

DEPARTMENT OF GEOSCIENCES  
OREGON STATE UNIVERSITY

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SEMINAR  
RE-THINKING WATER AND FOOD SCARCITY: CAN  
SCIENCE AND TECHNOLOGY SOLVE THE GLOBAL  
CRISIS?

by

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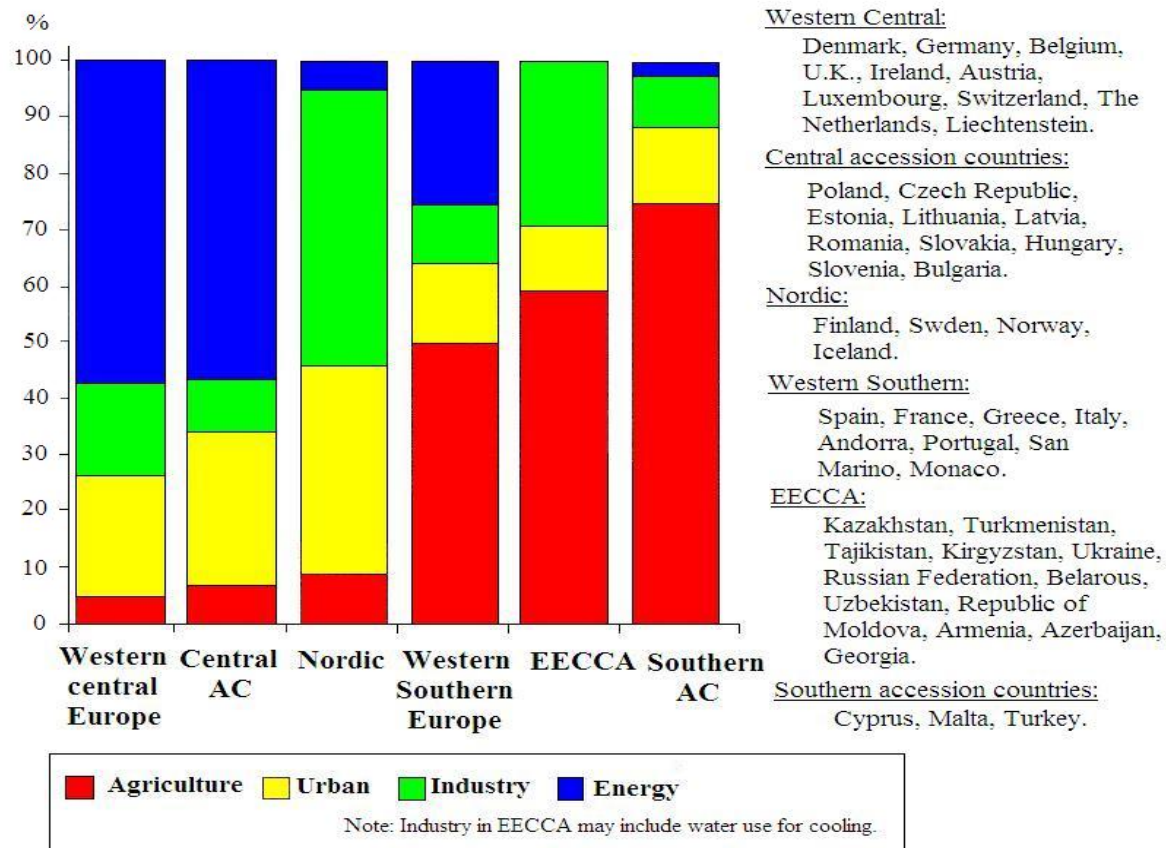
# TABLE OF CONTENTS

1. Introduction.
2. Virtual Water, Hydrological footprint and Food security..
3. Desalinization.
4. The “Silent Revolution” and its causes.
5. Benefits and costs of the Silent Revolution.
6. Pervasive hydromyths on groundwater.
7. Silent Revolution impact on water policy.
8. Relevance of remote Sensing and GIS on water policy.
9. Ethical issues.
10. Conclusions.

# 1. INTRODUCTION (I)

- Cheap transport, Membrane Technology and Intensive groundwater use are a relatively new phenomena.
- Should a water crisis occur, it will be felt mostly in irrigation in arid and semi-arid regions.
- Though important, urban water supply only amounts to 10% of worldwide consumptive use.

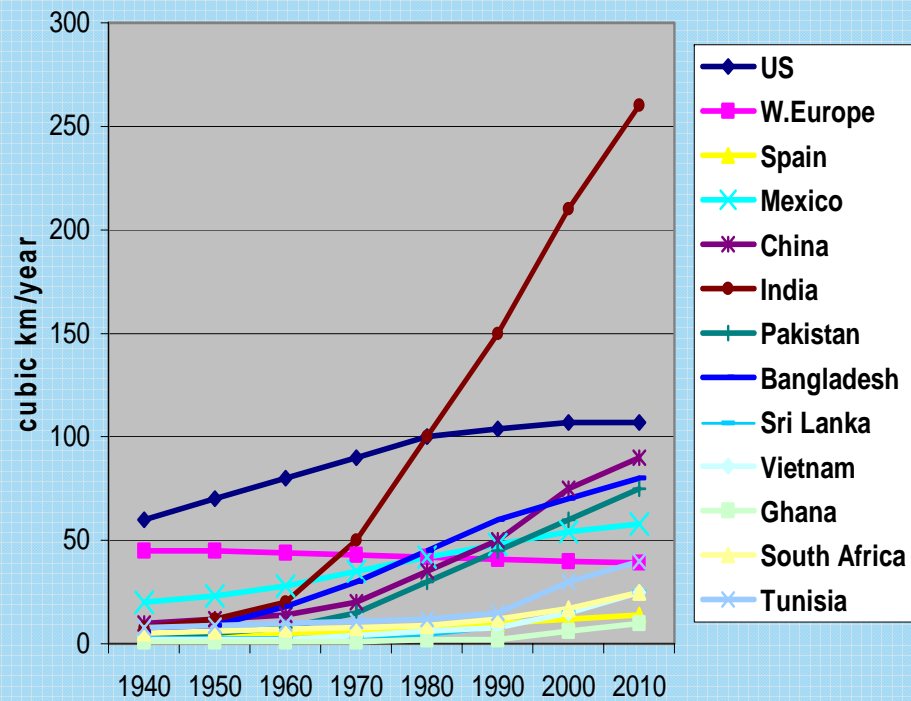
# 1. INTRODUCTION (II)



Sources: Eurostat new Cronos, EEA questionnaire (2002); Aquastat (FAO), 2002 for EECCA countries.

# 1. INTRODUCTION (III)

Figure 1 Growth in groundwater use in selected countries  
(author's estimates)



Source: Shah (2004)

## 2. VIRTUAL WATER, HYDROLOGICAL FOOTPRINT AND FOOD SECURITY (I)

Virtual water is the amount of water necessary to produce a good o services.

1 kg wheat .....	1.000	kg water
1 kg beef .....	20.000	kg water

## 2. VIRTUAL WATER, HYDROLOGICAL FOOTPRINT AND FOOD SECURITY (II)

Hydrological footprint means the amount of water (blue and green) that a human being requires for all her/his needs (about 90% for food).

vegetarian diet

~800 m<sup>3</sup>/year

red meat diet

~ 1.500 m<sup>3</sup>/year

## 2. VIRTUAL WATER, HYDROLOGICAL FOOTPRINT AND FOOD SECURITY (III)

Total Water resources	110.000 km <sup>3</sup> /year
Green Water	70.000 km <sup>3</sup> /year
Blue Water	40.000 km <sup>3</sup> /year

### Human needs

<u>diet</u>	<u>population</u>	<u>km<sup>3</sup>/year (blue + green)</u>
Vegetarian	7.000.10 <sup>6</sup>	~6.000
Redmeat	7.000.10 <sup>6</sup>	~12.000
Vegetarian	10.000.10 <sup>6</sup>	~8.000
Redmeat	10.000.10 <sup>6</sup>	~15.000

between 5-13% of Total Water Resources



## 2. VIRTUAL WATER, HYDROLOGICAL FOOTPRINT AND FOOD SECURITY (IV)

Food security is today more related to economic capacity than to water scarcity.

There exist some problems:

- a) WTO – hidden monopolies
- b) Threat of political embargo
- c) Domestic social changes required

### 3. DESALINIZATION. MEMBRANE TECHNOLOGY (I)

The energy cost to desalinate one cubic meter of sea water has decrease from almost 20 kwh/m<sup>3</sup> to less than 4 kwh/m<sup>3</sup>.

The most common technology today is **REVERSE OSMOSIS (RO)** (Membrane technology).

### 3. MEMBRANE TECHNOLOGY (II)

The current total cost for RO is between US \$ /0.5-0.6/m<sup>3</sup>, with full time operation and large plants.

Smaller cost for (subterranean) brackish water (US \$ 0.10 – 0.20).

### 3. MEMBRANE TECHNOLOGY (III)

Currently in Spain about 7% of the population drinks (desalinated) sea water.

The cost of desalination is affordable in most cases for urban water supply in cities near the coast.

### 3. MEMBRANE TECHNOLOGY (IV)

Theoretically it can be used for irrigation of high value crops (greenhouse).

Value of crop	60.000 €/ha/yr
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Cost of Water (5.000 m <sup>3</sup> x US \$0.6/m <sup>3</sup> )	3.000 €
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Cost of water < 5% of crop value

However, as long as groundwater is cheaper its use in agriculture is minimum. This is the Spanish current debate.

## 4. THE “SILENT REVOLUTION” AND ITS CAUSES (I)

- It has been carried out by million of modest individual farmers.
- Water decision makers have seldom paid attention to this phenomenon.
- It has produced great socio-economic benefits, as well as some problems (mainly environmental).
- Documented problems to date are practically missing due to the enormous groundwater storage capacity of most aquifers and to the social changes.

## 4. THE “SILENT REVOLUTION” AND ITS CAUSES (II)

- Wide availability of cheap well drilling technologies.
- Invention and commercialization of the submersible pump.
- Hydrogeology has become a solid body of science.

**HOWEVER, THE SILENT REVOLUTION IS MAINLY  
MARKET DRIVEN, EXCEPT IN VERY POOR  
COUNTRIES**

# 4. THE “SILENT REVOLUTION” AND ITS CAUSES (III).



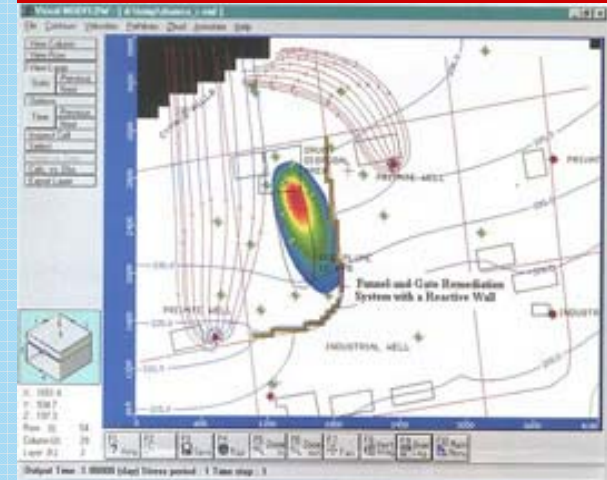
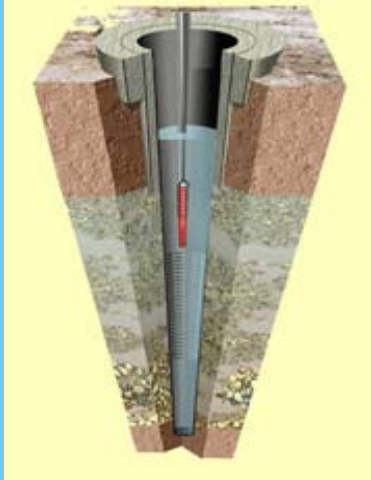
From the dug-well to the deep borehole.



From the water wheel to the pump.



From the water-witches to Hydrogeology.





## 5. BENEFITS AND COSTS OF THE SILENT REVOLUTION (I)

- Cheap, quick and secure source of drinking water for people (poor and not-so-poor).
- Allows for “small” irrigation (e.g. India).

## 5. BENEFITS AND COSTS OF THE SILENT REVOLUTION (II)

- Low abstraction cost (even without “perverse” energy subsidies).

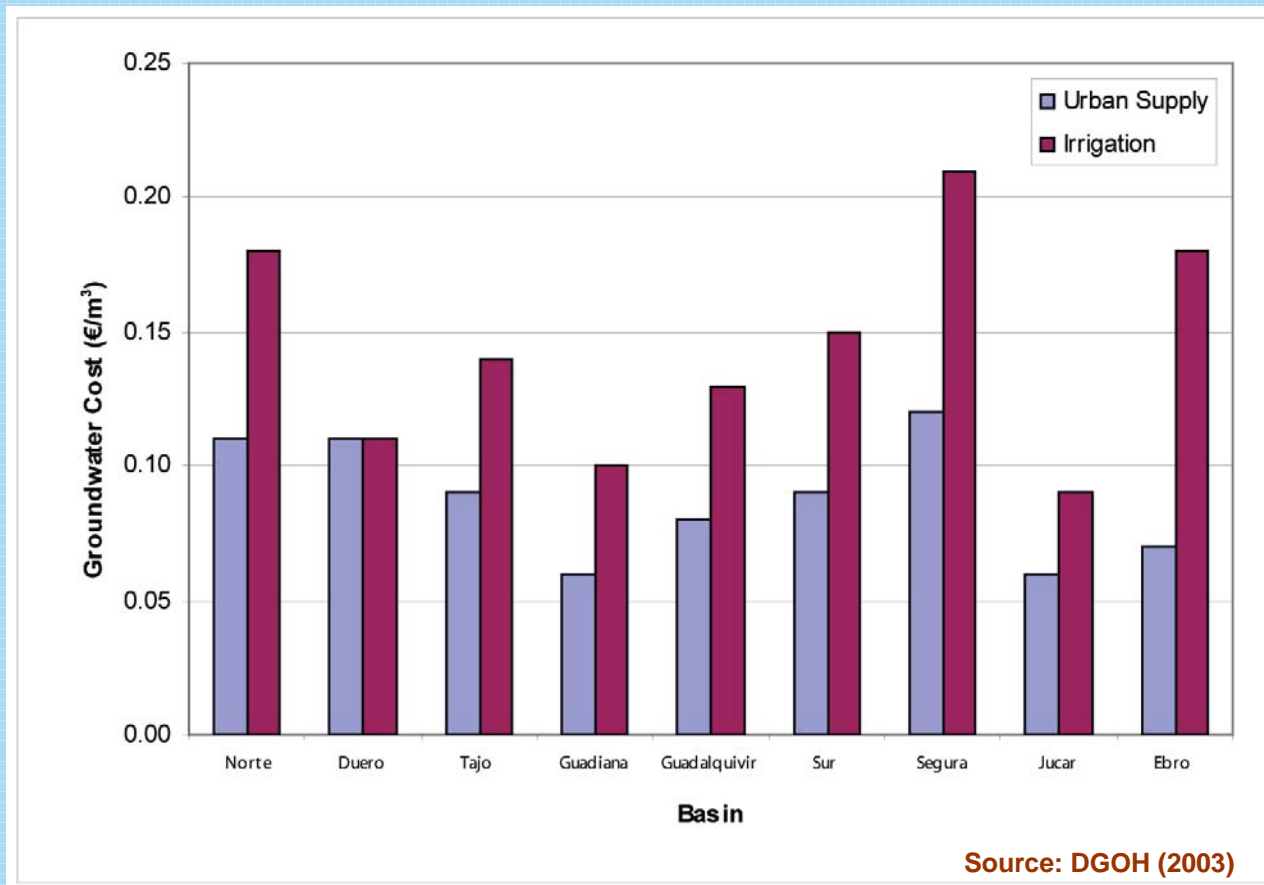
Abstraction cost usually between 0.02 – 0.20 US\$/m<sup>3</sup>

Irrigation cost dependent on crop type: 50 – 1000 US\$/ha

- Significantly **“more crops and jobs per drop”** than in surface water irrigation systems.
- In Industrial countries this motto is changing **“more cash and nature per drop”**

# 5. BENEFITS AND COSTS OF THE SILENT REVOLUTION (III)

Groundwater unit volume cost in Spain



## 5. BENEFITS AND COSTS OF THE SILENT REVOLUTION (IV).

- Negative effects may appear:
  - Groundwater level depletion (often irrelevant, although the most frequently referred to).
  - Groundwater quality degradation is usually the most important. It also may be due to poor land-use planning (e.g. Netherlands; Murray-Darling Basin, Australia).
  - Land subsidence (Mexico, Osaka, Bangkok...)
  - Ecological impacts on surface water courses and wetlands (irrelevant wherever poverty is the main ecological problem).

## 6. MOST PERVASIVE HYDROMYTHS ON GROUNDWATER

- Paraphrasing Hamlet:  
“FRAILTY, FRAILTY, THY NAME IS GROUNDWATER”
- “EVERY WATER WELL BECOMES DRY OR BRACKISH”
- Groundwater development is a “PILLAR OF SAND”, prone to collapse:

**DOCUMENTED CASES OF SOCIO-ECONOMIC HAVOC CAUSED BY INTENSIVE GROUNDWATER USE ARE STILL PRACTICALLY UNKNOWN**

# 7. SILENT REVOLUTION IMPACT ON WATER RESOURCES POLICY (I)



**SARAGOSSA, Oct 2002**



**BRUSSELS, Sep 2001**

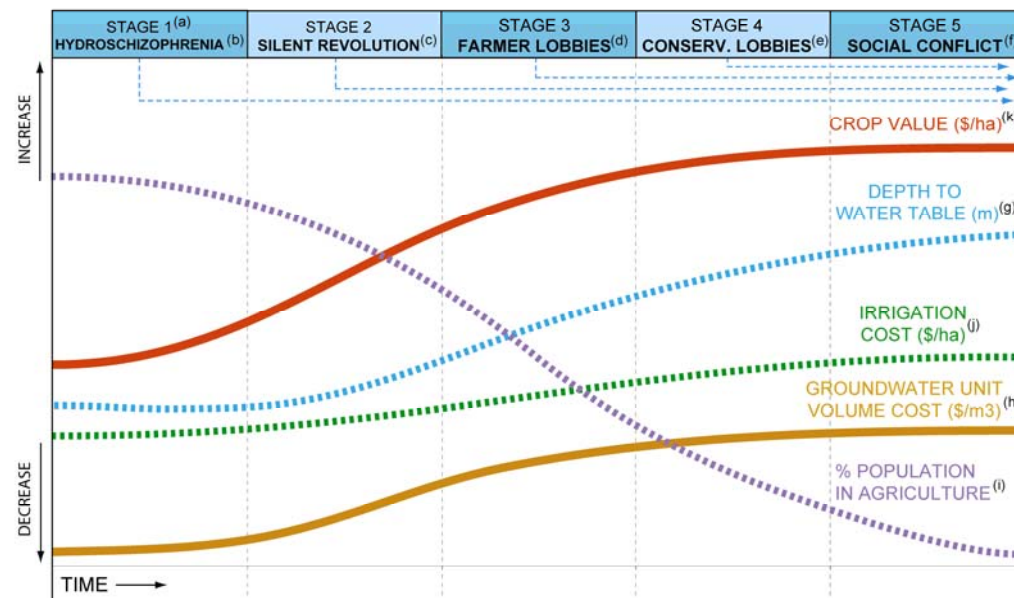


**VALENCIA, May 2003**

**CLAMOROUS SOCIAL  
CONFLICTS IN SPAIN**

# 7. SILENT REVOLUTION IMPACT ON WATER RESOURCE POLICY IN W.R. (II)

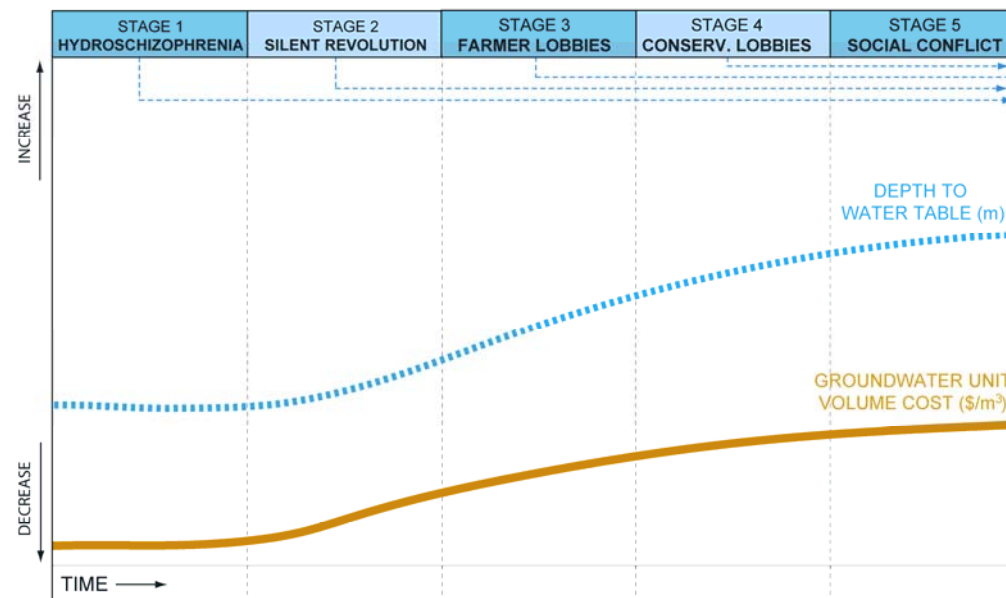
ROUGH (GROUND)WATER POLICY TRENDS IN ARID AND SEMI-ARID COUNTRIES



EXAMPLES	STAGE 1 <sup>(a)</sup> HYDROSCHIZOPHRENIA <sup>(b)</sup>	STAGE 2 SILENT REVOLUTION <sup>(c)</sup>	STAGE 3 FARMER LOBBIES <sup>(d)</sup>	STAGE 4 CONSERV. LOBBIES <sup>(e)</sup>	STAGE 5 SOCIAL CONFLICT <sup>(f)</sup>
	California (1920-1980) Texas (1930-1980) Arizona (1950-2000) Spain (1950-2000) India (1950-2000) Mexico (1960-2000)	California (1930-1960) Texas (1940-1990) Arizona (1960-2000) Spain (1960-2000) India (1960-2000) Mexico (1970-2000)	California (1950-1980) Texas (1970-2000) Arizona (1970-2000) Spain (1970-2000) India (1980-2000) Mexico (?)	California (1980-2000) Texas (?) Arizona (1990-2000) Spain (1990-2000) India (?) Mexico (?)	Spain (Ebro Transfer, 2000-2004) California (CALFED, 1999-2004) India (Energy Subsidies, 2000-2004)

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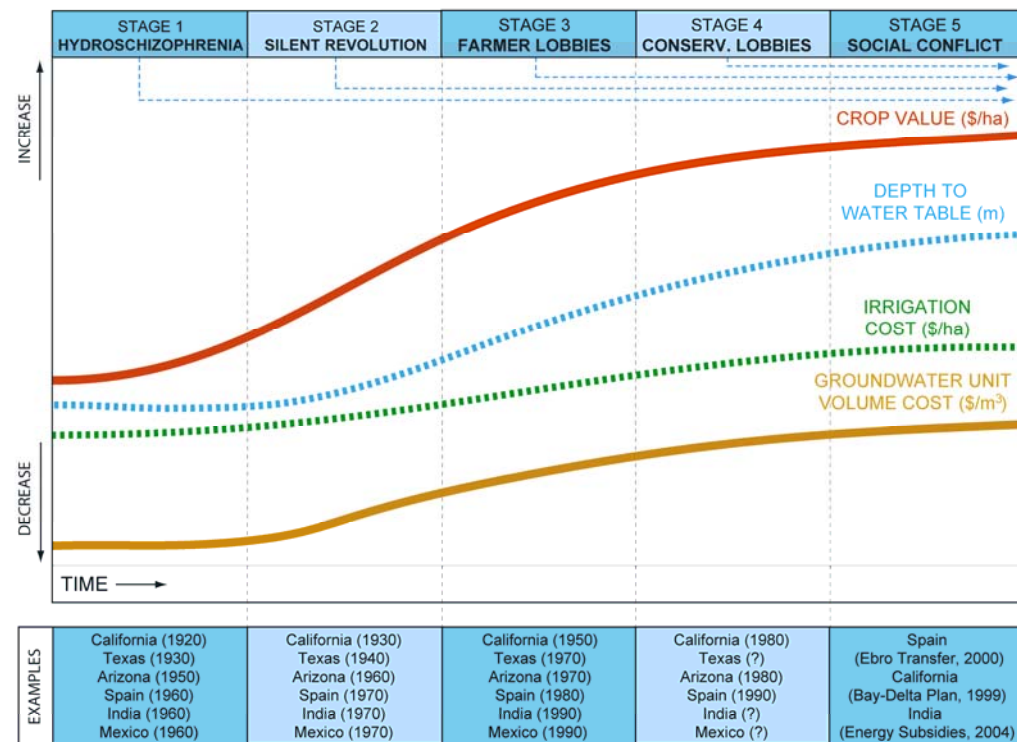


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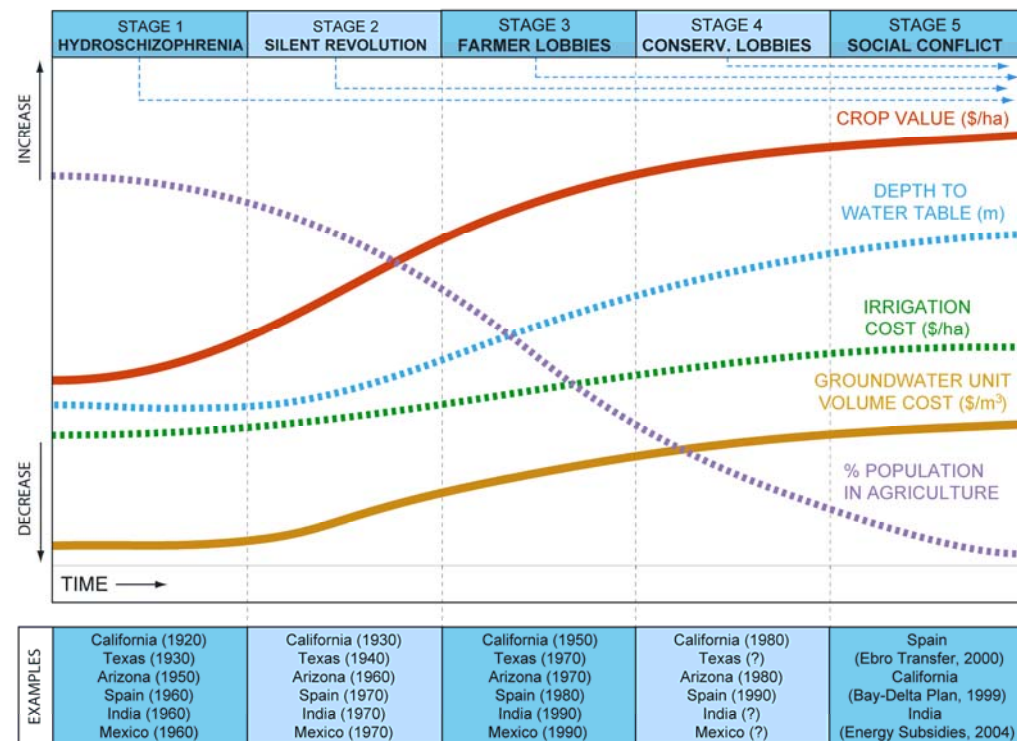
# 7. SILENT REVOLUTION IMPACT ON WATER RESOURCE POLICY IN W.R. (IV)

ROUGH (GROUND)WATER POLICY TRENDS IN ARID AND SEMI-ARID COUNTRIES



# 7. SILENT REVOLUTION IMPACT ON WATER RESOURCE POLICY IN W.R. (V)

ROUGH (GROUND)WATER POLICY TRENDS IN ARID AND SEMI-ARID COUNTRIES



## 8. RELEVANCE OF REMOTE SENSING GIS, AND INTERNET (I)

- Possibly the radical problem in most hydrological conflicts is the illusory accuracy of data, when they are not false. Half-truths are worse than open lies.
- Generally transparency and availability on these data is scarce.

## 8. RELEVANCE OF REMOTE SENSING GIS, AND INTERNET (II)

- The most frequent inexact data are:
  - a) Irrigated surfaces and the types crops.
  - b) The inventory of groundwater uses and rights.
- Remote sensing can usually provide these data in a fast and cheap way.

## 8. RELEVANCE OF REMOTE SENSING GIS, AND INTERNET (III)

- GIS and Internet allow to elaborate and disseminate the data to the general public with a small investment.
- Usually these problems could be solved quickly if there is political willingness.

## 9. SOME ETHICAL ISSUES (MAINLY IN RELATION TO THE SILENT REVOLUTION)

- In most cases, there exists a blend of:
  1. Ignorance: Hidrogeology being a rather “new” science.
  2. Arrogance: Professional “clicks”
  3. Institutional inertia.
  4. Corruption: probably the main obstacle to attain adequate water management.

**Groundwater development is less prone to corruption:**

- a) Smaller investment required
- b) Shorter implementation time

## 10. CONCLUSIONS (I)

### A) VIRTUAL WATER

Virtual water trade is facilitating the food security in water poor countries.

Some political obstacles remain in relation to the World Trade Organization.

## 10. CONCLUSIONS (II)

### B) DESALINATION

Membrane Technology (RO) is already allowing to solve urban water supply in coastal areas.

In the future it may also be used for irrigation of high value crops.



# 10. CONCLUSIONS (III)

## C-1) GW SILENT REVOLUTION

- In the last decades, a spectacular increase in groundwater irrigation has taken place in many arid and semi-arid countries.
- This is a Silent Revolution, carried out by millions of farmers, and it is generally market driven.
- Groundwater irrigation can achieve the “more crops and jobs per drop” motto.
- A worldwide assessment on the relative socio-economic efficiency of surface versus groundwater is required.

# 10. CONCLUSIONS (IV)

## C-2) GW SILENT REVOLUTION

- Groundwater governance requires a participatory approach of all stakeholders.
- Groundwater development is less prone to corruption than surface water projects.
- Most governments can afford the investment of putting their groundwater resources to good use.

**A willingness is needed to fight ignorance, negligence, arrogance and corruption.**

# 10. CONCLUSIONS (VI)

## REMOTE SENSING, GIS, AND INTERNET

- There are cheap and available tools that can play a crucial role in order to achieve a participatory management.
- The main problem seems to be back of political willingness.