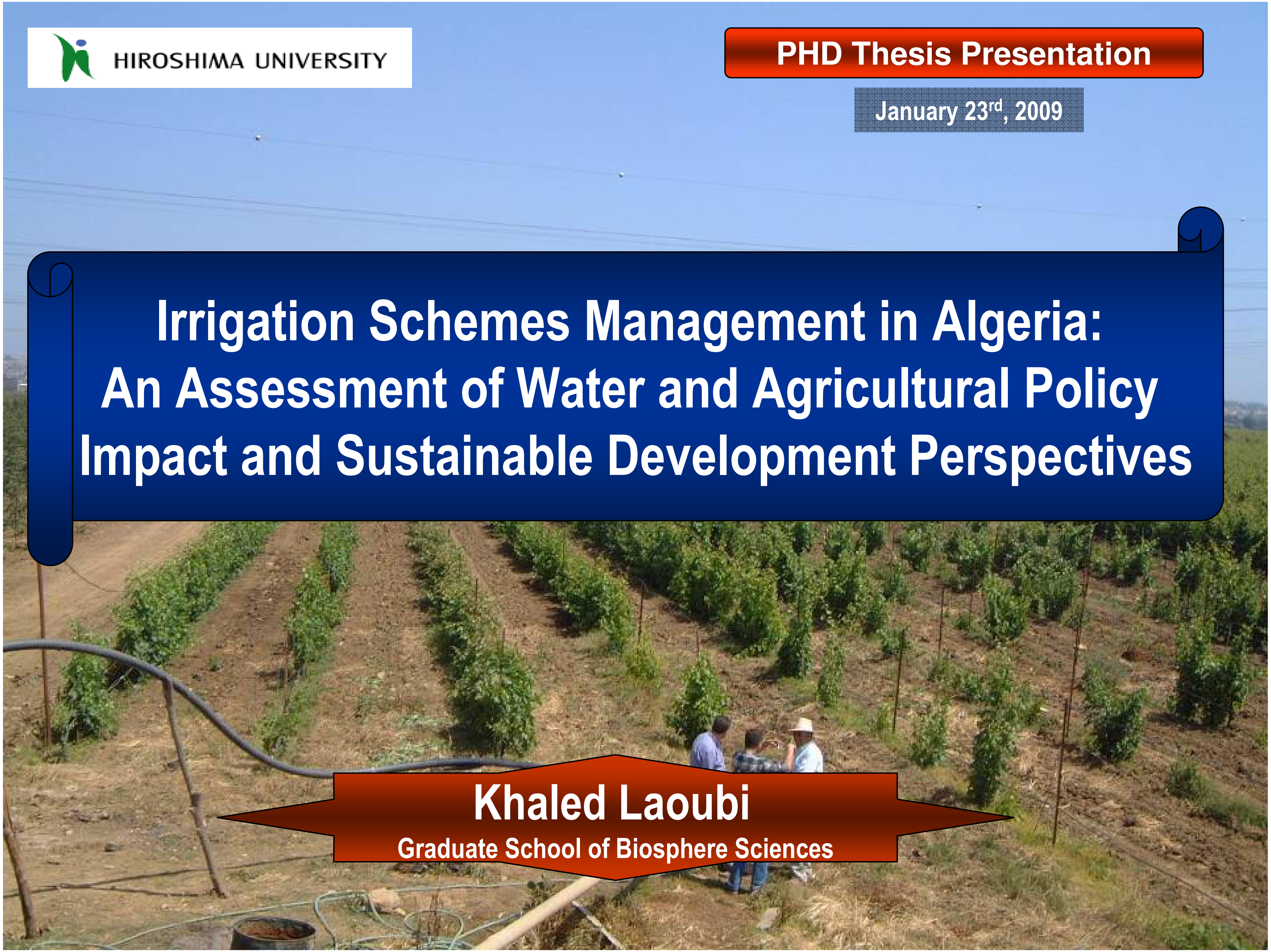
HIROSHIMA UNIVERSITY

PHD Thesis Presentation

January 23rd, 2009



Irrigation Schemes Management in Algeria: An Assessment of Water and Agricultural Policy Impact and Sustainable Development Perspectives

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CONTENTS

CHAPTER1

INTRODUCTION

- Agriculture is a strategic component of Algerian's economy with 25% of the labor force and 10% of the GDP.
- Due to semi aridity of the country, irrigation plays an important role in enhancing the agricultural development for food security.
- Indeed with less than 6% of total cultivated area, irrigation contributes to more than 50% of the total agricultural output.
- Irrigation is an effective tool for economic development and poverty reduction, and the best irrigated agricultural areas are located in the irrigation schemes.
- They constitute an optimal area in terms of high performance and high value-added agricultural product.

Reform and Policy

Water Reforms

Agricultural Policy

Objective: Enhancing the Performance & Sustainability of Irrigation Schemes

Water Management: Reforms and Measures

Institutional

In 1996

Integrated water management at watershed level
Improve efficiency of water management

In 2000

Creation of Ministry of water resource
Water is a strategic sector

In 1985 & 2005

Creation of irrigation agencies
Financial autonomy for scheme sustainability

Regulatory

In 1996

Water is an economic good

In 1998 and 2005

Increase in irrigation water prices
objective of cost recovery for viability of irrigation schemes

Recovery economic plan

2001- 2009

Heavy investment on hydraulic infrastructures, rehabilitation, extension and development of irrigation schemes

A New Agricultural Policy: The Event of "PNDA"

In 2000

"Program of National Agricultural Development"

- Improve food security
- + Investment & natural resources conservation
- Convert production systems, intensify & expand irrigated areas,
- Induce the development & modernization of farms.

- Accompanying measures: Supervision, follow up, evaluation & technical guidance from both central & local agricultural administrations & institutes.

- The total agricultural support to investment amounted to 3% under PNDA (2000-2006)

PROBLEM STATEMENT & JUSTIFICATION 1/2

Pressure on water resources

- Water resource in Algeria is very limited and unequally distributed in space and time.
- The country has among the lowest per capita water supplies in the world
- The renewable water resources amount to 600 m^3/year per-capita, it is below the threshold of 1000 m^3/year per capita (UN threshold for water poverty).
- By year 2050, Per capita water availability will fall below the 400 m^3/year [World Bank2007].
- Competition for these finite resources is to considered with great apprehension it will be a challenge for the country's future.

Pressure on land resources

- The land area per head of population has decreased by more than 72% from 0.73 ha per capita in 1962 to 0.20 ha per capita in 2000 [CNES, 2004].
- During this time, more than 200 thousand ha of best agricultural area has been lost, located mostly in the irrigated areas [CNES, 1999].
- The ratio is expected to reach 0.19 ha per capita in 2010 and 0.17 ha per capita in 2020 [CNES, 2004].
- The consequences of these changes will be a considerable increase in food import dependency.

PROBLEM STATEMENT & JUSTIFICATION 2/2

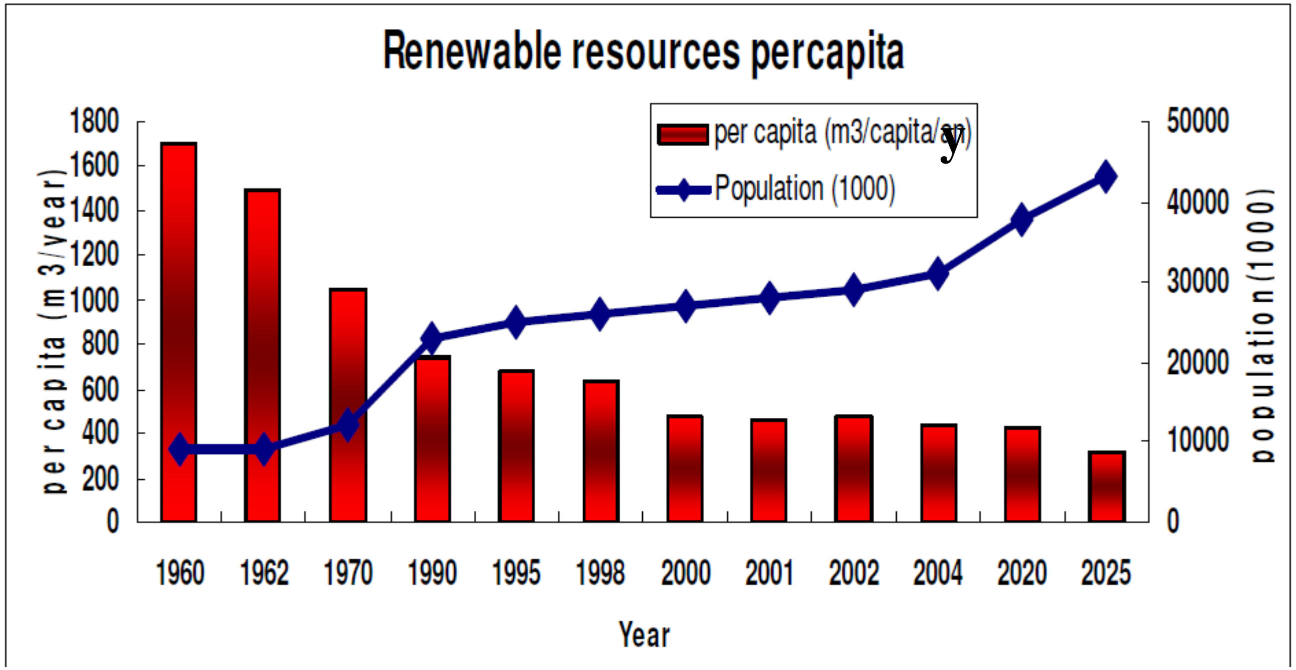
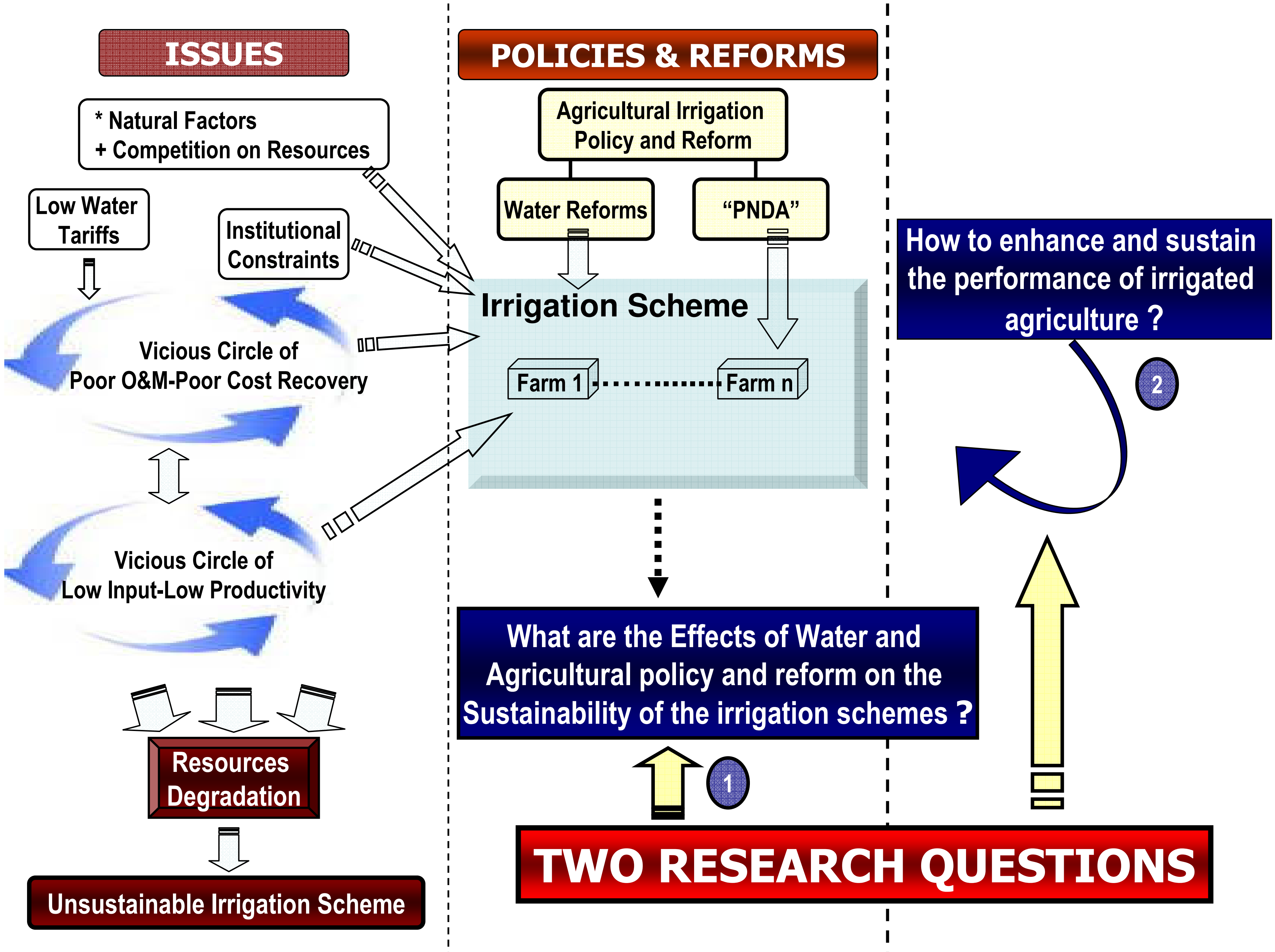


Figure: Trend of population and renewable water resource per capita

Source: MWR, FAO, WB and National reports.

- **Algeria is <u>not self-sufficient</u> country and increasing population growth, coupled with urbanization and industrialization, and an increasing demand for limited natural resources, is placing extreme pressure on the country's water resources.**

- **Thus, the need to produce more food with limited resources requires an increase in the efficiency of land and water use, and more specifically, enhancing the performance and sustainability of irrigation schemes**


ISSUES
* Natural Factors
+ Competition on Resources
Low Water Tariffs
Institutional Constraints
Vicious Circle of Poor O&M-Poor Cost Recovery
Vicious Circle of Low Input-Low Productivity
Resources Degradation
Unsustainable Irrigation Scheme
POLICIES & REFORMS
Agricultural Irrigation Policy and Reform
Water Reforms
“PNDA”
Irrigation Scheme
Farm 1
Farm n
What are the Effects of Water and Agricultural policy and reform on the Sustainability of the irrigation schemes ?
1
How to enhance and sustain the performance of irrigated agriculture ?
2
TWO RESEARCH QUESTIONS

Sub-Questions

Chapter2: Performance assessment of irrigation schemes

- Did the irrigation schemes become self-financially sustainable?
- What has been the effect of the reforms on overall performance of the schemes?

Chapter3: A typology of irrigated farms as a tool for sustainable management of irrigation schemes

- Have the latest agricultural irrigation policy changes benefited all existing farms?
- What are the factors that prevented the achievement of PNDA objectives?
- How have farmers adapted themselves to their bio-physical and socio-economic environment?

Chapter4: Effects on irrigation profitability in irrigation schemes

- Is irrigated agriculture profitable under the current policies of water and agriculture?
- What are the factors affecting their profitability and are farmers able to pay irrigation water supply?

OVERALL OBJECTIVE

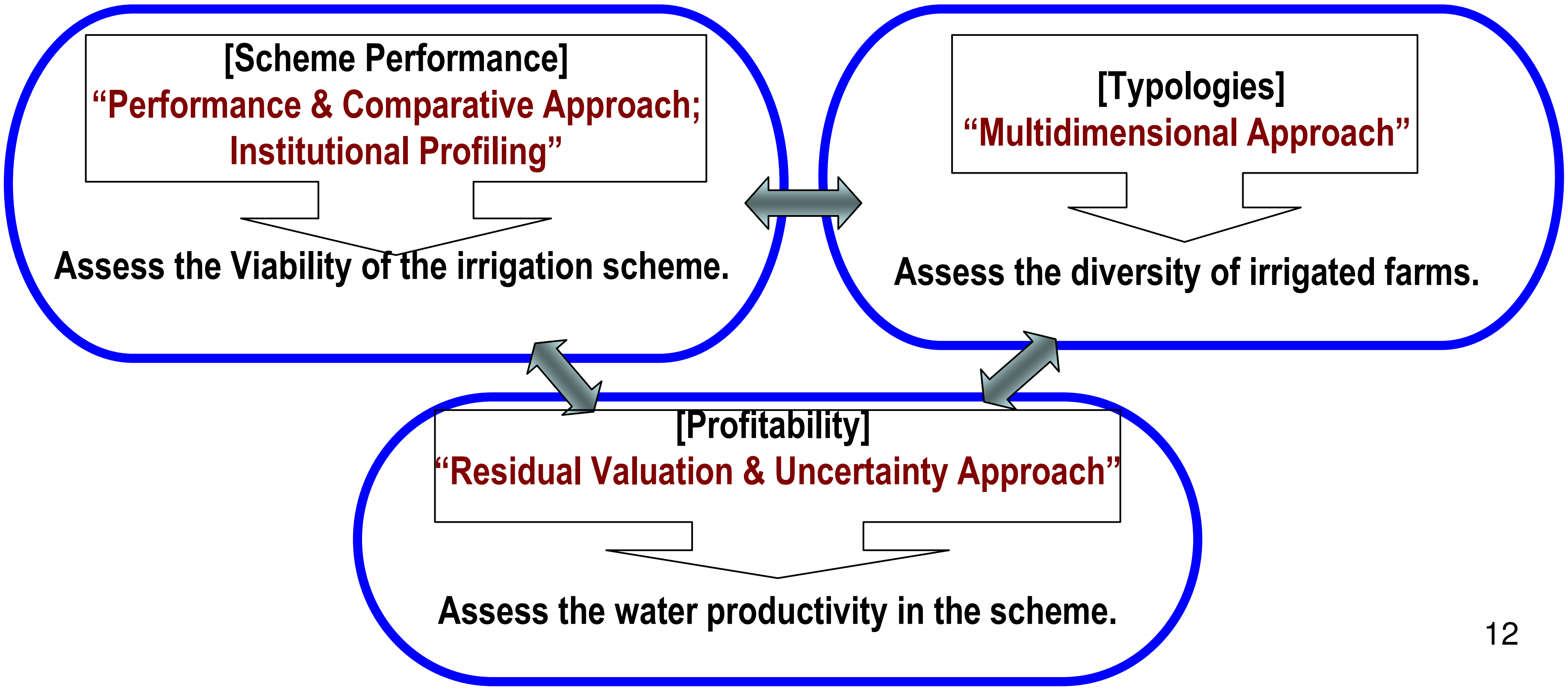
- To determine what effects water and agricultural policy have on the performance of irrigation management and irrigated agriculture in Algeria.

SPECIFIC OBJECTIVES

- To assess the viability of the irrigation schemes under water reforms.
- To characterize the structural and functional diversity of the irrigated farms.
- To provide insight into the profitability of irrigation during the transition period under the current agricultural irrigation policies.
- To provide recommendations toward sustainability of water and land use in irrigated agriculture

CONCEPTUAL FRAMEWORK

- **Given the complexity of an irrigation scheme, a number of different fields need to be investigated.**
- **A multi-approach analysis has been adopted in this research study. Three interrelated aspects are examined: *(1)* The viability of the irrigation scheme; *(2)* The performance of the land and water resource systems; and *(3)* The economic value of the water resource.**



HYPOTHESES

- (I) The low water price, lack of maintenance of the irrigation systems and water allocation constraints minimize cost recovery and therefore the viability of the irrigation schemes.

- (II) The socio-economic environment of the farmers and inadequate irrigation system operation hinder the effectiveness of irrigation agricultural policy and therefore the sustainability of the scheme.

- (III) The Socio-economic factors influence water productivity and consequently the opportunity for cost recovery from farmers in the irrigation scheme.

LITERATURE REVIEW

Theory and Concepts

- Irrigation Management
- Water Scarcity, Water cost, Water Price, Water Value
- Evaluation Techniques
- Institutions
- Sustainability
- System Theory

METHODOLOGY

- **Research sites:** Two Irrigation Schemes East Mitidja (Hamiz) and West Mitidja (T1).

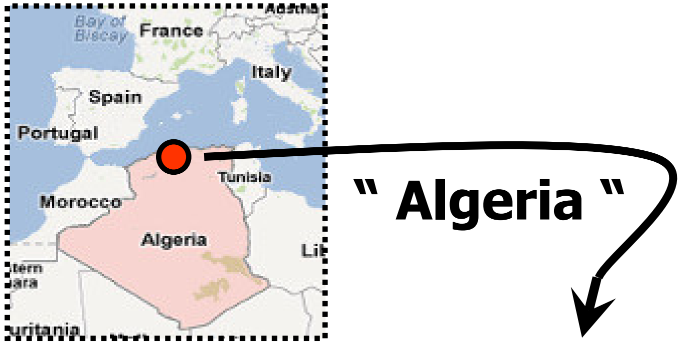
- **Selection Justification:** The Mitidja Valley is considered to be the most fertile region Algeria, and it represents the heart of the regional agriculture in the northern part of the country.

- **Survey's target population:** Farmers, irrigation agency ONID, key informant and staff from Ministry of water resources, Ministry of agriculture, DSA, Chamber of agriculture, ONID and ANB agencies.

- **Data collection:** Desktop research - Direct interview & Group discussion – Structured & semi-structured questionnaire.

Study Area

- ◆East Mitidja (Hamiz)
- ◆West Mitidja (T1)



METHODOLOGY

Methodological Approaches:

- Performance and Comparative Approach
- Institutional profiling
- Systemic method
- Valuation method
- Uncertainty approach

Analytical Methods:

- **Descriptive statistics**
- **Performance indicators**
- **Diagram techniques**
- **Typology Building Technique:**

Multiple correspondence analysis & Ascendant hierarchical clustering algorithm

- **Residual Valuation Technique**
- **Sensitivity Analysis**

CHAPTER 2

Performance Assessment of Irrigation Schemes

OBJECTIVES

- To assess the viability of the irrigation schemes under water reforms.
- To investigate the factors that affects the efficiency of irrigation management in the schemes.

DATA COLLECTION

- A database has been established based on Secondary data. It was carried out between 2005-2007.

- Data sources: Annual reports of operation and maintenance (1998-2005); Annual balance sheets and irrigation reports (1998-2005) of the irrigation agency ONID; Annual reports of water resource use for agriculture in provincial basis and schemes of national agency of dams (ANB) and ONID; Technical reports of hydro management and agricultural development of Mitidja region (1988-2006) from ONID.

- Short survey regarding farmers' views, opinions, and comments on the irrigation management in the schemes.

- Personal observations were made on the irrigation scheme sites, and significant information on institution investigation and irrigation management was obtained with key informant persons such as staff members from Ministry of water resources, Ministry of agriculture, DSA, Chamber of agriculture, ONID and ANB.

DATA ANALYSIS

Performance Indicators

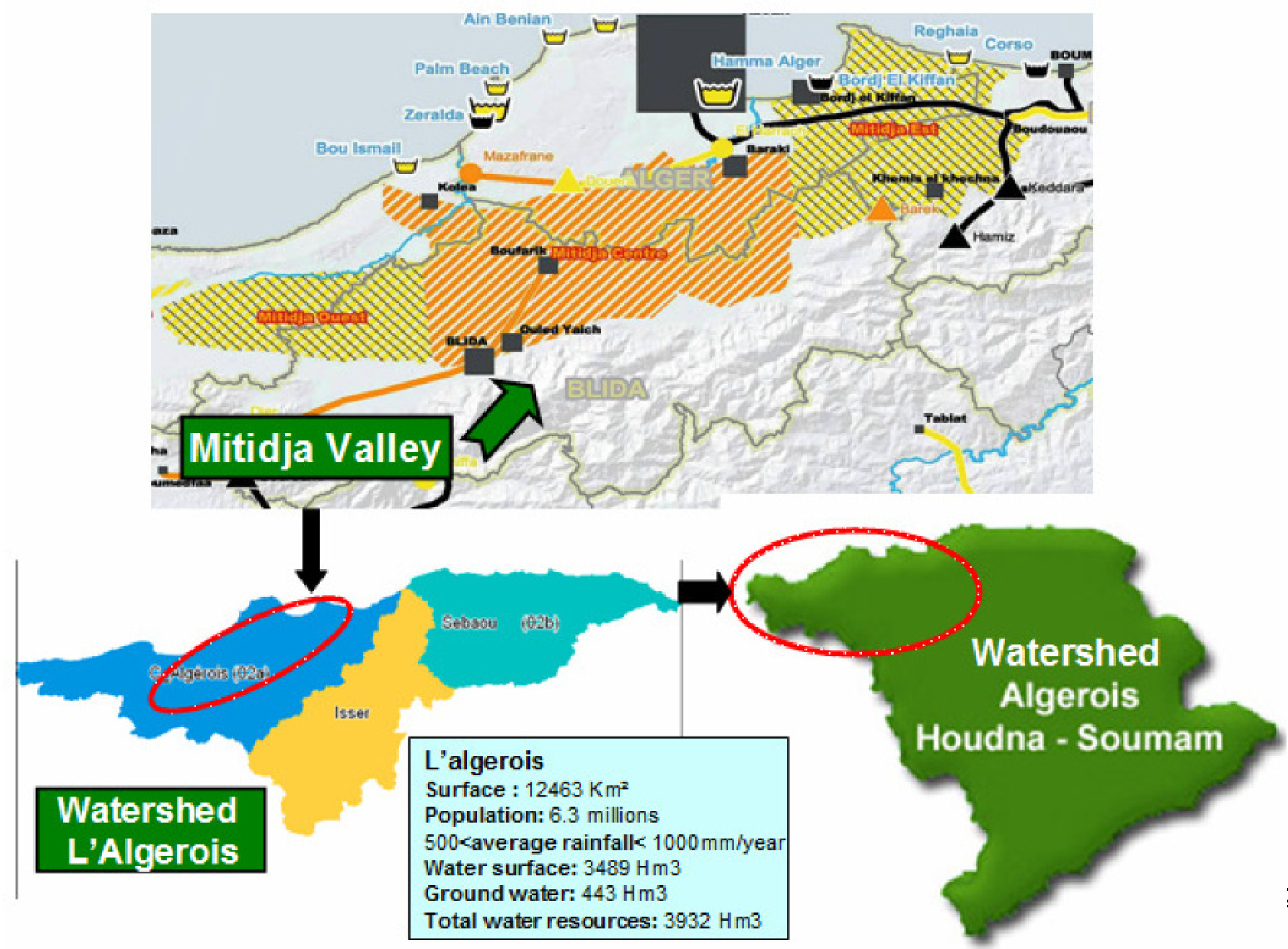
Table1: Performance indicators (IPTRID and IWMV):

Environmental Performance	**Irrigation rate:** *the actually irrigated area *100 / the irrigable area*
System Operation Performance	**Water Usage per unit area (m^3/ha):** *Gross quantity of water for the given year* (m^3) */ Actual irrigation area (ha)* **Conveyance efficiency ratio:** *Volume delivered*100 / Volume diverted*
Economic performance	1. **Cost recovery ratio (%):** Gross revenue collected / total *O&M cost* 2. **Total O&M cost per unit area (Da/ha)** 3. **Revenue per unit volume of irrigation water supplied (Da/ m^3)** 4. **Total O&M cost per unit of water supplied (Da/ m^3)** 5. **Maintenance costs ratio** 6. **Personnel costs ratio** 7. **Maintenance costs per hectare (Da/ha)**

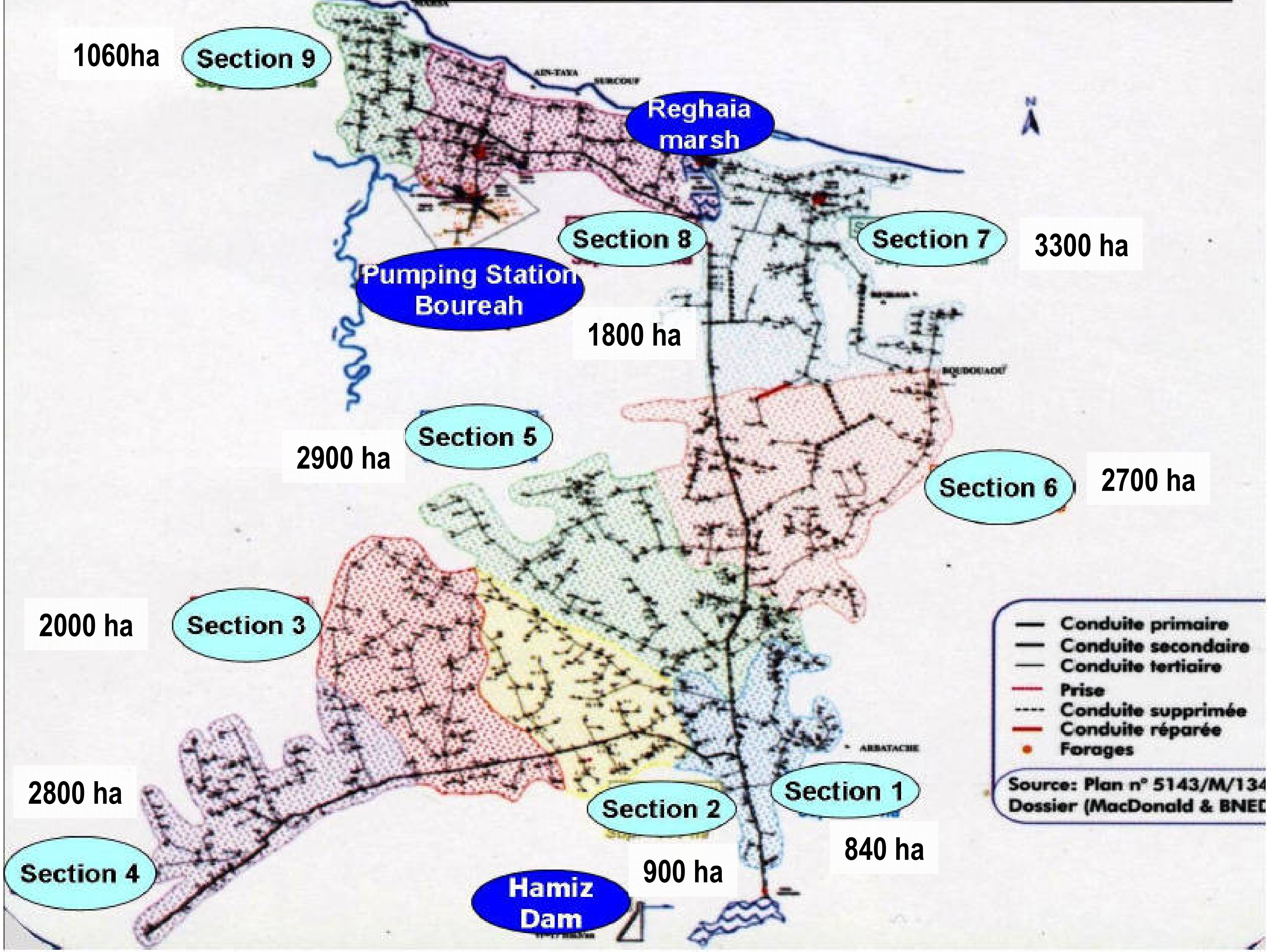
Diagram techniques

Flowchart diagram will be used for institutional profiling**:** It is a graph-based description of the process that allow to expose the key elements of the institutions related to irrigation management

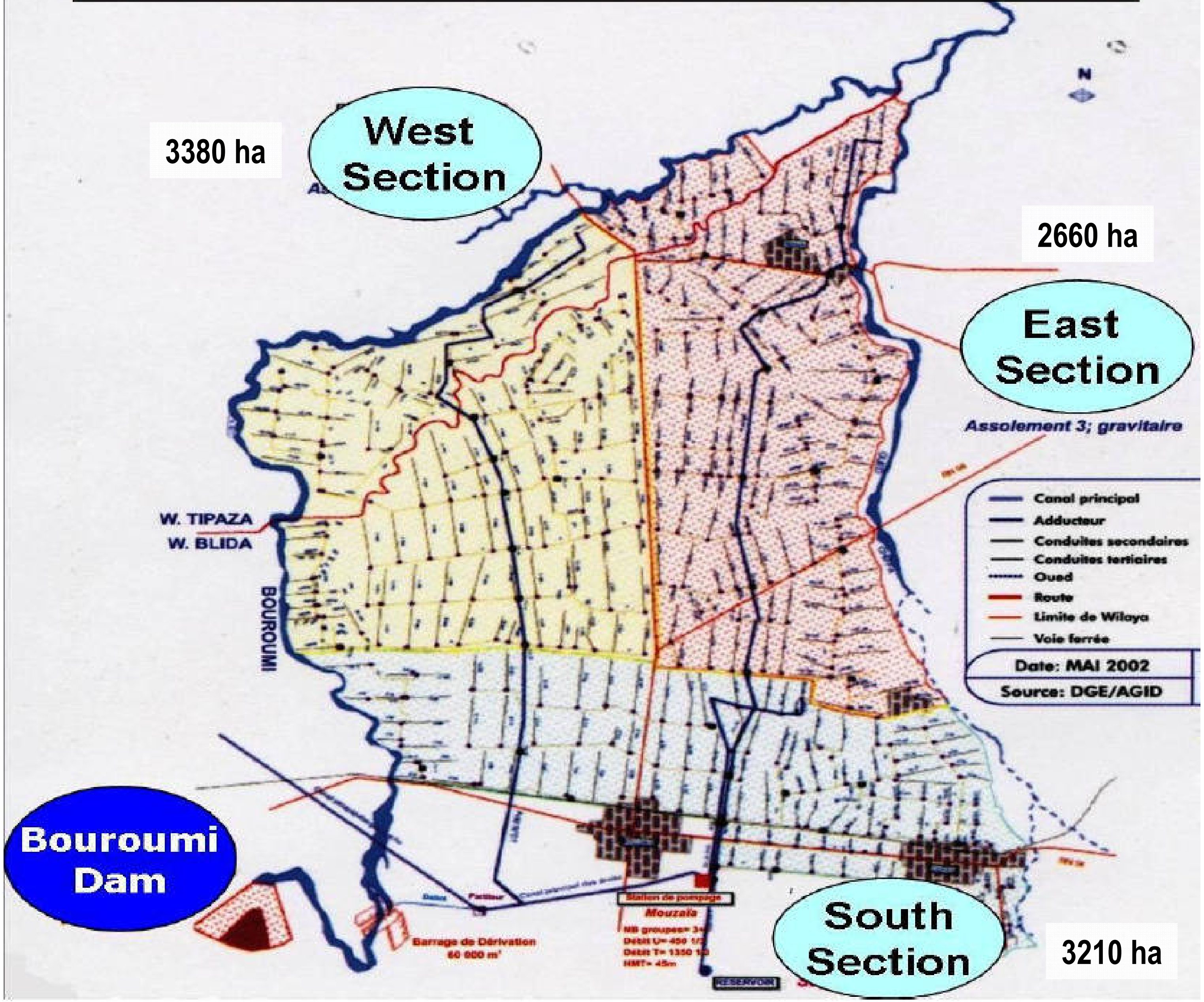
Geography location of Mitidja plain in the l'Algerois watershed



Features of the East Midtija scheme



Features of the West Midtija scheme



RESULTS AND DISSCUSSIONS

Environmental and system operation performance assessment

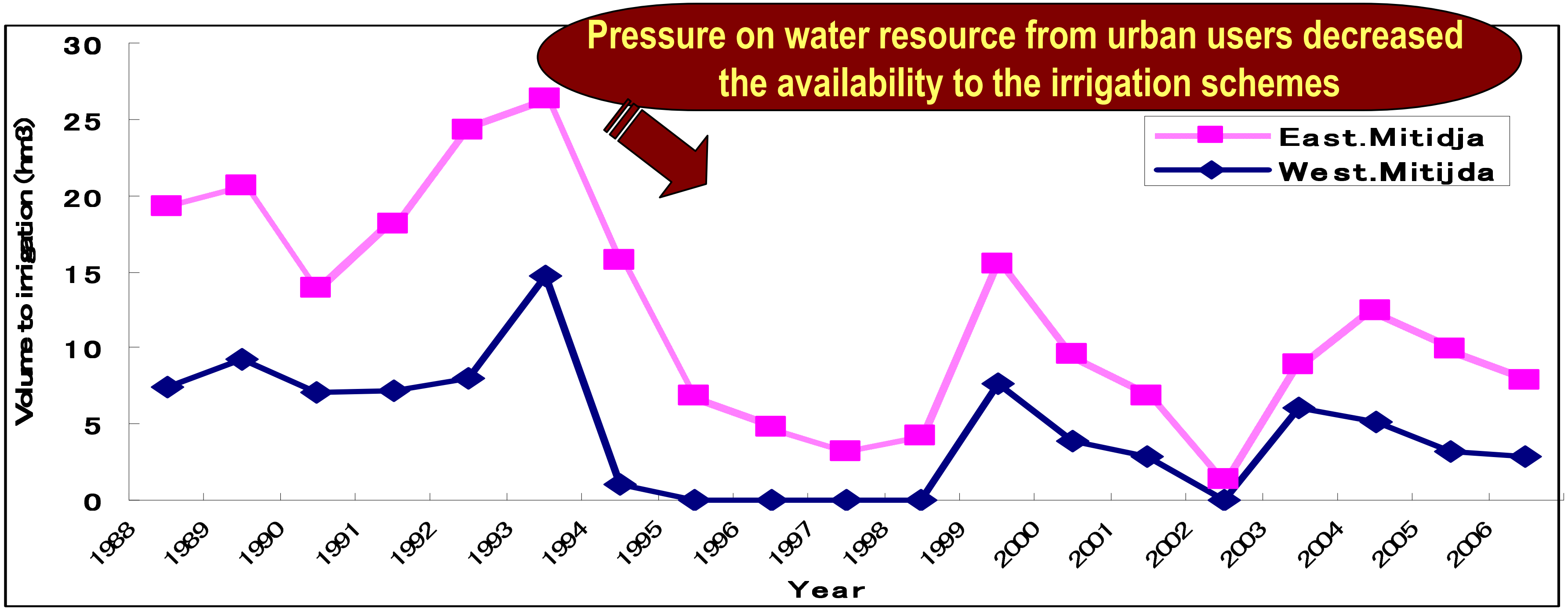
Table2: Environmental and system operation performance assessment (1988-2006)

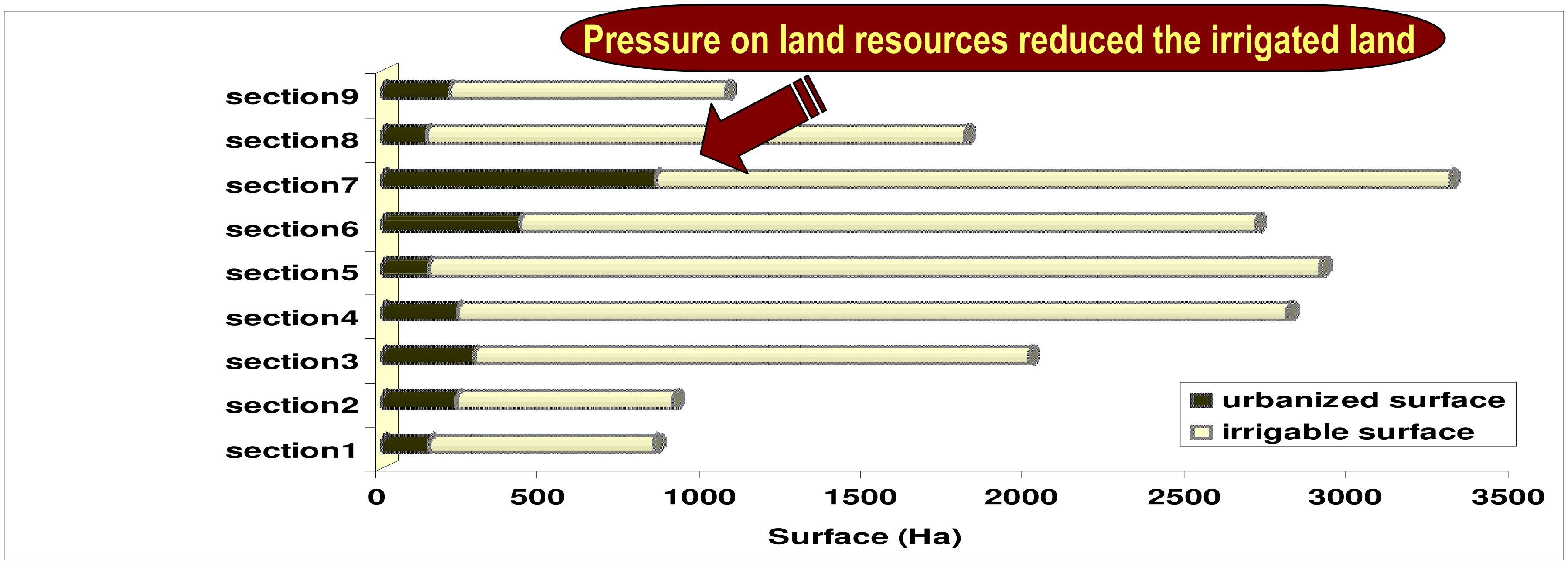
	Average (1988-1998)*		Average (1999-2004)**		Average (2005-2006)***	
Scheme Indicators	East Mitidja	West Mitidja	East Mitidja	West Mitidja	East Mitidja	West Mitidja
Irrigation rate (%)	28.18	14.57	19.45	11.04	18.25	9.37
Conveyance efficiency (%)	76	75.77	65	63.3	50.2	45.5
Water delivery (m3/Ha)	2533.6	4832.3	2462.85	4308.4	3274	4622.5

* Before the 1st water pricing reform (199
** During the 1st water pricing re
*** During 2nd water policy ref

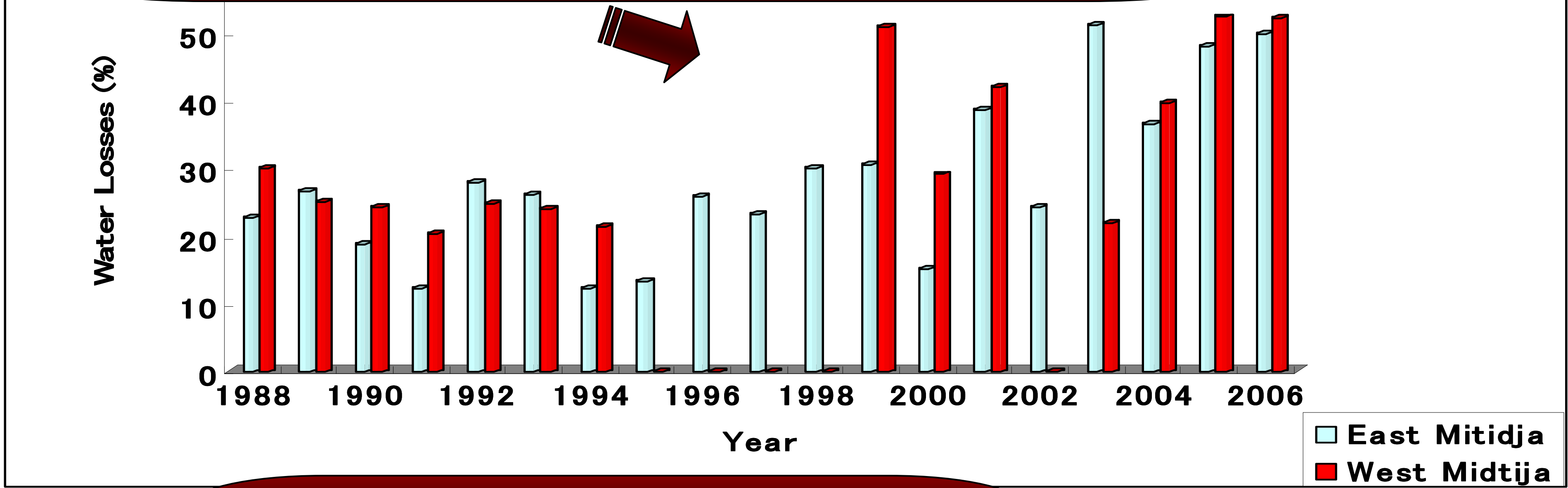
- IR decreased in both schemes by 35% in average in the period of 2005-2006
- Conveyance efficiency decreased in both schemes by almost 50%
- Water delivery increased in both schemes

Factors affecting the performance of the schemes

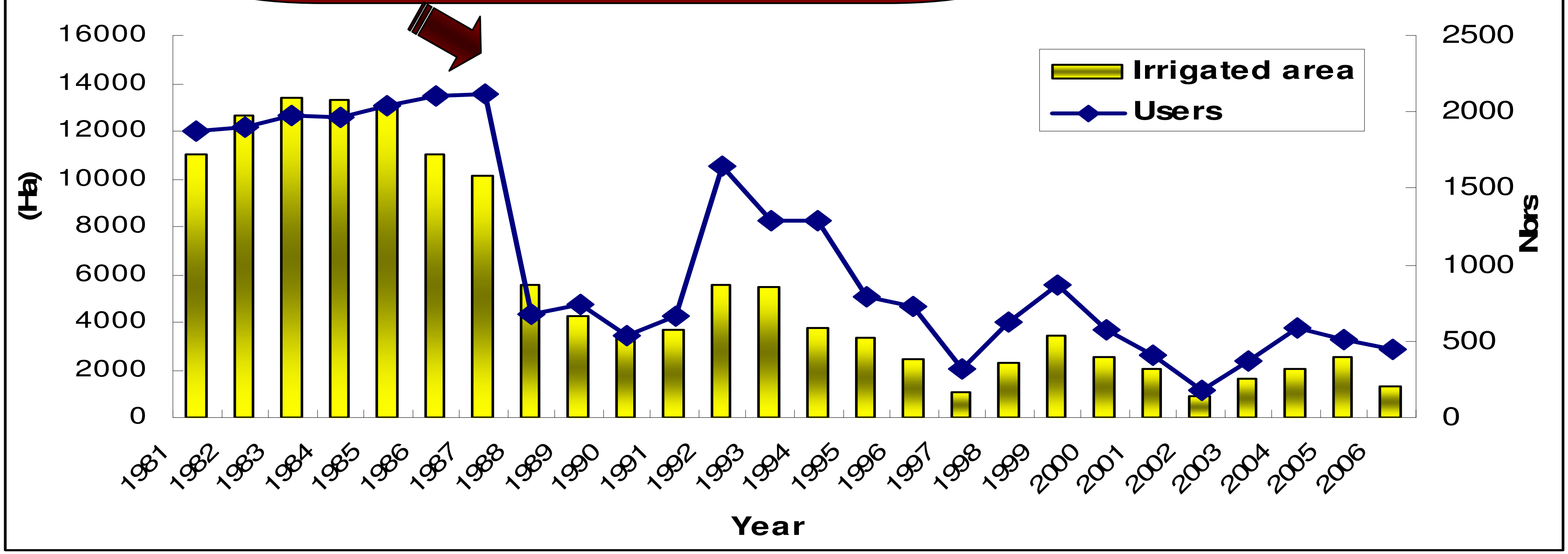




The water losses in both schemes exceeded 30% during the period 1999-2004 and 49% during the period 2005-2006 in average



Decrease in number of water users and irrigated areas



Reasons for low level of conveyance efficiency

- The general age of the irrigation system especially in the East Mitidja scheme
- The frequent stoppage of water release without advance notice resulted in repetitive damage on the network.
- Difficulties in performing maintenance on the threshold of intake structure and cleaning reservoirs during the flood.
- Lack of spare parts / Lack of means to intervention / Acts of sabotage and deterioration of facilities.
- At the downstream of the dam El Moustakbel: acts of vandalism perpetrated on the entire network, theft, and destruction of hydraulic equipment such as valves, suction, irrigation hydrants and water mains.
- Increased rates of breakage and sabotage of several sections of the network.
- The corrosion of steel water mains due to their advanced age (rupture).

Reasons for low level of conveyance efficiency (ctd..)

- Defects located at the joints (water leakage on plot)
- Illegal connecting to irrigation system.
- Siltation of diversion weir
- In Mitijda West, mishandling of valves by farmers, and theft of water during the night.
- Inadequate investment in the maintenance of works and of the facilities in good working and profitable condition. This reduced the efficiency of irrigation system. Cases of the pumping station of Reghaia (05 GEP40 must be renovated) and culvert (1 KM).
- The earthquake of 2003 that hit the area and which has interrupted the irrigation for 21 days.
- Absence on the ground of the water police and particularly the irrigators associations which can serves as counterweight to such practices.

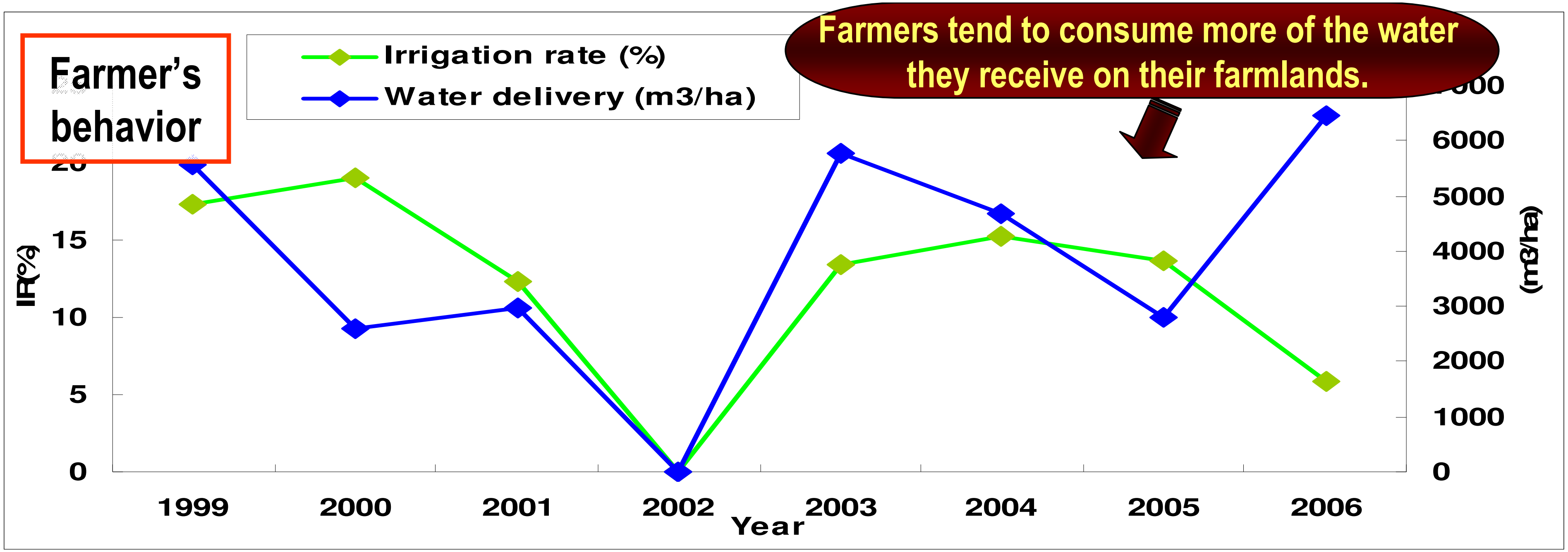


Figure 4: Trend of water delivery/ha and IR in East Mitidja scheme.

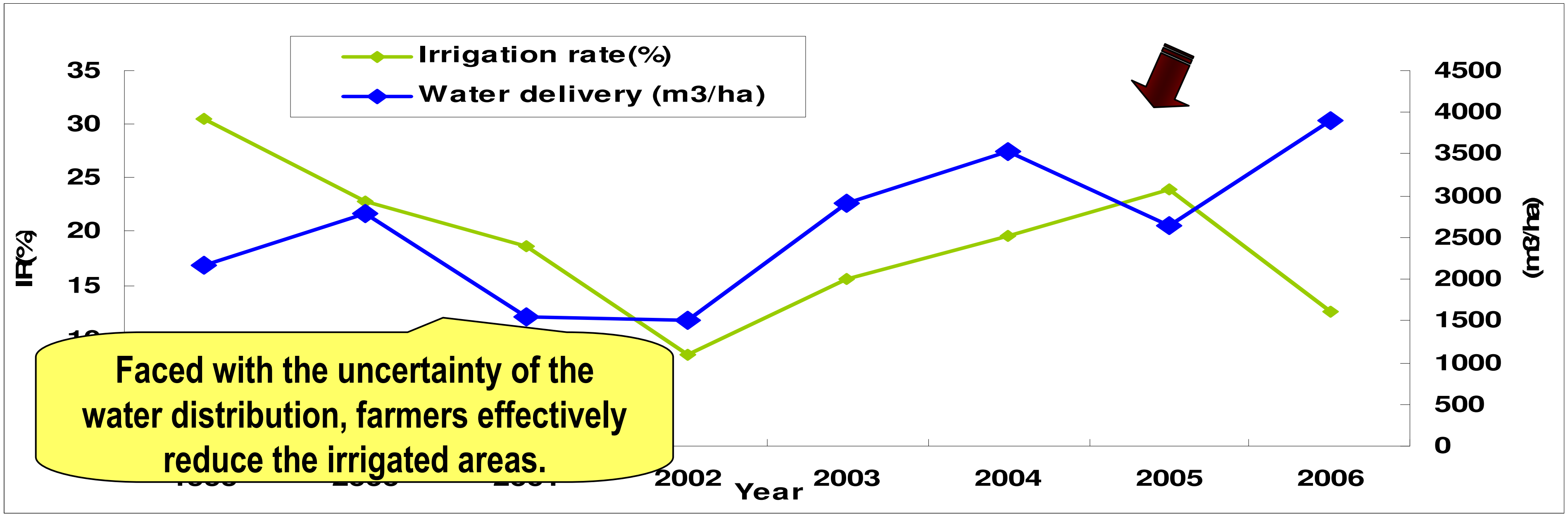
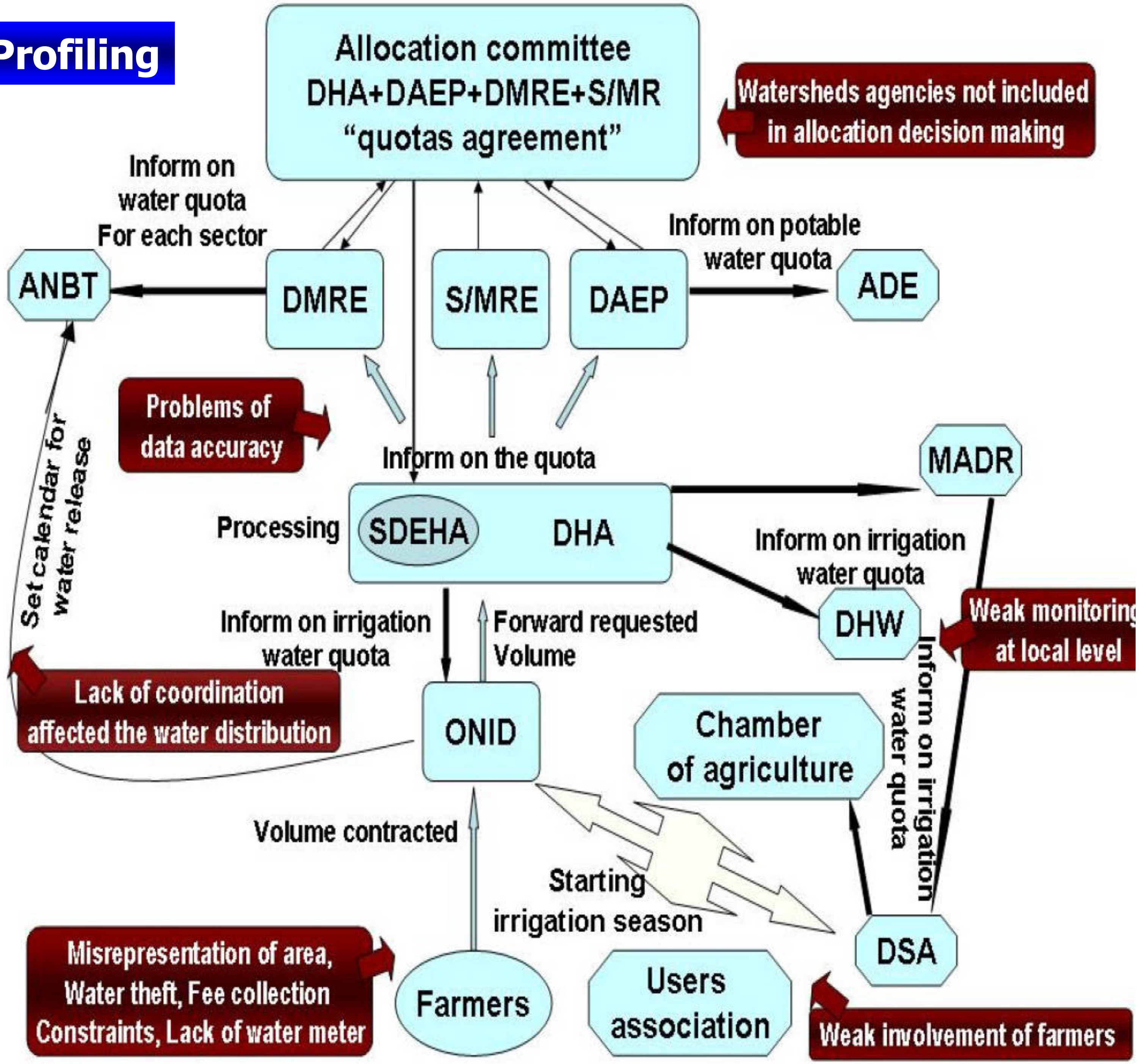


Figure 5: Trend of water delivery/ha and IR in West Mitidja scheme.

Institutional Profiling

DHA: Directorate of irrigation
DAEP: Potable water supply Directorate
DMRE: Water resources mobilization directorate
S/MRE: General secretary of Ministry of water resource
ANBT: National agency of dams and large transmission mains
ADE: Algerian water authority
SDEHA: Sub directorate of the operation and regulation of agricultural water management
DHW: Hydraulic directorates of Provinces
ONID: National agency for irrigation and drainage
DSA: Directions of agricultural utilities



Institutional Profiling outcomes

The objective the institutional profiling is to ascertain the elements of the institutions for understanding their impact on water resource management and decision making.

Keys findings:

At Ministry and intermediary level:

- **Non inclusion of watershed agencies in the decision making regarding water allocation mechanism.**
- **Poor coordination between ANBT and ONID regarding the program of water release, particularly if the dam serves two groups of users at the same time, i.e., agricultural and urban.**
- **Problems with the data itself where the water agencies sometimes provide non-reliable data.**
- **Lack of coordination exists between agencies at the ministry of water resources and the departments of other ministries.**
- **Lack of coordination and conflict of interests between ONID (irrigation management) and municipality (urbanization plan).**

Institutional Profiling outcomes

At local and scheme level

Keys findings:

- Low farmers participation in water users' organizations.
- Only Algiers Committee representatives of the DHW, DSA, Chamber of Agriculture, and Regional ONID have been able to gather the farmers, for their own education, while the other provinces have not succeeded in this regard.
- Misrepresentation of areas used by farmers and water theft disrupts water distribution activity and causing serious financial damage to the agency.
- Inadequacy of the irrigation system components with regard to farm configuration.
- Difficulties in recovering fees at the end of the irrigation season.
- The farmers settle their debt only at the beginning of the next irrigation season which creates difficulties in managing claims and deprives the agency of resources to adequately prepare for the new irrigation season.
- Late response from ONID staff In case of breakage occurrence on network, where some farmers waited for more than 2 weeks and sometimes one month. Consequently, the affected farmers have lost a proportion of their irrigation rates resulting in yield losses.

Financial performance assessment

Table3: Financial performance indicators in ***East Mitidja Scheme*** (1999-2006)

	1999	2000	2001	2002	2003	2004	2005
Water price (Da)	1.25	1.25	1.25	1.25	1.25	1.25	2.5
O&M costs (Da)/Volume (m^3)	5.78	6.83	10.56	36.50	23.23	8.30	4.70
Water Revenue (Da)/Volume (m^3)	1.39	1.55	1.74	2.31	3.27	1.80	4.21
Recovery ratio (%)	24	23	16	6	14	22	90
O&M costs (Da)/Area(ha)	13209.2	15468.7	20295.1	54936.7	39309.8	29391.8	12435.7
Maintenance budget ratio	0.07	0.03	0.03	0.17	0.06	0.28	0.11
Personnel costs ratio	0.49	0.64	0.70	0.49	0.40	0.47	0.60

O&M costs still higher than the water price

Costs of water losses are not covered.

Recovery ratio below the financial sustainability ratio

Rising in energy expenses

Personnel costs ratio is very high compared to maintenance costs ratio

Maintenance is carried out only in the case of emergency and there is no money for the replacement.

Financial performance assessment

Table4: Financial performance indicators in ***West Mitidja Scheme*** (1999-2006)

	1999	2000	2001	2002*	2003	2004	2005
Water price (Da/m^3)	1.25	1.25	1.25	1.25	1.25	1.25	2.5
O&M costs/Volume (Da/m^3)	2.33	4.80	7.75	-------	4.94	4.70	9.38
Water revenue/Volume (Da/m^3)	1.32	1.36	1.45	-------	1.65	1.43	2.87
Recovery ratio (%)	57	28	19	-------	33	30	31
O&M costs/Area (Da/ha)	12,997.1	13,868.9	23,156.5	-------	28,542.7	21,981.2	26,185.8
Maintenance budget ratio	0.05	0.05	0.08	-------	0.06	0.07	0.06
Personnel costs ratio	0.69	0.74	0.70	-------	0.54	0.59	0.47

Same issues and performance outcomes as in the East Mitidja scheme

Fee collection became a structural constraint for the West Mitidja scheme

The importance number of private drill-holes/wells deprived the agency from realizing potential revenue

Factors affecting the performance of the schemes

Table4: Maintenance expenses per ha in both schemes (1999-2005)

Maintenance costs per ha ($/ha)	1999	2000	2001	2002	2003	2004	2005	Average
East Mitidja	12.7	7.1	7.6	96.6	33.3	108.5	17.5	40.51
West Mitidja	7.9	8.8	23.9	----	21.4	19.4	21.5	14.73

The average of Maintenance costs is below the international and regional norms US$100 to 150 /ha

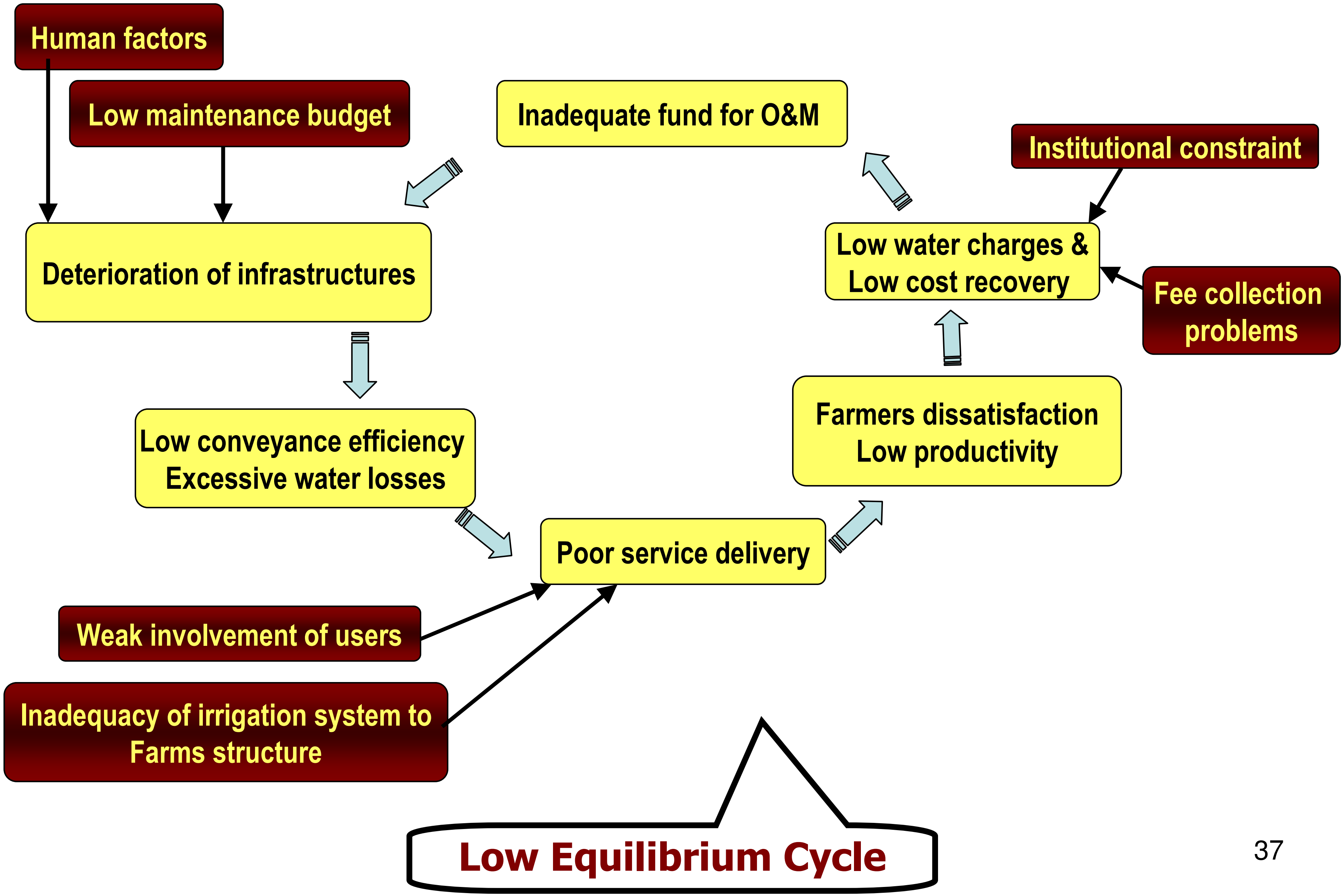
Table5 : Turnover structure of the schemes

East Mitidja	2003	2004	2005
Water revenue (%)	23.72	16.65	40.12
Works (%)*	60.61	75.61	52.66
Services provided (%)*	15.67	7.73	7.21

West Mitidja	2003	2004	2005
Water revenue (%)	22.34	22.84	11.84
Works (%)	44.06	36.37	85.78
Services provided (%)	0.65	6.35	0.03
Equipment sale (%)*	32.95	34.44	2.35

Works have become the major sources of income rather than water revenues

Effect of factors on the financial performance



CONCLUSION

- The water policy still did not create a sustainable environment to the irrigation scheme.
- Drought, increasing competition from urban water users, institutional constrains, land reform, problems with hydro mechanical and irrigation equipments made complications for the irrigation management.
- Low water charge; fee collection constraints; and limited irrigation revenues have resulted in insufficient expenditures on operation and maintenance (O&M).
- As consequences, it contributes to the deterioration of irrigation infrastructure, lead to greater water conveyance losses and reduced delivery efficiency.
- In addition, low maintenance budget, human factors, lack of coordination between agencies of water sector and local level led to *deterioration* of infrastructure and shrinkage of irrigated area.
- All these factors and constraints led to low equilibrium cycle for both schemes.


Irrigation schemes


Irrigation schemes
TOYOTA


Irrigation schemes


Irrigation schemes

CHAPTER 3

A Typology of Irrigated Farms as a Tool for Sustainable Management of the Irrigation Schemes

OBJECTIVE

- To characterize the diversity of irrigated farms with an analysis of their structural and functional aspects

Methods for constructing farm typologies

Resulting from an analytical and statistical analysis of an existing database

Classification based on a simple descriptive and statistical analysis

Classification without specific purpose (Perrot, 1990), and is insufficient to assess the diversity of farms (Cochet and Devienne, 2004).

E.g. European classification of agricultural holdings

based on direct surveys and interviews with farmers

Based on structural (farm size, land tenure, etc.) and functional criteria (farmers' decisions making in their biophysical and socio-economic environment).

Goal-oriented approach

Provide solutions at the farm level in the context of agricultural Development (Perrot, 1990)

The approach considers the objectives of the farmers as they are faced with a set of internal and external constraints and opportunities (Bonneviale et al. 1989].

System Approach

METHODOLOGY

SAMPLE DATA

- Surveys were conducted on the scheme between June and August 2007 using a well-structured questionnaire.
- Using a method of stratified random sampling in 3 different strata by land ownership type.

Sample of irrigated farms in the *East Mitidja scheme*.

Farm type	ONID database	Percentage (of total farms)	Sample size (number of farms)	Percentage (of each stratum)
EAC	478	38.62 %	54	11.30 %
EAI	32	2.58 %	4	12.50 %
Private	723	58.40 %	76	10.51 %
Others *	5	0.40 %	0	0 %
Total	1238 **	100 %	134	10.82 % (Average)

Sample of irrigated farms in the *West Mitidja scheme*.

Farm type	ONID database	Percentage (of total farms)	Sample size (number of farms)	Percentage (of each stratum)
EAC	344	77.30 %	38	11.04%
EAI	19	4.27 %	2	10.53 %
Private	80	17.98 %	9	10.53 %
Farm pilot	2	0.45 %	0	0 %
Total	445	100 %	49	11.01 % (Average)

DATA ANALYSIS

- **The data analysis was conducted in two stages** (Lebart *et al*., 2000; Lebart, 1994; Le Roux and Rouanet, 2004).

① ***Multiple Correspondence Analysis (MCA):*** **It is a GDA (geometric data analysis) method, a Euclidean cloud of points representing the individuals is constructed, and the principal axes and variables are determined. A restricted number of axes are interpreted, providing a summary of the data** (Le Roux and Rouanet, 2004).

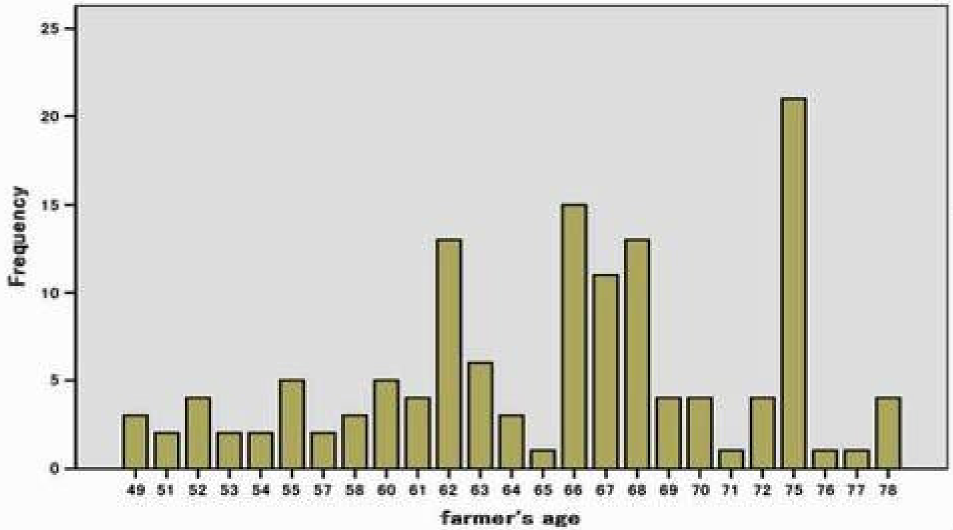
② ***Ascendant Hierarchical Classification (AHC):*** **This method allows for a partition of the individuals based on their factorial coordinates using the Ward distance criterion for minimizing intra-class variance and maximizing variance between classes. A classification that best summarizes the information is then chosen** (Le Roux and Rouanet, 2004; Lebart *et al*., 1984).

- **The data preparation was carried out with SPSS 15, and MCA and AHC were carried out with SPAD v5.5 (Portable System for Data Analysis Software).**

Descriptive analysis of East Mitidja scheme 1/2

RESULTS

Farmer's age



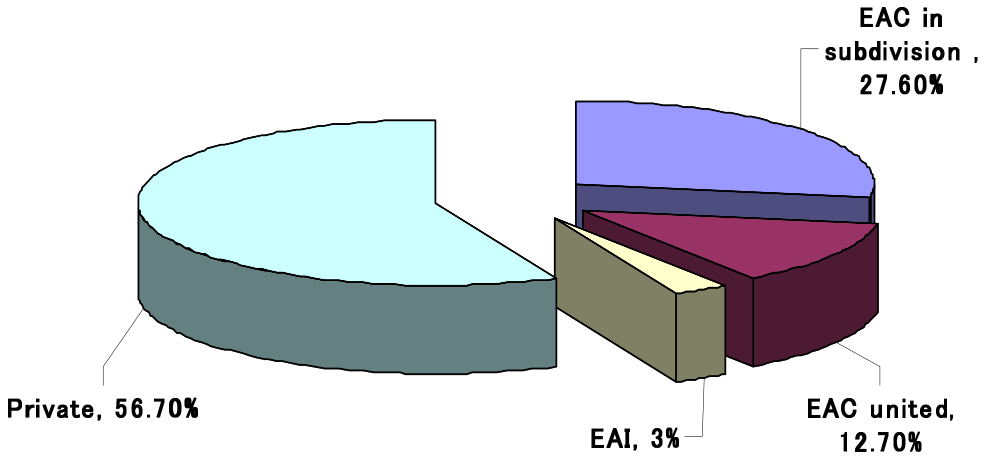
Education

Education	Frequency	Percent
No education	115	85.8
Primary. education	15	11.2
Junior school education	2	1.5
High school education	1	.7
University	1	.7
Total	134	100.0

Member of Agricultural Association

	Frequency	Percent
Member of association	5	3.7
no membership	129	96.3
Total	134	100.0

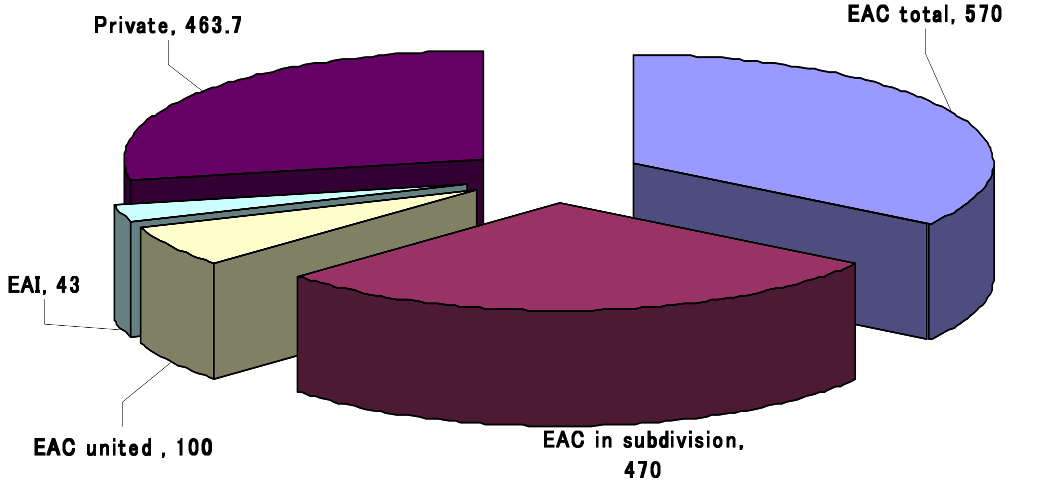
Forms of ownership in the sample by percentage



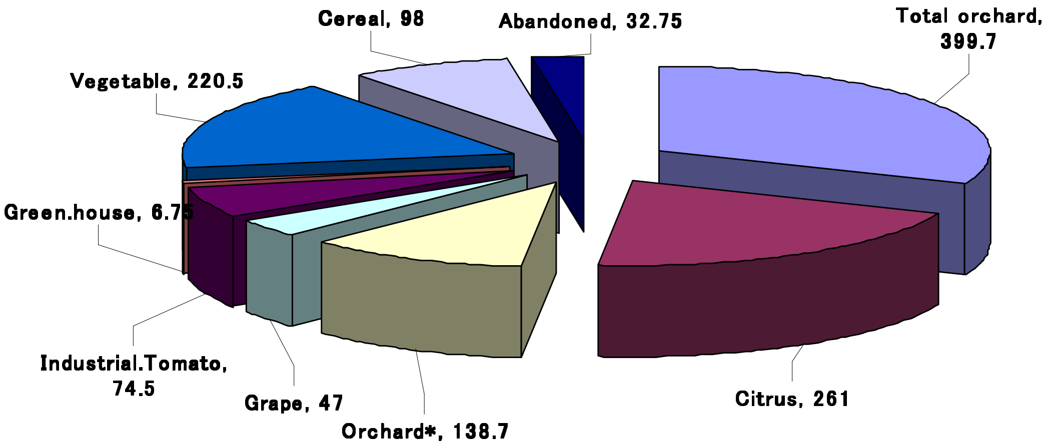
Descriptive analysis of East Mitidja scheme 2/2

RESULTS

Total agricultural area (ha) by ownership form



Total area by farming system (ha)



Total orchard include citrus, peach, apple and pear
*Orchards: Peach, apple and Pear

Number of farms by size

Size (ha)	Farms	
	Number	Percent
<=1ha	15	11.19
1<Size <=2	27	20.15
2<Size <=4	21	15.67
4<Size <=8	29	21.64
8<Size <=12	15	11.2
12<Size <=15	10	7.46
15<Size <=20	13	9.7
Size >20	4	2.99
Total	134	100

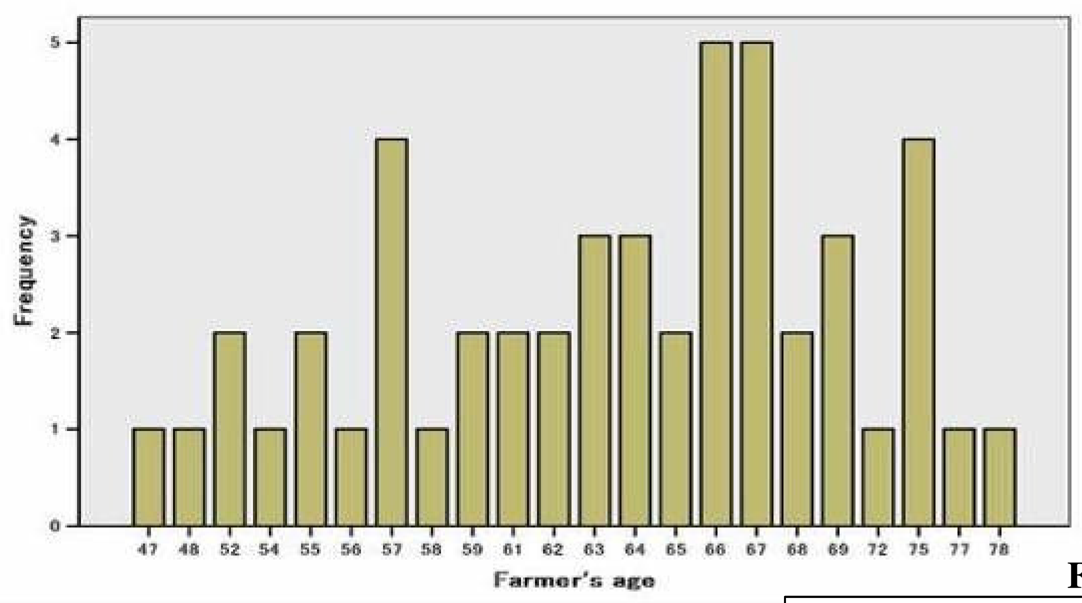
Water and irrigation technique use

	Frequency	Percent
Water surface	128	95.52
Conjunctive use	6	4.47
Saving technology	4	2.98
Gravity	130	97.01

Descriptive analysis of West Mitidja scheme 1/2

RESULTS

Farmer's age



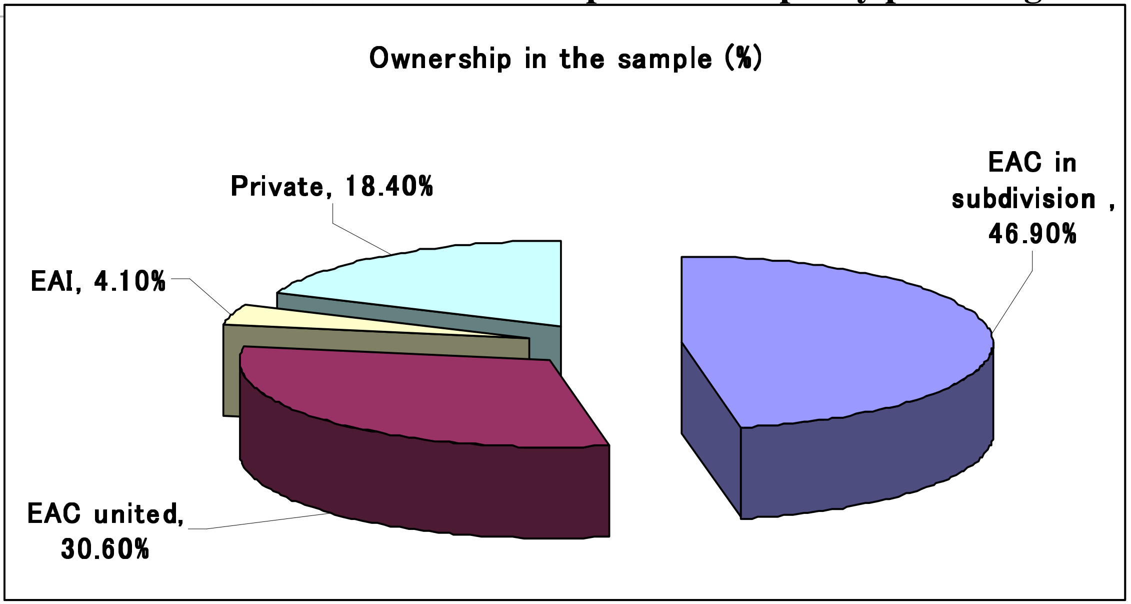
Education

	Frequency	Percent
No education	39	79.6
Primary level	9	18.4
University	1	2.0
Total	49	100.0

Member of Agricultural Association

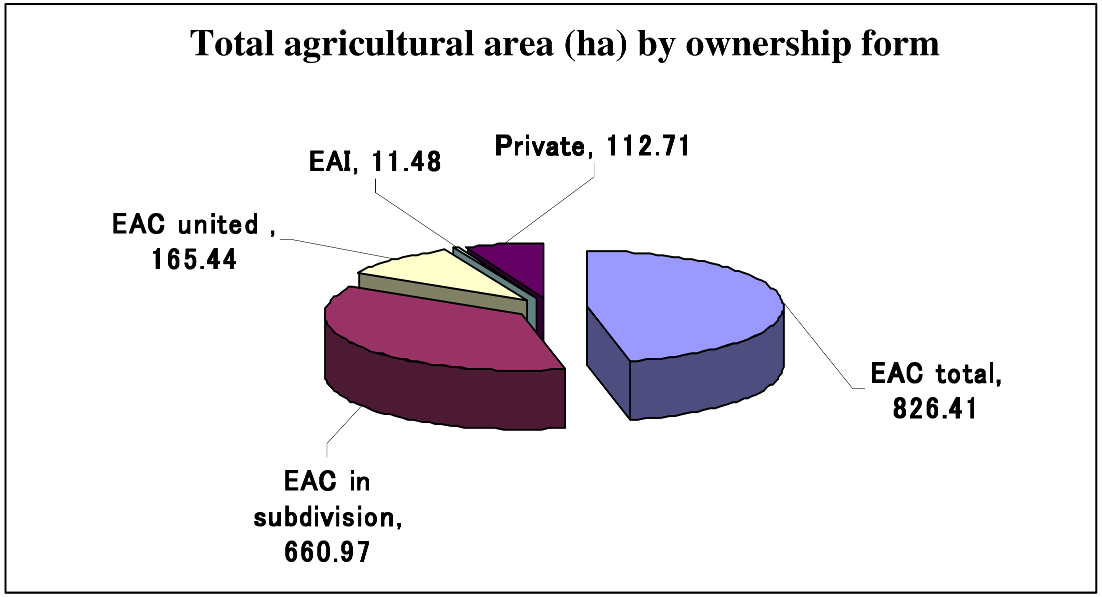
	Frequency	Percent
Member of association	6	12.2
no membership	43	87.8
Total	49	100.0

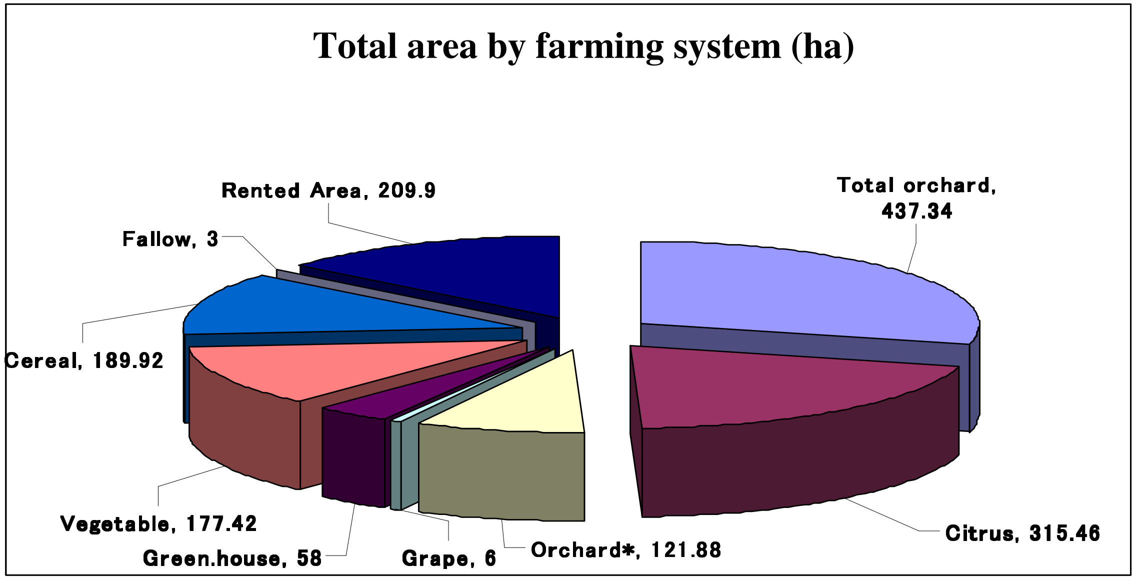
Forms of ownership in the sample by percentage



Descriptive analysis of West Mitidja scheme 2/2

RESULTS





Total orchard: Citrus, peach, apple, pear, apricot, plum and medlar
*Orchards: Peach, apple and pear, apricot, plum and medlar

Number of farms by size

Size (ha)	Farms	
	Number	Percent
<=5ha	4	8.16
5<Size <=10	10	20.41
10<Size <=15	10	20.41
15<Size <=20	7	14.29
20<Size <=25	1	2.04
25<Size <=30	7	14.29
30<Size <=40	6	12.24
Size >40	4	8.16
Total	49	100

Water and irrigation technique use

	Frequency	Percent
Water surface	4	8.3
Conjunctive use	45	91.7
Saving technology	20	41.7
Gravity	29	58.3

Building Typology

In East Mitidja scheme

Variables used in the Multiple Correspondence Analysis

```
SELECTION OF CASES AND VARIABLES
ACTIVES CATEGORICAL VARIABLES
    21 VARIABLES       68 ASSOCIATED MODALITES
------------------------------------------------------------------------------------------
   1 . Landownership status                                                 (   4 MODALITES )
   7 . Family labor                                                         (   4 MODALITES )
   8 . Agricultural land area                                               (   5 MODALITES )
   9 . Irrigation technique used                                            (   3 MODALITES )
  10 . Source water used                                                    (   2 MODALITES )
  11 . Ground water assets                                                  (   2 MODALITES )
  12 . Subsidies                                                            (   2 MODALITES )
  13 . Farm investment                                                      (   2 MODALITES )
  14 . Marketing channel                                                    (   3 MODALITES )
  15 . Farm equipment                                                       (   2 MODALITES )
  16 . Off-farm income                                                      (   2 MODALITES )
  17 . % of irrigated area/TAA                                              (   5 MODALITES )
  18 . % of citrus/TAA                                                      (   4 MODALITES )
  19 . % of orchard/TAA                                                     (   4 MODALITES )
  20 . % of grape/TAA                                                       (   4 MODALITES )
  21 . % of industrial culture/TAA                                          (   4 MODALITES )
  22 . % of green house/TAA                                                 (   2 MODALITES )
  23 . % of vegetable/TAA                                                   (   4 MODALITES )
  24 . % of cereal/TAA                                                      (   2 MODALITES )
  25 . Farm income                                                          (   5 MODALITES )
  26 . % of abandoned area/TAA                                              (   3 MODALITES )
------------------------------------------------------------------------------------------
SUPPLEMENTARY CATEGORICAL VARIABLES
     5 VARIABLES       15 ASSOCIATED MODALITES
------------------------------------------------------------------------------------------
   2 . Age                                                                  (   4 MODALITES )
   3 . Education                                                            (   5 MODALITES )
   4 . Agricultural training                                                (   2 MODALITES )
   5 . Source of information                                                (   2 MODALITES )
   6 . Organization membership                                              (   2 MODALITES )
------------------------------------------------------------------------------------------
CASES
----------------------------- NUMBER -------------- WEIGHT ---------------
 WEIGHT OF CASES    : Weight of objects, uniform equal to  1.             UNIF
 KEPT ............ NITOT =     134       PITOT =             134.000
 ACTIVE .......... NIACT =     134       PIACT =             134.000
 SUPPLEMENTARY ... NISUP =       0       PISUP =               0.000
--------------------------------------------------------------------------
```

Results of Multiple Correspondence Analysis in East Mitidja

Table6: Eigen values, raw and modified rates for the first MCA axis.

	Dim 1	Dim 2	Dim 3	Dim 4
Eigen values (λ)	0.2437	0.2142	0.1541	0.1153
Raw rates of inertia	11.89%	10.45%	7.52%	5.63%
Modified rates	32%	23%	9.23%	3.64%
Cumulative modified rates	32%	55%	64%	68%

- **Dimension 1 (11.89%):**

Discriminates between large EAC farms in subdivision and Small private farms that are not subsidized.

- **Dimension 2 (10.45%):**

Opposes EAC farms in union based on citrus farming system with some investment done on the farm. On the other side, we find farms based on vegetables farming system & less than half of their area is irrigated.

- **Dimension 3 (7.52%):**

Identifies farms that own ground water assets, conjunctive use of water resources, use the gravity technique and water-saving technologies together.

Results of Multiple Correspondence Analysis in East Mitidja

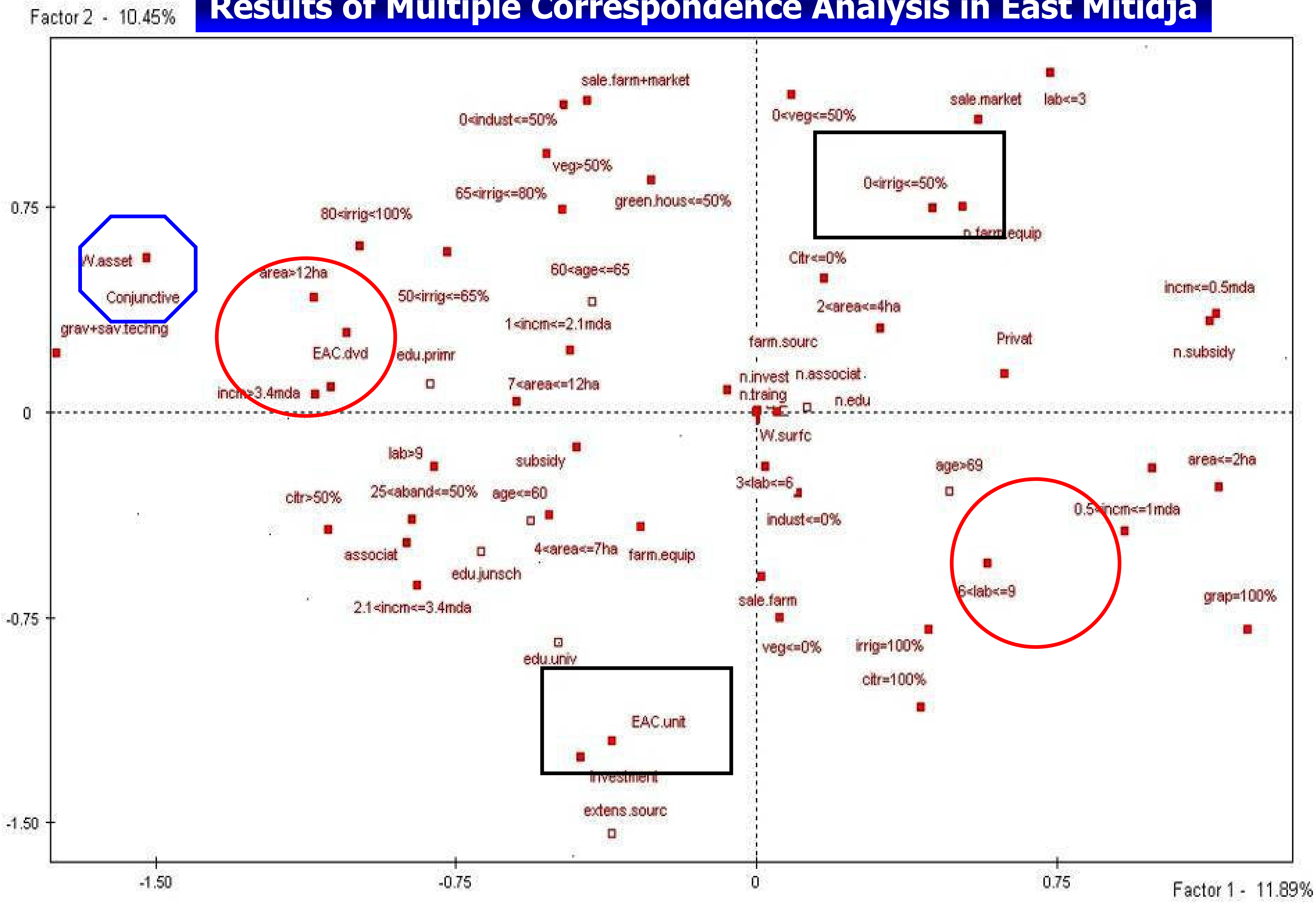


Figure 1: Representation of dimensions 1 and 2.

Results of Cluster Analysis in East Mitidja scheme

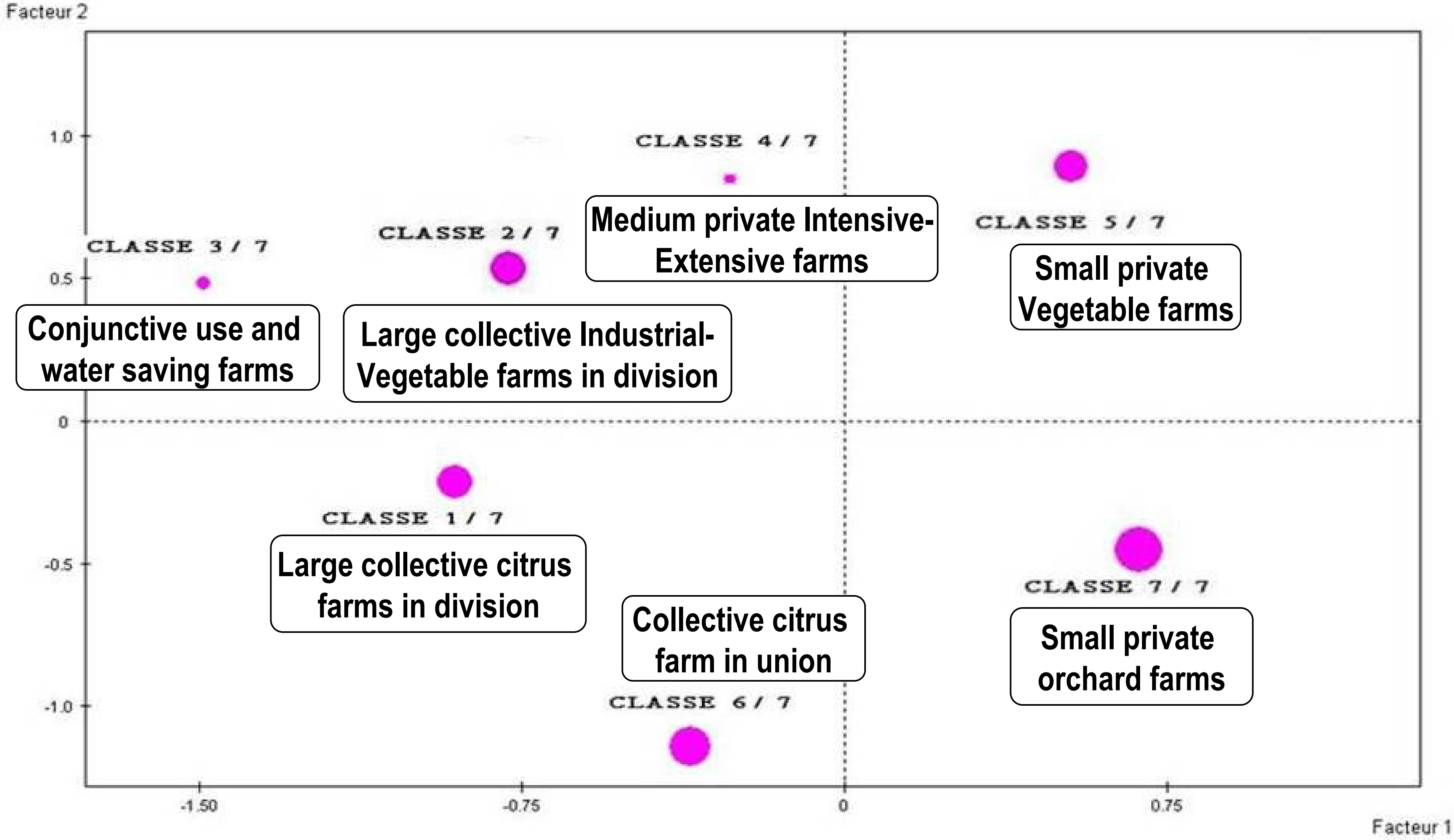


Figure: Representation of farmers' types in the 2 first axes of the MCA

Farm typology in East Mitidja scheme

CLASS 1 (22 farms): Large collective farms in division - land fragmented into smaller parcels between its members due to conflicts -.Area greater than 12 ha. Between 25 to 50% of the total area is abandoned. Main farming system based on citrus. Gravity as irrigation technique**.** no contact with extension services, no investments. Only with Agric. subdivisions

CLASS 2 (22 farms): Large collective farms in division with an area greater than 12 ha and farming system based on association of industrial culture and vegetable. Gravity as irrigation technique. no contact with extension services, no investments. Only with Agric. subdivisions

CLASS 3 (7 farms): Farms using water saving technologies and conjunctive use of water resources. Varied farming system and size. Subsidized farms. no contact with extension services. Only with Agric. subdivisions.

CLASS 4 (5 farms): Medium private farms with farming system based on intensive and extensive vegetable. Subsidized farms. Gravity as irrigation technique**.** no contact with extension services. Only with Agric. subdivisions

CLASS 5 (21 farms): Small private farms based on extensive vegetable farming where irrigated area is less than 50%. Not subsidized. Gravity as irrigation technique. no contact with extension services, no investments

CLASS 6 (27 farms): Collective farm in union - land is not fragmented and its members are still united in farming activities and decision-making -.Area less than 7 ha. Farming system based on citrus. Farm equipment. Subsidized farms. Gravity as irrigation technique. In Contact with extension services, made investments.

CLASS 7 (30 farms): Small private farms with an area less or equal to 2 ha, farming system based on either citrus or grape. Not subsidized. Gravity as irrigation technique. no contact with extension services, no investments

Building Typology

In West Mitidja scheme

Variables used in the Multiple Correspondence Analysis

```
SELECTION OF CASES AND VARIABLES
ACTIVES CATEGORICAL VARIABLES
    21 VARIABLES        65 ASSOCIATED MODALITES
---------------------------------------------------------------------------------------
   1 . Landownership status                                              (   4 MODALITES )
   6 . Agricultural land area                                            (   5 MODALITES )
   7 . Irrigation technique used                                         (   3 MODALITES )
   8 . Source water used                                                 (   2 MODALITES )
   9 . Ground water assets                                               (   3 MODALITES )
  10 . Farm investment                                                   (   2 MODALITES )
  11 . Subsidies                                                         (   2 MODALITES )
  12 . Marketing methods                                                 (   3 MODALITES )
  13 . Farm equipment                                                    (   2 MODALITES )
  14 . Drainage                                                          (   2 MODALITES )
  15 . % of irrigated area/TAA                                           (   5 MODALITES )
  16 . % of citrus/TAA                                                   (   4 MODALITES )
  17 . % of orchard/TAA                                                  (   3 MODALITES )
  18 . % of grape/TAA                                                    (   2 MODALITES )
  19 . % of green house/TAA                                              (   2 MODALITES )
  20 . % of vegetable/TAA                                                (   3 MODALITES )
  21 . % of cereal/TAA                                                   (   3 MODALITES )
  22 . % of fallow/TAA                                                   (   2 MODALITES )
  23 . % of rented area/TAA                                              (   3 MODALITES )
  24 . Farm income                                                       (   5 MODALITES )
  25 . Family labor                                                      (   5 MODALITES )
---------------------------------------------------------------------------------------
SUPPLEMENTARY CATEGORICAL VARIABLES
     5 VARIABLES        13 ASSOCIATED MODALITES
---------------------------------------------------------------------------------------
   2 . Age                                                               (   4 MODALITES )
   3 . Education                                                         (   3 MODALITES )
   4 . Source of information                                             (   2 MODALITES )
   5 . Organization membership                                           (   2 MODALITES )
  26 . Agricultural training                                             (   2 MODALITES )
---------------------------------------------------------------------------------------
CASES
----------------------------- NUMBER -------------- WEIGHT ----------------
 WEIGHT OF CASES   : Weight of objects, uniform equal to  1.              UNIF
 KEPT ............ NITOT =     48     PITOT =            48.000
 ACTIVE .......... NIACT =     48     PIACT =            48.000
 SUPPLEMENTARY ... NISUP =      0     PISUP =             0.000
--------------------------------------------------------------------------
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Results of Cluster Analysis in West Mitidja scheme

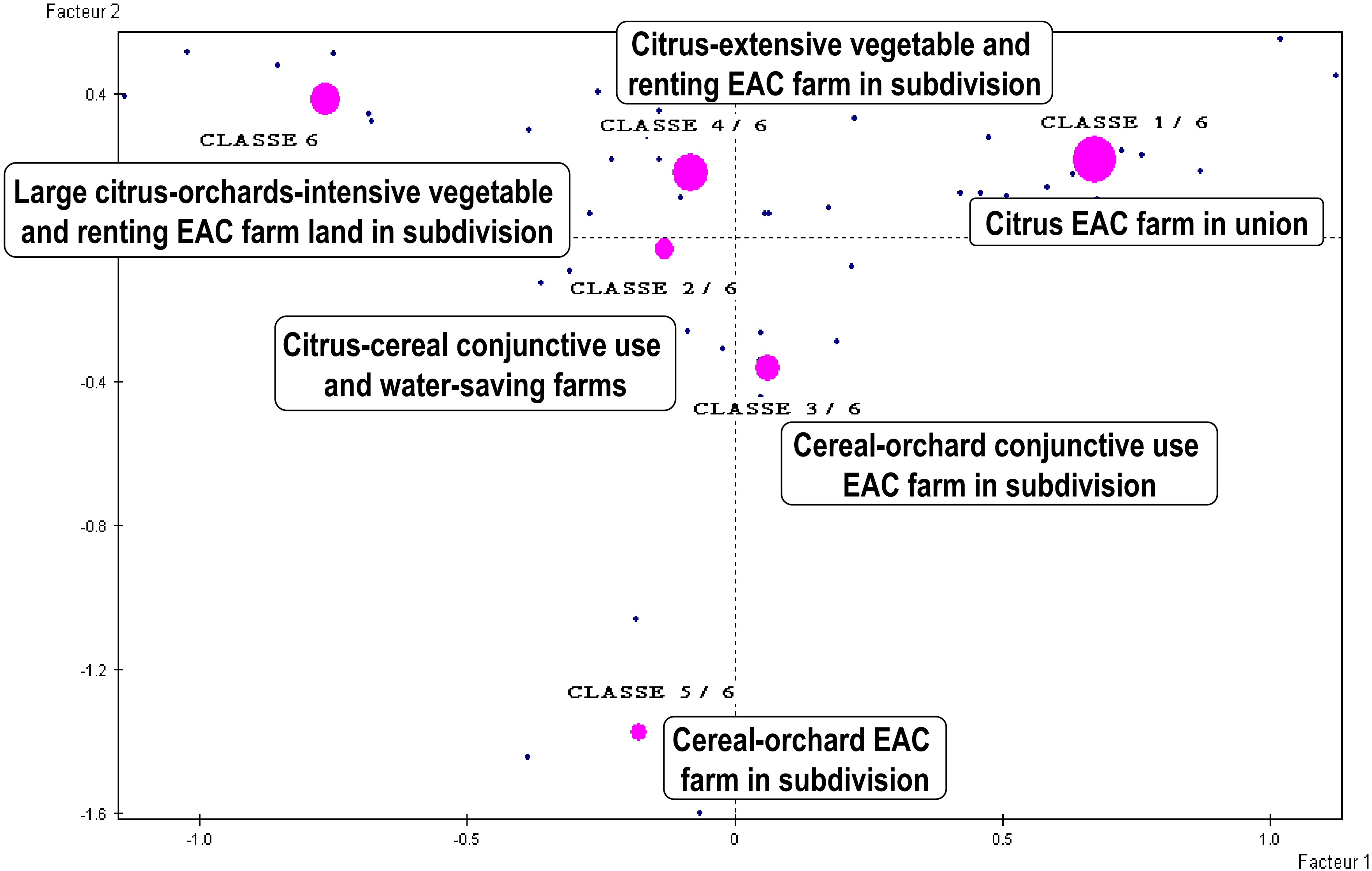


Figure: Representation of farmers' types in the 2 first axes of the MCA

Farm typology in West Mitidja scheme

Class 1 (14 farms). EAC farm in union that is well organized, Area < 7 ha, farming system based on citrus. Conjunctive use of water and water saving. Made investments, Subsidized and in contact with extension services, the average age < 60 years old.

Class 2 (4 farms): Citrus-cereal farming systems, cereal area < 50% of TAA. No investments, gravity technique, subsidized, conjunctive use and water-saving technology, no contact with extension services, marketing as a sale at the farm.

Class 3 (7 farms). Cereal-orchard farms, cereal > 50% of TAA, conjunctive use EAC farm land in subdivision", no contact with extension services, and no investments.

Class 4 (11 farms). EAC farm land in subdivision, citrus-vegetable farming, and less than 50% of TAA is rented and used for vegetable cultivation. No contact with extension services, and no investments.

Class 5 (4 farms). EAC farm land in subdivision, use only surface water, cereal-orchard farming, gravity system, irrigation<30%, the age > 70 years old, and the marketing channel is a sale at the farm.

Class 6 (9 farms). EAC farm land in subdivision, area > 25 ha, citrus-orchards farming. More than 50% of TAA is rented and used for intensive (greenhouse) and extensive vegetable, gravity and water-saving technology and conjunctive use of water resources, >1 tube well. no contact with extension services and no investments.

Key discussion results

- The variable farm size was not found to be the only principal variable of heterogeneity in the irrigated farms. The other functional and structural variables used in this study have been the main contributors to this heterogeneity.

➢ <u>Land ownership constraint</u>

- PNDA policy have not benefited all farm types. Ownership status is the main cause of the failure of this policy.
- As results, Farmers are not interested in agricultural information, have no contact with extension services, they have made no investments and they have not introduced innovations to their farms
- Disengagement of some farm types from government support due to a lack of confidence in the state. This situation forced farmers to associate with external financing sources that in very often cases has no link with the world of farming and whose primary concern is the speculation and immediate gain without concern of investment aiming to improve the production factors .
- Logic of farmer's class 2 and 4 in West Miiidja: short-term speculative crops that require minimal investment, or to rent part of their farm land to other farmers without legal documentation because the EAC farm land is still state-owned property.

➢ Complications for the irrigation management

- Problems of supplying water and fee collection to the classes of EAC farm land in subdivision The division of collective farm lands into peasants' personal plots – gathered either by a family relationship, either regional or even by center of interest- induced dispute and even confrontation between members over the use of water resources.
- These farm types created serious problems for the irrigation agency in estimating the volume consumed (it should be noted that the water delivery is not metered) and agreeing on the amount owed by each farmer.
- Competition at the irrigation intake and the priority of irrigation given to the orchards causes jealousy among other farmers.
- Access and sharing of water resources remains unreliable for some farmers including dissatisfaction from the low water pressure and low flow rate .
- Furthermore, the delay of the starting of irrigation campaign in the irrigation schemes due to lack of maintenance of the irrigation system and availability of water, discourages the farmer to start the agricultural works.
- As consequences, these situations above created a feeling of pessimism among many farmers.

➢ Water availability constraints

- Abandonment of part of the farmland (class 1) and also in under-irrigated farmland (class 5)
- Most farms who benefited from PNDA acquired storage tanks “long-term-sustainable structure”, rather than acquiring water-saving technologies (classes 1, 2 and 6) -short-term- sustainable structures requiring technical knowledge.
- While installing the water-saving technologies, no extension services to supervise them, no technical assistance and no follow-up.
- The gravity system is still the most dominant technique in the scheme. The typology also shows that farmers with groundwater assets are more likely to use water-saving technologies such as class 3 in East Mitidja and class 1, 2, 4 and 6 in West Mitidja, than those without.
- The distribution of equipped area with water saving technologies in Class 3 concern mainly the orchard with more 67% of total area and vegetables with less than 23% of total area. While in West Midtija, it concern mainly citrus and vegetables under green house
- For the classes who do not benefit subsidies, the lack of investment, the predominance of small agricultural surface, and undefined ownership status, show that the traditional method of irrigation (furrow higher water losses) will may last for a long time.

➢Farm functioning

The constraints mentioned above have made many farm's type unable to meet intensification goals.

- Classes 5 and 2 generally do not have or follow any specific rotation plan. Due to lack of financial credit, they decide the cultivation plan for each land parcel at the beginning of each agricultural cycle (short-cycle crops requiring minimal agricultural equipment and labor).
- Due to Land ownership, same outcome has been observed in classes whose one of the faming system is based on rainfed cereal in West Mitidja. In fact, the cereal farming is characterized by low use of inputs particularly fertilizers and pest and disease control which resulted in yield less than 10.5qx/ha in average..
- In class 2, industrial tomato farming represented more than 50% of the total agricultural area; however, due to a lack of national policy to revitalize the agribusiness industry sector forced this group of farmers to develop farming diversification strategies that reduce risk and expenditure.
- Low use of input- low productivity in farmers group (2 and 5) while Class 4 seek higher income through modernization.
- Orchards are not farmed using modern techniques of farming in class1 and 7 compared to Class6. Farmers of these classes are reluctant to try innovation and are subject to pressure from other farmers; therefore information and technology are not important for these groups. By contrast, class 6 farmers plan to diversify and develop other species of citrus in the future.
- Due to a lack of resources and market uncertainty, the sales at the farm is the most adopted marketing system in the scheme. However, it deprived farmers to improve their income and discouraged them from making investments in their farms.

CONCLUSION

- Our typology provided a means of understanding the diversity of farmers with regard to their socio-economic environment.
- It also helped us to identify those farms that fall into broad categories of unsustainability.
- The PNDA - have a differential effect on various types of farmers, favoring some and discouraging others.
- The results of PNDA policy failed to meet expectations, and are insignificant in terms of the adoption of irrigation techniques.
- The bio physical and socio-economic environment constraints, and the lack of environmental support prevented the implementation of various development programs.
- This situation led to the unsustainable exploitation of the water and land resources.


Irrigated farms


Irrigated farms


Irrigated farms


Irrigated farms


Irrigated farms


Irrigated farms


Irrigated farms

CHAPTER 4

Effects on Irrigation Profitability in Irrigation Schemes: The Case of the East Mitidja Scheme.

OBJECTIVE

◆To provide insight into the profitability of irrigation under the current agricultural irrigation policies.

SPECIFIC OBJECTIVES

A) Evaluate the water productivity by crops and farmers groups.

B) Assess the sensitivity of water productivity to production factors.

C) Assess the implications of the findings in terms of water prices and cost recovery

METHODOLOGY

Residual Valuation Method (RVM):

- The residual method also known as farm budget technique is the most common deductive method applied to irrigation water valuation (Young, 2005).

- It seeks to find the maximum return attributable to the use of water input.

- It expressed mathematically as: Pw*= {TVPy- [(PK X QK) + (PL X QL) + (PR X QR)]} capital (K), labor (L), land (R), irrigation water (W), TVP represents Total Value of Product Y; quantity of resource (Q).

- This method can be applied to evaluate the water productivity in the selected case study. Water productivity has been computed by subtracting production costs from total revenue and then dividing the residual value by the quantity of water used.

DATA ANALYSIS

- Only East Mitidja scheme was selected for this study.
- On the sample farms, data were collected on Input and output costs and quantities (variable and fixed costs)
- Following steps were used to analyze the data.

✓ **1st step**: *Using RVM, we estimate water value or return to water by crop types*

✓ **2nd step**: Assess the sensitivity of the return to surface water to variations of different input parameters by crops' types.

✓ **3rd step**: Using RVM, we estimate the water value at farmer groups' level (based on typology).

✓ **4th step**: Assess the sensitivity of the return to surface water to variations of crop price by farmers' types .

✓ **5th step**: Comparison between water values, water costs and water price as well as simulation of income variation to water price changes.

1st step:

RESULTS AND DISSCUSSION

Water values by crop types:

Table8: Returns to surface water in Mitidja East scheme

Crops*	Potato	Industrial	Grape	Apple	Carrots	Onion
Profit (Da/Ha) under rainfed	[illegible]	[illegible]	[illegible]	[illegible]5,000	46,000	58,000
Profit (Da/Ha) with irrigation (1)	[illegible]	318,500	335,900	316,850	117,750	119,900
Profit (Da/Ha) with irrigation (2)	[illegible]	[illegible]	[illegible]	[illegible]	280,000	------
Water used (m^3) (1)	6,48[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4,000
Water used (m^3) (2)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	------
Return to water (Da/ m^3) (1)	18.09	[illegible]	27.18	31.52	14.35	12.35
Return to water (Da/ m^3) (2)	63.59	86.08	112.52	113.31	58,50	------

The net profit under irrigation with different crops per hectare is greater than the one with rainfed.

Returns to water vary not only among crops but also depend on the irrigation technology used

Returns to water for crops using water saving technologies are higher than those using gravity irrigation system.

(1) Using gravity system
(2) Using water saving irrigation technology (sprinkler and drip)

*high yield
Da1=$0.014 (2006)

Key findings

- Analysis of returns from using surface water resources shows that returns to water vary not only among crops but also depend on the irrigation technology used.

- Higher Returns to water were achieved due to water use efficiency.

- The improvement of systems efficiency for different crops has increased the profit by almost 180% on average.

- Public subsidies for water-conserving irrigation investments had contributed to increase the return to water in the scheme.

- Nevertheless, it should be mentioned that the use of fertilizers and chemicals in Algeria is still low compared to those countries with intensive agriculture in Mediterranean region

- The higher proportion of the return to water can also be explained by the semi arid conditions of the scheme, which make irrigation a crucial input of production.

2nd step:

Sensitivity analysis

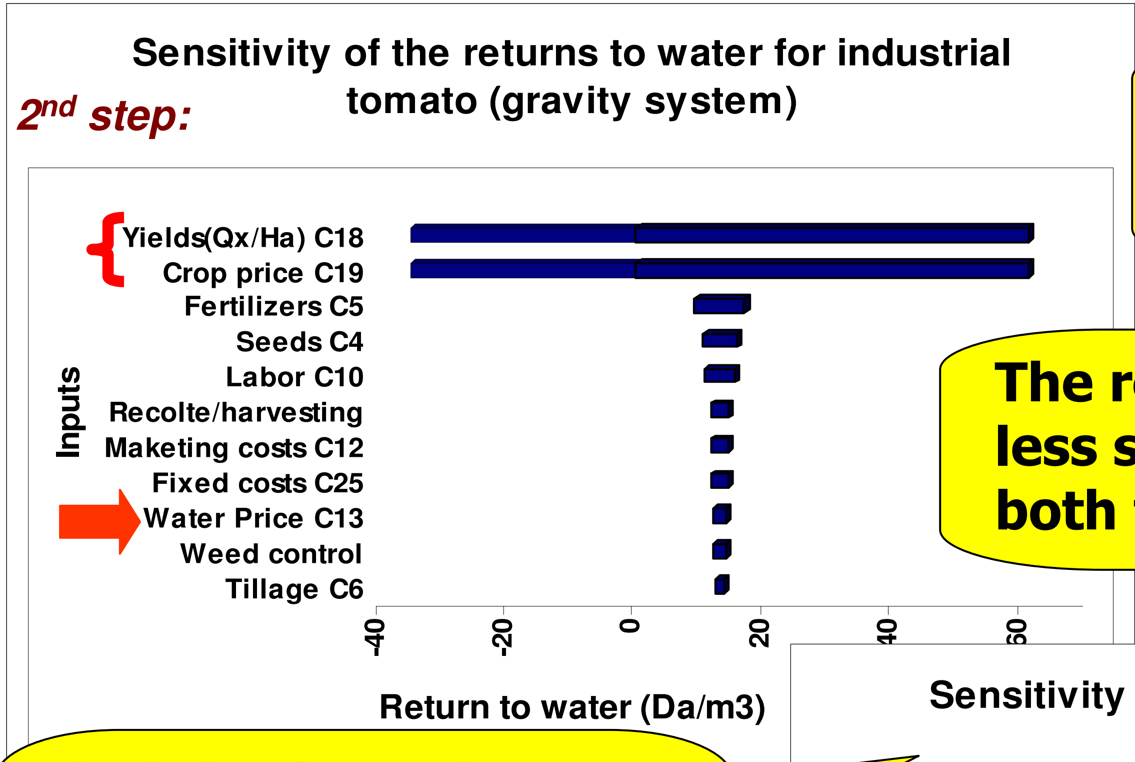
- ❑ The sensitivity analyses presented here include variation of different input such as water price, crop market price, yield, seeds cost, fertilizers cost, labor cost and fixed costs.

- ❑ The model output values of the return to water were measured at different intervals.

- ❑ For each input parameter, simulations were conducted for the correct value (s), ±13 percent, ±26% and ±40 %.

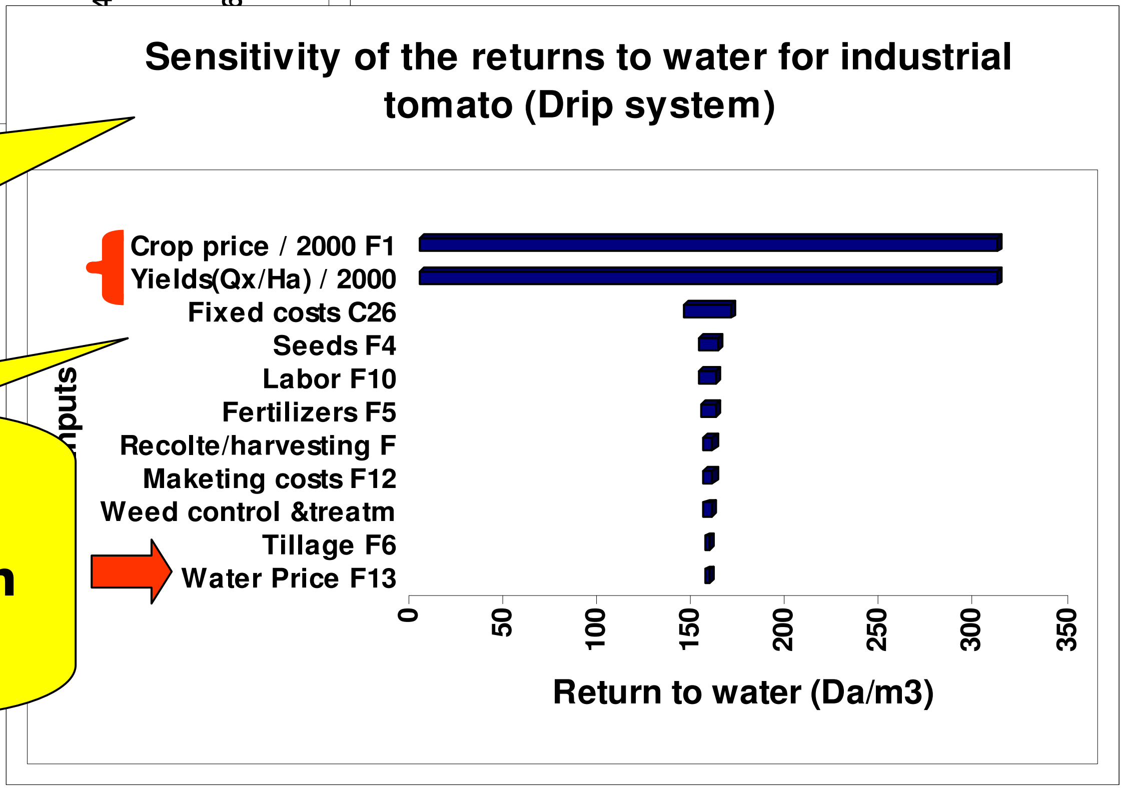
- ❑ The results of sensitivity analysis are displayed as a "tornado" type chart, with longer bars at the top representing the most significant input variables.

2nd step:



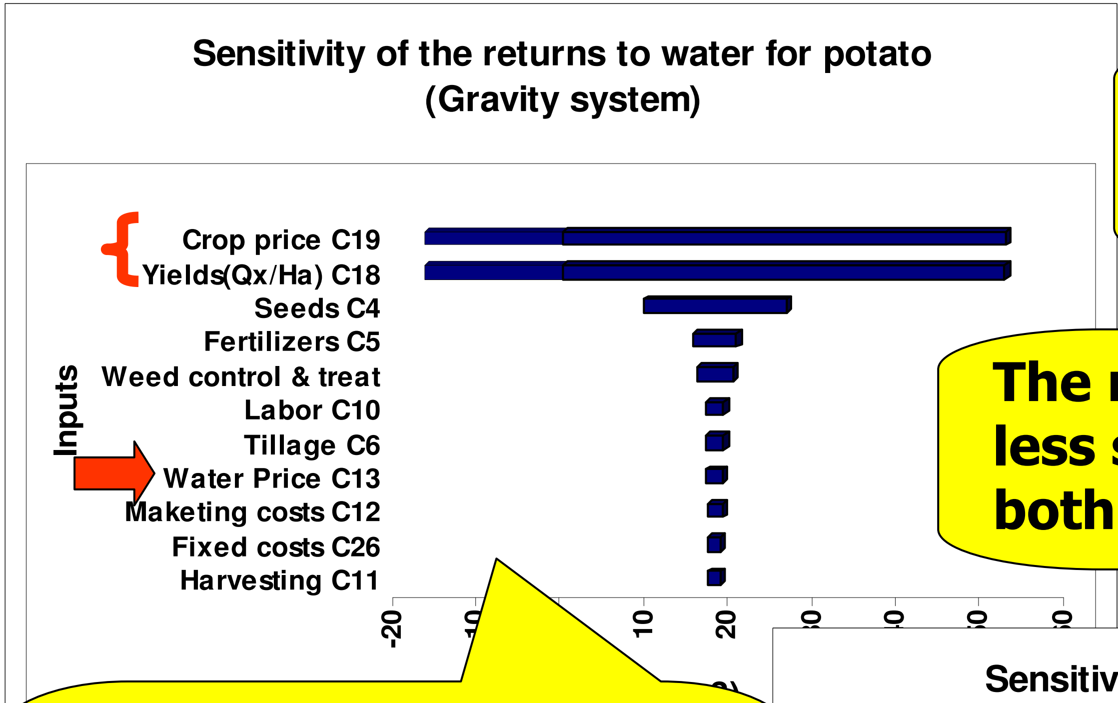
Most Factors affecting returns to water were: *crop market price and yield*.

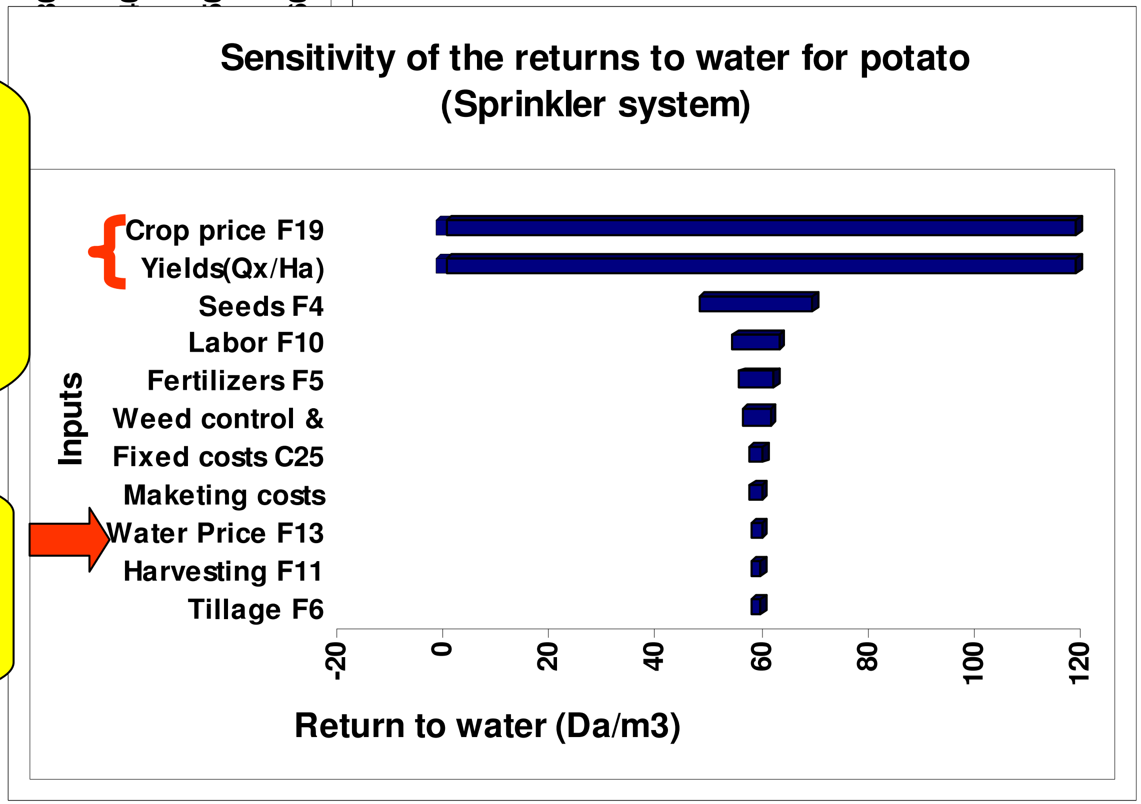
The return to water was found less sensitive to *water price* for both figures



The irrigation technology plays an important role in variation of different input on the return to water.

The irrigation technology allowed an efficient application and reduction in amount of fertilizers.



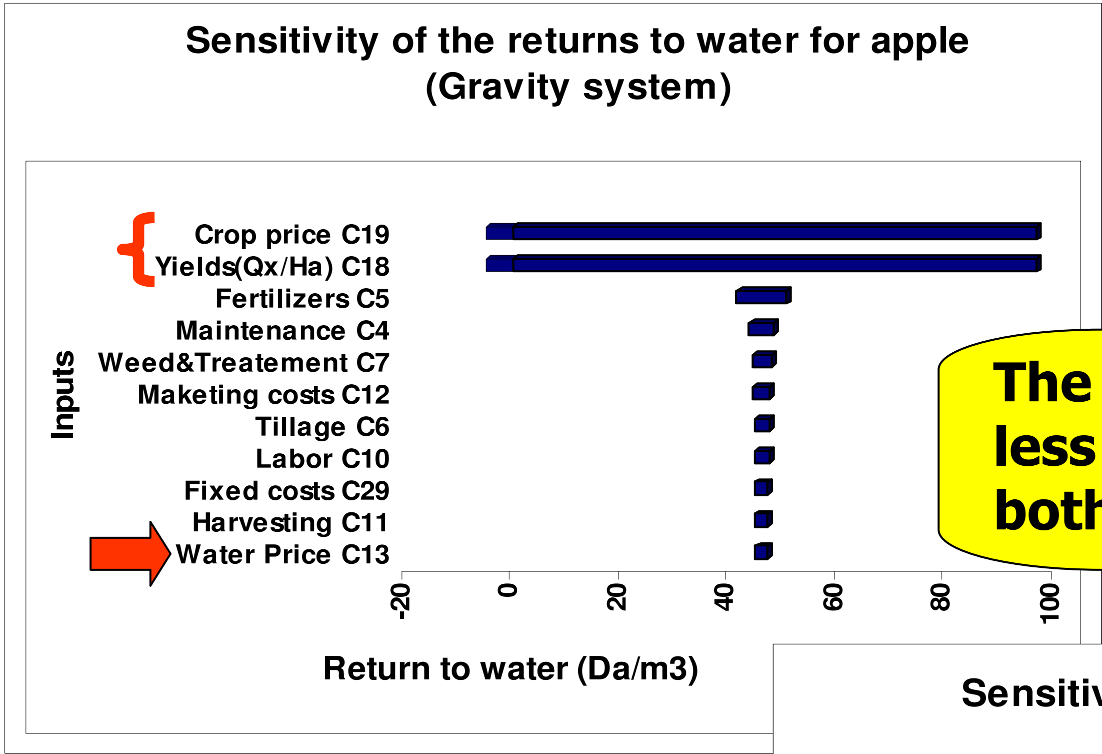


Most Factors affecting returns to water were: *crop market price and yield*.

The return to water was found less sensitive to *water price* for both figures

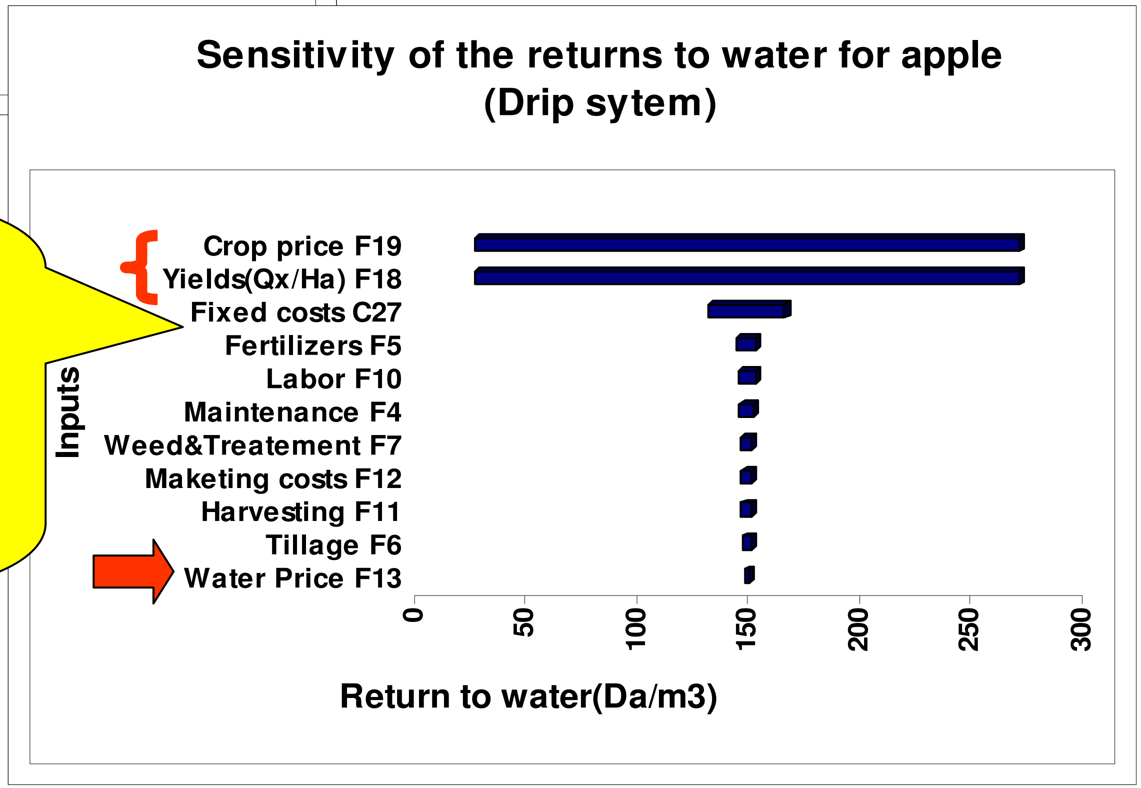
Using gravity system the fixed costs show low impact on returns to water. [low capital costs and simple to operate].

Seeds still have a great impact on return to water (*sensitive in both systems*)



Most Factors affecting returns to water were: *crop market price and yield*.

The return to water was found less sensitive to *water price* for both figures



Using irrigation technologies the *fixed costs* has a great impact on return to water (more sensitive then in gravity irrigation system).

3rd step: **Water values by Farm groups**

Table9: Farm groups' characteristics

Group1	***Size (ha):*** **16.** ***Irrigated area (%)*****: 62.50.** ***Irrigated crop (ha)*****: Citrus; 10**
Group2	***Size (ha):*****16.28.** ***Irrigated area*** **(%): 87.** ***Irrigated crop (ha)*****: Industrial tomato: 5.4, Potato: 2.3, Sweet Peppers: 0.75, Eggplant: 1, Carrot: 0.5, Turnip: 0.15, Zucchini: 1.1, Salad: 0.2, French Beans: 1.8, Onion: 0.2, Cabbage: 0.7**
Group4	***Size (ha):*** **4.92.** ***Irrigated area (%)*****: 93.** ***Irrigated crop (ha)*****: Greenhouse: 1.07, Potato; 0.68; Tomato; 0.59; Sweet pepper; 0.37; Eggplant; 0.2; Carrot; 0.12; Zucchini; 0.67; French Beans; 0.42; Cabbage; 0.46**
Group5	***Size (ha):*** **2.47.** ***Irrigated area (%)*****: 40.42.** ***Irrigated crop (ha)*****: Potato 0.164; Sweet Peppers; 0.077; Eggplant 0.067; Carrot; 0.192; Turnip; 0.038; Zucchini; 0.365; French Beans; 0.096**
Group6	***Size (ha):*** **6.18.** ***Irrigated area (%)*****: 100.** ***Irrigated crop (ha)*****: Citrus; 6.18**
Group7a	***Size (ha):*** **2ha.** ***Irrigated area (%)*****: 100.** ***Irrigated crop (ha)*****: Grape; 2**
Group7b	***Size (ha):*** **0.83ha.** ***Irrigated area*****: 100%.** ***Irrigated crop (ha)*****: Citrus; 0.83**

3rd step. ctd:

Water values by Farm groups

Table10: Results of returns to water in East Mitidja scheme

Farm Groups	Total non-water costs (Da)	Total profit (yield*prix) (Da)*	Total revenue (Da)	Total water volume (m^3)	Returns to water (Da/m^3/ha)**
Group1	778,500	2,900,000	2,121,500	51,000	41.59
Group2	1,599,49	2,713,700	1,113,852	34,924.6	24.32
Group4	1,724,261	3,428,330	1,704,069	13,622.94	76.91
Group5	79,484.16	111,130.4	31,646.22	1,900.44	15.36
Group6	940,596	3,708,000	2,767,404	33,124.8	83.54
Group7a	182,200	540,000	357,800	10,800	33.12
Group7b	53,825.5	224,100	170,274.5	4,233	40.22

* Da1=$72.64 (2006). **return to water=average returns to water from combined crops per group of farms.

Lowest value due to technical and natural factors

Lowest value in orchards farms due to poor management & lack of maintenance for a long period, less use of input & experience problems with aging trees

4th step:

Sensitivity Analysis by Farm groups

Table11: Price fluctuation and returns to water in the irrigation scheme

Farm Groups	Returns to water	Returns to water If crop price -10%	Returns to water If crop price -20%	Returns to water If crop price -30%
Group1	41.59	35.91	30.22	24.54
Group2	24.32	14.51	4.70	-5.10
Group4	76.91	59.49	42.07	24.65
Group5	15.36	9.91	4.46	-0.98
Group6	83.54	72.35	61.15	49.96
Group7a	33.12	28.12	23.12	18.12
Group7b	40.22	34.93	29.63	24.34

* Returns to water in Da/ m^3

In Groups 2 and 5, returns to water reduced by more than 37% in average

For the remaining groups, It reduced by less than 18.44% & this is due to their higher revenues per hectare.

Reducing crop price by 30% will result in negative returns for Groups 2 and 5

5th step:

Water Cost, Water Price and Water Value

Table12: Comparison of Water Cost, Water Price and Water Value in the irrigation scheme

Costs	Total O&M costs (10^3Da)	Volume (hm3)	Water Cost (Da/m3)	Water price (Da/m3)	Water Value Average (Da/m3)
Cost (Da)	15,576.7	5,117,868	3.04	2.5	45.00

- The calculation of O&M cost is based on the energy, operations, and maintenance costs of providing the irrigation service, excluding capital expenditures and depreciation (Cost Recovery Objective).

The average water value > the costs of irrigation supply > the water price
i.e. "Irrigation is profitable in the scheme"

5th step, ctd:

Simulation of water price changes on farmer's income

Table13: Farms' income at water price, O&M costs and marginal costs

	Income (10^3Da) at Da 2.5/m^3	Income (10^3Da) at Da 3.04/m^3	Income variation (%)	Income (10^3Da) at Da 19.2/m^3	Income variation (%)
Group1	1,920	1,892.4	-1.43	1,068.3	-44.35
Group2	1,020.9	1,002.	-1.84	437.7	-57.13
Group4	2,647.2	2,639.9	-0.27	2,419.7	-8.59
Group5	26.5	24.6	-7.17	-5.2	-119.78
Group6	2,688.3	2,670.4	-0.66	2,135.1	-20.57
Group7a	330	324.6	-1.63	163	-50.6
Group7b	118.7	116.4	-1.92	47.9	-59.55

If farmers pay the O&M cost, the income will decrease insignificantly by only 2.73% on average.

If the farmers pay the marginal costs, the income will decrease by more than 50% on average and more than 119 % for Group 5

CONCLUSION

- Water values were found greater than the water price as well as the cost of water delivery.
- The return to water was found less sensitive to water price for all crops and farmers' groups.
- The returns to water were found to be very sensitive to crop price fluctuations, particularly for Groups 2 and 5, and less for farms based on orchards farming.
- Irrigation under the current price is profitable even using some technologies (high fixed costs). This fact explains that maximizing a profit depends primarily on the other inputs.
- The bio physical and socio-economic environment of the farmers contributed to less investment in agriculture, and thus resulted to low water productivity.
- If water price levied to O&M costs, the farmers' income will decrease insignificantly; but, if it is levied to the marginal cost, some farmers' groups in the scheme may not be able to pay.

CHAPTER 5

Conclusion, Recommendations & Research implications

CONCLUSION 1/2

➢ *As regards to water policy*

- The current policies have led to mixed results. Indeed, the policies are strongly oriented to supply-side management.
- Water policy has not worked as efficiently in terms of water allocation between users. The lack of coordination at the institutional and local level has led to poor monitoring of scarce water-supply services.
- Weak involvement of stakeholders along with the indifference of local administrations, exacerbates irrigation management issues.
- The cost recovery principle has not achieved the expected goals of sustainable irrigation schemes. The water price did not reflect the total cost of irrigation supply.
- The maintenance budget in both schemes is below the international and regional norms.
- Inadequacy of the irrigation system components with regard to farm configuration, Fee collection constraints, water losses, socioeconomic environment and human factors have also worsens the water management in the schemes.
- As results, both irrigation schemes are in low equilibrium cycle.

CONCLUSION 2/2

➢ As regards to agricultural policy

- The results of PNDA were below the expectations and the main failure of the policy is the farm diversity.
- The policy of modernization of the farms was selective. It hit few farmers, particularly which had the potential.
- The socio-economic and biophysical constraints have been an obstacle to investments and development of the farm and thus led to unsustainable irrigation scheme.
- However, irrigation under the transition period is profitable for all farmers' groups in the irrigation scheme, including those who benefit from subsidies and those who do not.
- Maximizing a profit depends primarily on the other production inputs.
- The profitability of using irrigation was found to be very sensitive to crop price fluctuations.
- The water cost as well as water price are low compared to returns to water.
- The simulation results of increasing water price to the marginal cost showed that farmers with low returns will be adversely affected and may not be able to irrigate.

Recommendations & Research implications

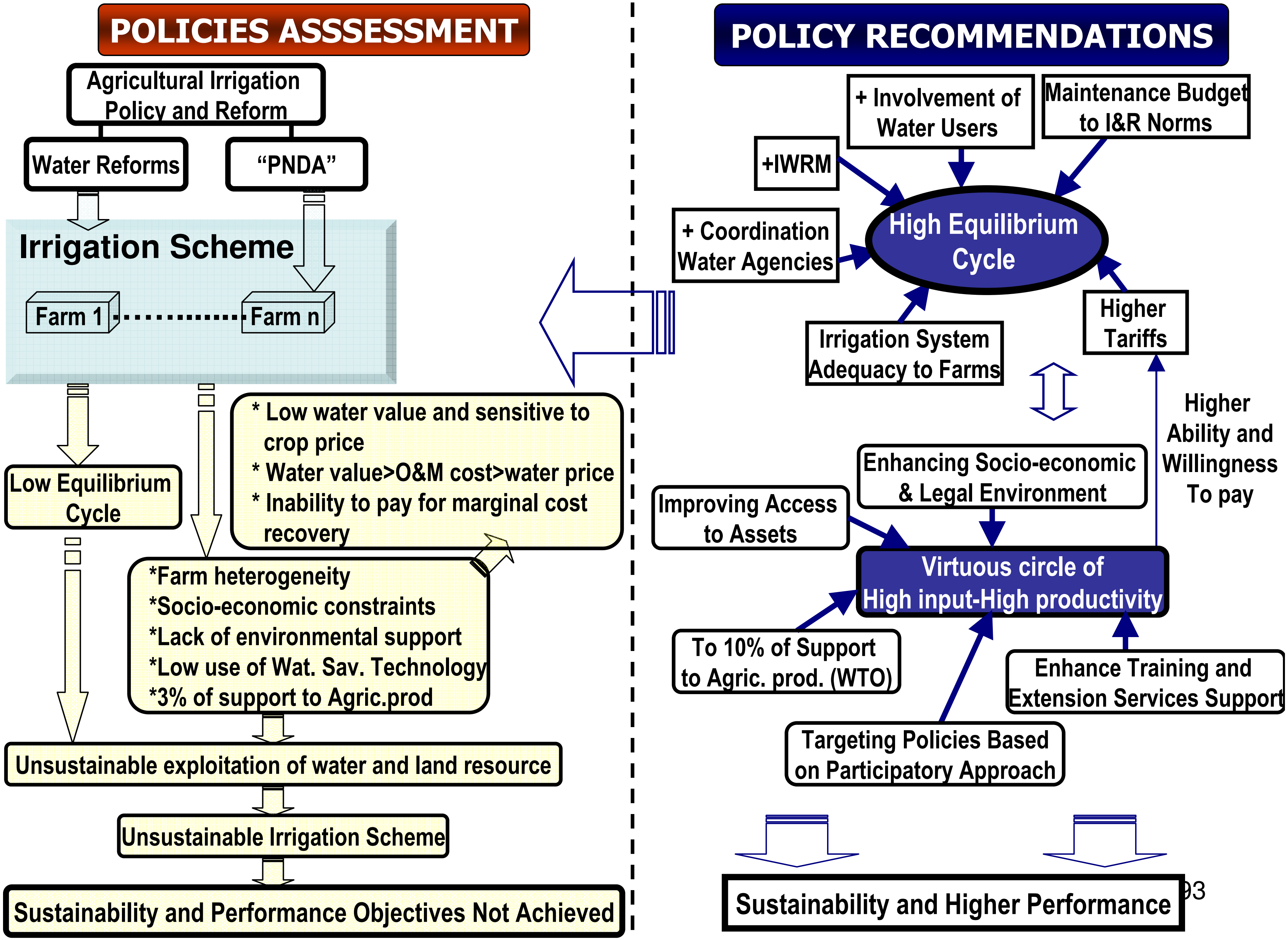
- The multi-approach analysis used in the thesis seeks to provide a new irrigated agriculture policy strategy that will remove the constraints to sustainable development of irrigated agriculture in Algeria and also in other scarce water countries.

  Thus, recommendations can be made for the sustainable management of irrigation schemes.

- The water policy should move toward water conservation approach.
- Decentralization and increased involvement of all stakeholders.
- Water management should be integrated into urban policy planning and management.
- Institutionalization of public-private partnerships in irrigation development
- Enhanced coordination between water agencies and institutions
- Irrigation system upgrades
- Cost-effective operation and maintenance
- Capacity development for both staff and farmers
- Awareness campaigns and mentoring will guide farmers toward high productivity and efficient use of inputs.
- Development and promotion of affordable and appropriate irrigation technologies
- Pricing and incentives for improvements in water-use efficiency
- The use of water meters to improve accountability
- Improvement of the billing system to recognize the particularities of each crop type.

Recommendations & Research implications

- The success of implementation of agricultural policies and irrigated agricultural development requires a participatory approach that involves both farmers and their working groups.
- Such approaches must take into account the biophysical, technical, socioeconomic and legal constraints faced by farms.
- Moreover, Solutions should promote longer-term strategies that take into account the heterogeneity of irrigated agriculture.
- Our system approach used in this study is a useful tool to identify and characterize farm diversity so that solutions can be offered to all farmers.
- In recognizing this diversity, we may better understand the barriers to modernization, the consequences of development activities and what support is necessary to achieve sustainable modernization.
- Therefore, our research outcomes may help decision makers to implement appropriate interventions in terms of resources, conditions and interests that are compatible with each identified group of farms. It may also help policymakers to identify priorities.


POLICIES ASSSESSMENT
Agricultural Irrigation Policy and Reform
Water Reforms
"PNDA"
Irrigation Scheme
Farm 1
Farm n
Low Equilibrium Cycle
* Low water value and sensitive to crop price
* Water value>O&M cost>water price
* Inability to pay for marginal cost recovery
*Farm heterogeneity
*Socio-economic constraints
*Lack of environmental support
*Low use of Wat. Sav. Technology
*3% of support to Agric.prod
Unsustainable exploitation of water and land resource
Unsustainable Irrigation Scheme
Sustainability and Performance Objectives Not Achieved
POLICY RECOMMENDATIONS
+ Involvement of Water Users
Maintenance Budget to I&R Norms
+IWRM
+ Coordination Water Agencies
High Equilibrium Cycle
Irrigation System Adequacy to Farms
Higher Tariffs
Higher Ability and Willingness To pay
Enhancing Socio-economic & Legal Environment
Improving Access to Assets
Virtuous circle of High input-High productivity
To 10% of Support to Agric. prod. (WTO)
Enhance Training and Extension Services Support
Targeting Policies Based on Participatory Approach
Sustainability and Higher Performance

Thank You