Interdisciplinary approach for research on water management: a vision from a research Unit in France

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IRSTEA UMR G-EAU

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Context: Challenges for new cropping systems

- Irrigated land: 20% of cultivated area → 40% of production
- In order to feed 9 billion people → big expectation with irrigation systems
- Only 4% of the cultivated land is irrigated in Africa, especially by lack of investment
- Save water: concept of irrigation efficiency
- Do not pollute
- New sources of water, including wastewater reuse, rainwater harvesting

Part 1

The UMR G-Eau: the Joint Research Unit - Water Stakeholders and Uses-
IRSTEA

Public research institute (EPST)

- 9 centres
- Workforce of 1400 including 500 scientists, 200 doctorate and 40 post-doctorate students
- 110 M€ budget including 79 M€ Core Budget and 31 M€ contracts (2010)

IRSTEA 2020 strategic plan based on 3 scientific challenges

Multi-sectoral approaches for land and water management

Risk management and the viability of environmental systems

Methods and techniques for environmental quality
International partnerships

Canada:
- Laval University, INRS,
- University of British Columbia,
- McGill University,
- Ministry of Natural Resources

US:
- USGS, MIT,
- UC Berkeley,
- UC Davis

Brazil:
- Sao Paulo University,
- Brasilia University, EMBRAPA,
- National Water Agency (ANA)

Mediterranean area:
- IAV Hassan II Marocco,
- INRGREF Tunisia

South Africa:
- Cape Town University, IWMI

Australia:
- ANU, CSIRO, USYD,
- UTS, UNSW, Univ. of Western Australia,
- Monash Univ.,
- Newcastle Univ.

New Zealand:
- NIWA, Landcare Research

UMR GEAU: the Joint Research Unit Water Stakeholders and Uses

- Initiative
  - From researchers of various institutions in Montpellier interested in the link between social and technical management of irrigation systems
- Research objects
  - Water management at different scales: water basin, irrigated systems, domestic water services
  - Interactions between biophysical mechanisms and decision-making processes:
- Knowledge and methods:
  - For the managers (water planning->operational management ->software) and the water authorities (forecasting, negotiation)
  - To improve performances of irrigation systems
  - To evaluate and validate the usefulness of methods / tools
- Training students and professionals
UMR Basis and staff

<table>
<thead>
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<th></th>
<th>Cirad</th>
<th>AgroParisT</th>
<th>Ird</th>
<th>Camagref</th>
<th>IAMM</th>
<th>SupAgro</th>
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<td>6</td>
<td>14</td>
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<td>3</td>
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<td>0.25</td>
<td>5</td>
<td>6.3</td>
<td>0</td>
<td>0</td>
<td>15.3</td>
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<tr>
<td>Total</td>
<td>21.75</td>
<td>6.25</td>
<td>19</td>
<td>38.3</td>
<td>3</td>
<td>3</td>
<td>91.3</td>
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</tbody>
</table>

- 91 permanents staff:
  - 76 Engineers and researchers, 1/3 abroad:
    - hydrology, hydraulic (27)
    - Agronomy, plant and soil science (19)
    - Economy, management science (17)
    - Sociologist, anthropologist (12)
- 30 PhD students in 2007, 3/5 abroad
- 20-25 Scientists Overseas: Cirad 12; Ird 9

Component 1: From operational management to allocation scenarios

- 11 scientists hydrology, hydrogeology, hydraulics, cybernetics
- 6 PhD students

- Scale and context:
  - Basin, groundwater table, Canal

- Objective:
  - Planning (sharing water/space)
  - Coordination of public policies

- Topics:
  - Functioning of water institutions
  - Hydraulic regulation of rivers and canals
  - Tools to support planning activities (integrated models)
Component 2 : public policies and management of water services

- **30 scientists**: Economy – Human sciences – Social Simulation
- **12 PhD students**
- **Expertise**: Economy, management

- **Scale and context**:
  - water services (irrigation system, wastewater utilities...)
  - 3 entities: Local Public authorities / Managers / Users
- **Objectives**:
  - Optimization of water production processes
  - Improve the performances of the water services
- **Topics**
  - Institutional agreements between entities
  - Regulation of water demand

Component 3 : Water practices and uses

- **28 scientists**: Agronomy, Fluid Mechanics, Economy, Geography, Soil Sciences; 12 PhD
- **Expertise**: Innovation process analysis
- **Scale and context**:
  - Final user of water service: Individuals or local communities
- **Objectives**:
  - Understanding of users strategies and practices
  - Interactions between water uses and the environment
- **Topics**:
  - Demand and its drivers – sensitivity to “control processes”
  - Water users practices and their consequences on water / soil / aquatics ecosystems / farms incomes
  - Innovative technologies: identification, analysis and acceptability
  - Users participation to the management structures
Part 2

Some Examples
From technique to human sciences
1. Comparing irrigation techniques
2. Laboratory for study and research on Irrigation material
3. SIC hydrodynamic software
4. The AquaStress project: mitigation of water stress at regional scale
5. Aquimed: Co-construction of adaptive strategies as response to CC
6. WAG, a toolkit for building RPG about water management

Example 1: Comparing sprinkler irrigation (RGI) to SDI

Semi-arid climate
Different irrigation levels

Agronomy
Plant and soil science
Computer science
Information technology
Materials and Methods

Site description

SDI plot: 3 lateral spacings
- 160 cm (SDI-160)
- 120 cm (SDI-120)
- 80 cm (SDI-80)

Surface: 1.65 ha
Deep loam soil
average holding capacity of 180 mm m$^{-1}$

Results

Water productivity

$$WP = \frac{\text{Grain Yield}}{\text{Total Water Use}}$$

Irrigation Water productivity

$$IWP = \frac{\text{Grain Yield}_{\text{irrigated}} - \text{Grain Yield}_{\text{rainfed}}}{\text{Irrigation}}$$
Example 2 LERMI
Laboratory for Study and Research on Irrigation Material

Improving irrigation performance to increase water use efficiency, prevent adverse impacts and assure durability.

Drip irrigation performance

- Water distribution uniformity
- Preventing clogging
- Efficiency of micro-irrigation
- Durability of equipments
- Clogging mechanisms
Different forms of clogging
(chemical, physical, biological)

Model = fluid mechanism concepts, fluid particles interactions, shear stress and biofilm development

Experiments = model calibration / validation

• Sprinkler Irrigation:
  - Water distribution uniformity
  - Efficiency of sprinkler irrigation
  - Environmental impact: aerosol production
  - Formation and transport of droplets

  Impact on the soil or the plant: infiltration, erosion, soil leaching, compaction
• **Study of the physical mechanisms**
  Dispersed phase as a function of the initial conditions (pressure, atomization regime, instabilities, drift)
• **Validate and initialize the model** (size distribution, velocity...)

**Sprinkling systems and waste water reuse**

• **Context:**
  – Variability of climate and rainfalls ➔ scarcity
  – Higher sensitivity of the environment
  – In southern Europe summer is associated to drought and tourism
    • higher need for fresh food
    • Higher waste production
  – Develop waste water reuse
    • Decrease pressure on good quality waters
    • Mitigate urban pollutions
    • Add value to a waste
  – In France, development of dedicated regulation
  – Reduce the risks associated irrigation technology
Conclusions LERMI

- Labs have a Central role = independence reference
  - Need to build trust (quality insurance, communication policy)
  - Associate research to testing for farmers or industry
- Researchers and lab policy shall integrate farmers needs and constraints
  - Consistency of modernization policy (industrial capacity, extension service, water allocation, soils)
  - Micro-irrigation is not a miracle technology
- Necessary involvement in research with university
  - Keep research consistency regarding farmers and policy makers demand
  - Conduct research toward application
  - Keep a link between field and industry

Example 3
SIC² hydrodynamic software

Simulation and Integration of Control for Canals
Links between efficiency and management

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<th>Regulation</th>
<th>Efficiency</th>
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<tr>
<td></td>
<td>(Manual)</td>
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<tr>
<td></td>
<td>30 à 40 %</td>
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<td></td>
<td>(Partial. Autom.)</td>
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<td></td>
<td>40 à 70 %</td>
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<tr>
<td></td>
<td>(Complet. Autom.)</td>
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<td>70 à 90 %</td>
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SIC Main features

• Unsteady flow calculation in irrigation canals and rivers (Preissmann scheme)
• True steady flow calculation (with loop calculation)
• Offtake devices (gates, weirs, pumps, etc.) with different calculation modes (discharge, position, opening, width, etc)
• Cross devices (gates, weirs, Mixte, Amil, Avis and Avio automatic gates)
• Minor, Medium, Major beds + reservoirs

• Regulation modules
• SCADA interface (Supervisory Control And Data Acquisition) to control a real canal. E.g. : Gignac Canal
• Sediment transport and Quality modules
• Interfaces in French, English, Spanish
Conclusion Hydraulic simulation

- A software for hydraulic simulation
- A software for the design and test of automatic controllers
- For canals, rivers, sewage systems
- Interfaces with many third party softwares (MatLab, Scilab, etc)
- More than 25 years of experience

Example 4 The AquaStress project

- Water stress is a global problem with economic and social implications.
- The mitigation of water stress at regional scale depends not just on technological innovations, but also on the development of new integrated water management tools and decision-making practices.
- AquaStress is an EU funded integrated project (IP) – FP6
  - delivering interdisciplinary methodologies enabling actors at different levels of involvement and at different stages of the planning process to mitigate water stress problems.
- The project needs both academic and practitioner skills to generate knowledge in technological, operational management, policy, socio-economic, and environmental domains.
- Contributions come from 35 organizations, including SMEs, from 17 Countries
Scientific innovations

• In order to improve the understanding of water stress from an integrated multisectoral perspective to support:
  – diagnosis and characterization of sources and causes of water stress;
  – assessment of the effectiveness of water stress management measures and development of new tailored options;
  – development of supporting methods and tools to evaluate different mitigation options and their potential interactions;
  – development and dissemination of guidelines, protocols, and policies;
  – development of a participatory process to implement solutions tailored to environmental, cultural, economic and institutional settings;
  – identification of barriers to policy mechanism implementation;
  – continuous involvement of citizens and institutions within a social learning process that promotes new forms of water culture and nurtures long-term change and social adaptivity.

Case Study - stakeholder driven approach

• Aquastress adopts a Case Study - stakeholder driven approach and is organized in three phases:
  – characterization of selected reference sites and relative water stress problems,
  – collaborative identification of preferred solution options,
  – testing of solutions according to stakeholder interests and expectations.

It makes a major contribution to the European communities objectives stated in the FP 6th, and supporting the Community Directive 2000/60/EC and the EU Water Initiative.
Example 5 Aquimed

Co-construction of adaptive strategies with local stakeholders of coastal Mediterranean aquifers as a response to climate change

Hydrogeology
Hydrology
Climatology
Agronomy
Economy
Sociology

Participatory reflections for local adaptation to CC?

- Growing call to define adaptation measures to CC at local level => interest to undertake foresight analyses with local stakeholders

- Possible problems:
  - Gap between expert and local actors stakes, time frame and perceptions
  - Type of natural resources and institutional set up that may not be favourable (planning and management capacities, complex or currently sufficient resource, etc.)
  - Possible lack of local stakeholders’ interest in/capacity to participate.
Aquimed Projet

Taking into account the diversity of local situations:
which methods to enable and organize foresight analyses
- with local stakeholders
- to improve adaptive capacities to climate change?

- **Objectives:** To develop and test methods to:
  - Discuss CC impacts and adaptive strategies at different levels with local stakeholders
  - Improve stakeholders’ capacity to collectively anticipate future changes

- **Study cases:** coastal aquifers in risk/current situation of overexploitation, as areas especially vulnerable to CC impacts

Methodology: main steps

- **Workshop 1:** Diagnosis of issues & driving forces
- **Workshop 2:** 4 scenarios of socio-economic changes
- **Workshop 3:** 2030 & 2050 climate change scenario + impact on water resources
- **Workshop 4:** 3 groundwater management scenarios

- **Input material:**
  - Interviews
  - 4 scenarios of socio-economic changes
  - 2030 & 2050 climate change scenario + impact on water resources
  - 3 groundwater management scenarios

- **Sharing of results & exchange:**
  - Evaluation of alternative groundwater allocation mechanisms
  - Vision of water scarcity level in 2050 + Climate change impact & possible adaptation at farm level (2050)
  - Final common workshop

- **Methodology: main steps**

- **Workshop 1:** Diagnosis of issues & driving forces
- **Workshop 2:** contrasted visions of agriculture change by 2030
- **Workshop 3:** Vision of water scarcity level in 2050 + Climate change impact & possible adaptation at farm level (2050)
- **Workshop 4:** Evaluation of alternative groundwater allocation mechanisms

- **Final common workshop**

- **Sharing of results & exchange**

- **2-3 farmers groups** + **1 group of institutional representatives**
Lessons learnt: methods for participatory foresight analysis of CC impacts and adaptation

- Discussion of adaptation to CC is possible, even in contexts where local stakeholder involvement is not initially granted
  - Some possible ways to embed this issue in collective reflection over evolution of agriculture and territories, at different scales
  - For instance: entry by agriculture to later talk about water

- Diversity of possible methodologies
  - Depending on context, local situations of researchers...
  - Diversity in the way of producing knowledge based on scientific models and actor knowledge
  - Added value of having study cases in three countries to making explicit the key "points" where decisions have to be taken regarding
    - Use of scenarios as intermediary object
    - Group formation and invitation
    - Time scale and way to introduce CC

Example 6
Wat-A-Game, a toolkit for building role-playing games about water management
WAG: Idea and Rationale

- To understand, Represent, Simulate and Manage a Catchment
- Combining a method and some simple robust bricks to build participatory simulations (role playing games) for water management and governance processes associating policy makers, technicians and the public.
- A custom mock-up of your catchment where water tokens (marbles) circulate, fill dams and aquifers, are captured and consumed by the users-players for the activities they have chosen, and are partly returned to the environment mixed with pollution or sediments. (and Yes, you can see it!).
- Where everyone can understand and discuss economic, social and environmental impact of action choices.
- And where new social rules and policies can then be explored and tested, through dialogue with elected representatives, experts and decision makers.
- For locally relevant, usable and useful serious water games

What is WAG?

- A set of configurable components for building a « playable » catchment

- Land Plot Cards
  - types: sector, area
  - Ownership: private, common land

- Hydrologic connections and infrastructures

- Water tokens
  - Clean and dirty

- Events
  - Random, scenario, Playability and qualitative aspects

- Infrastructures
  - Costs & Water Transformation

- Actions & Services
  - Water Need & Costs
  - Water Return & Production
  - All or Nothing
Modelling with WAG

Stakeholders or students can build a playable representation of their catchment

Simulations with WAG

Players circulate and manage clean and dirty water marbles