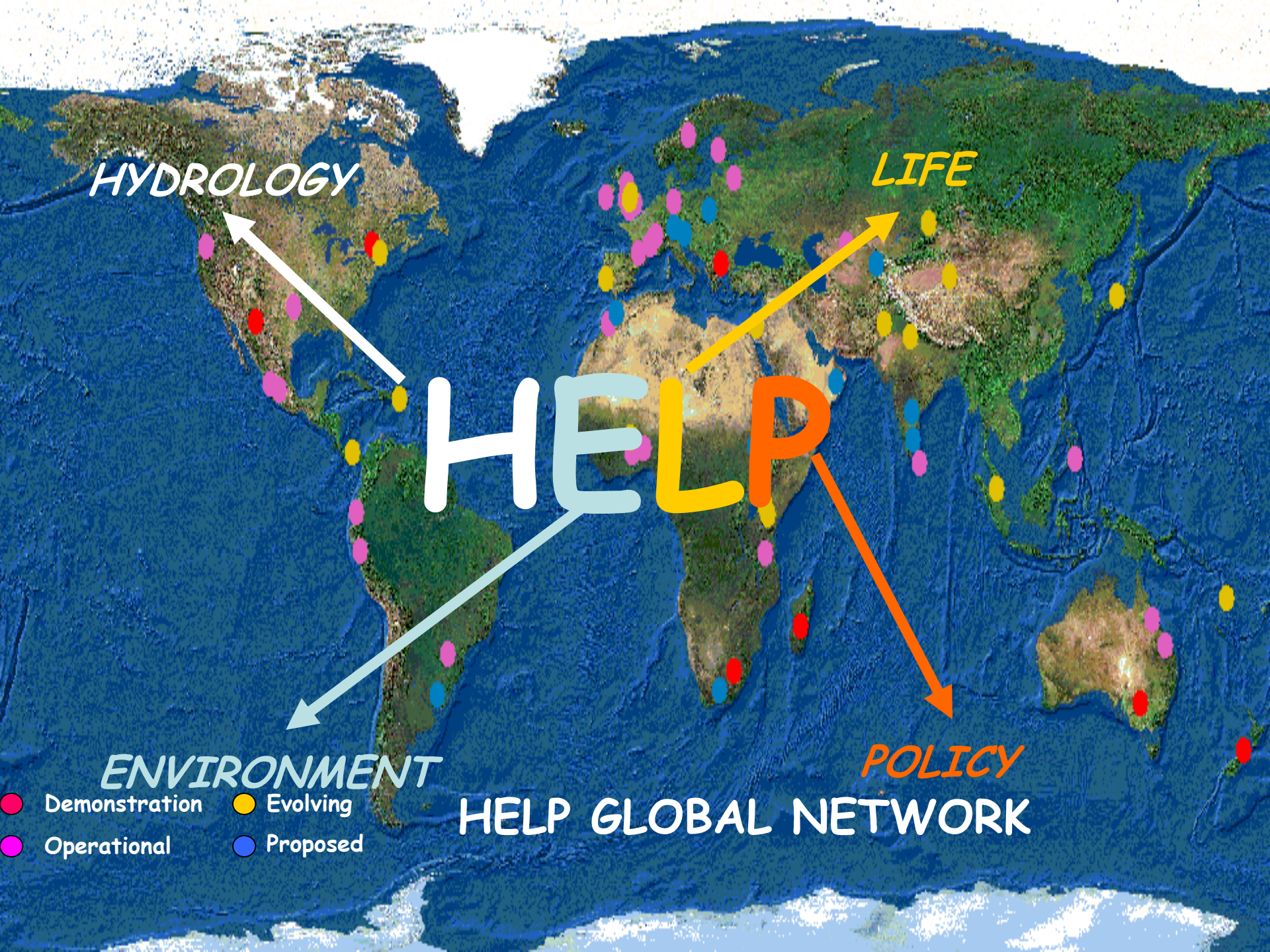
WILEY-VCH

Risk Analysis of Water Pollution

Second Edition *July 09*

A UNESCO-HELP CASE STUDY


DESIGN OF A NEW RESERVOIR UNDER CLIMATE CHANGE
ENERGY
AGRICULTURE
ECOLOGY


HYDROLOGY
LIFE
HELP
ENVIRONMENT
POLICY
Demonstration
Evolving
Operational
Proposed
HELP GLOBAL NETWORK

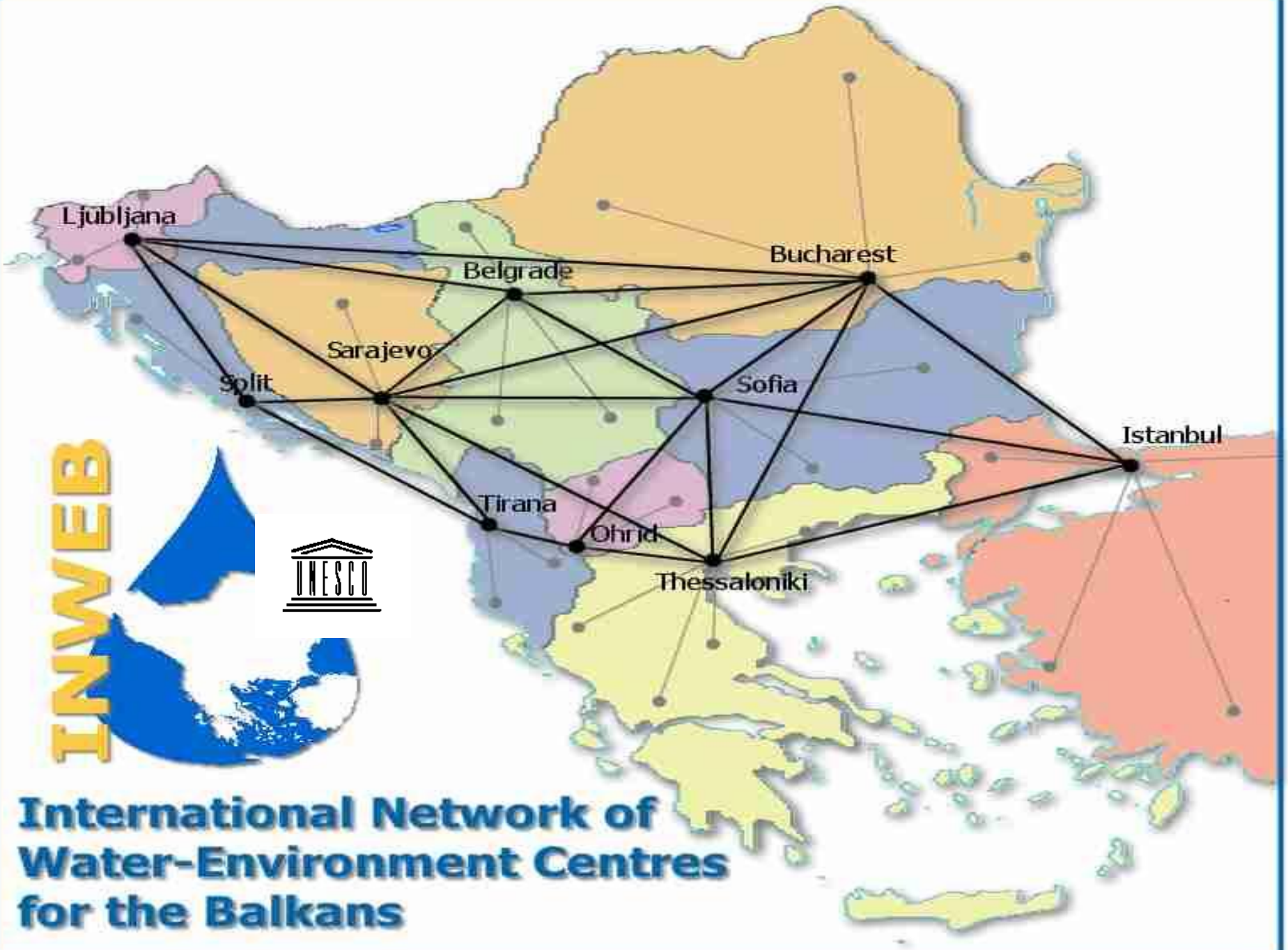
From Potential Conflict

to Co-operation Potential

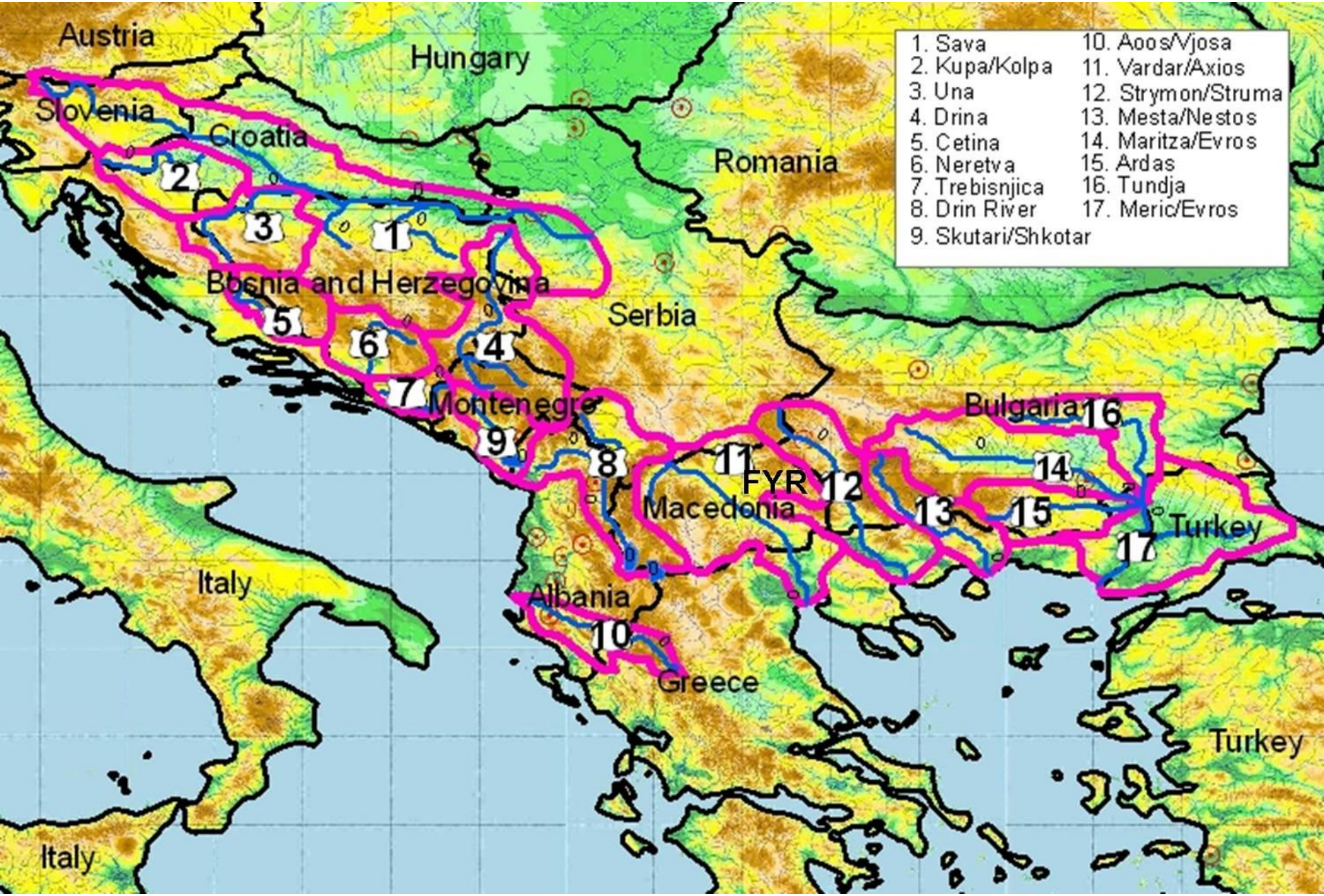
Water for Peace

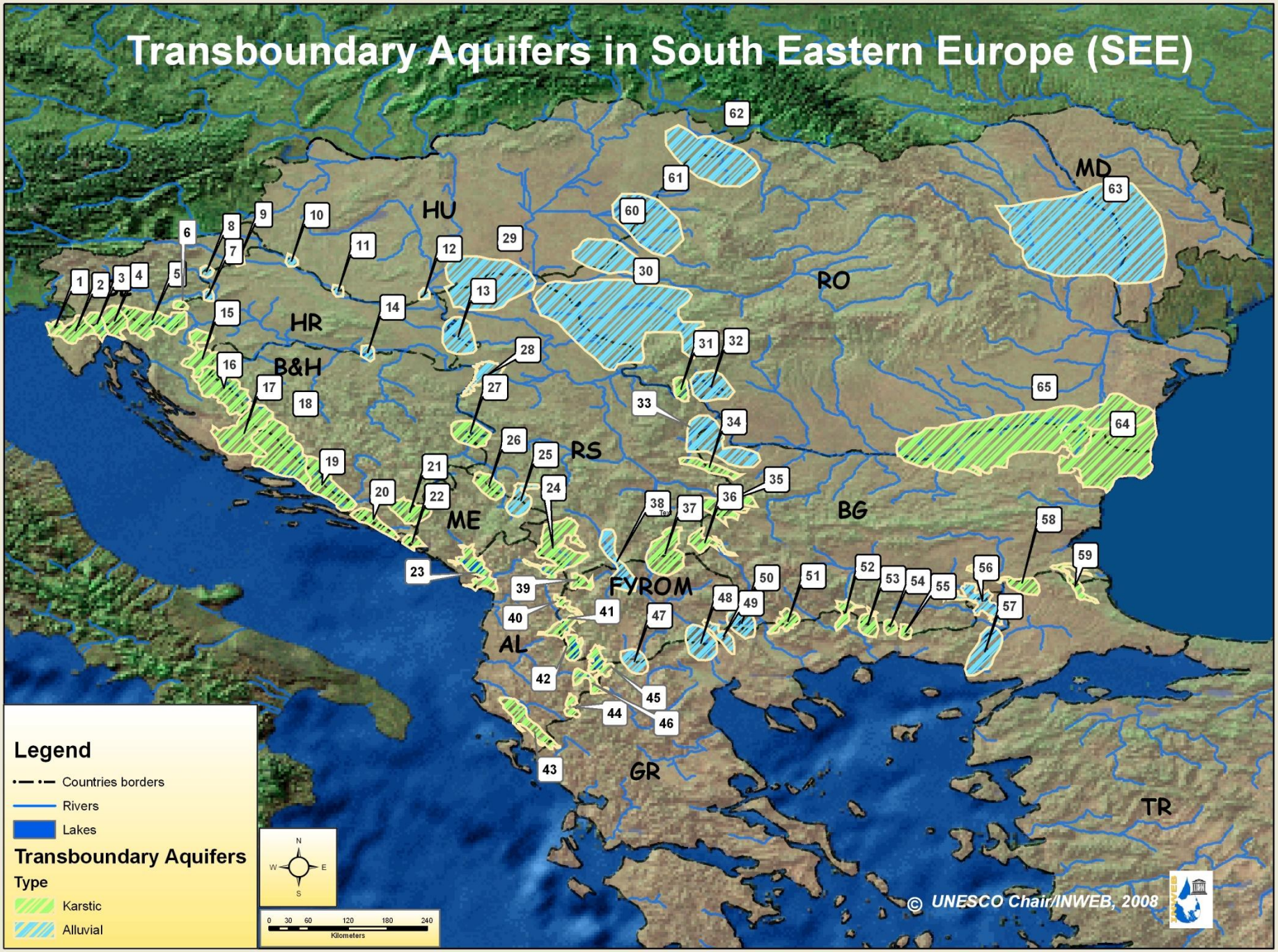
a contribution to

World Water Assessment Programme



International Network of Water-Environment Centres for the Balkans


Austria
Hungary
Slovenia
Croatia
Romania
Bosnia and Herzegovina
Serbia
Montenegro
Bulgaria
FYR
Macedonia
Albania
Greece
Turkey
Italy
Italy
1. Sava
2. Kupa/Kolpa
3. Una
4. Drina
5. Cetina
6. Neretva
7. Trebisnjica
8. Drin River
9. Skutari/Shkotar
10. Aoos/Vjosa
11. Vardar/Axios
12. Strymon/Struma
13. Mesta/Nestos
14. Maritza/Evros
15. Ardas
16. Tundja
17. Meric/Evros


Transboundary Aquifers in South Eastern Europe (SEE)
HU
MD
RO
HR
B&H
RS
ME
BG
FYROM
AL
GR
TR
Legend
Countries borders
Rivers
Lakes
Transboundary Aquifers
Type
Karstic
Alluvial
N
W
E
S
0 30 60 120 180 240
Kilometers
© UNESCO Chair/INWEB, 2008

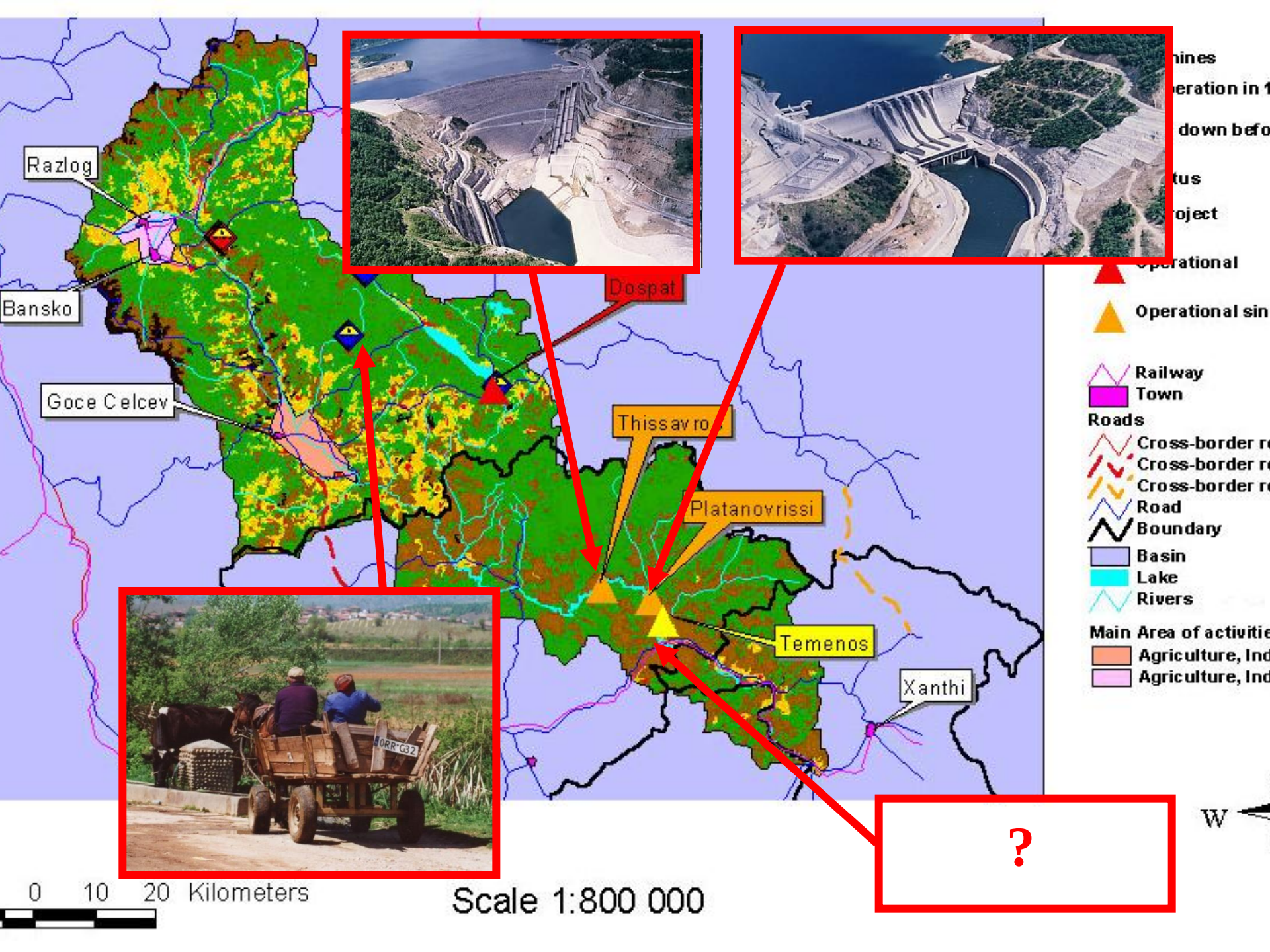
a transboundary river - dam

a transboundary river delta - aquifer

Extensive construction activities

Nationalpark Pirin

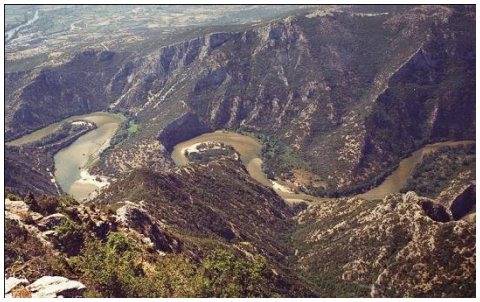
Extensive agricultural activities


Razlog
Bansko
Goce Celcev
Dospat
Thissavros
Platanovrissi
Temenos
Xanthi
?
0 10 20 Kilometers
Scale 1:800 000
Railway
Town
Roads
Road
Boundary
Basin
Lake
Rivers
Operational
Operational sin
W

What value for the lower Nestos environment ?

A typical wetlands environment

- The **Nestos gorges** forms a protected environment open to leisure kayaking
- The **Nestos Delta** has long been famous in the **birding** world
- It is the site of a unique **riparian forest** (Kotza Orman)
- Its **coastal environment** is favorable to fish breeding and farming



Concepts in environmental economics

Natural resources as : Common good & Natural Asset

Scarcity implies management and proper evaluation

Externality: « the result of an activity that causes incidental benefits or damages to others with no corresponding compensation provided to or paid by those who generate the externality »

« Externalities should be quantified and valued, and included in the any project statement for economic analysis »

Opportunity cost: « the opportunity cost of a commodity is the value of the best alternative use to which those resources could have been put »

What are wetlands?

Definition of wetlands (According to RAMSAR Convention on Wetlands)

Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salty.

Types of wetlands

estuaries – deltas, mudflats, salt marshes

marine – shorelines and coral reefs

riverine – water meadows, flooded forests and plains

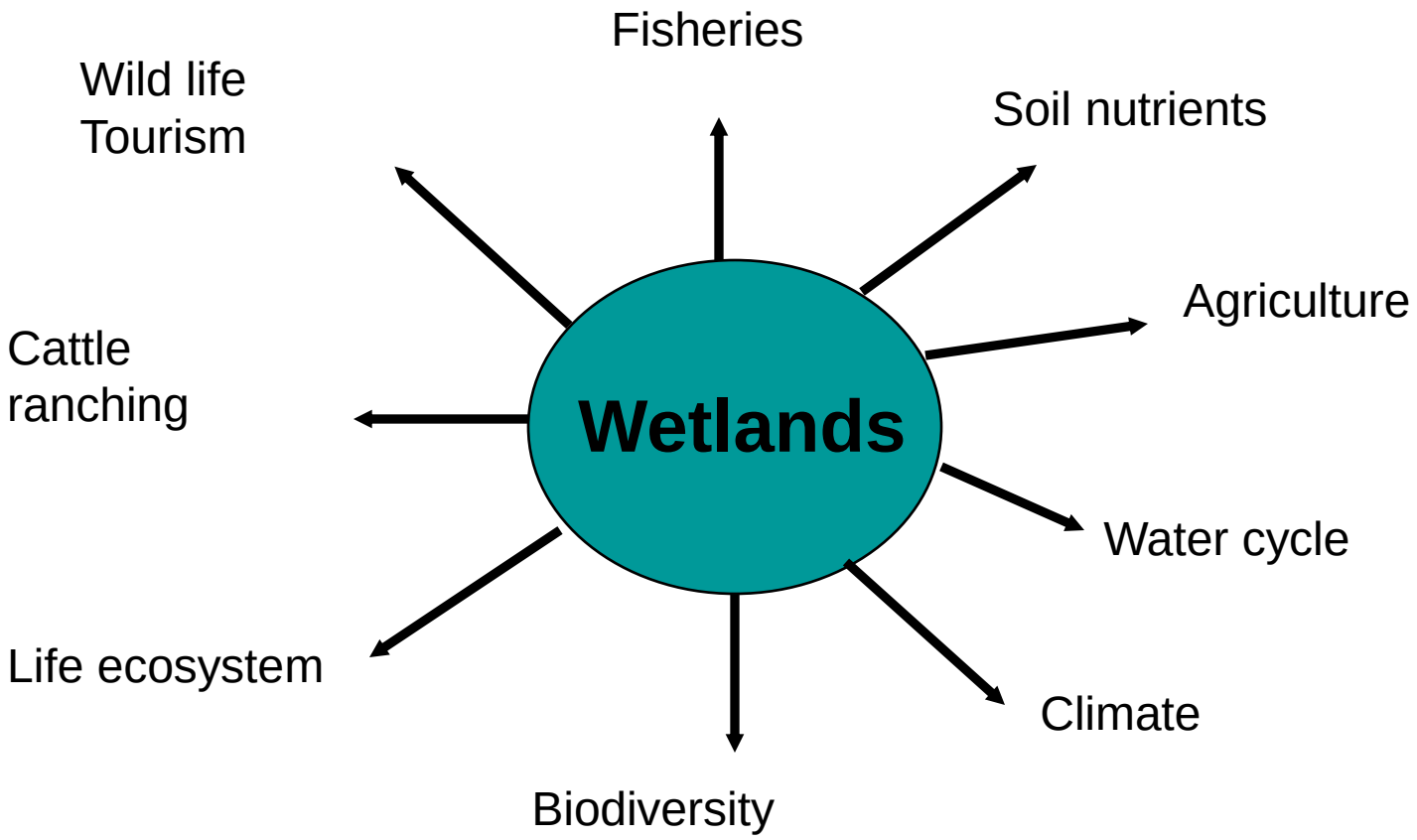
palustrine – papyrus swamp, marshes, fen

lacustrine – ponds, kettle lakes, volcanic crater lakes

Importance of wetlands

Wetlands are among the Earth's most productive ecosystems.

Typical functions of wetlands



Total economic value

Total economic value (TEV) =
Direct Use Value (DUV) + Indirect Use Value (IUV)
Option Value (OV) + Non Use Value (NUV)

- **DUV** : Production and consumption of goods
- **IUV** : Ecosystem functions and services
- **OV** : Protection value (premium) on possible future uses
- **NUV** : Instrisic significance (cultural, aesthetic, heritage…)

Existence Value : attached to the flood plain in order to maintain its sole existence

Legs value : protection value according for a leg to the next generation : biodiversity, culture heritage

(http://biodiversityeconomics.org/valuation/valuation-topics.htm)

Total economic value of wetlands

DIRECT VALUES	INDIRECT VALUES	OPTION VALUES	NON-USE VALUES
Production and consumption goods such as: Water, Fish, Firewood, Building poles, Thatch, Wild foods Medicines, Crops, Pasture, Transport, Recreation, *… etc …*	**Ecosystem functions and services such as:** Water quality and flow, Water storage and recharge; Nutrient cycling; Flood attenuation, Micro-climate, *… etc …*	**Premium placed on possible future uses or applications, such as:** Agricultural, Industrial, Leisure, Pharmaceutical, Water use, *… etc …*	**Intrinsic significance of resources and ecosystems in terms of:** Cultural value, Aesthetic value, Heritage value, Bequest value, *… etc …*

DUV : Kayaking, tourism, fisheries

- **Kayaking** is a relatively activity in the lower Nestos stream. Overall income could be topped at 1 million Euros/year at present. It is bound to develop in the future with possible conflicts dams output flow regimes.

- **Green tourism** along and around the Nestos gorges is supported by the local authorities as well by EU funded programs. Income can be evaluated at 1 million Euros/year with potential development.

- **Fisheries and mussel beds** are essentially located around Keramoti and the coastal lagoons of the delta. Overall income is estimated at 5 million Euros/year.

IUV : Biodiversity (Ecological)

- The Nestos river beds in the Delta rank among the **World's top 100 areas** for the number of migratory **bird species** as well as diversity of amphibians, reptiles and plants.

- The riparian forest of Kotza Orman support diverse populations of **mammals** (loutra) and amphibians.

Protection programs are under way either through national initiatives (RAMSAR) or EU programs (NATURA 200) or even private donors through NGOs (EPO-Living Lakes, HOS)

Overall amount of projects spending is estimated at 1 million Euros/year

EV : Existence value

- **Existence value** (EV) could in the future be substantial and **dominate** the sum of other values (DUV+IUV)

- Efforts in estimating EV are based on contingent valuation studies which estimate the « **willingness to pay for existence (WTP)** » using a sampling questionnaire approach

- A WTP of **0.5 Euro per adult per year** for the nations of the European Union could be very conservative. It would total to **80 million Euros/year**, which is **6 times** the present tourism fisheries and protection programs turn-over for the Nestos delta.

Economic valuation of wetlands: a guide for policy makers and planners (**http://www.ramsar.org/lib_val_e_2.htm**)

A compensation value for the impacts?

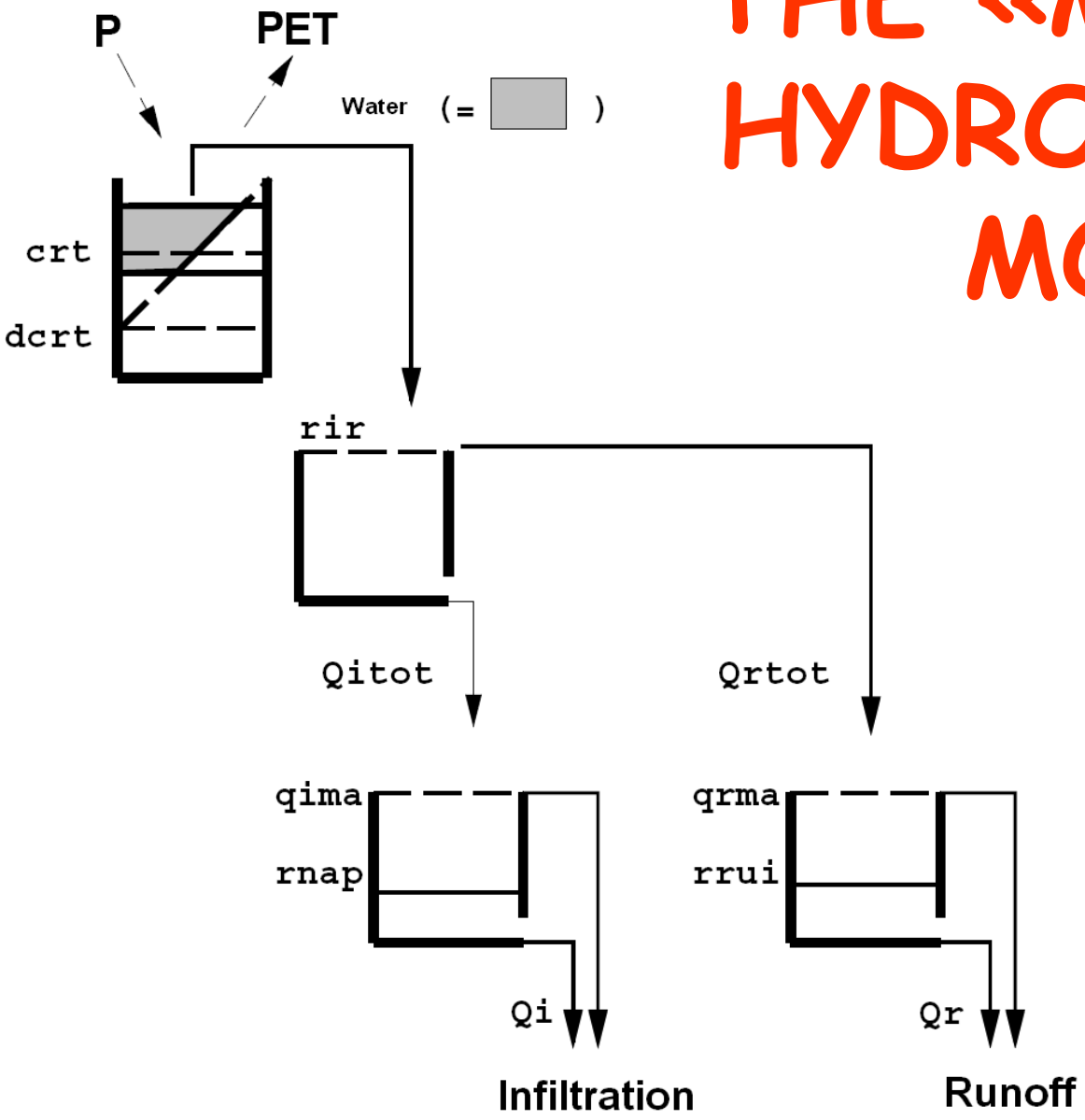
Pre dam construction impact studies have estimated that all environmental related activities in the delta could be sustained by **a minimum flow of 6 m3/sec**

What form of compensation if the requirements are not met ?

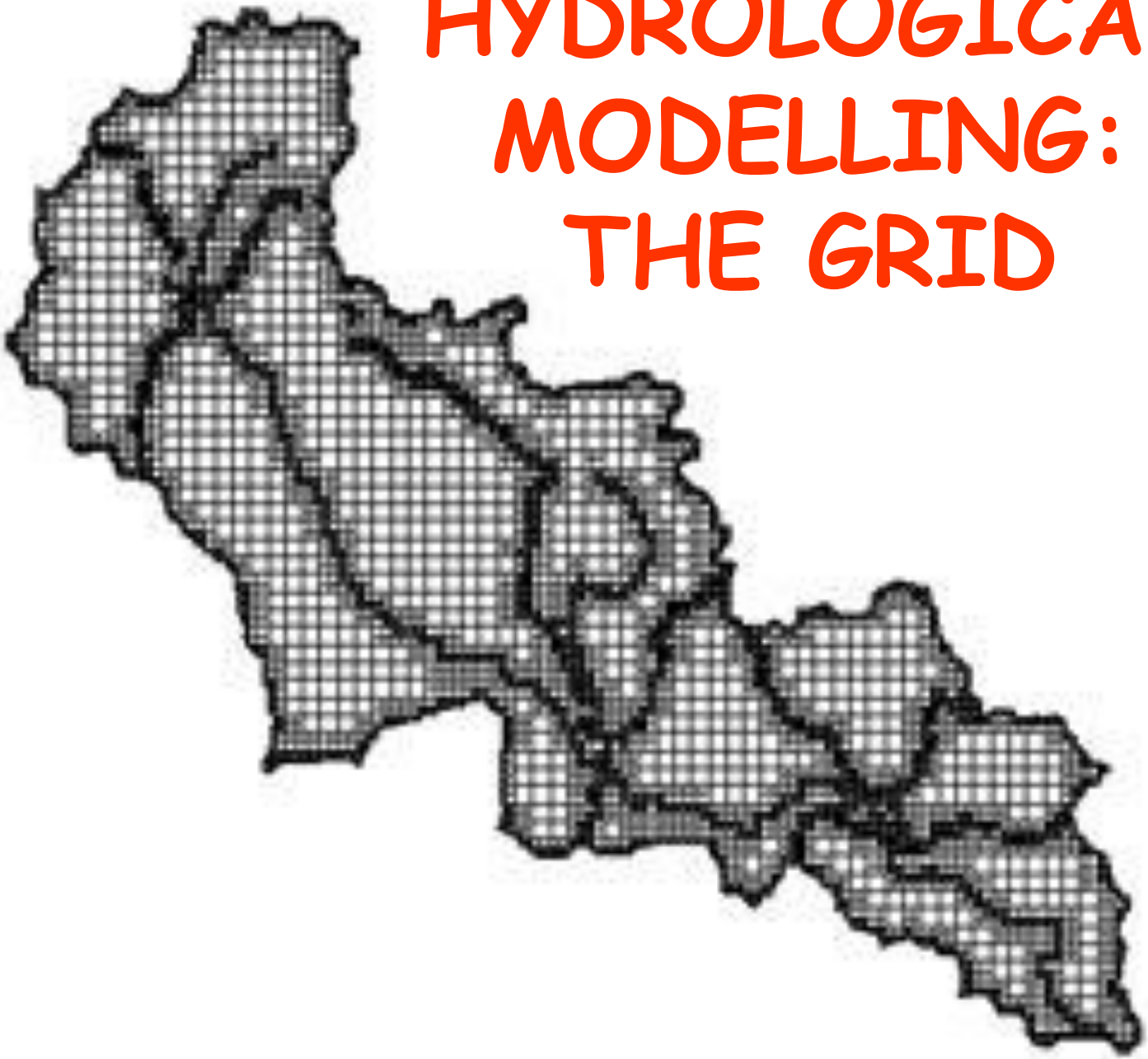
One needs to evaluate the consequences of low flow :

- **Intense erosion of Keramoti beaches**
- **Displacement of sediments to the Keramoti harbour and fish farms**
- **Loss of birding grounds**
- **Salinization of delta mouth : groundwater + vegetation (Kotza Orman)**

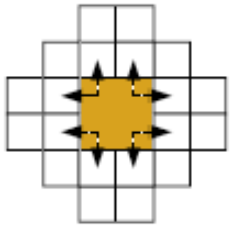
THE «MODCOU» HYDROLOGICAL MODEL

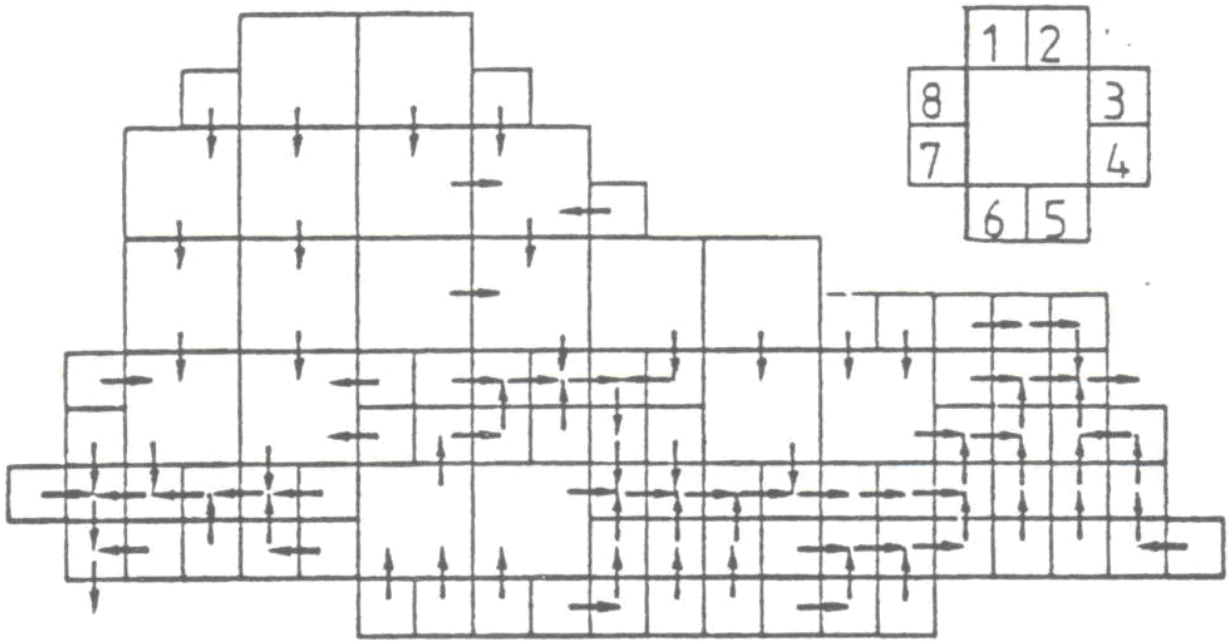


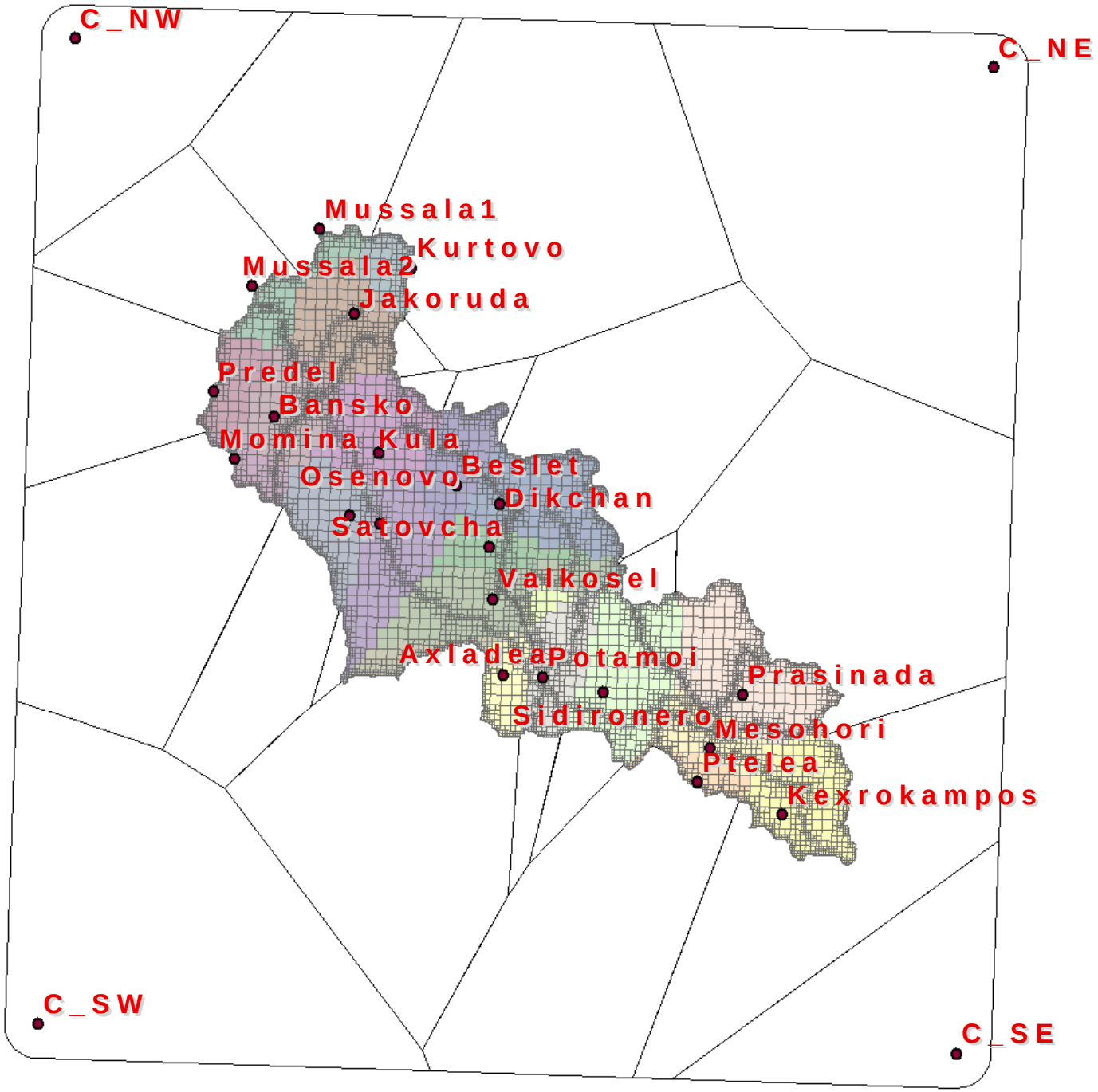
HYDROLOGICAL MODELLING: THE GRID



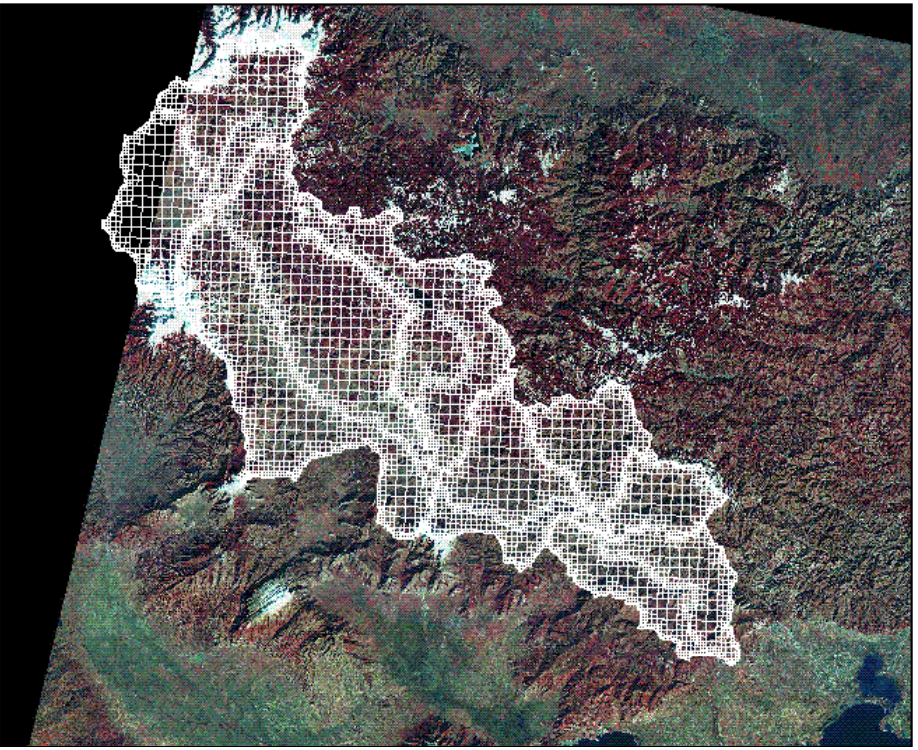
THE «MODCOU» GRID

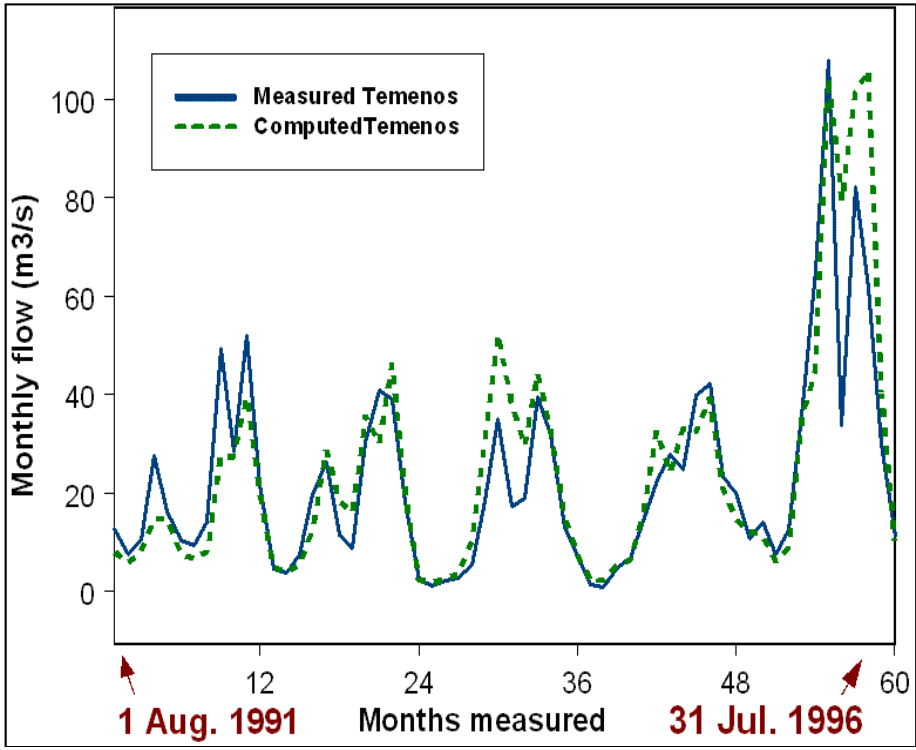


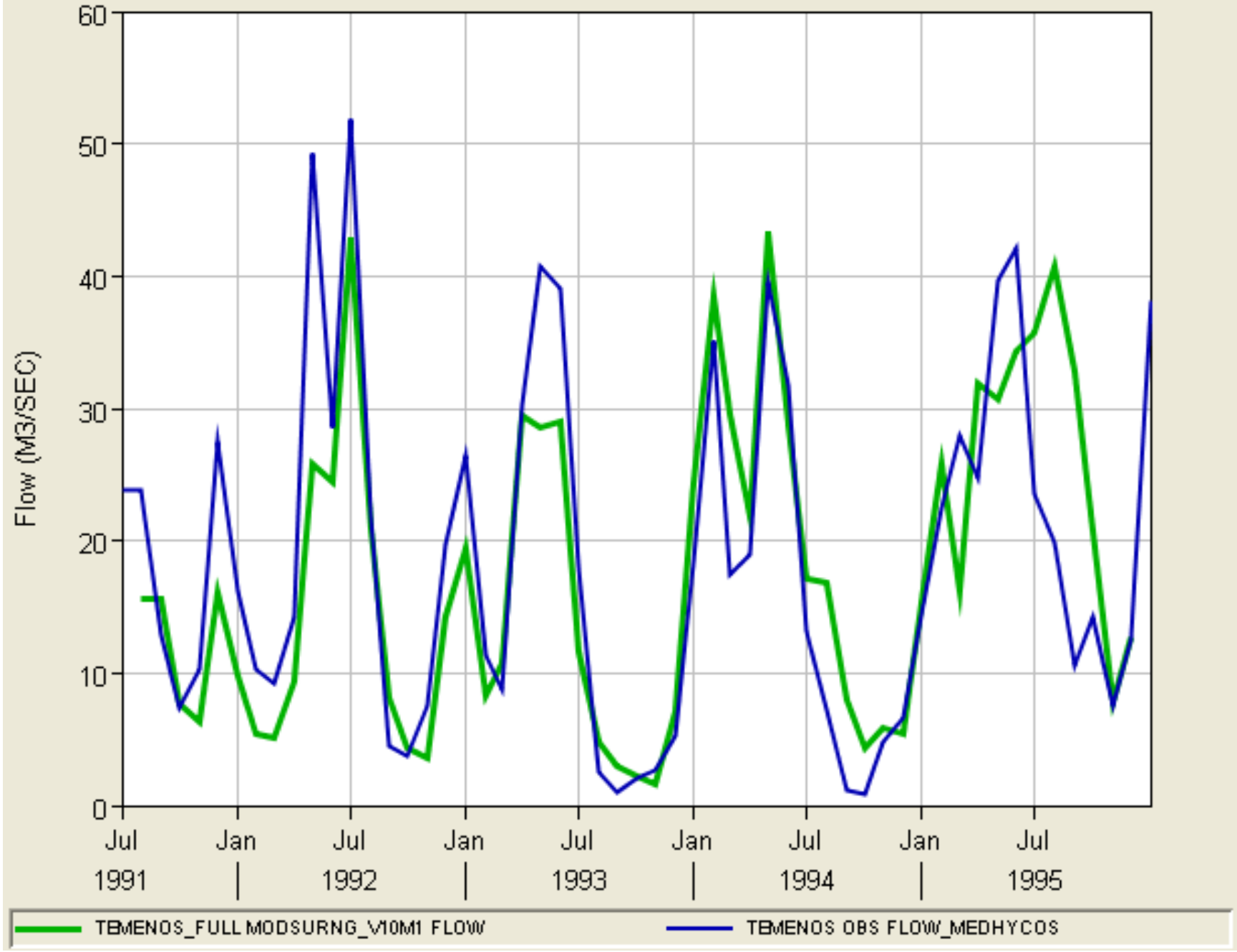


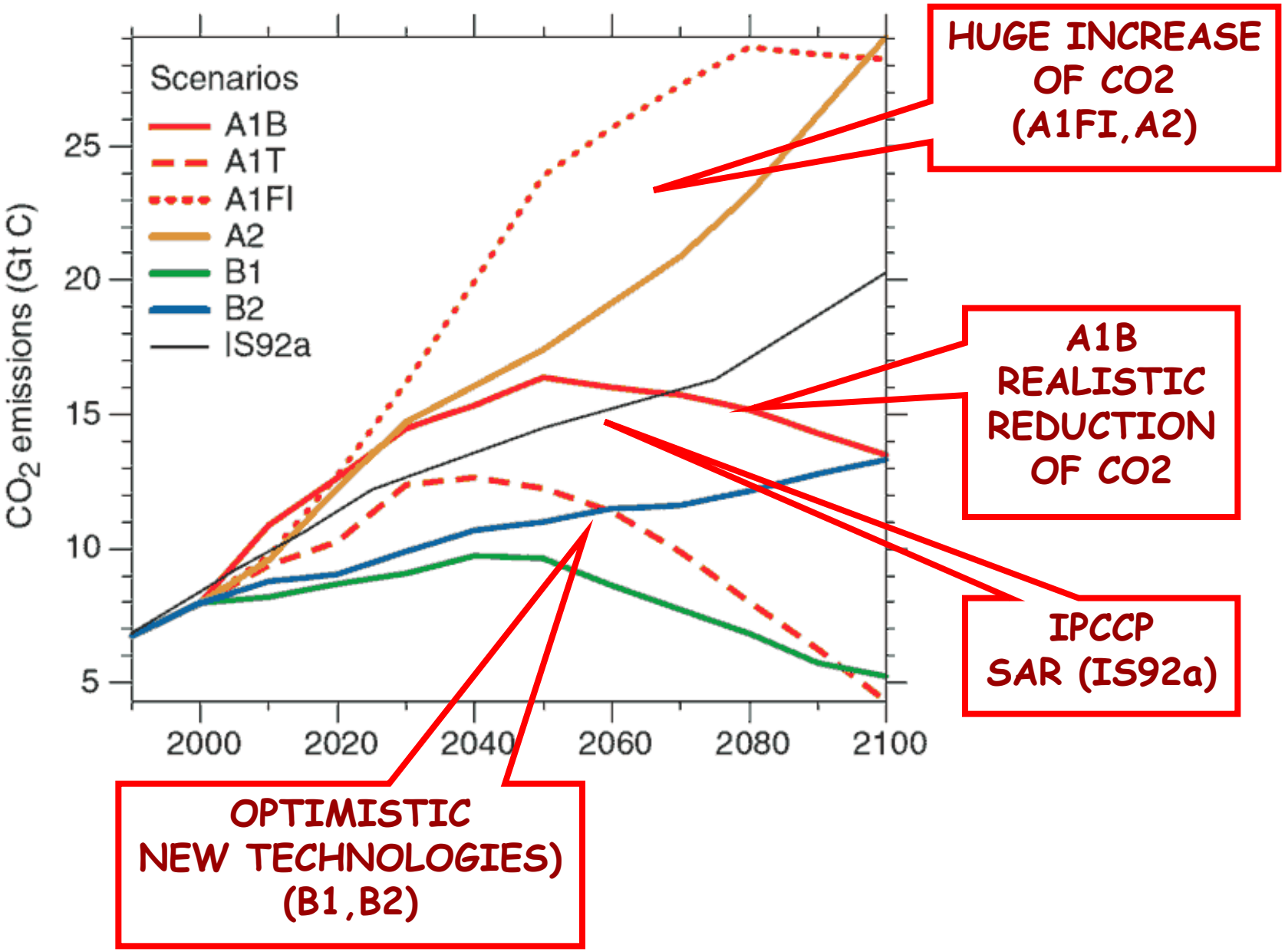

C_NW
C_NE
Mussala1
Kurtovo
Mussala2
Jakoruda
Predel
Bansko
Momina Kula
Beslet
Osenovo
Dikchan
Satovcha
Valkosel
Axladea
Potamoi
Prasinada
Sidironero
Mesohori
Ptelea
Kexrokampos
C_SW
C_SE

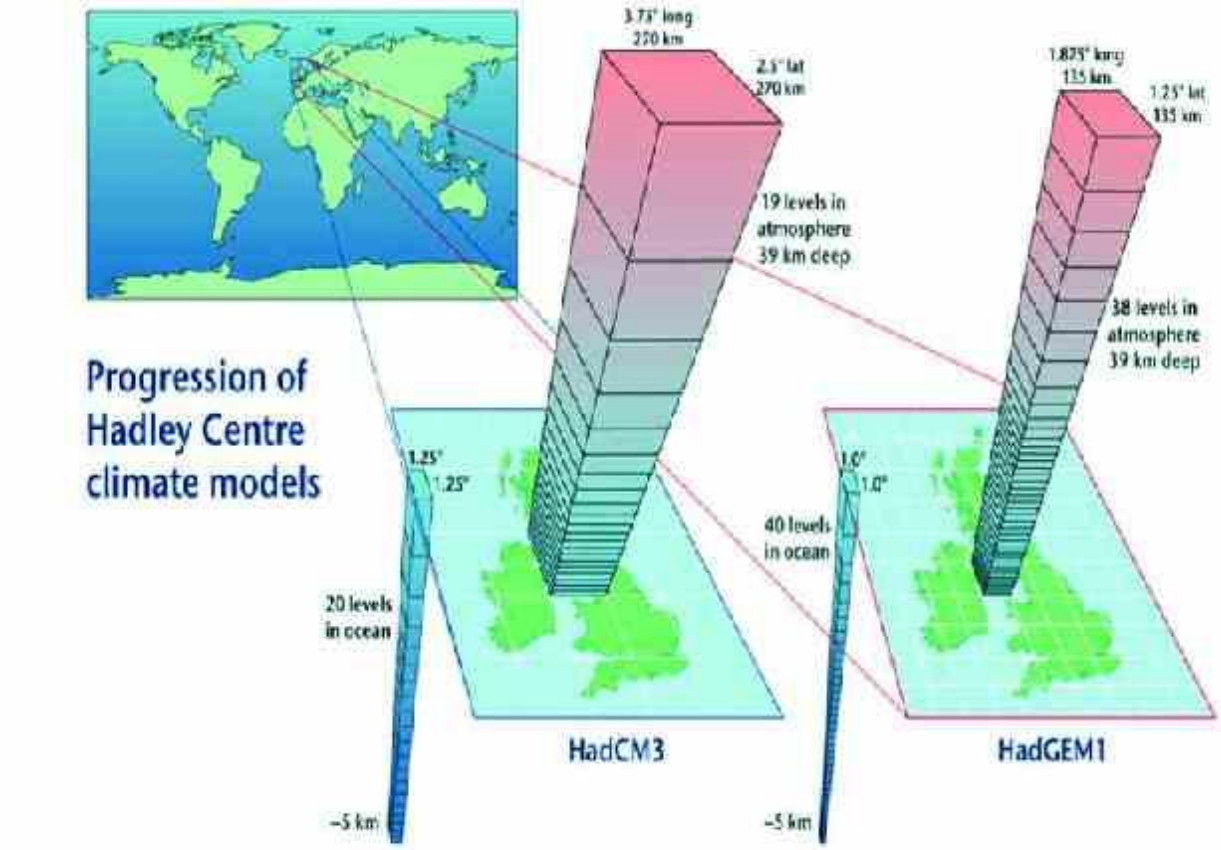
HYDROLOGICAL MODEL CALIBRATION

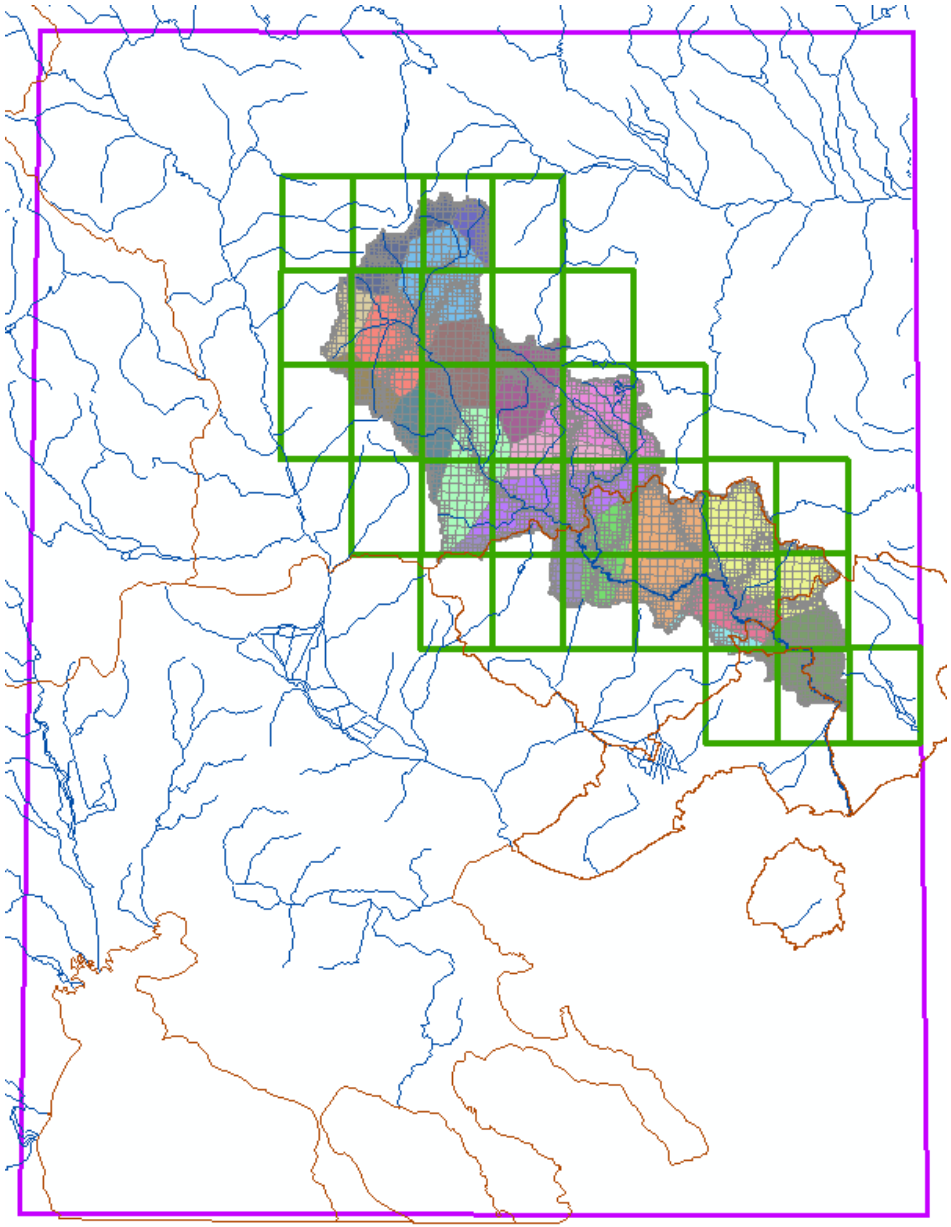


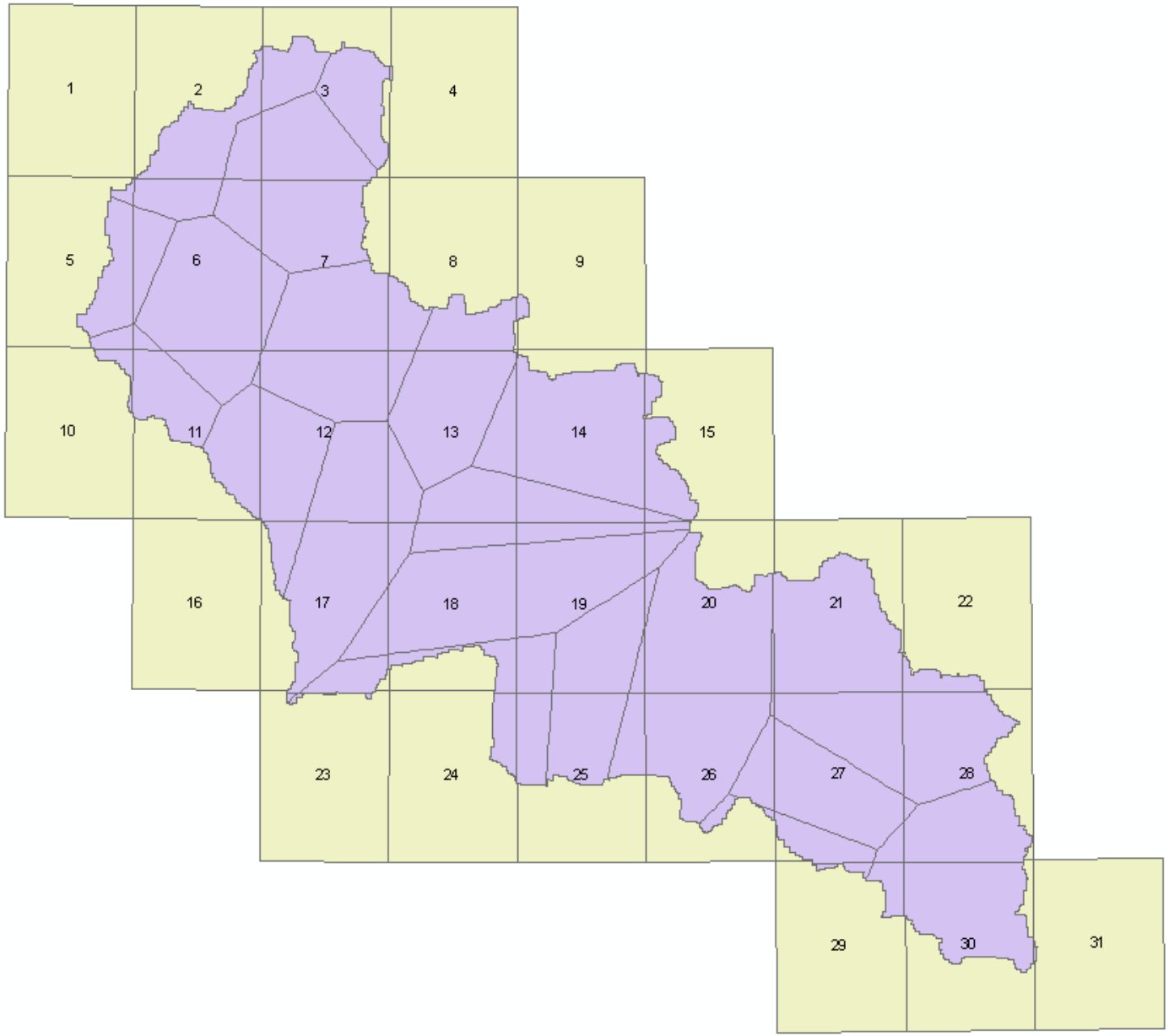


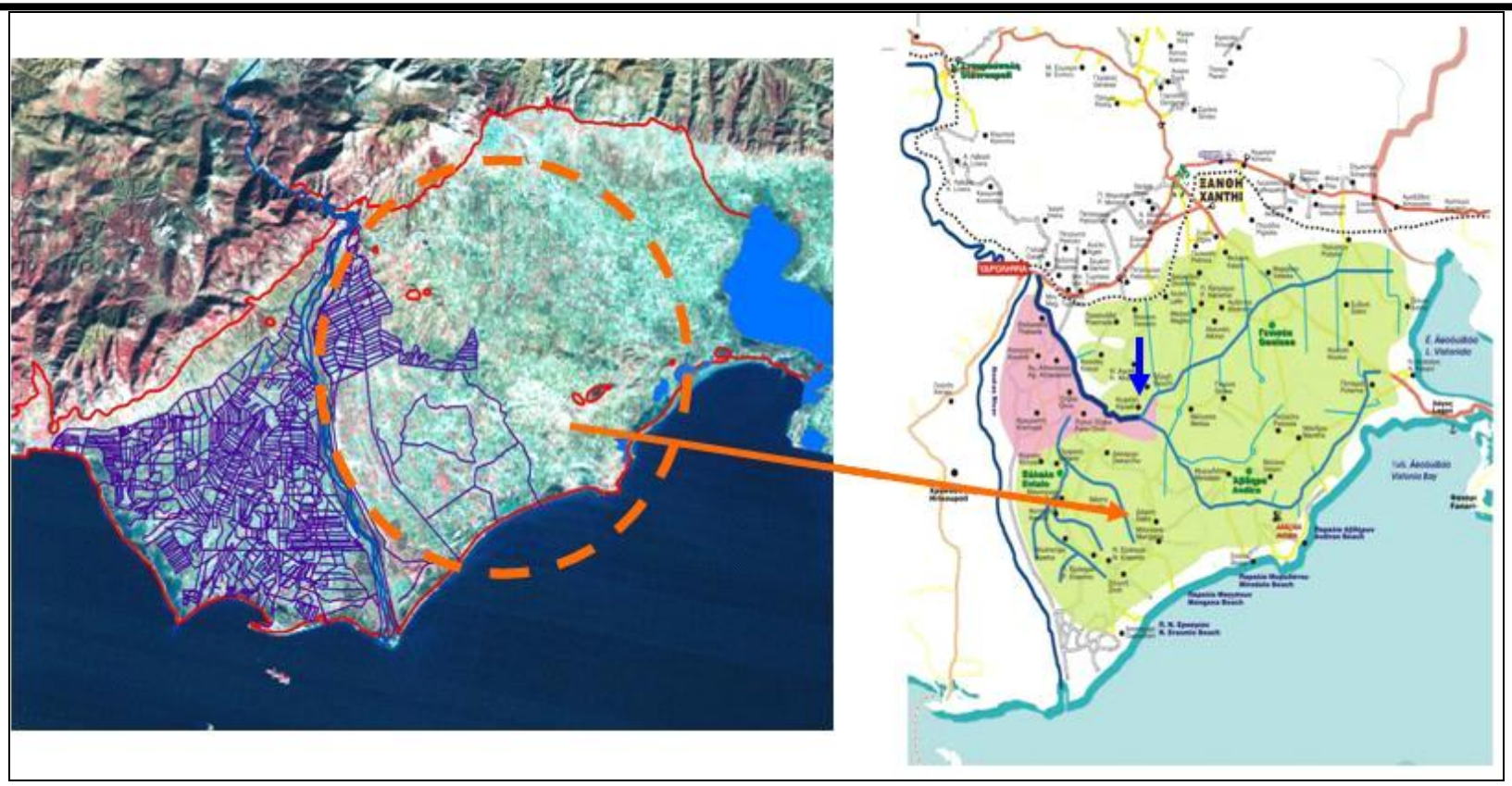

60
50
40
30
20
10
0
Flow (M3/SEC)
Jul
Jan
Jul
Jan
Jul
Jan
Jul
Jan
Jul
1991
1992
1993
1994
1995
TEMENOS_FULL MODSURNG_V10M1 FLOW
TEMENOS OBS FLOW_MEDHYCOS


Scenarios
A1B
A1T
A1FI
A2
B1
B2
IS92a
CO_2 emissions (Gt C)
25
20
15
10
5
2000
2020
2040
2060
2080
2100
HUGE INCREASE OF CO2 (A1FI,A2)
A1B REALISTIC REDUCTION OF CO2
IPCCP SAR (IS92a)
OPTIMISTIC NEW TECHNOLOGIES) (B1,B2)


Progression of Hadley Centre climate models
3.75° long 270 km
2.5° lat 270 km
19 levels in atmosphere 39 km deep
1.25°
1.25°
20 levels in ocean
~5 km
HadCM3
1.875° long 135 km
1.25° lat 135 km
38 levels in atmosphere 39 km deep
1.0°
1.0°
40 levels in ocean
~5 km
HadGEM1



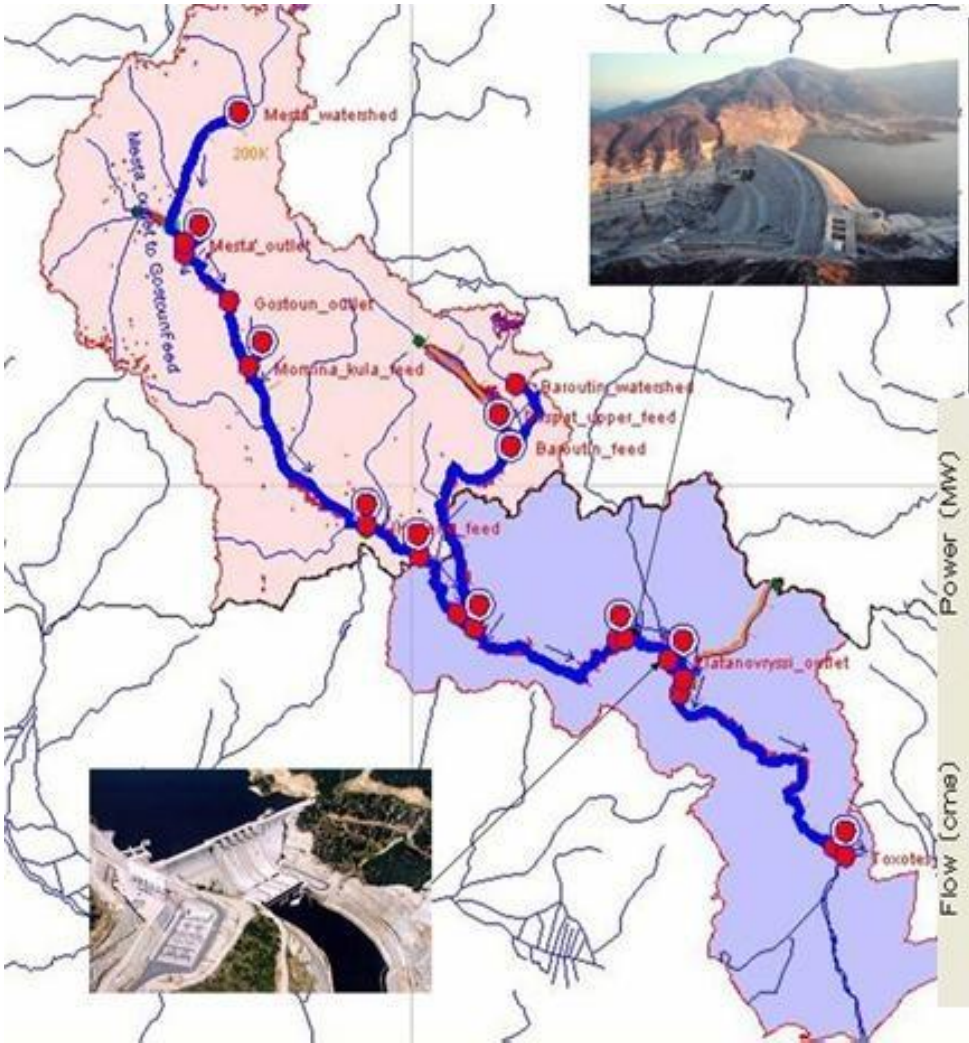

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31



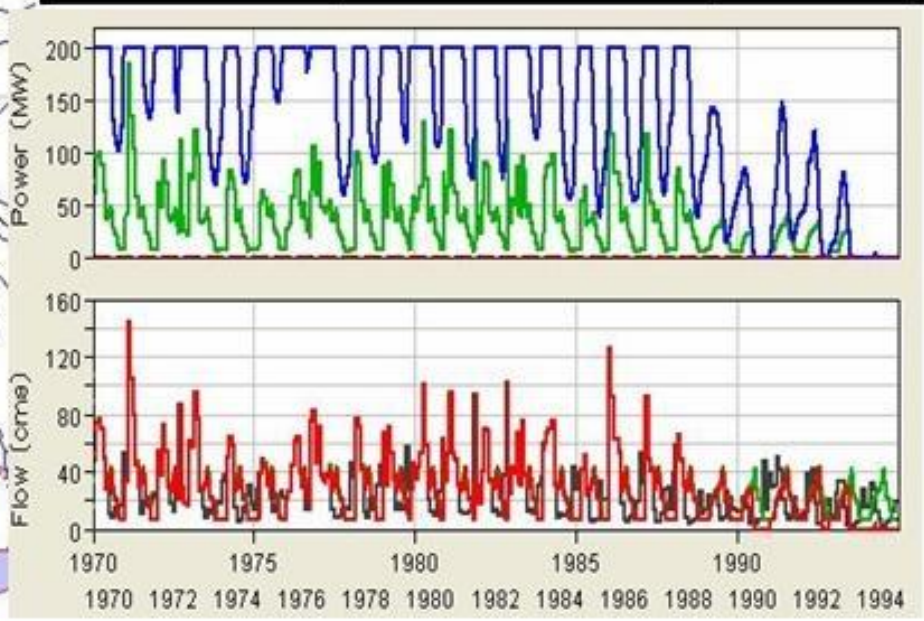
a) Current irrigation network in the Nestos delta

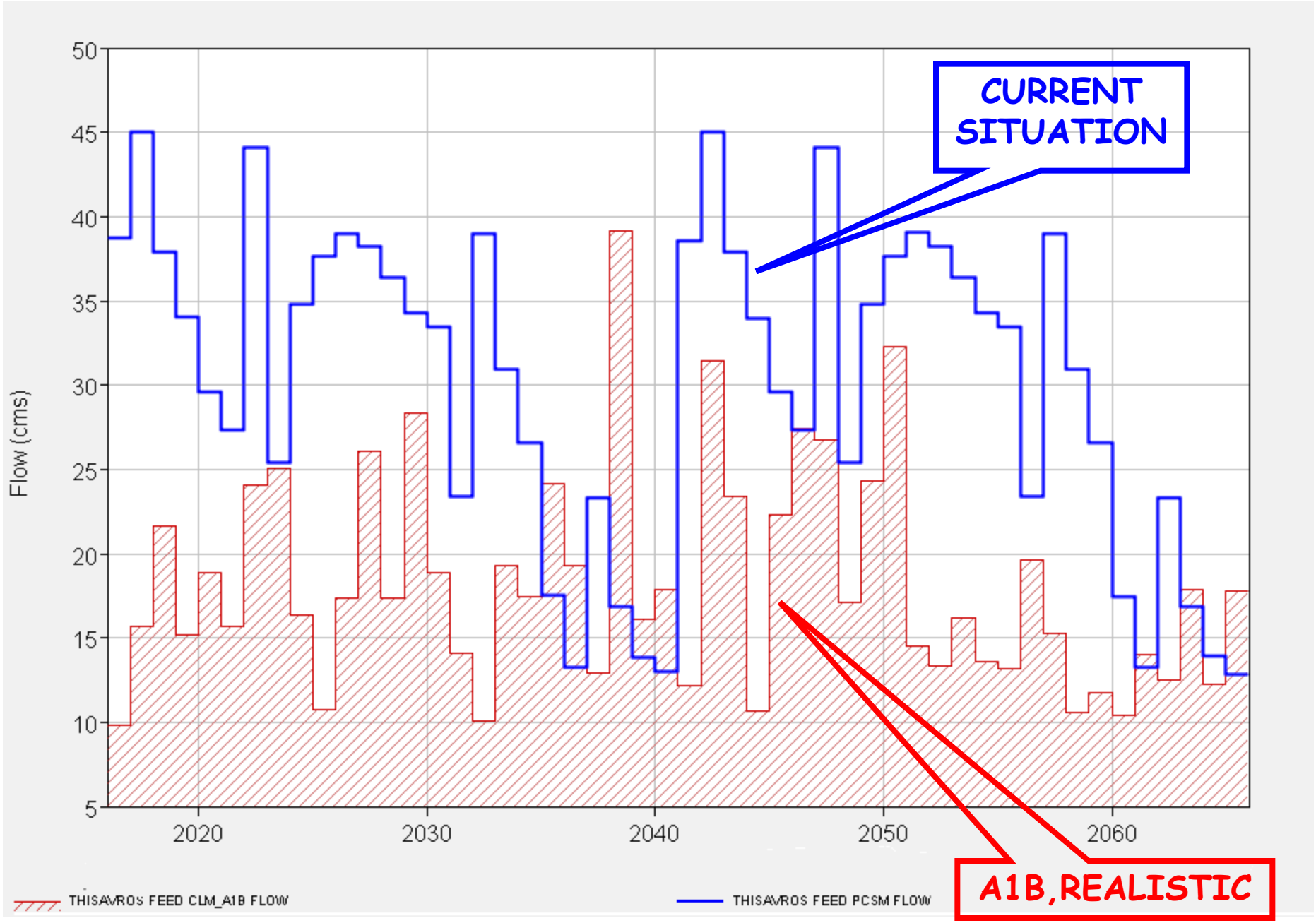
b) Future water diversion for irrigating the plain of Xanthi

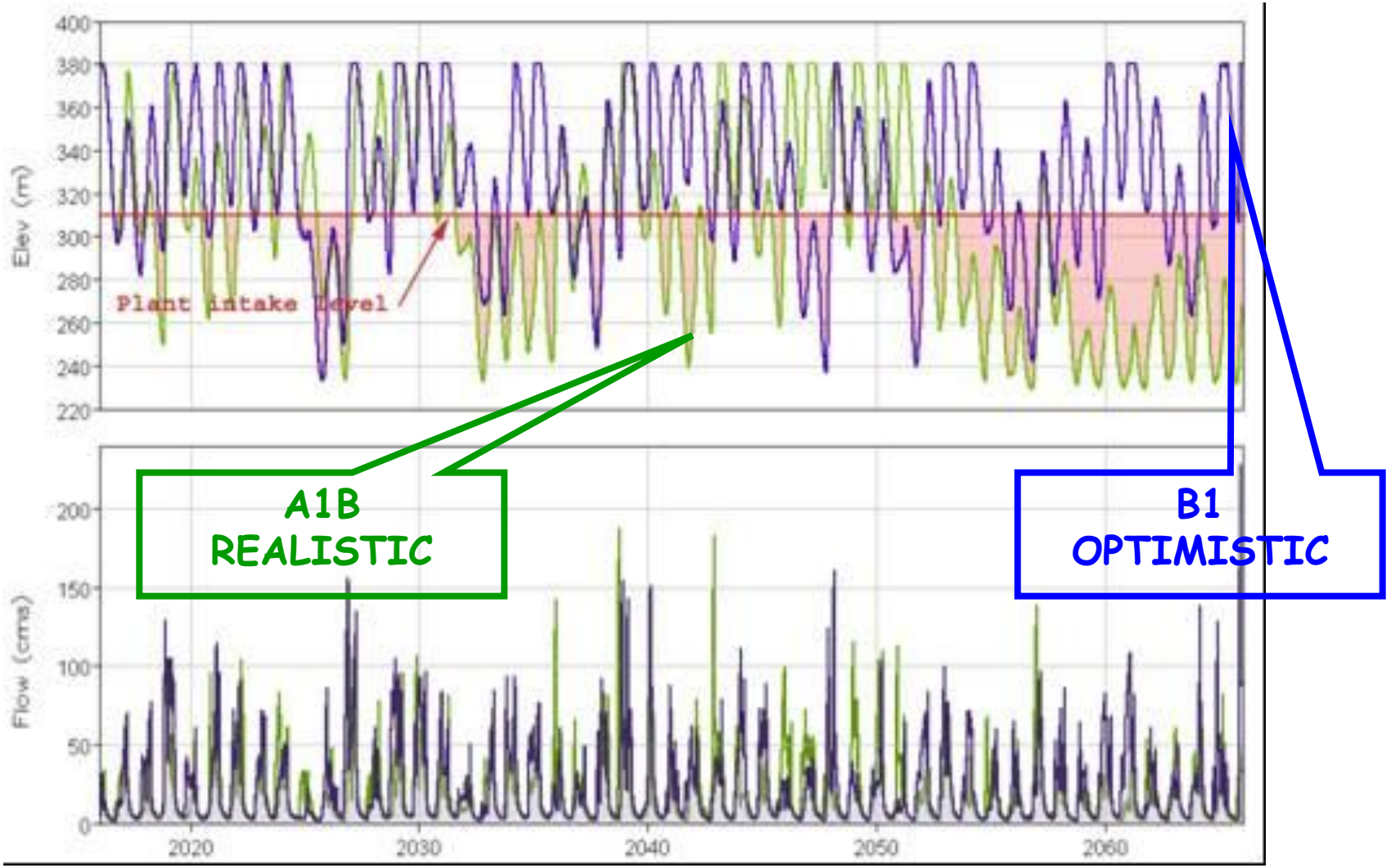
HYDRAULIC MODELLING: THE HEC-ResSim MODEL



Dams of Nestos	Level of tailrace tunnel (m)	Power (MW)
Thissavros	226	300
Platanovryssi	151	100
Temenos	126	20

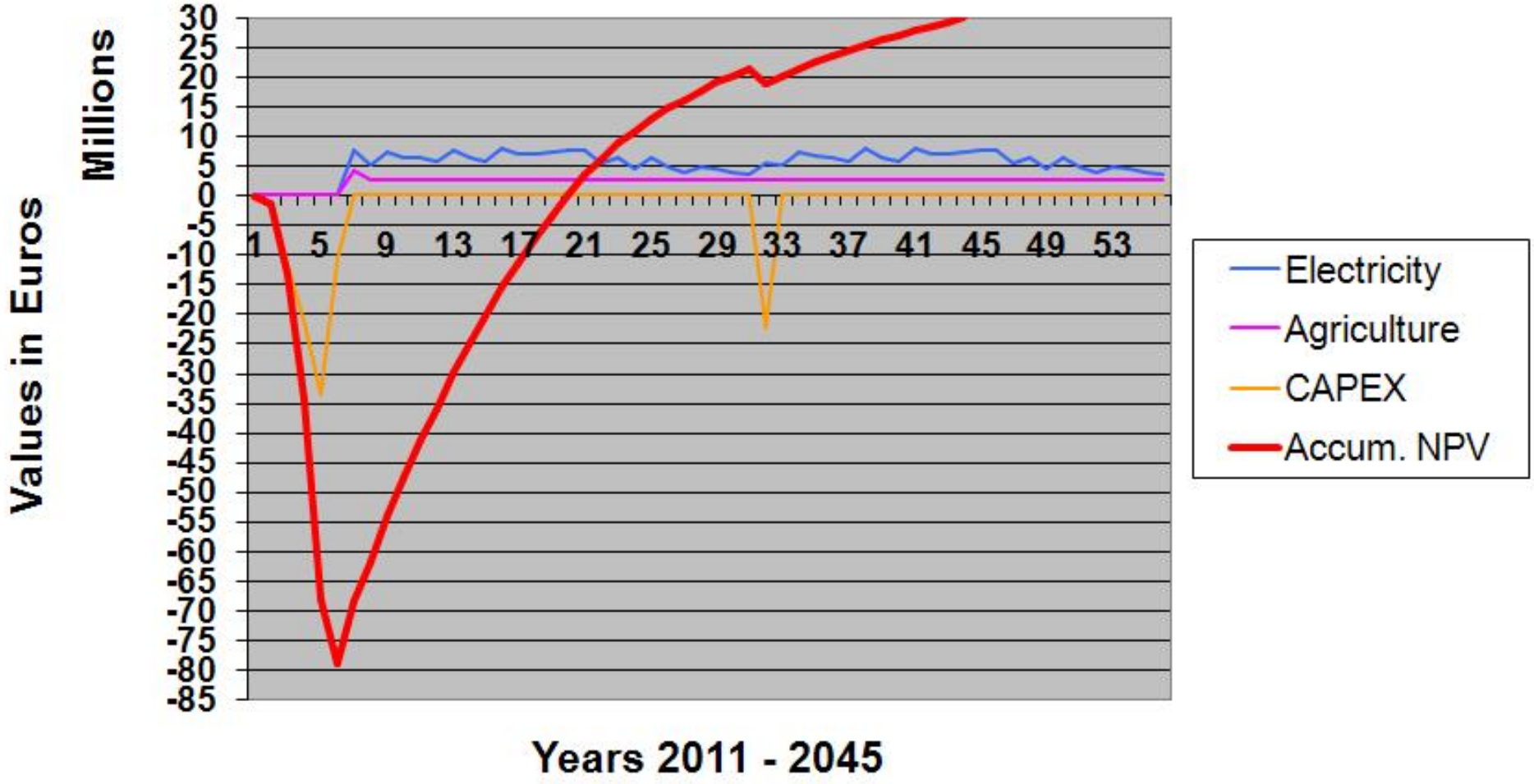



CURRENT SITUATION
A1B,REALISTIC
Flow (cms)
50
45
40
35
30
25
20
15
10
5
2020
2030
2040
2050
2060
THISAVROS FEED CLM_A1B FLOW
THISAVROS FEED PCSM FLOW

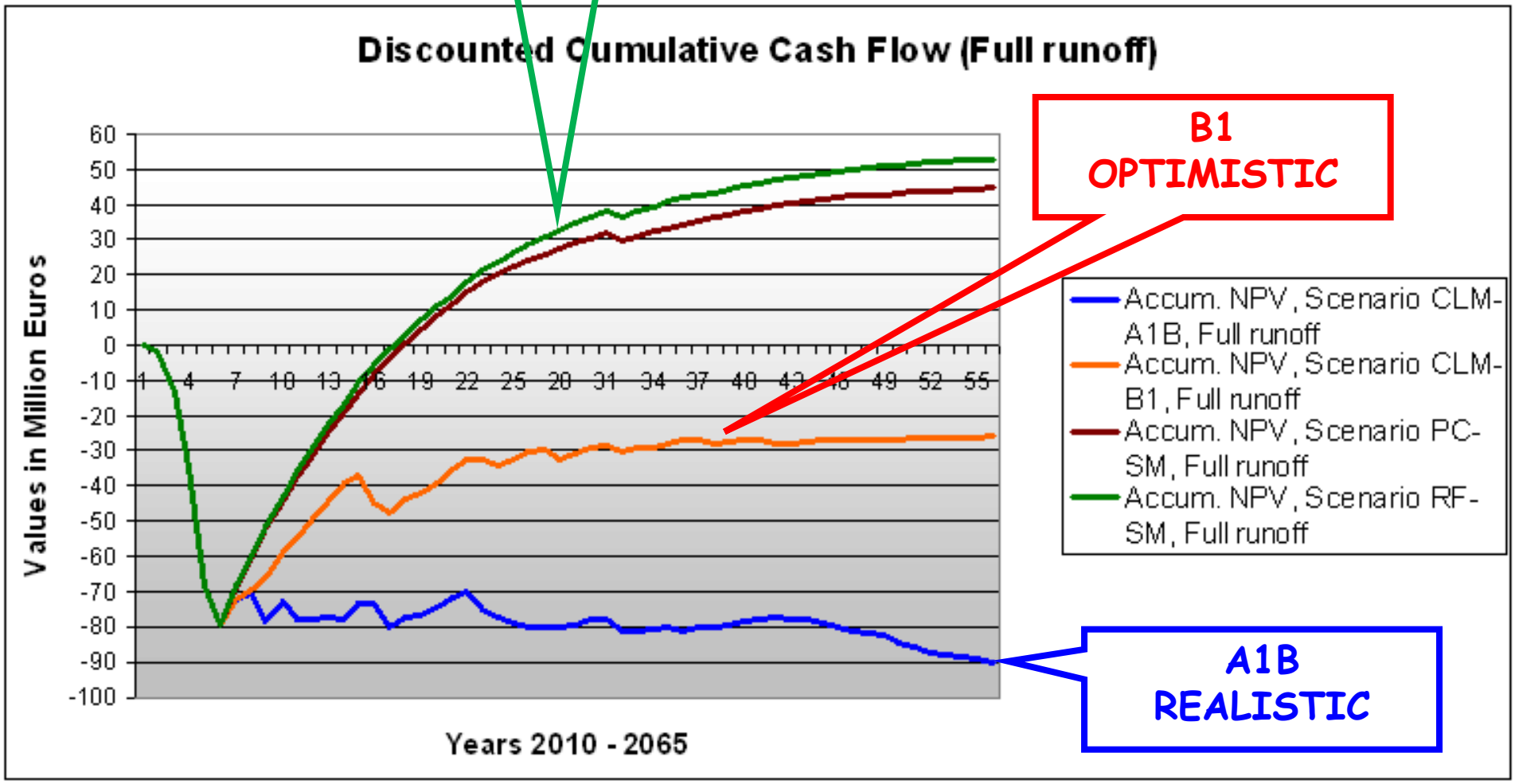


Comparison between CLM-B1 (blue) and CLM-A1B (green) 50 years HEC-ResSim results for the pool level (m) and inflow (cms) entering the Thissavros lake

Discounted Cumulative Cash Flow



PRESENT CLIMATE



B1
OPTIMISTIC

A1B
REALISTIC

CONCLUSIONS

- CLIMATE CHANGE AND ENERGY PRODUCTION IN TRANSBOUNDARY RIVERS:

  A VERY CHALLENGING ISSUE

- IMPORTANCE OF SOCIO-ECONOMICS AND HYDRO-POLITICS (example: the "HELP" Mesta/Nestos Case)


Thank you!
Ευχαριστώ !